Data-Driven Practices and Sustainability in Business Operations

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Foreword

This collection of studies focuses on sustainability, digitalization, and innovation in all their diversity, reflecting the most important economic, technological, and social challenges of our time. The authors cover a wide range of topics: the studies range from agricultural and environmental economics to digital transformation, artificial intelligence, and data-driven decision-making, to human resource development, social enterprises, regulatory issues, and corporate performance measurement. Particular emphasis is placed on the complex interpretation of sustainability, which manifests itself not only in environmental but also in economic, social, and institutional dimensions. In addition to their theoretical foundation, the studies included in the volume contribute to scientific discourse and support organizational and policy decision-making with empirical results and practical examples.

We trust that this collection of studies will be useful reading for researchers, educators, students, and practitioners alike, and that it will contribute to deepening scientific dialogue and encouraging future-oriented thinking.

We would like to express our gratitude to the authors who contributed to the publication of this volume with their valuable work.

Miskolc, December 2025

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Cluster-Based Strategies for Sustainable Development: A Bibliometric Analysis

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Abstract: This study aims to discuss cluster-based approaches to sustainable regional development in Hungary based on bibliometric data. Information from the Web of Science database was used to analyze publications, citations, and research activities. The paper's findings reveal how clusters can create collaborative environments for improving governance systems -temporal organization of territories for sustainable innovation in Hungary. Considering this approach, the study provides a unique roadmap of best practices in various countries that would help Hungary to achieve its desired status in the region – that of a sustainability champion. From this research, knowledge is gained on how cluster-based strategies can encourage sustainable development and future proof.

Key words: Cluster-Based Strategies, Sustainable Regional Development, Governance Frameworks, Bibliometric Analysis, Regional Sustainability
Jel Codes: G38, L10, Q01

Introduction and literature review

Sustainability still poses a challenge in modern generations as societies seek to concurrently pursue economic development, social justice, and environmental conservation (Sachs et al., 2019; Mishra et al., 2024). In an effort to enhance the idea of sustainable development, which is a process aimed at meeting the needs of the present without compromising the ability of future generations to meet their needs, there is cutting-edge focus on developing policies and measures meant for geographical characteristics and an economic profile existing in the region are just the right combination for the analysis of the new strategies for the sustainable regional development (Camagni & Capello, 2013). This study employs emblematic analysis to build a coherent cluster-based framework, as a basis for responding to sustainability challenges through governance, economic, and collaborative innovations, and situating Hungary within its sustainable practice context (Porter, 1998; Buzási, 2023).

Bibliometric technique proves a drastic vital knowledge for discovering research trends, identification of core publications and research flagship, and providing well-structured framework for academics to discuss (Chen et al., 2021; Effah et al., 2023). Based on the identification, this study provides the diversification and change trajectory of sustainability research from the Web of Science and indexes the publication and citation impact, authors, institutions, and the cooperation network (Wang et al., 2022; KSH, 2022).

Based on geographical locations, cluster initiatives are recognized globally as bearing capacity in achieving innovative aptitude resource optimization, and technology development through the affiliation of businesses, suppliers, and institutions (Porter, 1998; Delgado et al., 2014; Szlávik et al., 2016).

Hungary has a suitable territorial capital, while active actors and solid scientific and knowledge background make the country appropriate for further development of the sustainable regional clusters (Camagni & Capello, 2013; Csete & Szabó, 2015). The country's capacity to adopt cluster framework with sustainability concerns to improve economic effectiveness and ecological responsibility (Sachs et al., 2019; IMF, 2024). The aspects of the governance models and collaborative networks are the key factors in the continuation of cluster initiatives considering the incorporation of sustainability policies into the public and private institutions (Siddiqui and Cohn, 2019, European Parliament, 2023). Neoclassical institutionalism has emphasized that legal frameworks are critical for public resources long-term sustainability at the regional level of management of such initiatives (Borras, 2013, Edquist, 2013).

Cluster organizations promote synergized strategy formulation since they allow public, private and academic players to come together, share information and knowledge and to foster innovation (Porter, 1998). This is in harmony with world sustainable development trends, including the Sustainable Development Goals of the United Nations: the ninth, concerning Industrialist, Innovation, and Infrastructure; the eleventh, Sustainable Communities and Cities; and the seventeenth, Partnerships (United Nations, 2015). This research underlines the elements of the F strategy (a Foresight-based, Flexible, Focused, and Future-oriented approach) including long-term partnerships, and cluster strategies as the cornerstones to Hungary's sustainable regional development more so in the cluster development perspective (Camagni & Capello, 2013, Buzási, 2023). particularly the United Nations Sustainable Development Goals (SDGs), including SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 17 (Partnerships for the Goals) (United Nations, 2015). This research emphasizes the importance of flexible governance achieving -term partnerships, and cluster strategies as foundational elements for Hungary's sustainable regional development (Camagni & Capello, 2013; Buzási, 2023).

The expected contribution of this research is to indicate strategies for building STI (Science, Technology, and Innovation) for sustainable regional clusters, improving governance structures, and using resources more efficiently so that Hungary can become a source of benchmark for sustainable regions around the world (Mishra et al., 2024). Prior bibliometric investigations endorse the efficacy of these approaches in elaborating recourses, aligning them to policymaking, and fostering interdisciplinary views toward sustainability (Effah et al., 2023; Raman et al., 2024).

In a combination of theoretical and empirical analysis this study adds to academic literature while applying practical experience to aid international endeavors in the field of regional sustainable development.

Regional Sustainable Development

Sustainable regional development focus on strengthening and improving the economic, social, and structure of the region in order to increase the capacity to respond to economic and social risks that are: After many years, this field has embraced concepts and paradigms with the objective of linking local development with sustainable development worldwide examples being United Nations – Sustainable Development Goals – SDGs (Sachs et al., 2019). The idea supports the balancing of near-term economic development and sustainable resource and social management

for the future challenges comprising resource scarcity, climate change, and socio-economic imparity (Camagni & Capello, 2013). It is worth noting that in recent studies, there is the emphasis on adoption of the innovative forms of governance and intersectoral cooperation implementation regarding sustainable development as continuous integration into regional practices and policies (McCann & Ortega-Argilés, 2016).

In the European context sustainable regional development has been twinned with ideas such as smart specialization and circular economy which emphasize efficiency of resource use and undergoing innovation. Further, the tentative nature of growth strategies, different regional affiliation of the Hungarian economy, and its undiscovered opportunities also make it an interesting site for investigating these strategies. Thus, Hungarian scholars have underlined the importance of capturing Hungary's regional policies into core European sustainability perspectives, as well as mobilizing the country's territorial assets and coalition forming potentialities for durable development (OECD, 2019).

Cluster-Based Strategies

The use of cluster and Porter based strategies is being adopted in most nations as being coherent ways of enhancing sustainable regional development. Cluster theory was first developed by Porter (1998), whereby it defined clusters as geographically proximate units of related businesses, suppliers, and institutions that offer efficiency and generate ideas. Scholars have extended this concept toward the sustainability goal in the recent past arguing that clusters ought to facilitate social interactions, accommodate sustainable initiatives and enhance the efficient use of available resources (Wang et al. 2022).

Clusters allow private, public and academic stakeholders to develop sustainable strategies based on the information exchanged; developing shared projects that meet the sustainability goals set by different entities (Chen et al., 2021). This demonstrates that Hungary's potential for developing sustainable clusters lies at the regional and research level. For instance, some sectors such as agriculture, renewable energy and advanced manufacturing could be the building blocks of clusters that enhance regional competitiveness for a green economy and social needs. Nonetheless, experimenting with cluster-based strategies is critically contingent on governance structures and policies that allow for social learning and fair sharing of the resulting benefits (Sachs et al., 2019).

Governance and Collaboration

As previously discussed, governance and collaborative networks are central to cluster-based strategies. Sustainability planning integrates strategic goals at all levels while sustainability management frameworks facilitate governance of sustainability issues within planned interventions. One of the most important preconditions for sustainable clusters in the face of dynamic changes and multiple interest groups has been identified as the concept of adaptive governance (OECD, 2019). Recent studies also put stress on the network's dependencies, covering intersectoral and interregional level, with the aim to bring together the ideas and resources for innovations (McCann & Ortega-Argilés, 2016).

In Hungary, the efficiency of networks to provide liaison could assist in eradicating disparity of regions and enhancing inclusion. These networks engage actors from private enterprises,

government institutions and academia into cluster-creation processes and can complementarity enhance the impact strategies based on clusters. However, there is disconnection in policies due to fragmentation, and no incentives for collaborations, not to mention a weak engagement of stakeholders to foster and enhance these collaborations (Chen et al., 2021)

Methodology

Bibliometric analysis is today one of the most effective tools for mapping research and, therefore, devising the right strategies in sustainable development. Since publication data, citations, and authors form a co-authorship network, bibliometric methods offer useful information regarding the developmental courses of relevant specializations or forthcoming topics (Wang et al., 2022). These techniques also help in finding important papers, collaborative research activity and possibly fulfilling the purpose of bibliographic coupling by directing the researchers towards area of research with high impact factors.

Bibliometric surveys on sustainability over the recent past provide evidence that such approaches prove useful when depicting research trends and contributing to policy making. For example, Chen et al. (2021) conducted a bibliometrics analysis to visualize the integration of green technologies in cluster-based strategies, and proposed solutions to actors. Bibliometric analysis for Hungary can contribute to the identification of research findings, the evaluation of regional policies, as well as the construction of cluster-based framework instruments specific to the socio-economic conditions of Hungary.

From researchers' perspective, the analyzed sources also indicate the possibilities of sustainable region development and the cluster approach. According to the author, incorporating clusters with adaptive governance and collaborative networks presents a strong model for delivering Hungary's sustainable goals. Nevertheless, apart from the more conceptual focus of the literature, extant studies lack concrete suggestions for practical implementations in reference to the Hungarian case only. In this manner, bibliometric analysis serves as a valuable method for narrowing the gap between practice and research to facilitate the identification of practical recommendations and the focus of research to meet national and regional needs. Furthermore, the author considers that increasing the number of international partnerships and integrating innovative approaches to work, including using technology and big data in consideration, can improve the efficiency of cluster approaches to development.

First, the literature is reviewed to outline the theoretical framework of sustainable regional development and cluster strategies. This section presents bibliometric analysis that describes the typical research trends and the process of developing the conceptual framework. The findings describe bibliometric data and recommendation strategies for Hungary and are discussed in the results section. Focusing on the discussion of the findings as well as the conclusion section, the relationship implications and policy recommendations are given while considering further research directions.

To identify the research trends in sustainable regional development and the cluster-based approach, the study used bibliometrics as the main methodological tool. Bibliographic analysis is applied in the study with the aim of determining publication trends, citation analysis, and collaboration over time, and thus, provides the quantitative backing required to examine the development of the field.

Search Conditions and Date of Search

The identified literature search was performed in the Web of Science (WoS) database, restricted by appropriate keywords that correspond to the research goals oriented towards SRD and CBAs. To cover all the fields of interest, the use of primary keywords like 'Sustainable Regional Development', 'Cluster Strategies', 'Proximity Economy', 'Sustainable Governance' and 'Collaborative Development' was chosen. To maximize coverage of related terms, 'Territorial Resources', 'Sustainable Innovation' and 'Networking for Sustainability' were used alongside the terms. Using Boolean operators (AND/OR), the research findings were refined to determine the relationship between sustainable development and the cluster concept accurately. For example, queries like: (("sustainable development" OR "regional sustainability") AND (cluster strategies OR collaborative development) AND (governance structures OR territorial resources)) concedes supported excluding irrelevant documents but at the same time, kept 'diverse' subscriptions. ALS was also used in combination with filters for assessing peer-reviewed only to ensure that only authoritative sources were included and by limiting its sources to review papers and peer reviewed conference proceedings.

The search was done in publications with the time frame of a decade from the year 2014 to 2024 inclusive, on sustainability, clusters, and governance framework. This period was chosen to incorporate the latest developments in the field while at the same time conducting a long-term analysis of the tendencies and developments. This enhances the likelihood of capturing recent and therefore, valid issues and approaches to sustainability throughout the leading HEIs within the ten-year period under focus. The search was done on December 20, 2024, thereby including current literature in the review. This date denotes the last time data was collected so it gives a large picture of the current academic research on sustainable regional development and clustered approach. Through several investigations, this systematic method of data gathering enhances the reliability and relevance of the study outcomes: it is useful toward the development of effective and evidence-based strategies toward sustainable regional development and planning not only in Hungary but around the world.

Search Results and Recording Process

The search performed in the WoS database provided a total of 330 publications that best correspond to the topics covered by the All-title keywords identified for the themes set for the research: sustainable regional development and cluster-based initiatives. These outcomes cover a wide range of fields, including environmentalism, legal regulation, regional development, and technoeconomic activities. The variety of the retrieved records proves the interdisciplinarity of sustainability research and identifies the degree to which it is interested to various academic disciplines like economics, regional planning, environmental science, and business management.

Publication Distribution was between 2014 to 2018: Average annual production of 25 articles per year up to the middle of the first decade, which reflects the formation of the initial discourse on the sustainability-cluster concept.

2019 to 2024: An increase in publication frequency and the highest number of publications in 2023 (53). This trend reflects the increasing focus on sustainable innovation, cluster development and regional management as a response to global sustainability issues.

Thematic Concentrations:
Cluster Strategies and Sustainable Innovation were mentioned in 45 ½ % of the records, which underlines the prominence of both notions in the context of sustainable development. Both Practical Applications and Governance Structures and Collaborative Development were identified in close to 38% of the articles showing the importance of managing and engaging with clusters in a sustainable manner.
Proximity Economy and Territorial Resources appeared in 22% of the publication, as entrepreneurs start to focus on localized resource management and the development of autarkic economic systems.

Geographical Scope:
While a larger number of studies involved China (20.6%), England (13.6%) and the USA (11.2%), more European countries contributed to the research with Germany (9.7%) and Hungary (4.5%). For the specifics of Hungary's presence in the dataset, the emphasis on the centrality of the cluster-based approach to the process of regional development in Central Europe reasserts itself, thus backing up the focus of this research.

Highly Cited Publications:
The paper, "Designing Agroecological Transitions" (Duru et al., 2015), with the greatest number of citations within the dataset, achieved a citation count of 411, suggesting that there is a significant hyperlink between the agroecological evaluation of clusters, cluster development and sustainability. Others include "Environmental Policies and Governance Structures" by Elmagrhi, Oral, Akcay, and Bulut (2019) with 338 citations focusing on governance antecedents to environmental performance.

Recording Process:
All the findings were documented and segmented based on publication year, relevance and citation analysis. A detailed spreadsheet was created to log the following key attributes for each record:

- Title of Publication
- Authors and Affiliations
- Publication Year
- Journal or Conference
- Total Citations (if applicable)
- Keywords and Abstract Highlights
- Country of Origin

Furthermore, bibliometric analysis in the Web of Science was used to map co-authorship ties, cited references, and keyword groups. This approach was effective in identifying patterns of research topics and cooperation.

The quantitative data captured and documented becomes the raw form of evidence in the subsequent bibliometric analysis to provide more strategic directions for sustainable regional development of Hungary through clustering techniques.

While the recording process tallies with the storage of the said data, it also categorizes and selects the most relevant pieces to the topic of this article, the cluster-based sustainability strategies of Hungary. These three processes make it possible to smoothly transfer data from the data collection stage to the analysis and identification of high-value insights that inform the creation of the article.

The applied Bibliometric Techniques Applied were as follows:

- Co-authorship Analysis: Used the author Contribution analysis to determine who among the authors is most centrally placed and which authors have closely knit groups.
- Institutional Collaboration Analysis: To draw attention to the organizations that contribute significantly to SD research, institutional partnerships have been aligned.
- Country-Level Analysis: Evaluated inter-country cooperation by identifying the location of the countries that have contributed.
- Keyword Co-occurrence: In reviewing the publications, the important keywords that frequently occur have been presumed to point out similar issues and trends.

Research results

Determination of the number of publications per year is one of the parts of the methodology used and is described in this chart. The figure discussed below presents the annual publication frequency and the emergence of the topic in the period of 2014-2024. This research uncovers the mounting trend of the field over the years indicating the increase in the current years. For instance, comparing the number of publications, the publication count increased from 16 in 2014 to 53 in 2024, reflecting the increasing importance of the subject of sustainable development and cluster approaches in scientific production.

This temporal analysis is useful for the next steps of defining the periods of increased academic activity, appearance of topics, and absence of publications. It also aids positioning the extensive discussion within sustainability research by linking publication frequency patterns to global and regional events including policies, environmental issues, and technologies.

It is easier to understand the direction of the research activity from Fig 1. of publication trends. This will be supported by the thematic analysis of the content of key articles and identifying their thematic focus and methodological direction.

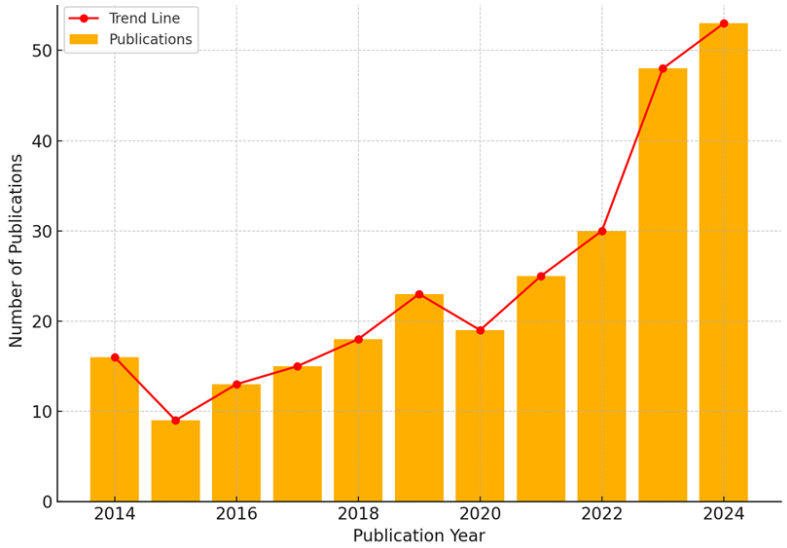

Figure 1. Number of publications per year
Source: own research

Table 1 summarizes the top cited articles of the topic.

Table 1. Citation analysis of top 10 top-cited articles highlighting key contributions to sustainability, governance, and regional development research

Title	Authors	Publication Year	Total Citations	Average per Year
Designing agroecological transitions; A review	Duru et al.	2015	411	41.1
A study of environmental policies and regulations, governance structures, and environmental performance	Elmagrhi et al.	2019	338	56.33
Factors affecting corporate environmental disclosure in emerging markets	Gerged, A. M.	2021	141	28.2
Institutionalizing the urban governance of climate change adaptation	Aylett, A.	2015	137	13.7
Climate policy integration in the land use sector	Di Gregorio et al.	2017	118	14.75
Integrating Nutrition and Child Development Interventions	Black et al.	2015	88	8.8
Protected Areas in a neoliberal world and the role of tourism	Job et al.	2017	81	10.13
Reflexive governance: exploring the concept	Feindt et al.	2018	80	11.43
Grand Societal Challenges and Responsible Innovation	Voegtlin et al.	2022	74	18.5
Experiences of host communities with carbon market projects	Mathur et al.	2014	65	5.91

Source: own research

The subjects of the top articles can be identified as themes in sustainability research, including particularly governance, innovation, and regional development approaches. This is captured by the most cited paper in the specialty, 'Designing agroecological transitions; A review' published in 2015 with 411 citations on how the principles apply to the actual transformation processes of agroecological practices. In the same vein, "A study of environmental policies and regulations" (2019), it has the citation of 338 but with a more magnificent annual average of 56.33, this goes to show that there is upraise towards the governance structure as well as environmental performance.

Some of the recent publications include 'Factors affecting corporate environmental disclosure in emerging markets,' published in 2021, and 'Synergy/trade-offs in the Yangtze River economic Belt,' published in 2023; Despite the relatively recent publication, all show strong influence and may indicate emerging interest in ESG topics and regional ecology. Papers from the earlier years such as "Measuring good governance for complex ecosystems" published in 2014 remain as some of the most useful literature for any researcher whereas papers produced in this year such as "Grand Societal Challenges and Responsible Innovation" remains as some of the most relevant literature in the current society.

As such, this bibliometric analysis by pinpointing key studies situates this research within the most significant trends while incorporating new approaches at the same time In this way, the findings of this research provide a strong framework for designing cluster-based strategies for effective and sustainable regional development in Hungary.

Web of science category

The dissemination of publications clearly shows that sustainability research involves multiple domains or rather disciplines. Environment has been a key research interest with Environmental Studies publishing 98 articles and Environmental Sciences 90 articles in the system. Technological enhancement for sustainability solution bears importance where Green Sustainable Science Technology is published 68 articles. Various disciplines include Geography (27 articles), Regional Urban Planning (24 articles) and Economics (23 articles) demonstrating how spatial, urban, and economic aspects are exemplary within sustainable development approaches. Moreover, employing the categories like Business (22 publications), Management (25 publications), and Urban Studies (16 publications) also marked shifts in discourse on organizational leadership, corporate governance, and city planning for sustainable future. This distribution of the research categories shows that sustainability is a complex issue that demands inter- and multi-disciplinary efforts. It is noteworthy that all these research endeavors taken together offer cross-cutting support in enhancing the worldwide sustainability goals and meeting current societal concerns.

Countries network

The analysis of the geographical distribution emphasizes that some regions have made extraordinary contributions. The People's Republic of China tops with 68 records (20.6%), followed by England with 45 (13.6%) and the USA with 37 (11.2%). These statistics indicate that developed countries dominate the area of sustainability studies.

European nations such as Germany with a contribution of 9.7%; France 3.9% and Scotland 3.6% also fancy their percentages as they have been traditionally more inclined to environmental and sustainable development policies. Curiously, South Africa (5.7%) and India (3.6%) denote that internal dynamics in the Global South are actively engaging with the sustainability debate.

Some other countries which include Brazil and Switzerland contributed 2.7% each while other countries including Kenya and Saudi Arabia contributed 1.5% each in relation to other countries' contribution to sustainability challenges. These findings offer trends in international research, indicating focused expertise in developed countries and nascent research interest in developing countries.

This analysis is helpful to explain that the research focuses on the global level and the collaboration between different regions. It also raises awareness to the role of encouraging and strengthening knowledge production from the global south for balance in progress towards sustainable development goals (SDGs).

The publishers

The data set presented shows the distribution of the analyzed records according to the activity of certain publishers. First, Elsevier contributes the most with 18.79% of the publications, MDPI with 13.03%, Springer nature with 11.21%, Taylor & Francis with 10.61%. Out of 239 included records, the presence of these four publishers is overwhelming since they contribute more than 50% of the total records which evidently validate their dominance in academic publishing for the relevant areas of research. Other key players are Wiley with an overall percentage which came to 7.27%, Emerald Group Publishing with 4.55%, and Frontiers Media SA with 3.33%. Many publishers produce 2 records each: ASCE, BMJ Publishing Group, and IEEE account for 0.61%; 67 smaller publishers produce 20.30%, indicating that many contributors participated.

In my opinion results elucidate the fact that there are some giant players like Elsevier and MDPI, which produce a huge number of publications; at the same time, numerous new publishers introduce novelties into the context. This reveals both a flow of information from the center and dissemination to a larger unit, which is important in capturing the orientation of publications in the field.

Sustainable development goals (SDGs)

Figure 2 reflects the distribution of the analyzed records in terms of the selected SDGs. Among all 24 SDGs, SDG 13, Climate action, has the largest share of the total publications, with 33.64%, or 111 records, because climate change is a hot topic now. In the second place is SDG 9, Industry, Innovation, and Infrastructure contributing 32.73% (108 records). This shows the importance of innovation and infrastructure, which are the relevant forms of development, towards sustainable growth.

SDGs 15, Life on Land, is the third most popular with 30% (99 records) pointing to the focus paid to maintaining the terrestrial environment. Sustainable Cities and Communities which fall under the SDG 11 occupies 28.48% (94 records) and is relatively on the rise.

SDG 2 on ending hunger, achieving food security and improved agriculture is the highest-ranked project, at 22.73% and 75 records.

To be specific, SDG 14 Life Below Water accounted for the largest share with 21.52% of the total, followed by 71 records.

SDG 6 Clean Water and Sanitization has 7 records while affordable and clean energy has 6 records and Food and Nutrition Security has 8 records all contributing to 3% each, SDG 4 Quality Education has 8 records while Industry, innovation, and infrastructure have 6 records all contributing to 2% each while remaining 7 SDG's have less than 2% share in total with means SDG 8.

Both SDG 6 Clean Water and Sanitation and SDG 7 Affordable and Clean Energy represent 10% (33 records each) share emphasizing clean water availability and renewable resources.

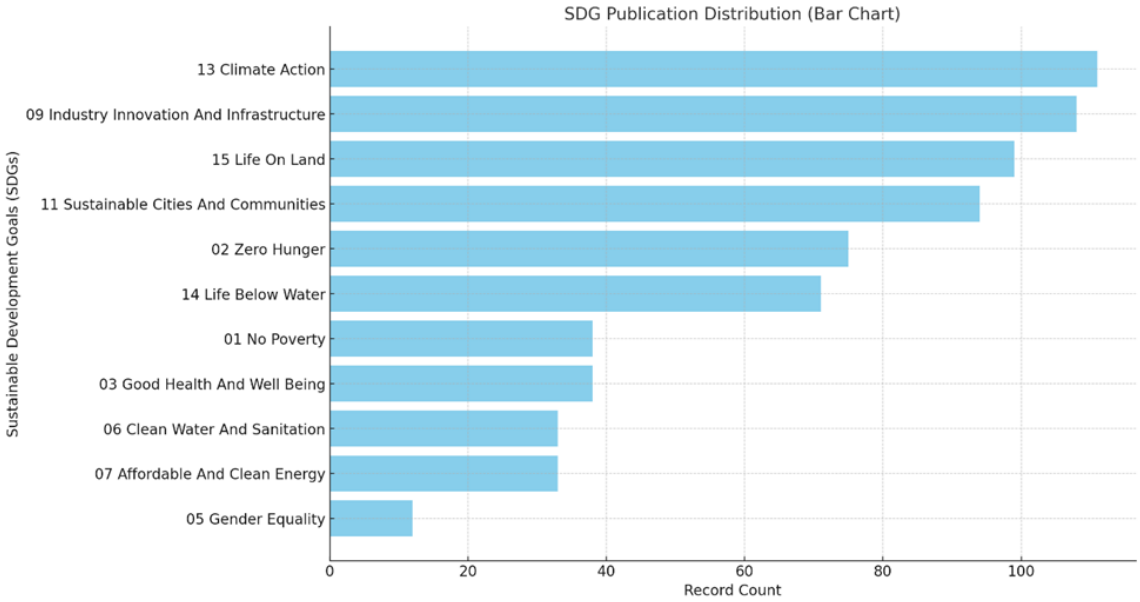

Figure 2. Publication Distribution Across SDGs
Source: own research

Keyword co-occurrences

Also, in the analysis of keywords it is possible to identify the interconnection of activities that contribute to sustainable regional development and those based on the development of clusters. Terms like Sustainable Development, Sustainable Innovation, and Sustainable Governance are quite interconnected; it denotes using multiple approaches in resolving problems in relation to regional sustainability.

In the subdomain level, several keywords such as cluster strategies, proximity economy and collaborative development are found grouped closely, suggesting that many of the papers are being published with the themes of geographic clustering and collaboration in developing and sustaining sustainability initiatives. The evidence identifying Sustainable Clusters and Territorial Resources

indicates that the regional capital and place-specific institutional arrangements are critical for tailor-made sustainable solutions.

Additionally, the high manifestation of Sustainable Networking and Governance Structures suggest organizational collaboration and thus dynamic framework in the continuous achievement of sustainable development. This networked approach is consistent with increasing interest in clusters for Sustainability Companies and Innovative Practices, confirming clusters to enable regional economies for change toward post pandemic futures.

In conclusion, the keyword co-occurrence analysis provides important insights into the interplay of governance, innovation and collaborative networks which are at the core of the cluster-based strategies for building sustainable regional development (Fig. 3).

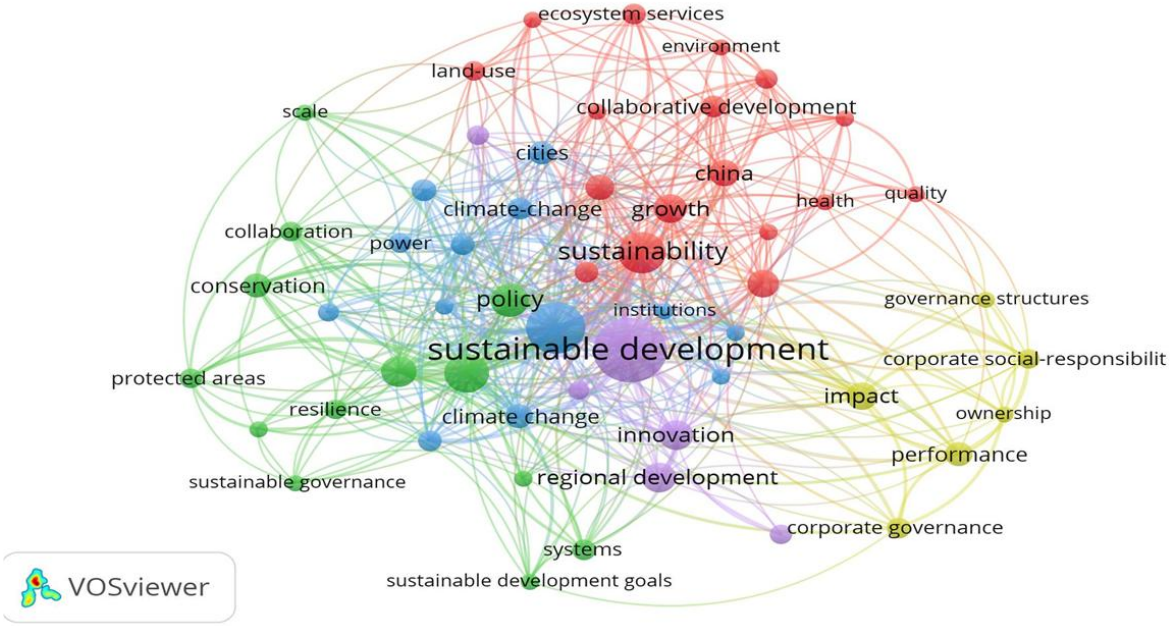

Figure 3. Keyword Co-occurrence Network in Sustainable Regional Development
Source: own research

Data collection

Main domain: sustainable regional development
Sustainable regional development is the framework within which regional development happens considering the economic, social, and natural environment. Sustainable development aims at the approach for the current generation's needs while preserving resources for future generations, management and steering regions towards green economy and fair resource share. A sustainability company is an ideal ally of these principles because it integrates environmental, social, and governance objectives into their organizational operations to build regional sustainability and appropriate economic development. Central to this shift is sustainable innovation by embracing technologies and the creation of new business models that foster efficiency, utilization of resources and reduction of negative impacts on the environment. This type of creation is generalizable across industries thus providing green compliant solutions to support regional competitiveness. Another is sustainable governance to guarantee that most of the determinations being taken in organizations

consider accord, environmental responsibility, as well as economic balance. Policies such as sustainability reporting, sustainable procurement and cut ties with the sectors that harm the environment, bad regulatory frameworks for business and lack of democracy eventually create foundations for sustainable development in the regions and nations. In total, these contribute to the construction of a complete strategy that enables regions to address social and economic inequality, start and pursue local sustainable development which is resource-efficient, along with being significant pioneers in the shift to circular economy and achieving carbon neutrality.

Sub domain: Cluster-Based Approach in Sustainability

Sustainability through a cluster-based approach centers on revitalizing innovation and strengthening the virtual connections between organizations and industries that form the geographical region. The foundation of this approach is therefore the concept of cluster strategies, which espouses partnership in forging regional competitiveness between private firms, academic institutions and government agencies. These clusters are innovation platforms that prospective stakeholders can organize around to coordinate access to resources, information exchange and foster economic development while promoting sustainability. One is the proximity economy, the concept that most products should be sourced locally so that there is little to no shipping required, increase in social bonding and fortification of regional economies. It also strengthens the cluster model more by creating cooperation that allows the sharing of research, related infrastructures, and policies. This cooperative framework nurtures sustainable clusters: it ensures resource efficiency, environmental care and green innovation amidst cluster operations. There are sound governance structures in these clusters that make policies, regulations and leadership structures flexible, accountable and in tandem with sustainability goals. Furthermore, the application of territorial capital boosts the opportunity of natural, manpower and industrial capabilities of a region for growth and development. Finally, sustainable networking takes cluster advantages to a next level, where clusters in different regions are connected to each other to share sustainable practices and technologies. Altogether these form a strong framework for sustainability that shows how goals at the micro and macro level completed through clusters' activities could support and correlate with global sustainability objectives.

In authors' opinion, sustainable regional development is best supported by bottom-up programs such as cluster approaches. Clusters are effective collaboration platforms for local businesses, institutions, and governments, which work to develop new solutions for sustainability issues. Of course, this bottom-up approach helps to move faster by translating region-specific advantages and fostering sustainable development ownership by all stakeholders. The proximity economy emerges as the most significant factor in this regard; it dials down environmental impact and increases sustainability by fostering local sourcing. Another important aspect of sustainable management is that of sustainable governance where policy making is both; policy making is both transparent and inclusive of sustainability goals in the environment as well as the economy. Clusters as they are arranged here, connect economic development to sustainability, which is a result of sustainable networking and collaboration between clusters and across regions. The analyzed countries, including Hungary, are in possession of a varied and prospective supply of territorial values alongside rapid access to new sectors that can help such regions set an example in terms of the model being promoted for sustainable regional development. Enhancing these linked systems is the way forward to support perpetual regional resilience and sustainability.

Some of the important actors in the organization's collaboration network are CSIRO (Commonwealth Scientific and Industrial Research Organization) that work with several universities including "univ sheffield," "univ maryland" and "univ queensland." Multiple clusters can also be distinguished: European institutes and several Australian institutes are closely connected.

- In terms of centrality, CSIRO can show that it oversees uniting multiple institutional research endeavors.
- Scholars from institutes located in Asia, Europe and North America indicate internationalization of sustainable development research.
- Valuable connections established with highly connected institutions could offer ways of obtaining international funds as well as projects.

Country Collaboration Network

The countries most active within collaboration include China, USA, as well as Germany, signaling the roles they play in global research for sustainability (Fig. 4). New names which are formed as per the above knowledge map include "sweden," "norway", and "poland" which belong to the regional clusters representing intra Euro coop. Other SEMs including ''Developing Nations'' also display rise in engagement; consequently, there is heightened concern for sustainable development as seen by ''india'' and ''brazil'.

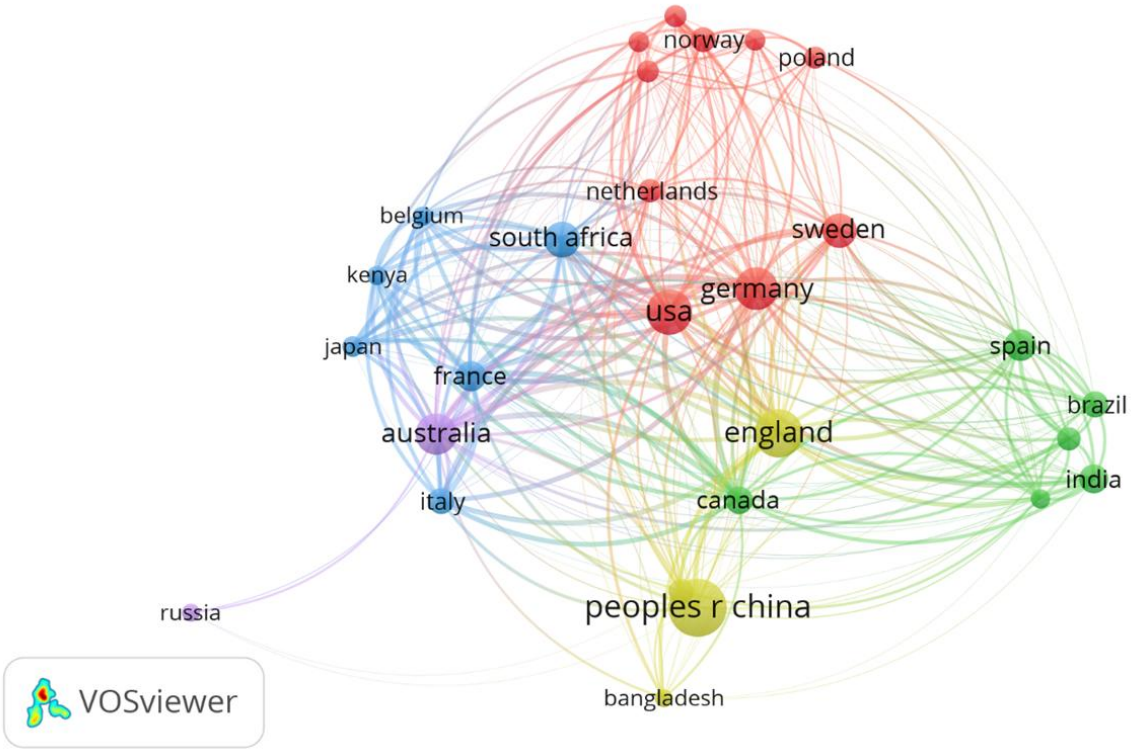

Figure 4. Country-level collaboration network in sustainability research
Source: own research

Cluster-Based Strategies and Governance

The study further posits that cluster-based strategies are crucial in supporting sustainable regional development from business, governments as well as university clusters. This is in line with global

trends such as the United Nations Sustainable Development Goals where this research aligns with the UN-SDG 9, industrialization, innovation and infrastructure as well as UN-SDG 11, sustainable cities and communities.

Governance and collaboration network

- Adaptive Governance Models become critical in addressing emergent and complex sustainability issues, promoting multi-stakeholder engagement, and linking sustainability policies at different organizational levels appropriately.
- Cluster organizations allow for sustained relationships that increase the improving the innovation, resource use and the competitiveness of the region.
- Territorial capital processes are central to cluster-based frameworks for Hungarian regional development to engage stakeholders in sustainability.

Key findings and their implications

Also, CSIRO's role has been proved to have significant impacts on the formation of the discursive formation of sustainability through dictation and analysis. These findings imply that the leadership and experience gained in cluster-based approaches increase the speed of the implementation of new governance models across various regions. Even higher frequency of publication in the last ten years can be attributed to the rising importance of implementing sustainable development frameworks.

On geographical aspect, it is true that China, USA and Germany highlighted the function of economically developed countries. But the involvement of developing nations such as India and Brazil gives a welcoming twist toward increased participation internationally. This means that sustainability initiatives are more and more being seen as collective commitments, which go beyond economic divisions.

Cluster strategy as a tool for sustainability

The analysis underlines the arguments that state that cluster-based strategies cannot be viewed solely as economic instruments, they are the frameworks for development of mechanisms of resilience and sustainability. From the national and regional resources and industries and especially from the relevant policies supported clusters can make innovative clusters to develop the overall economy of the regional and national level. The opportunities of applying these frameworks in Hungary indicate the country's readiness to build on territorial capital and concord with the general sustainability policies within the European Union.

Governance and adaptive model

These issues of governance models linked to the cluster strategies outline how difficult problems of sustainability may be solved. As the research findings have shown, adaptive governance helps keep the cluster initiatives relevant across changes in the environment, society, and economy. When it comes to Hungary, that focus on the flexibility of the governance systems could help maximize the cluster's performance and allocate the resources fairly.

As a summary, a bibliometric analysis results not only contribute to the literature of knowledge but also provides useful advice to the policymakers and industrialists. Cluster based strategy is one of the promising tools to fulfil the gap between innovation and sustainability in the context of Hungary. Based on the benchmark analysis of the world's successful regions, we understand the necessity to expand cooperation between the public and private sectors for the creation of competitive and sustainable clusters of regional importance.

Authors highlight that the findings raise the awareness of the necessity of Hungary to develop cluster initiatives through the following: development of capacity which will foster interdisciplinary collaborations and development of sustainable business clusters. Also, a stronger focus on the function and capacity of institutional structures at the territorial level and on territorial planning can contribute to intensifying work towards achieving regional agendas and objectives for sustainable development.

To summarize, bibliometric analysis is the basic platform for the policies and future research to be built. For the case of Hungary, through the enhancement of adaptive governance, innovations, and communication systems, the country has the potential to be seen as the key driver in sustainable regional development for both the European region, and the global sustainability framework.

Conclusion and future research directions

In line with the research carried out in this paper on bibliometric analysis, the importance of the cluster-based approach in sustainable regional development is on the rise. Using co-authorship network analysis, the work recognizes the interconnected nature of sustainability research performed by authors, institutions, and countries. It is notable that the core contributors like 'costanza, r' and CSIRO are assigning themselves to the cluster frameworks for SDGs leadership.

The results do affirm that sustainable regional development entails the cooperation and cohesion of public, private, and academic sectors. Experience has shown that even in cluster-based approaches there is a significant improvement in both innovation, efficient use of resources and improvement of governance systems. Accordingly, subsequent investigations and surveys suggest that, due to the opportunities that cluster initiatives provide for developing the territorial assets of industrial sectors, Hungary can become part of a coherent European sustainability strategy. However, the demand for the adaptive governance models and the dense collaborative networks which define the interactions is still high to maintain long-lasting success.

The geographical perspective from the point of view of geography in which China, USA, and Germany hold the advantage, and consequently, economically developed countries assume the leading role. Furthermore, the promising trend is the development of due recognition through equal contributions from countries like India and Brazil, alongside other Global South country entries which is thus depicting a more full-scale earth community. The lack of focus is considered as the focal issue in the matter of starting a partnership to solve all humankind's sustainability problems.

Future Research Directions

Expanding cluster analysis to emerging sectors:
The upcoming scientific reports should put a premium on the study of cluster strategies in newly emerged industries such as renewable energy, digital technologies, and circular economies. These fields are highly competitive, but they can also provide new vehicles for regional development and resilience improvement.

Integrating big data and AI into cluster strategies:
Integrating forward-looking technologies such as AI and embedded data treatment tools into clusters can accentuate their decision-making, resource allocation, and innovation capabilities. It would also be beneficial to further investigate the influence of digital technology on the cluster's overall capacity and the benefits of using digital tools.

Strengthening stakeholder engagement and policy alignment:
In the context of future research, disclosing the core principles that concern the stakeholder in cluster policy formation and governance should be a raised question. An evaluation of cluster management cases may make public organizations compatible with private ones if both are flexible enough to suit each other.

Longitudinal studies on cluster impact:
Longitudinal studies, when confronting the long-term consequences of IT clusters applications on the economic, social and environmental spheres, bring about a much more accurate picture. This is a way for the policymakers to analyze the current issues that are important for economic growth and improve everything that is not perfect for the earth by giving them the chance to take meaningful decisions about the benefits and problems of the implemented projects.

Regional case studies and comparative analysis:
The future shall belong to those who are the ones that will be able to initiate cross-country analysis on cluster technologies in different sectors, with an emphasis on Central and Eastern Europe. The first category, called technological spillovers, will be created through opportunities like this and demonstrate the approaches that might be implemented in Hungary and other countries around it.

As a result, cluster-based strategies are viewed as a sustainable regional development process, which is an effective means for the area. As a result, the social and economic innovation process will be strengthened with the engagement of all the stakeholders. In Hungary, regional and cluster development should involve processes related to research, innovation policy, and entrepreneurship, which are necessary ways forward for sustainable regional development. On the other hand, Hungary is in the same boat to which research and policy must steer the country to on the way, so it does not stay the same as why it was during communism.

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Market Launch of Herbal Honeys with the Help of Neuromarketing

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Abstract: With the spread of health awareness, there is an increasing demand for beekeeping products these days, which drives domestic beekeepers to continuous development and innovation. One possible direction of product innovation in beekeeping is the combination of various apitherapy products with medicinal herbs. It is important for beekeepers that innovations attract attention and that the products are placed on the market in an appropriate manner. New products must also be introduced to customers by applying appropriate marketing techniques, which is a time-consuming and costly process. In addition to traditional marketing techniques, it is worth using new marketing techniques for this purpose. In the case of herbal honey products, beekeepers may want to exploit the potential of neuromarketing. Emotional branding, the principle of "first impression", sensory experiences and storytelling can all be applied to herbal beekeeping products. Product innovation alone is not enough; marketing innovation is also needed for success.

Keywords: Neuromarketing, Apitherapy, Medicinal herbs, Medicinal honeys, Marketing theory, Consumer habits
JEL code: Q13

Introduction

Apitherapy (Latin: apis = bee) is the medicinal use of bee products, which has been used for centuries as part of naturopathy and phytotherapy. This includes the use of honey, pollen, propolis, royal jelly, bee venom, apilarnil, podmore and combinations thereof. (Bruneau, 2019.) Herbal honeys are particularly valuable in apitherapy, as the natural active ingredients of honey are combined with the power of herbs, thus they can have an enhanced effect on various problems. They are considered specific, as they combine the products of the two phytotherapeutic areas as a complementary therapy, and in all cases it is necessary to consult the treating physician. (Kovács, 2017.) Honey is an excellent carrier: it dissolves and stably preserves the active ingredients of the herbs, making them more valuable. The beneficial effects of honey have been known for centuries, but now we can also exploit its suitability as a solvent. The targeted effect of herbs is effective in the case of certain health problems: e.g. they can have expectorant, sedative, or immune-boosting effects. If we make mixtures, they can be used both internally and externally, e.g. as tea, on their own, as a wrap, in cosmetics (Šedík, - Zagula et al. 2018.)

1. Theoretical Knowledge for the Marketing of Herbal Honeys

The marketing of herbal honeys is a special field that combines the worlds of natural health preservation, functional foods and gastronomic experience. Many health problems can occur in people, for which herbs and apitherapy products can be used to solve them. (Frederick, 2023.)

1.1. Product Positioning and Product Knowledge

Herbal honey is a functional food that is not only a food, but also has a health-preserving effect. It is often made in small batches, from local ingredients, and represents high quality, therefore it can be considered a craft and/or premium product. Due to the dual product image (food and natural "medicine" at the same time), special attention must be paid to legal communication. These products can even be purchased as gifts, and can also be included in special diets, since honey is a natural sweetener. It is also important to familiarize Consumers with these products as thoroughly as possible, because they are recommended for consumption by children or the elderly, athletes, and patients recovering from surgery. In addition, the herbs used and the type of honey used for soaking can be customized according to the problem that arises, taking into account the age and general condition of the Consumer.

1.2. Target Group Definition

The range of products that can be prepared can be very diverse. Given this, the targeted Consumer layer will also be very heterogeneous. According to customer feedback, there is an increasing demand for such products. There are health-conscious customers for whom it is important to consume natural materials and foods in order to protect their health: e.g. mothers who are looking for domestic products made from natural materials for their children, which also have other beneficial effects as an added value of the herbs. Those who are fans of natural medicine, phytotherapy, folk medicine, and who are open to innovative ideas, also increase the demand for products. Representatives of the older generation, who prefer traditional remedies because they already consume many artificially produced medicines, can therefore become active consumers of products designed for various problems in terms of several products. Consumers with gastronomic interests should not be overlooked either. There is an increasing interest from the owners of restaurants, guesthouses, and guest houses, who view such handicraft products as a curiosity for their guests' tables. (Šedík-Horska et al. 2018.)

1.3. Marketing Mix (4P Model)

Today, in our ever-changing, digitalizing world, we have to resort to new methods in the course of our marketing activities, renewal also characterizes the conditions for business success in an innovation-oriented competition, it is important to satisfy customer needs as accurately as possible, a marketing strategy approach focusing on changing needs and the creation of new markets, innovation-driven marketing is needed. (Piskóti, 2014.) However, we must not stray from the basics, which are built on the 4P principle. The marketing mix is a combination of marketing tools used in the interest of market success. Edmund Jerome McCarthy first created the 4P form in 1960, which includes analysis, consumer behavior, market research and planning. The 4 Ps are an abbreviation of the following English words: Product, Price, Place, Promotion (H-Well Ltd. website, 2025)

Product
Every product or service must meet the needs of consumers, taking into account the supply and demand landscape, and then the development of your own marketing strategy can follow. (selection, branding, services, packaging) (H-Well Ltd. website, 2025) During the production of

herbal honeys, we combine some apitherapy product with one or more medicinal plants (e.g. linden, thyme, propolis, ginger, lavender, which can be: filtered, pasteurized or raw, or processed honey, or even a combination of several methods). When packaging, you should strive to use environmentally friendly packaging materials, such as small bottles, gift boxes, environmentally friendly design, and the use of recyclable packaging materials.

Price

The price is the amount paid by the Buyer as consideration for the product. When determining the price to be paid, costs and expected benefits must be taken into account, and the price set must be at a level that buyers are willing to pay. Pricing is a complex process, which includes preparing the pricing strategy, setting the price, determining possible discounts, rebates, and payment methods. We must know that for each Buyer, value always means something different, such as: functionality, monetary value, social significance, psychological value, health preservation or maintenance, environmental awareness, sustainability. (H-Well Kft. website, 2025) *When setting prices, it is advisable to consider the following:*

- Premium product pricing is justified by the added value – medicinal herbs, craftsmanship, the longer time required for production – this may be one of the reasons for setting a higher price compared to the unit price of normal, raw honey.
- Price range: basic product or gift box packaging, or even gift packages consisting of several products. e.g.: propolis honey, wax candles, pollen – royal jelly – comb honey in gift packaging as a Christmas or even birthday gift. (Keszthelyi, 2020)
- Discounts: participation in a loyalty program, multiple purchases, i.e. returning customers, package discounts, discounts of up to several percent in the case of quantity purchases, other discounts when purchasing on the web, lower prices from regular customers or returning purchases.

These methods are already used by many beekeepers, but even fewer have recognized the changes in market demands. The above options are very distant for older beekeepers, they are less open to such innovations. Members of the younger beekeeper generation are already using new marketing methods more often, with the help of which they can achieve higher profits.

Place – Sales channels

Farmer markets, organic shops, gift shops, and larger chain stores open up space for such new products made from honey. Potential consumers can be better targeted. Another possible and even more convenient market space is creating your own webshop, or perhaps appearing on partner sites, from where Customers can reach the website or online store with one click (Pellet, Frank, 2018). Gastronomic festivals, craft fairs, or smaller markets and fairs selling products specific to Hungarian products or the given region, in addition to frequently visited natural values, can be considered as particularly large market spaces. (Szente, Szakály, 2017)

Promotion – Promotion

The promotion of herbal honeys purposefully combines the traditional natural, health-conscious image of honey and the functional, aromatherapy, and wellness associations of herbs. The goal is for the consumer to associate value, naturalness and trust with the product – not a medical cure, but a healthy experience that fits into a lifestyle. In communication, positive, natural, experience-based messages are the most effective, such as: “The taste of nature, the power of herbs.”,

“Harmony of honey and plants.”, “Handcrafted care in every drop.”, “A gift from nature – for the whole year.” Content marketing: blog posts, recipes, product information according to the effects of honey + herbs, accurate information is very important. The power of social media (Instagram, Facebook, TikTok) is gaining more and more ground, its use is characterized by the fact that it also includes aesthetic product photos and videos about the composition of the products, i.e. making or having short Reels videos made attracts the attention and interest of future consumers. (Kotler, Keller, 2016)

1.4. Storytelling and Branding

Storytelling is a communication technique and art in which information, ideas or emotions are conveyed through a narrative structure. With the help of stories, the audience can more easily identify with and remember the message, and a deeper connection can be established with the storyteller. Storytelling is not just about conveying information, but also about creating an experience. (Andrade G. 2018.) It is worth highlighting a story primarily from the Producer's perspective, such as "Who makes the honey?", displaying a master beekeeper qualification in the logo, or on labels or posters, this is also a meaningful advertisement for Consumers. The approach to the history of local ingredients is also important, e.g.: "This lavender comes from the Bakony Mountains." It is worth linking an offer to seasons or even holidays, e.g.: Christmas package or spring immune honey, or perhaps to a problem, such as: relieving flu symptoms, in case of colds, immune strengthening for children or the elderly, reducing inflammation, blood purification, etc. (Kovács, 2017.)

2. The Emergence of Neuromarketing in the Marketing of Herbal Honeys

Neuromarketing is a modern branch of marketing that uses the functioning of the human brain (knowledge of neuroscience and psychology) to examine how consumers make decisions when purchasing. This toolkit is becoming increasingly important in the marketing of herbal honeys, especially in the market of premium, health-conscious products. (Zaripova, et. al. 2023.)

2.1. Emotional Branding

According to neuromarketing, we make purchasing decisions not rationally, but emotionally, and then “explain” them to ourselves with logic. Neuromarketing is an applied field based on the intersection of marketing and cognitive/neuroscience: its goal is to study consumer decisions, emotional reactions and preferences using neurophysiology and psychophysiology (e.g. fMRI, EEG, eye tracking, skin conductance) to identify how the brain responds to marketing stimuli and how these influence purchasing behavior. The experimental and theoretical results of neuromarketing can be applied to marketing strategy, advertising design, product development and consumer research. (Zurawicki, 2010.)

Application for herbal honeys: It should be characterized by a family-like, close-to-nature image, such as: “Grandma’s recipe”, “a gift from nature”, “A pinch of natural medicine for everyday life”, “Nature’s pharmacy” slogans, which should draw the attention of consumers to these products that have been further thought out and developed in terms of content. There should be an authentic face behind the products (e.g. a portrait of a beekeeper, a story of a local farmer, a master beekeeper’s

diploma). When designing the label and logo, we always use natural, warm colors (honey, flower colors), handwritten labels, which can awaken a nostalgic mood in consumers or increase trust in the product.

2.2. Visuality and Packaging – "First Impression" Principle

The brain processes most information visually. The first 3-5 seconds of packaging and appearance are crucial, often the visuals convince the consumer to make a purchase. The primary role of packaging is to stop the eyes (shelf-stop), quickly communicate the most important information, and convey an emotional/identity message to the customer. The first impression is decisive: in many cases, the consumer forms a judgment that affects their purchase intention in a fraction of a minute (or seconds). According to scientific studies, the color, shape, and surface of the packaging all have a significant impact on perception (quality, healthiness, premium feel, etc.). (Solomon, 2016.)

Effective packaging elements from a neuromarketing perspective:
The golden color of honey and the green herbal shades refer to naturalness and health preservation. The motifs that attract attention the most are those that show organic shapes (e.g. leaf motif, hexagon – honeycomb shape). The colors used reinforce the proximity to nature, refer to the materials used (honey, plants). In terms of texture, sustainability and environmentally friendly packaging are important (e.g. paper labels, natural wooden caps), so the sense of touch also affects emotions and conscious product choice.

2.3. Smells, Tastes – Sensory Experiences

Sensory marketing is part of neuromarketing, which examines how vision, smell, taste, hearing, and touch influence consumer decisions. (Zaripova, et. al. 2023.) Tasting at fairs: the experience of taste acts as an anchor in the consumer's brain, associating it with the sight and the product description. During the tasting of the product, a scent sample (for example, the scent of lavender honey) is also recorded in the Buyer, at this time memories and positive feelings are activated, and the Buyer associates herbal honey with the scent.

2.4. Storytelling

Storytelling is particularly effective for herbal honey, as Interested Parties can geographically delimit the areas of Hungary, such as the following sentence: "This thyme honey comes from the wildflower hills of Zemplén." The story not only conveys information, but also builds experience and trust. (Kovács, 2017)

2.5. Quick Decision – The Laziness of the Brain

Neuromarketing proves that the human brain likes simplified, visual cues that enable quick decisions. Consumers often make decisions in a short time, based on intuition, so communication requires fast, emotional and attention-grabbing elements. (Fiske et al., 1991.) A solution in product communication is the use of simple pictograms, such as the slogans "100% natural", "artisanal", "local producer herbal honey". Another important thing is color coding (e.g. lavender honey –

purple ribbon, ginger – yellow), thus the color scheme associated with the given product is fixed in the Customer, and he will continue to look for the usual product and quality accordingly in the future. It is worth using clear, short slogans, such as: “Pure nature – enclosed in a spoon.”, or “Honey, which nature wrote.”

Table 1. Application of neuromarketing tools in the marketing of herbal honeys

Area	Application of neuromarketing	Tools in the marketing of herbal honeys
Examples	Emotion Storytelling, nostalgia	Beekeeper portrait, “grandmother’s recipe”
Sight	Packaging, colors	Natural paper label, green and gold
Taste	Tasting, fragrance sample	At fairs, in stores
Simplicity	Visualized information	Piktogram, color code
Trust	Authenticity, face behind the brand	Presentation of a family farm

Source: own editing

The areas in Table 1 (emotion, sight, taste, simplicity, trust) come from the above literature. I paired the neuromarketing tools with the concepts, and in the third column I listed the special solutions that may be specific to herbal honeys.

3. Marketing Plan: “Honey Written By Nature”

Below are some details of a possible marketing plan.

3.1. Objective

To introduce a premium category, artisanal herbal honey product line to the domestic market, which can also serve as a natural immune booster, health-conscious dietary supplement and gift item. Table 2 contains the target groups that show increased interest in herbal honeys.

Table 2. Target groups

Main target group	Characteristics
Health-conscious adults (25–55 years)	Organic food consumers, reform kitchen fans
Parents with young children	Looking for natural solutions for colds, immune boosting
Seniors	Traditional medicinal effects, nostalgia, reliability
Gastro-interested	Gourmets, gift and specialty seekers

Source: Zurawicki L. 2010., Oravecz T. 2019., own editing,

The second column defines the reasons why they can be considered as potential buyers in relation to beekeeping product innovations.

3.2. Positioning

We consider functional foods to be those foods that are exclusively considered food, which, in addition to the basic nutritional-physiological effects, have a positive effect on the body, improving health and well-being, and reducing the risk of certain diseases, in everyday nutrition, and the effect is also visible when consuming the usual daily amount. (Webbeteg website, 2025.) A premium artisanal product is a high-quality, unique item, the production of which is dominated by manual work based on professional knowledge, and which is made from better than average raw materials and with special care. (Szakály, 2011.)

We consider it a functional food due to product development (special effects) - the dual power of honey and herbs appears to reinforce each other. That is why we consider them premium artisanal products, because they are produced in small batches, handmade, using specific expertise, from local production. They can be a natural gift, especially for Christmas, but also for birthdays or name days. We should strive to use health-conscious packaging and create a unique design (Hoffmann, 2004)

Slogan suggestions:
“Honey as nature intended.”
“Herbal indulgence in every spoonful.”
“Sweet medicine for everyday life”

3.3. Appearance of Marketing Mix (4P) for Herbal Honeys

PRODUCT – The product: Basic honey varieties provide the starting point, such as linden honey, rapeseed honey, acacia honey, using which the following herbal variants are made: Lavender honey – with a calming effect, Thyme honey – a respiratory tract cleanser and a cold reliever, Ginger-lemon honey – immune-boosting, anti-inflammatory. Unpacking formats: 250 ml, 500 ml bottles; gift box version recommended. In terms of design, the natural, wooden cap, paper label must be made with hand-drawn motifs in such a way that the shapes and colors are engraved in the memory of the Customers for further product recognition. Storytelling also appears in the products, as a short “producer story” can be read on the back label of each bottle.

PRICE – The price: In the case of this type of handmade products, you should aim for premium pricing, but at an affordable level, e.g. 250 ml: 2,990 HUF – 3,490 HUF, 500 ml: 4,990 HUF – 5,490 HUF, we can even create package discounts, create gift packages, or treat our customers to a little surprise with their orders. There can also be seasonal promotions, such as an immune-boosting package for winter, a relaxation package for summer.

PLACE – Developing sales channels is very important, such as your own webshop – with a recipe blog, tips for proper consumption. It is also worth delivering the products to the shelves of organic stores and herbalist shops, and it is advisable to appear at farmers' markets or even join regional product sales associations, such as: Dandelion Basket Producers' Association, or even in gift shops, delicatessens, and events, such as: gastrofestivals, advent fairs, and village days.

PROMOTION – Emotional and experience-based promotion is needed, such as: creating video content about the process of making honey, presenting a beekeeper portrait. It is advisable to hold scent and taste tastings in organic stores, markets, and fairs. Instagram and TikTok campaigns to encourage the development of aesthetic, "slow life" style videos, honey tea, and a morning routine. Influencer marketing is also becoming increasingly popular, in the form of promotion by naturopaths, dieticians, and gastrobloggers. Their key message could be, for example: “my morning starts with this”, which is used to formulate a message for those who watch the videos. Content marketing can also be a promotional tool to encourage the consumption of medicinal herbs, such as: writing blog articles: “The secret power of thyme”, “Honey for young children – what should we pay attention to?”, or sending a newsletter: in the form of seasonal

recommendations, recipe ideas, and we can also start a gift campaign: with a purchase, a mini, up to 50 ml honey sample as a gift.

Table 3 summarizes the neuromarketing tools in terms of their occurrence in the marketing of medicinal honeys.

Table 3. Application of neuromarketing tools in practice

Area	Tool	Application
Emotion	Storytelling	Presentation of family beekeeping
Visuality	Product design	Natural materials, leaf motifs
Scent, taste	Sensory marketing	Tasting, fragrance samples at fairs
Quick decision	Pictograms	"100% natural", "local product"
Trust	Person behind the brand	Beekeeper face, name on the label

Source: own editing

3.4. Steps for Launching the Product (Launch Plan)

After successful product development, the first step is to initiate the licensing process, followed by the development of the product's packaging and image. Taking into account market trends, it is advisable to launch your own webshop, which requires continuous innovation and updating tasks as time goes on. Later, it may also be necessary to display new products. The introductory campaign often determines the course and form of the entire year's promotional campaign, e.g. "honey tasting summer", "immune boosting autumn", "declaration of war on influenza". It is also recommended for beekeepers to use the help and work of marketing professionals, so it becomes necessary to activate Influenszer partners before the introduction of products at any time of the year, before the start of the season. Appearing at fairs and selling in organic stores may also be recommended (Barrett, 2024.)

Summary

Herbal honeys combine the natural healing properties of honey with the targeted therapeutic power of herbs. Honey is an excellent solvent and preservative that can preserve the active ingredients of herbs for a long time. Modern apitherapy and naturopathy are increasingly recognizing and applying this combination for various health-preserving purposes. (During their consumption, the enjoyment value, prevention and support of a health-conscious lifestyle are realized at the same time.) The increasing demand in the market, especially for natural immune boosters, stress relievers and digestive enhancers, confirms the product's raison d'être. In summary, the health benefits add up, and herbal honeys support the immune system, can reduce inflammation, improve sleep, digestion and help prevent various minor diseases. Consumers are becoming more aware and willing to turn to natural products instead of or in addition to synthetic drugs. The demand for functional foods – especially among health-conscious, young or middle-aged segments – favors the popularity of herbal honeys. The product can be well communicated along the lines of "tradition meets modernity", especially when associated with local, artisanal or organic values. Herbal honeys are not only gastronomic specialties, but also valuable tools for conscious nutrition and a healthy lifestyle. With appropriate communication, packaging and consumer education, these products can be successfully positioned according to the needs of modern customers – thus they can play a significant role in the natural health preservation market.

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Financial Literacy and Future Concern: Strengthening the Sustainability Mindset of Future Business Leaders

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Abstract: Global shifts toward sustainable development demand the emergence of future business leaders who not only possess financial competence but also have a strong sustainability mindset. Although previous studies have examined financial literacy and sustainable behavior, research integrating financial literacy, Sustainable Finance Literacy (SFL), and future concern into a single conceptual framework to explain the formation of a sustainability mindset in future business leaders is still limited. This study aims to fill this gap by examining the direct and indirect relationships between financial literacy, SFL, future concern, and sustainability mindset. Using an explanatory quantitative design and involving business students in Indonesia, the data were analyzed using Partial Least Squares. The research results indicate that financial literacy and SFL have a significant impact on future concern and sustainability mindset, with SFL being the strongest predictor. In addition, future concern has a direct effect on sustainable mindset and mediates the relationship between financial literacy, SFL, and sustainable mindset. These findings emphasize the importance of a future-oriented approach in translating financial competencies into sustainable leadership values. The study underscores the need to integrate sustainable finance, futures thinking, and transformative learning in business education to develop future leaders who are financially competent and sustainability oriented.

Keywords: Financial Literacy, Sustainable Financial Literacy, Future Concern, Sustainable Mindset
JEL Code: G53, D91, Q01, D14, M14

Introduction

Over the past two decades, the business world has faced increasing pressure to address global challenges such as climate change, biodiversity crises, social inequality, and economic instability. The Sustainable Development Goals (SDGs) agenda positions the private sector as a key actor expected to contribute not only through technological innovation but also through responsible managerial and financial practices. In this context, business leaders can no longer view sustainability as a peripheral issue; rather, it is a strategic component that determines an organization's long-term competitiveness. Business education and leadership development programs, therefore, are required to prepare future business leaders with a strong and consistent sustainability mindset (Chiang et al., 2022; Landrum, 2021).

At the same time, financial literacy is recognized as one of the most important forms of human capital in making economic decisions, both at the individual and organizational levels. Lusardi and Mitchell show that adequate financial literacy is correlated with better financial planning, more rational saving behavior, and more efficient selection of investment instruments throughout an individual's life cycle (Lusardi & Mitchell, 2014). The OECD/INFE measurement framework then emphasizes that financial literacy encompasses the dimensions of knowledge, attitude, and behavior, so it is not merely the ability to calculate, but also the mental readiness to make responsible financial decisions. In the context of prospective business leaders, financial literacy serves as a prerequisite for understanding the financial implications of corporate strategies, including strategies related to sustainability.

As the sustainability agenda develops, the concept of financial literacy has expanded into sustainable finance literacy (SFL), which is the ability to identify and evaluate financial products based on their claimed sustainability characteristics (for example, green bonds, ESG mutual funds, or socially impactful investment instruments). Filippini and colleagues measured SFL among households in Switzerland and found that higher levels of SFL were associated with a greater tendency to hold sustainable investment products (Filippini, Leippold, & Wekhof, 2024a). Further studies using a randomized controlled trial design showed that specialized SFL education programs significantly increased literacy while also encouraging participation in sustainable investments (Filippini, Leippold, & Wekhof, 2024b). These findings indicate that SFL can serve as a bridge between financial goals and sustainability goals, especially if instilled early in future business leaders.

Beyond aspects of financial knowledge, psychological factors related to future orientation have also been receiving increasing attention. The concept of future concern or futures consciousness refers to an individual's capacity to understand, anticipate, and prepare for the future, as well as the willingness to consider the long-term consequences of current actions. Lalot and colleagues indicate that futures consciousness is positively related to pro-environmental engagement and support for long-term public policies (Lalot, Ahvenharju & Uusitalo, 2025). Meanwhile, the literature on Consideration of Future Consequences (CFC) explains that individuals who consistently consider long-term consequences tend to adopt more environmentally and health-responsible behaviors (Fan et al., 2024). These concepts are highly relevant to the business world, as a company's strategic decisions almost always have cross-generational impacts.

Some cross-country empirical evidence has begun to show that financial literacy is associated with sustainability indicators. For example, Salahodjaev and Sadikov found that countries with higher levels of financial literacy tend to have better environmental performance, measured through the Environmental Performance Index (Salahodjaev & Sadikov, 2025). Other studies have found that financial literacy correlates with sustainable entrepreneurial activity and environmentally friendly process innovation at the company level, both in entrepreneurship and small to medium-sized enterprises (Burchi & De Tommaso, 2021; Molina-García et al., 2025). These findings suggest that financial literacy has the potential to contribute to sustainable development, not only through purely economic efficiency but also through more environmentally and socially friendly behavioral choices.

Nevertheless, research gaps are still clearly apparent. First, most studies examine financial literacy and sustainability at the level of general consumers, retail investors, or small business operators, rather than specifically focusing on prospective business leaders being trained through higher education and leadership programs. Second, few studies integrate financial literacy (including SFL) with psychological constructs such as future concern or future consciousness within an explicit framework, even though behavioral theories, such as the knowledge–attitude–behavior model or the Theory of Planned Behavior, imply that knowledge (literacy) often operates through attitudes and future orientation before manifesting as behavior or thought patterns (Lusardi & Mitchell, 2014; Granthaalayah Publication, 2024). Third, studies on the sustainability mindset in business education are indeed increasingly developing, especially through the use of the Sustainability Mindset Indicator (SMI), but the systematic relationship between SMI, financial literacy, and future concern is still very rarely studied (Rimanoczy & Klingenberg, 2021).

In response to this gap, this article proposes a conceptual framework and research design that considers financial literacy (including SFL) as a core cognitive capability; future concern/futures consciousness as a dimension of attitude and time orientation; and sustainability mindset as a psychological outcome reflecting the readiness of prospective business leaders to integrate sustainability into decision-making. This framework also incorporates practical experience (e.g., internships, entrepreneurial projects, or involvement in ESG initiatives) and exposure to sustainability education (Education for Sustainable Development/ESD) as factors that may strengthen the relationship between financial literacy, future concern, and sustainability mindset (Chiang et al., 2022; Landrum, 2021). Thus, the main contribution of this article is to present a model that explicitly connects financial, psychological, and educational dimensions in an effort to prepare future business leaders who are not only financially competent but also oriented towards long-term sustainability.

Literature Review

Financial Literacy: Definition, Dimensions, and Measurement

In economic and financial literature, financial literacy is generally understood as a combination of knowledge, skills, and attitudes that enables individuals to make effective and responsible financial decisions. Lusardi and Mitchell emphasize that financial literacy affects decisions throughout the life cycle, ranging from saving, debt management, to retirement planning (Seifert, Palan et al., 2025). The OECD/INFE framework subsequently formulates financial literacy into three domains: knowledge, behavior, and attitudes; this framework is widely used as a reference standard in various countries. Other research indicates that financial literacy is influenced not only by demographic factors such as age, gender, and education, but also by psychological factors such as self-efficacy and attitudes toward risk. For example, the study by Moreno-Herrero and colleagues found that knowledge, attitudes, and self-confidence are interrelated in shaping the financial behavior of young students. Similarly, Kawamura et al. highlighted that financial literacy can have a dual impact: on one hand, it helps make better decisions, but on the other hand, it can interact with behavioral biases if not accompanied by a healthy attitude (Gedvilaitė et al., 2022). From a business perspective, financial literacy has been shown to affect business sustainability. Research on SMEs in various contexts indicates that higher financial literacy is associated with better access to financing, the use of financial technology (fintech), and more sustainable business performance (Ratnawati et al., 2024; Zaniarti, Veronica and Arsytania, 2022).

Financial Literacy and Sustainable Finance Literacy (SFL)

The development of the global sustainability agenda has led to the emergence of the concept of sustainable finance literacy (SFL), which is the ability to recognize, understand, and evaluate financial products and policies that claim sustainability (green bonds, ESG mutual funds, social impact investments), including the risk of greenwashing. Filippini, Leippold, and Wekhof measured SFL in households in Switzerland and defined it as 'the knowledge and skills to identify and assess financial products based on their sustainability characteristics' (Filippini et al., 2024).

They found that many respondents with good basic financial literacy did not have adequate SFL; this means that a person may be proficient in managing personal finances but still struggle to distinguish genuinely sustainable financial products from those that merely claim to be so. In a follow-up study based on a randomized controlled trial (RCT), the same team showed that a short but structured SFL education program could significantly improve SFL while also encouraging more sustainability-oriented investment choices (Filippini, Leippold & Wekhof, 2024). Seifert and colleagues then developed a more comprehensive SFL instrument and demonstrated that SFL predicts sustainable investment behavior more strongly than general financial literacy in two representative samples in Austria (Seifert, Palan et al., 2025).

Sustainability Literacy and Sustainability Mindset

In addition to financial aspects, the literature on sustainability literacy highlights the ability of young people to understand environmental, social, and economic issues, as well as the interconnections among the three. A study by Gedvilaitė et al. on youth in the Baltic countries shows that sustainability literacy and financial literacy are related, and that integrating both has the potential to strengthen sustainable decision-making abilities among young people (Gedvilaitė et al., 2022). On a deeper level, the concept of a sustainability mindset emerges as an effort to explain not only what a person knows about sustainability but also how they feel, evaluate, and act.

Rimanoczy and Klingenberg developed the Sustainability Mindset Indicator (SMI) as an instrument to map sustainability thinking patterns based on the principles of a sustainability mindset they formulated (systemic awareness, intergenerational empathy, and goal orientation) (Rimanoczy & Klingenberg, 2021). The SMI has been used in various business education contexts to assess the extent to which students or leadership program participants have internalized sustainability values and thinking patterns. The PRME Working Group on Sustainability Mindset has also adopted this approach as a framework for designing transformational learning experiences in business schools (PRME Working Group on Sustainability Mindset, 2022).

Future Concern, Future Consciousness, and Consideration of Future Consequences

Financial literacy can lead to sustainable choices and mindsets, so we need to look at the role of future orientation. The concept of Consideration of Future Consequences (CFC), introduced by Strathman and colleagues, describes the extent to which individuals consider the long-term outcomes of their current actions. Individuals with high CFC tend to avoid behaviors that are harmful to themselves and the environment in the long term (Dyssegaard, C.B., et al., 2016). More recently, the concept of futures consciousness has been developed to capture a broader capacity: not only the willingness to consider the future, but also the ability to imagine future scenarios, sense personal agency, and empathize with future generations. Lalot, Ahvenharju, and Uusitalo have shown that high futures consciousness is positively correlated with pro-environmental engagement and support for long-term policy in cross-country studies in Northern Europe (Lalot, Ahvenharju, & Uusitalo, 2025).

These findings are reinforced by science communication showing that reflective future thinking makes people more likely to reduce their personal environmental footprint and support ambitious

climate policies (Lalot et al., 2024). On the other hand, recent psychometric studies on the CFC scale and futures consciousness confirm their reliability and validity in measuring future orientation across different cultures. For prospective business leaders, this future orientation is crucial. Strategic decisions such as investment choices, business expansion, or changes in business models almost always have long-term consequences for employees, communities, and the environment. However, most research on futures consciousness still focuses on citizens or general consumers, rather than specifically on business students or leadership program participants. This opens up space for research linking futures consciousness, financial literacy/SFL, and a sustainability mindset in the context of business education.

Sustainable Finance Integration

Education for Sustainable Development (ESD) has become an important agenda in higher education, including in business schools. Various international studies and reports highlight that universities play a key role in equipping the younger generation with the knowledge, skills, and values needed to face sustainability challenges (Tsai, Jason, 2013). In the context of business schools, research shows an increase in courses related to sustainability, business ethics, and corporate social responsibility. Chiang and colleagues, for example, explain how business curricula can be aligned with ESD and PRME to strengthen sustainability competencies among students (Guthrie, C., 2024; Ribeiro L.M., et al., 2023). The PRME Working Group on Sustainability Mindset also provides guidance and best practices for integrating a sustainability mindset into management education.

Nevertheless, many studies criticize that the integration of sustainability in business schools is still often peripheral such as through one or two elective courses and has not yet touched the core financial competencies (Russell Woodward (2017); Harausová, H. and Chovancová, J., 2015). The results of a systematic review conducted by Wu and Shen show that higher education for sustainability still struggles with issues of cross-curricular integration, assessment of learning outcomes, and stakeholder engagement (Wu, Y., & Shen, J., 2017). The integration of sustainable financial literacy (SFL) into the business curriculum becomes highly relevant. Some early initiatives show that business students exposed to SFL and ESG topics demonstrate increased understanding of climate risks and the urgency of sustainable finance, but systematic empirical studies are still very limited.

Theoretical Framework and Hypothesis Development

The Theory of Planned Behavior (Ajzen, 1991) states that a person's behavior is determined by three main components: (a) Attitudes: positive/negative evaluations of a behavior; (b) Subjective Norms: social influence/perception of others' expectations; (c) Perceived Behavioral Control (PBC): perception of one's ability to perform the behavior. In the context of this study, TPB serves as an important framework for understanding how prospective business leaders assess and decide on actions that impact sustainability. Financial literacy can enhance perceived behavioral control, as leaders who understand finance feel more capable of making fair and appropriate financial decisions. Future concern is a dimension of attitude that reflects long-term beliefs and care. A sustainability mindset is the result of the interaction between attitudes, self-control, and sustainability norms assimilated through education and experience.

The Futures Consciousness Framework (Ahvenharju, Lalot, Uusitalo, 2018–2025) is a modern psychological theory that explains an individual's mental capacity to understand, anticipate, and give meaning to the future. This framework consists of five dimensions: (a) Time Perspective, which is the ability to think about the future in the long term; (b) Agency Beliefs, which is the belief that one can influence the future; (c) Openness to Alternatives, which is the willingness to consider various future scenarios; (d) Systems Perception, which is the understanding of systemic relationships and the complexity of the world; (e) Concern for Others/Intergenerational Empathy, which is the concern for future generations.

The Sustainability Mindset Framework (Rimanoczy & Klingenberg, 2021) explains sustainability. In modern business education, a sustainability mindset is considered a leadership competency because future leaders are expected to be able to integrate ESG into business strategy, make decisions based on long-term value, and balance financial profit with sustainability.

Research Hypothesis

The Effect of Financial Literacy on Future Concern

According to the Consideration of Future Consequences theory (Strathman et al., 1994), individuals with an understanding of risks and long-term consequences tend to have a higher future orientation. Financial literacy plays an important role in shaping an individual's ability to understand long-term implications such as inflation, compound interest, investment risks, and financial sustainability, thereby fostering the emergence of future concern.
Morgan & Trinh (2019) research shows that financial literacy can enhance long-term planning, while Amagir et al. (2020) emphasize that financial education strengthens the anticipatory mindset of young people. The study by Salahodjaev & Sadikov (2025) also reveals that countries with high financial literacy have better sustainability orientation, indicating a link between financial knowledge and concern for the future.
(H1): *Financial literacy has a positive effect on future concern*

The Effect of Sustainable Finance Literacy on Future Concern

Individuals who understand environmental risks, greenwashing, social impacts, and green financial instruments tend to be more aware of the long-term consequences of their decisions. According to the Futures Consciousness Framework (Ahvenharju et al., 2018), systemic understanding and risk awareness play a role in enhancing a future-oriented mindset. Zhang et al. (2019) found that green finance promotes increased future awareness among industry players. Meanwhile, Broadstock et al. (2021) discovered that investors with ESG understanding are more sensitive to long-term risks and climate change. These findings indicate that SFL plays a significant role in shaping future concern.
(H2): *Sustainable finance literacy has a positive effect on future concern*

The Effect of Financial literacy on the sustainability mindset

Financial literacy, including sustainable finance literacy (SFL), provides individuals with a framework to assess the social, environmental, and economic implications of financial decisions. Research shows that individuals with higher financial literacy tend to make decisions that are not only financially beneficial but also wiser in the context of sustainability. Filippini, Leippold, and Wekhof (2024) found that SFL significantly increases the likelihood of a person choosing sustainable financial instruments such as ESG investments compared to those who only have basic financial literacy. Seifert et al. (2025) also indicate that SFL is a strong predictor of sustainable investment behavior, surpassing the influence of general financial literacy.
(H3): *Financial literacy has a positive effect on the sustainability mindset*

The Effect of Sustainable Finance Literacy on a Sustainability Mindset

Sustainable Finance Literacy (SFL) is an advanced form of financial literacy that includes understanding sustainable financial instruments, ESG (Environmental, Social, Governance), green investment, as well as climate risks. This knowledge is directly related to sustainability values and long-term thinking. Research by Filippini et al. (2024) proves that SFL is a strong predictor of sustainable investment behavior. Seifert et al. (2025) found that individuals with higher levels of SFL have a stronger preference for environmentally friendly financial decisions. Goyal & Joshi (2021) also affirmed that understanding ESG increases the sustainability orientation of the millennial generation.
(H4): *Sustainable finance literacy has a positive effect on a sustainable mindset*

The Effect of Future concern on sustainability mindset

Future concern or futures consciousness describes the extent to which a person thinks about the long-term impact of current actions. Individuals with a high level of futures consciousness tend to be more environmentally friendly, more careful, and more considerate of the well-being of future generations. Lalot, Ahvenharju, and Uusitalo (2025) found that futures consciousness directly enhances pro-environmental engagement and support for long-term public policies. Ahvenharju et al. (2024) also showed that a future orientation plays an important role in decisions focused on future generations, a key aspect of the sustainability mindset.
(H5): *Future concern has a positive effect on sustainability mindset*

Future concern mediates the relationship between financial literacy and sustainability mindset

The Knowledge–Attitude–Behavior (KAB) theoretical model states that knowledge shapes attitudes, and attitudes shape behavior. Similarly, financial literacy provides the necessary information to understand sustainable risks and opportunities; however, without a strong future orientation, that knowledge may not be actualized into a sustainability mindset. Research by Strathman et al. (1994) shows that Consideration of Future Consequences (CFC) mediates the relationship between knowledge and long-term behavior. Research by Filippini et al. (2024) also shows that sustainable financial literacy can trigger more positive long-term attitudes when individuals have a strong future perspective.
(H6): *Future concern mediates the effect of financial literacy on sustainability mindset*

(H7): *Future concern mediates the effect of sustainable finance literacy on sustainability mindset*

Research Methodology

This study uses an explanatory quantitative approach with the Partial Least Squares–Structural Equation Modeling (PLS-SEM) technique. The research model is predictive in nature and focuses on exploring the latent relationships between variables (financial literacy, future concern, sustainability mindset). The collected data are on a Likert scale and do not always perfectly follow a normal distribution. Hair et al. (2022) recommend PLS-SEM when the research goal is more focused on predicting relationships between latent variables and when the researcher is still at the theory development stage.

The research population consists of prospective business leaders, composed of students in business, management, accounting, finance, or economics programs at universities in Indonesia. The reason for choosing this population is that they are a group with the potential to occupy strategic positions in business organizations in the future, making them an important target for developing a sustainability mindset. The sampling technique used is non-probability purposive sampling with specific criteria. In PLS-SEM, the minimum sample size often refers to the '10 times rule' or power analysis. Hair et al. (2022) suggest using a minimum sample size of 10 times the largest number of paths (arrows) leading to a single construct in the structural model. However, to achieve better statistical power and considering the model involves mediation and moderation, this study targets a minimum sample size of 200-300 respondents.

Results and Discussion

Respondents

The results of data processing for respondents in this study were dominated by individuals with a bachelor's degree educational background. Out of the total participants, 185 respondents (69.55%) were at the bachelor's level, while 81 respondents (30.45%) were students or graduates of a master's program. In terms of gender, the majority of respondents were female. It was recorded that 200 respondents (75.19%) were female, while 66 respondents (24.81%) were male. Looking at age groups, the largest number of respondents came from the 23–28 age range, totaling 182 respondents (68.42%). In addition, there were 52 respondents (19.55%) aged between 18–23 years, and 32 respondents (12.03%) were in the 29–34 age range (Table 1.).

Table 1. Respondent Profile

Description		Frequency	Percentage (%)
Education	Bachelor	185	69.55
	Master	81	30.45
Gender	Male	66	24.81
	Female	200	75.19
Age	18-23	52	19.55
	23-28	182	68.42
	29-34	32	12.03

Source: Authors' own processed primary data, 2025

Outer Model Measurement

Evaluating the reflective outer model uses 4 criteria, namely testing the validity and reliability of the variables by looking at Cronbach's Alpha, Composite Reliability, and Average Variance Extracted (AVE) for each variable. The criteria for the test results are as follows:

1. Convergent Validity: An indicator is considered valid if the coefficient value > 0.60. In this study, all variable indicators have a loading factor value > 0.60. This means the indicators can be proven valid.
2. Discriminant Validity: A variable is said to be valid if the Average Variance Extracted (AVE) of each variable is > 0.50.
3. Composite Reliability: A variable is considered reliable if the Composite Reliability of each variable is > 0.60.
4. Cronbach's Alpha: A variable is considered reliable if the Cronbach's Alpha of each variable is > 0.60.

Table 2. Outer Model Results

Variable	Code	Loading factor	CA	CR	AVE
Financial Literacy (FL)	X110	0.736	0.886	0.908	0.524
	X12	0.742			
	X13	0.705			
	X14	0.723			
	X15	0.77			
	X16	0.715			
	X17	0.641			
	X18	0.746			
	X19	0.726			
Sustainable Financial Literacy (SFL)	X21	0.776	0.799	0.862	0.555
	X210	0.763			
	X22	0.767			
	X28	0.695			
	X29	0.719			
Future Concern (FC)	M1	0.639	0.904	0.92	0.534
	M10	0.713			
	M2	0.72			
	M3	0.747			
	M4	0.738			
	M5	0.772			
	M6	0.692			
	M7	0.748			
	M8	0.812			
	M9	0.716			
Sustainable Mindset (SM)	Y1	0.729	0.862	0.894	0.546
	Y2	0.742			
	Y3	0.71			
	Y4	0.762			
	Y5	0.768			
	Y6	0.74			
	Y7	0.721			

Source: Processed primary data, 2025

Inner Model Measurement

To evaluate the implications of the indicators and path coefficients, this study used a 500-sample bootstrap method, which shows goodness-of-fit (GoF). Accordingly, these findings indicate that the proposed sustainable finance and mindset model can be applied. The standardized residual root mean square (SRMR) is 0.076, and the normed fit index (NFI) test is 0.758, indicating model fit. After examining R2, future concern is explained by financial literacy, sustainable financial literacy, and sustainable mindset at 0.431 (43.1%). Future concern, financial literacy, and sustainable financial literacy explain sustainable mindset at 0.648 (64.8%). Finally, all R2 values are positive, indicating that all variables have good predictive relevance.

Direct Hypothesis Testing

Table 3 shows a significant relationship between financial literacy and future concern (β = 0.227, t-value = 3.698). Therefore, H1 is accepted. The relationship between sustainable financial literacy and future concern (β = 0.481, t-value = 7.322) is also significant. Therefore, H2 is accepted. Furthermore, the relationship between financial literacy and sustainable mindset (β = 0.341, t-value = 5.227) is significant, so H3 is accepted. The relationship between sustainable financial literacy and sustainable mindset (β = 0.348, t-value = 5.392) is also significant, so H4 is accepted. Finally, we evaluated the effect of future concern and sustainable mindset (β = 0.197, t-value = 3.602), which is also significant, and H5 is accepted.

Table 3. Direct Hypothesis Testing

Hypotheses	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Remarks
FL (X1) -> FC (M)	0.227	0.227	0.061	3.698	0.000	Supported
SFL (X2) -> FC (M)	0.481	0.485	0.066	7.322	0.000	Supported
FL (X1) -> SM (Y)	0.341	0.341	0.065	5.227	0.000	Supported
SFL (X2) -> SM (Y)	0.384	0.386	0.071	5.392	0.000	Supported
FC (M) -> SM (Y)	0.197	0.195	0.055	3.602	0.000	Supported

Source: Processed primary data, 2025

Mediation Analysis

The next step is to establish the mediation variable in this study. We propose future concern as a mediator of the relationship between financial literacy, sustainable financial literacy, and a sustainable mindset. The mediation test shows that future concern significantly mediates the relationship between financial literacy and a sustainable mindset. Therefore, H6 is accepted. In addition, future concern also significantly mediates the relationship between sustainable financial literacy and a sustainable mindset, so H7 is accepted.

Table 4. Indirect Testing

Hypotheses	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Remarks
FL (X1) -> FC (M) -> SM (Y)	0.045	0.044	0.016	2.805	0.005	Supported
SFL (X2) -> FC (M) -> SM (Y)	0.095	0.095	0.03	3.163	0.002	Supported

Source: Processed primary data, 2025

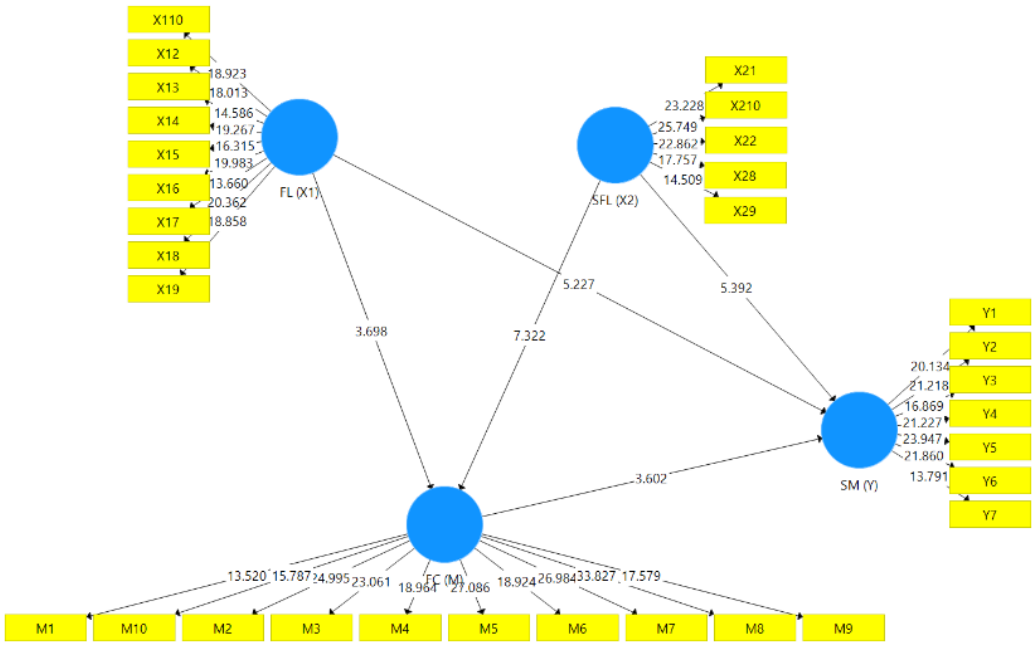

Figure 1. SBP Model

Source: authors' calculation, 2025

Discussion

The research results show that financial literacy significantly increases future concern. A fairly strong positive coefficient indicates that the higher a person's understanding of financial concepts, the higher their tendency to consider the long-term consequences of their financial and non-financial actions. These findings are consistent with the Knowledge–Attitude–Behavior (KAB) model, which asserts that knowledge forms the foundation for shaping attitudes and future orientation. Individuals who understand financial risks, the time value of money, and the long-term implications of economic decisions tend to have a more mature future awareness (Lusardi & Mitchell, 2014). Research by Fan et al. (2024) also shows that financial literacy is correlated with future-oriented behaviors, such as sustainable entrepreneurship and more effective environmental risk management. The study by Fan et al. (2024) also shows that financial literacy is correlated with future-oriented behaviors, such as sustainable entrepreneurship and more effective environmental risk management. Cross-country research by Salahodjaev & Sadikov (2025)

supports these findings, indicating that countries with high financial literacy have better environmental performance, which reflects collective future awareness.

The influence of SFL on future concern is the greatest among all the tested paths. This indicates that literacy regarding sustainable finance contributes most significantly to shaping long-term concern and awareness of risks to future generations. This finding aligns with the research of Filippini, Leippold & Wekhof (2024), which states that SFL not only enhances a person's ability to evaluate sustainable financial products. The study by Seifert et al. (2025) emphasizes that SFL is a strong predictor of sustainable investment behavior, which is inherently related to future orientation and attention to environmental changes and long-term economic systems.

The finding that financial literacy has a direct and significant impact on the sustainability mindset indicates that the ability to understand risk analysis, budgeting, and resource allocation contributes to a person's perspective on sustainability. Ratnawati et al. (2024) found that financial literacy strengthens managerial capability in managing sustainable businesses, particularly in the context of SMEs. Similar results were also found in the study by Zaniarti et al. (2022), which showed that financial literacy influences small businesses' ability to maintain business sustainability. Furthermore, the study by Burchi & De Tommaso (2021) demonstrates that financial literacy is closely related to the ability to make decisions oriented towards social and environmental impact.

The influence of SFL on a sustainability mindset is stronger than the influence of general financial literacy. The study by Gedvilaitė et al. (2022) shows that financial skills and sustainability skills reinforce each other in shaping the competencies of young people. Likewise, the research by Filippini et al. (2024) provides evidence that SFL education increases both sustainability awareness and sustainable investment practices.

The influence of future concern on sustainability mindset shows that the greater a person's awareness of long-term impacts, the higher their tendency to adopt a sustainability mindset. This finding supports the literature on futures consciousness, such as the research by Lalot, Ahvenharju & Uusitalo (2025), which shows that a future orientation enhances pro-environmental attitudes and support for long-term policies. Studies by She et al. (2021) and Strathman et al. (1994) also emphasize that individuals who consider long-term consequences are more responsible in their behavior.

Future concern has been proven to significantly mediate the influence of financial literacy and sustainable finance literacy on sustainability mindset. This finding is highly consistent with the Knowledge Attitude Behavior (KAB) model, which states that attitude serves as a bridge between knowledge (financial literacy) and behavior/mindset (sustainability mindset). The study by Ahvenharju et al. (2024) also emphasizes that futures consciousness is an important mediator in the relationship between knowledge and support for long-term policies.

Theoretical contributions

This study provides strong theoretical contributions by integrating behavioral theories, future psychology, and financial literacy into a comprehensive conceptual model. First, this research expands the application of the Theory of Planned Behavior (TPB) by showing that future concern

is a concrete form of attitude toward behavior related to long-term sustainability decisions. In the context of TPB, financial literacy and sustainable financial literacy not only enhance the perceived behavioral control of future leaders but also enrich the attitude formation process toward actions that impact sustainability through risk perception, long-term benefit estimation, and understanding of the systemic implications of business decisions. Thus, this study reinforces the argument that financial competence is a cognitive factor that shapes sustainability attitudes, which has not been previously explored in depth within the TPB framework.

The finding that financial literacy and SFL influence future concern confirms that knowledge alone is not enough to generate a sustainable mindset; that knowledge must go through a process of internalizing future-oriented attitudes before manifesting in mindset or behavior. This finding supports previous literature on Consideration of Future Consequences (Strathman et al., 1994) while also extending it to the context of sustainable business leadership. Thus, this study not only applies the KAB model but also develops a new model that incorporates future orientation as an attitudinal component (attitudinal bridge) that mediates the effect of knowledge on sustainability mindset.

This study deepens the Sustainability Mindset Framework (Rimanoczy & Klingenberg, 2021) by introducing financial literacy and SFL as antecedents that were previously not included in the theory. Sustainability mindset was previously understood primarily as a function of values, empathy, and systemic awareness; however, this study adds evidence that financial knowledge especially sustainability related financial knowledge is an inseparable cognitive element in this form of mindset. By showing that SFL is the strongest predictor of the sustainability mindset, this study expands the scope of the SMI framework by adding a new cognitive domain that has a direct relationship with sustainable leadership competence. This study also provides theoretical contributions through the operationalization of the Sustainable Finance Literacy (SFL) construct in the context of sustainability mindset formation. SFL has previously been widely studied in the context of investors or financial markets, but this research expands its application to the context of future business leaders in the educational environment.

Research Implications and Limitations

This study provides important implications for theory, business education, and leadership development practice. First, the finding that SFL has the strongest influence on future concern and sustainability mindset indicates that sustainable finance education needs to be a core part of business school curricula and leadership development programs. Universities and educational institutions can incorporate modules on green finance, ESG risk management, and sustainability assessment in financial instruments to strengthen student competencies. Second, the findings regarding the mediating role of future concern emphasize that sustainability cannot be instilled solely through technical knowledge, but requires learning that can build long-term orientation, cross-generational empathy, and systemic awareness. This suggests the need for pedagogical approaches based on reflection, experiential learning, futures thinking, and transformational learning in management and finance classes. Third, the research results provide practical implications for organizations that want to develop a sustainable leadership pipeline. Internal training programs can combine financial and ESG education with long-term planning exercises, scenario planning, and the development of strategic empathy. Fourth, the finding that financial

literacy affects the sustainability mindset implies that financial knowledge is the foundation for sustainable business behavior, so companies and policymakers need to promote broader financial literacy and SFL programs for the younger generation. Fifth, for future researchers, this model provides a theoretical basis for adding other variables such as social norms, moral identity, corporate purpose, or ESG regulations as factors that can strengthen the sustainability mindset of future business leaders.

This study has several limitations that need to be considered for interpreting the results and for the development of future research. First, the study used a non-probabilistic sample of business students and young aspiring leaders, so the findings cannot be fully generalized to the entire population of business leaders or professionals across industries. Second, this study used a questionnaire instrument with a Likert scale, so the results heavily rely on the respondents' subjective perceptions. Social bias, social desirability bias, or a lack of self-reflection may affect the quality of the data. Third, the study design is cross-sectional, so it cannot establish temporal causal relationships between financial literacy, future concern, and sustainability mindset. Another limitation is that the study does not differentiate the type of practical experience or the intensity of exposure to sustainability education in detail, so it cannot explain variations between groups in depth.

Conclusion

This study aimed to understand how financial literacy, sustainable financial literacy, and future concern contribute to the development of a sustainability mindset in prospective business leaders. The PLS-SEM analysis results showed that all tested influence paths were significant, with SFL being the strongest predictor of both future concern and sustainability mindset. General financial literacy also played an important role, although its influence was relatively lower than that of SFL. Future concern was proven to have a direct effect on the sustainability mindset and acted as a significant mediator between financial literacy and SFL toward the sustainability mindset. These findings provide empirical support for TPB theory, the KAB model, and the Futures Consciousness Framework, while also deepening the Sustainability Mindset Framework by incorporating the financial dimension as a key cognitive determinant. This study concludes that the development of future business leaders with sustainable character requires an integration of financial skills, sustainable financial literacy, and future-oriented thinking. Thus, business education needs to shift from a purely cognitive approach to a learning process that combines financial expertise, futures thinking awareness, and long-term sustainability values. This study not only expands theoretical understanding regarding the development of a sustainability mindset but also provides practical guidance for universities, policymakers, and organizations in developing future leaders who are financially competent and socially responsible.

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The behavioural economics approach and effects of the Save More Tomorrow (SMarT) programme on savings decisions

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Abstract: The Save More Tomorrow (SMarT) programme is an initiative by Richard Thaler and Shlomo Benartzi that applies the principles of behavioural economics to increase the propensity to save. The programme aims to help individuals achieve long-term financial security, particularly in the area of retirement savings. The SMarT mechanism is based on automatic commitment and increasing the savings rate linked to future pay rises, thereby minimising the immediate sense of cost and resistance arising from loss aversion. The study presents the programme's basic principles, the management of cognitive biases (e.g. present bias, hyperbolic discounting, inertia) and empirical results confirming a significant increase in savings rates. The research highlights that automatic mechanisms and nudge techniques are effective tools for improving financial decision-making. The long-term sustainability and adaptability of the programme are of paramount importance in the design of pension systems and corporate savings programmes. The analysis refers to related international research that confirms the role of behavioural economics in promoting financial well-being.

Key words: SMarT programme; behavioural economics; propensity to save; cognitive biases; automatic commitment
JEL codes: D91, G41, H55

Introduction

Making savings decisions is challenging for many individuals, especially when it comes to long-term goals. Behavioural economics points out that financial decisions are influenced by a number of cognitive biases, such as present bias and loss aversion. The Save More Tomorrow (SMarT) programme builds on these biases to offer a solution: it uses automatic mechanisms and gradual savings increases to help individuals commit to future financial security. The aim of this study is to review the principles, effects and related research of the programme.

The Save More Tomorrow (SMarT) programme and its main principles

The Save More Tomorrow (SMarT) programme is a behavioural economics-based savings strategy developed by Richard Thaler and Shlomo Benartzi. Making financial decisions is often challenging for people, especially when it comes to long-term savings. Their goal was to design a programme that would help employees who want to save more but lack the willpower to make that happen.

The Save More Tomorrow programme consists of the following components:

- Employees are approached well in advance of their planned pay rise to increase their contribution rate. Due to hyperbolic discounting, there should be as much time as possible between enrolment and commencement.
- If employees enrol, their contributions to the plan are increased starting with the first pay rise following the increase. This feature mitigates the aversion to perceived loss resulting from a pay cut.

- The rate continues to increase with each scheduled increase until the contribution rate reaches a predetermined maximum. In this way, inertia and status quo bias work to keep employees in the programme.
- Employees can opt out of the programme at any time, although it is expected that few employees will be dissatisfied with the programme.

The programme was essentially created to help people increase their savings, taking into account the various cognitive biases that influence our financial decisions (Thaler & Benartzi 2004). The significance of the programme lies in the fact that it helps people automatically increase their savings for the future, especially in the case of pension savings, without the need for immediate sacrifices.

The principles and significance of the programme:

1. Automatic participation and commitment to the future: The SMarT programme builds on the tendency of people to procrastinate when it comes to saving, especially if it means sacrificing their current income. The programme allows people to decide today to save a portion of their future pay rises. This helps avoid the immediate cost of the decision and prioritises future financial security.
2. Application of behavioural economics: SMarT is based on the premise that people naturally avoid discomfort and risk and tend to maintain the status quo. The programme exploits this by 'automating' decisions, reducing the effort required to increase savings (Benartzi, 2012).
3. Gradual savings increase: A key element of the programme is that savings increase gradually as people's salaries increase. This puts less strain on their current budget and they do not feel as much pressure to make immediate financial sacrifices.
4. Increases long-term financial security: The SMarT programme is one of the most effective ways to help people save more money in the long term, especially for periods such as retirement. People often underestimate the financial challenges of retirement, so this programme helps them gradually secure their financial future.

Presentation of the cognitive biases used

The SMarT programme takes into account several cognitive biases that often hinder rational financial decision-making: it either reinforces them or encourages individuals to make opposite decisions:

1. Present bias: People tend to prefer present consumption over future savings (Benhabib, Bisin & Schotter, 2010). This bias results in many people not saving enough money for the future (Gilovich, Griffin & Kahneman, 2002). The SMarT programme addresses this by automatically allocating a portion of future pay rises to savings, allowing participants to increase their savings without reducing their immediate consumption.
2. Loss aversion: People feel more pain from losses than joy from gains (Rapatyi, 2011). The estimated value of loss aversion is typically around 2.0, meaning that losses hurt roughly twice as much as gains feel good. Households may be reluctant to increase their savings rate because they do not want to experience a reduction in their household budget (Tréfás, 2016). The advantage of the SMarT programme is that it schedules savings for later (e.g. in the event of a future pay rise) rather than immediately, so participants do not feel that they are

currently losing money. The programme postpones the pain of saving, which makes the decision easier (Gal & Rucker, 2018).

3. Inertia: People often procrastinate on decisions or stick to the status quo, even if it is not the best for them (Nikolett, 2015; Scherer, 2022). The SMarT programme offers automatic enrolment, which reduces the burden of decision-making and increases participation rates. Automatic enrolment makes it easier for employees to start saving.
4. Self-control issues: People often struggle with self-control, especially when it comes to saving (Bryant, 2007). The SMarT programme commits participants to future savings in advance, reducing the need for self-control. This makes it easier for participants to achieve their financial goals (Sherman, Gawronski, Gonsalkorale, Hugenberg, Allen & Groom, 2008).
5. Framing: People's decisions are influenced by how an option is presented (De Martino, Kumaran, Seymour, B & Dolan, 2006). The SMarT programme frames savings positively as part of a future pay rise, which does not cause any pain for the individual either in the present or in the future. This approach helps participants view savings positively, recognise their future importance, and be more likely to commit to them (Cassotti, Habib, Poirel, Aïte, Houdé & Moutier, 2012).
6. Hyperbolic discounting: This bias refers to the tendency of people to value short-term benefits more highly than long-term ones (Ainslie & Haslam, 1992). The SMarT programme addresses this bias by scheduling savings for later, when future pay rises occur, so that current expenditure is not affected so individuals do not worry about losing out on short-term benefits, but it helps to increase savings in the long term (Azfar, 1999).

Presentation of the empirical results of the SMarT programme

The empirical results of the Smart programme (Save More Tomorrow™ - SMarT), inspired by Richard Thaler, were outstanding, particularly in terms of increasing retirement savings. The aim of the programme was to use behavioural economics tools to help people increase their long-term savings, with a particular focus on their retirement years.

Participants opted into the SMarT plan themselves. Under other circumstances, we might be concerned that the observed increase in savings rates among households joining the SMarT plan was due to some kind of immeasurable "savings propensity," but this concern seems misplaced for two reasons. First, SMarT participants saved very little before joining the scheme, so we might think that their propensity to save was newly formed. Second, the SMarT programme was only offered to employees who were unwilling to immediately increase their savings rate by 5 per cent, so it appears that the group that accepted the advisor's advice was more inclined to save than those who participated in the SMarT plan.

The main results observed when the programme was introduced were:

1. Increase in savings rates

The original SMarT programme was tested by Benartzi and Thaler at an American company. Over a period of 40 months, the programme yielded the following results: the average savings rate of those who joined the programme increased from 3.5% to 13.6%. This increase was significantly higher than that of those who did not join the programme.

2. Participation rates
Of those who were offered the programme, 78% joined. The majority of participants remained in the programme in subsequent years, confirming its sustainability. The vast majority (80%) of those enrolled in the SMarT plan remained in the programme until their fourth pay rise.

3. Effectiveness of automated decisions
Automatic tools, such as automatic increases in savings rates at the time of future pay rises, helped to reduce barriers arising from short-term self-control problems. Participants found it easier to accept deferred changes because they did not require immediate sacrifices.

4. Addressing behavioural biases
The programme successfully circumvented the problem of temporal inconsistency (when people prioritise present consumption over future savings). Due to hyperbolic discounting, people tend to value rewards in the near future much more highly than rewards in the distant future (Laibson, 1997). The SMarT programme exploits this phenomenon by having people commit in advance to saving a portion of their future pay increases. Because saving in the future seems less painful than saving now, people are more willing to make this commitment. This approach helps overcome procrastination and lack of self-control, which often hinder the achievement of savings goals.

By linking savings increases to pay rises, participants did not perceive saving as an immediate loss. Kahneman and Tversky (Tversky and Kahneman, 1992) discuss prospect theory in detail in their study. Utility is influenced by changes in wealth, not its absolute level. The authors compare this to the properties of human sensory perception. People react more strongly to changes in light, temperature, etc., and compare these to previous or familiar conditions. This is a reference point determined by past and present experiences or expectations based on them. Therefore, we perceive something with a certain temperature as hot or cold according to the experience of the subject/person, i.e. their reference point. According to the authors, the same is true for wealth, health and prestige.

People value gains and losses more than the absolute value of goods, and the weights of decisions are not the same as the probabilities of outcomes. If the probability of achieving high gains is high, the certainty effect occurs. People are averse to risk when considering alternatives with a high probability of gain. They prefer to accept less than the expected value of a risky game. Fear of disappointment appears. If the probability of achieving a high gain is low, the opportunity effect manifests itself. People tend to take risks even when the probability of winning, for example when buying a lottery ticket, is very low. This manifests itself in an overestimation of low probabilities, which is also the reason for the popularity of the lottery. If the probability of large losses is low, people are willing to pay more for insurance against loss than the expected value of the unlikely risky alternatives. In this case, risk aversion manifests itself in the fear of large losses.

5. Long-term results
In cases where the programme was followed over a longer period of time, it was found that savings rates remained stable or continued to increase. This confirms that behavioural interventions result in sustainable changes in the long term. Table 1 shows retirement income replacement rates, i.e. the ratio of retirement income to pre-retirement income. They did not have demographic or financial information on the employees included in their study, so they had to make assumptions

about their households' financial situations in order to calculate the likely effects of joining the SMarT plan. They performed calculations for employees who join the plan at ages 25, 35, 45, or 55, with three different annual incomes: $25,000, $50,000, and $75,000. Based on data from Hewitt Associates, initial account balances were estimated for some of the larger programmes they administer. In particular, account balances were calculated for people of similar age, income and savings rates. To avoid multiple accounts for individuals, they selected only those who remained with the same employer during the subsequent periods. In terms of savings and investment options, they assumed that employees would save 4 per cent in the plan when they entered the SMarT plan, increasing to 12 per cent. They also assumed that the employer would match 50 per cent of employee contributions on the first 6 per cent of employee contributions. Finally, they assumed that employees would choose a portfolio mix of 60 per cent equities and 40 per cent bonds.

The company in their study does not sponsor defined benefit pensions, so they did not assume that there were pension benefits. When this data was entered into the Financial Engines programme, the software provided multiple points of probability distribution for pension income, as shown in Table 1. The panel before SMarT shows the expected income replacement rates for our employees without joining the SMarT plan. We see values of 60 per cent or lower. The replacement rates are highest for the $25,000 income category, as social security provides significant replacement at this level. The panel after SMarT shows that income replacement rates are significantly higher with the SMarT plan, especially for those who join the plan at a young age. Obviously, increasing the savings rate is less effective when starting at age 55 than at age 25. Nevertheless, expected replacement rates never exceed 100%, so there does not appear to be a problem of encouraging people to save too much.

Table 1. Replacement rates

Retirement income replacement rates				
Age				
Before SMarT				
Income	**25**	**35**	**45**	**55**
25.000 USD	60%	58%	54%	50%
50.000 USD	51%	50%	50%	52%
75.000 USD	47%	45%	46%	41%
After SMarT				
25.000 USD	93%	81%	68%	56%
50.000 USD	84%	72%	63%	58%
75.000 USD	80%	68%	60%	47%

Source: own compilation

SMarT programme's theoretical and empirical results in literature

1. Following the success of the SMarT programme, other researchers have also examined the effectiveness of financial programmes based on behavioural economics principles. For example, Bland and Chambers pointed out, among other things, that a prior commitment to future tax refunds can increase savings (Bland & Chambers, 2020). Research has shown that when people commit in advance to saving their tax refunds, they are more likely to do so. This is the principle

behind the main cognitive bias of the SMarT programme, framing. This behavioural strategy can be particularly effective for low- and middle-income households, for whom tax refunds are one of the few opportunities during the year to save a significant amount of money.

According to Bland's research, people create mental accounts, which means that the source of money can influence how they spend it. For example, money from an "entertainment" source is more likely to be spent on entertainment. The research did not find statistically significant evidence that income from "adult" sources is more likely to be spent on adult purposes, but this money is more likely to be invested. A better understanding of emotional labels and their impact on money-spending decisions can help predict irrational behaviour and create environments that support better decisions.

2. In their study, "Save More Tomorrow" (SMarT) Programme and Household Balance Sheet: A Theoretical Examination, they review the SMarT programme and present a theoretical model that examines a representative household that hyperbolically discounts the future (Findley & Cottle, 2019). This means that the household places greater weight on current consumption than on future savings. The model examines how participation in the SMarT programme affects the household's overall financial situation, including savings and debts.

In terms of its impact on household balance sheets, the SMarT programme may increase pension savings, but this may be accompanied by a decline in other financial assets. The question is whether households will adjust their savings levels or even increase their debt in response to increased SMarT savings contributions. The study emphasises that the effectiveness of the programme must be assessed by looking at the overall household balance sheet, not just pension savings. The study concludes that most households have untapped borrowing capacity, particularly in advanced economies such as the United States. This means that households may be able to borrow to maintain their current consumption while increasing their retirement savings through the SMarT programme.

The research highlights how insights from behavioural finance can help households better prepare for retirement. Participation in the SMarT programme reduces consumption during working years but then increases consumption during retirement years, thereby successfully shifting financial resources from the working period of the life cycle to the retirement period, helping households to be better financially prepared for their retirement years.

3. The article, written in 2020 by Erin Cottle Hunt and T. Scott Findley – a year after their 2019 study on a similar topic – is titled "Short Planning Horizons and the Save More Tomorrow Programme" and examines the effects of the Save More Tomorrow (SMarT) programme on individuals with short-term planning horizons. The study provides theoretical support for the SMarT programme in a model with well-functioning credit markets and short-sighted individuals who only plan ahead for a limited number of years. Short-sighted individuals do not consider the part of the future that lies beyond the end of their planning horizon, but as time progresses, the planning horizon shifts forward and incorporates new information, which can lead to frequent re-optimisation as the individual ages. The mechanism of the short planning horizon has been documented to correspond to several key empirical observations of life cycle experiences,

including the hump-shaped age consumption profile and the decline in consumption upon retirement (Park & Feigenbaum, 2018).

The results show that individuals with shorter planning horizons benefit more from the SMarT programme. This means that people who plan only a few years ahead can significantly increase their lifetime consumption with the help of the programme. For example, if someone plans only five years ahead, participating in the SMarT programme can increase lifetime consumption by up to 13% if they do not have access to a social security programme. This is because the programme automatically increases the savings contribution rate, which helps individuals save more without having to actively make decisions. If the SMarT programme is chosen instead of social security, lifetime consumption can increase by 9% because the programme itself offers significant benefits, even if there are no other pension savings options. When the SMarT programme is used in conjunction with social security, lifetime consumption may increase by 3%. This shows that the programme can also be useful as a supplement, even if another pension savings system already exists.

Individuals with a longer planning horizon who plan several years ahead experience smaller but still positive benefits from the SMarT programme because, although these individuals are likely to be better prepared for the future, the programme can still help them increase their savings and improve their lifetime consumption.
These results contrast with an earlier finding that the SMarT programme does not affect consumption allocations and thus does not improve individuals' welfare, at least in the absence of significant credit market imperfections. However, the study shows that even with well-functioning credit markets, the SMarT programme can offer significant benefits, especially for short-sighted individuals who tend to underestimate the importance of long-term savings.

4. Raj Chetty and colleagues' 2014 study, "Active vs. Passive Decisions and Crowd-Out in Retirement Savings Accounts: Evidence from Denmark," examines the effects of retirement savings policies on wealth accumulation, with a particular focus on whether these policies change savings rates through active or passive decisions (Chetty, Friedman, Leth-Petersen, Nielsen & Olsen, 2014). The researchers used 41 million observations of Danish household savings and found that systems based on active decisions, such as tax incentives that require active participation by individuals, are less effective in increasing savings. They primarily encourage individuals to transfer their assets from taxable accounts to retirement accounts, which results in only a minimal increase in total savings. According to the study, every dollar of government spending on tax incentives increases total savings by only 1 cent.

In contrast, passive decisions, such as automatic employer contributions, which increase pension contributions if individuals do nothing, significantly increase wealth accumulation. Researchers estimate that about 15% of individuals are "active savers" who respond primarily by shifting assets in response to tax incentives, while 85% are "passive savers" who do not respond to tax incentives but are strongly influenced by automatic contributions. Active savers tend to be wealthier and more financially literate.

The study identifies three main reasons why automatic contributions are more effective than tax incentives in increasing savings rates:

- Tax incentives encourage relatively few individuals to save.
- Tax incentives have a significant crowd-out effect, meaning that individuals simply shift their existing savings.
- Tax incentives do not increase the savings of passive individuals, who are the least prepared for retirement.

This study therefore highlights that automatic savings mechanisms, such as the SMarT programme, may be more effective in increasing retirement savings, especially for passive savers who tend to underestimate the importance of long-term savings.

5. Felipe Kast and Dina Pomeranz's 2014 study, "Saving More to Borrow Less: Experimental Evidence from Access to Formal Savings Accounts in Chile," examines the effects of access to savings accounts on short-term debt and well-being. The study found that access to formal savings accounts reduced participants' short-term debt by approximately 20%. In addition, participants who experience economic shocks are less forced to reduce consumption, and their subjective well-being improves significantly (Kast & Pomeranz, 2014).

Similar to the Save More Tomorrow (SMarT) programme, which automatically increases the savings contribution rate, the study by Kast and Pomeranz also shows that automatic savings mechanisms can be effective in increasing savings and reducing debt. Both studies conclude that reducing barriers to saving and introducing automatic mechanisms can have a significant positive impact on individuals' financial situation and well-being.
The following methods were used in the research:

- Randomised controlled trial (RCT): Researchers randomly assigned participants to two groups: a treatment group that received access to free formal savings accounts and a control group that did not receive such access. This method allowed researchers to compare the outcomes of the two groups and determine the impact of the savings accounts.
- Data collection and analysis: Researchers collected data on participants' financial situations, including savings, debts, and spending habits.
  The data were analysed using statistical methods to determine the impact of access to savings accounts on short-term debt and well-being.
- Questionnaires and interviews: Participants completed questionnaires and participated in interviews to help researchers better understand their savings habits and the motivations behind their financial decisions.

According to a study by Felipe Kast and Dina Pomeranz, access to formal savings accounts reduced participants' short-term debt and improved their subjective well-being for several reasons:

- Easier access to savings: Access to formal savings accounts made it easier for participants to set aside money. This reduced their need to take out short-term loans when unexpected expenses arose.
- Voluntary savings mechanisms: Savings accounts automatically helped participants save without having to make active decisions. This was particularly useful for those who tended to procrastinate when it came to saving.
- Reduced consumption decline during economic shocks: Participants who experienced economic shocks were less forced to reduce their consumption because they already had

savings that they could access. This improved their subjective well-being because they did not have to make drastic changes to their lifestyles.

- Credit and savings as substitutes: The study showed that savings and credit act as substitutes for self-insurance. When participants had access to savings accounts, they were more likely to save than to take out credit, which reduced their debt.
- Reducing social pressure: Access to savings accounts reduced participants' compulsion to provide financial assistance to friends and family members, as their savings were in a more secure place.

These results are consistent with the goals of the Save More Tomorrow (SMarT) programme, which also emphasises the effectiveness of automatic savings mechanisms in improving financial stability and well-being.

6. Closer links between the Save More Tomorrow (SMarT) programme and the Consumer Financial Protection study can be observed in several respects (Campbell, Jackson, Madrian & Tufano, 2011). In the "Consumer Financial Protection" study, the authors discuss the necessity and effectiveness of financial regulation, with a particular focus on consumer financial markets.
Although the study does not directly address the Save More Tomorrow programme, there is a close connection between the topics examined by the authors and the programme's objectives, as both focus on improving and protecting consumers' financial decisions, which are as follows:
Application of behavioural economics: Both studies apply the principles of behavioural economics to improve financial decision-making. For example, the SMarT programme automatically increases employees' savings rates, exploiting people's tendency to maintain the status quo and postpone future decisions.

- Supporting financial decisions: The Consumer Financial Protection study emphasises the importance of financial regulation to protect consumers. Similarly, the SMarT programme aims to help employees make better financial decisions, particularly in the area of retirement savings.
- Automation and default settings: A key element of the SMarT programme is automation, which allows employees to automatically increase their savings without having to actively make decisions. This leverages the power of default settings, which the Consumer Financial Protection study also highlights as an effective tool for influencing consumer financial behaviour.
- Long-term financial well-being: The ultimate goal of both studies is to improve the long-term financial well-being of consumers. The SMarT programme helps employees gradually increase their savings, while Consumer Financial Protection emphasises the importance of financial regulation and protection to increase consumers' financial security.

7. Several interesting connections can be found between the study "Nudging and the choice architecture of offending decisions" by Pogarsky and Herman (2019) and the Save More Tomorrow (SMarT) programme, particularly in the application of behavioural economics and decision architecture (Pogarsky & Herman, 2019).

Both the Save More Tomorrow (SMarT) programme and the study by Pogarsky and Herman apply the principles of behavioural economics to influence people's decisions, mainly through nudge techniques, which are methods that subtly influence people's decisions without restricting their choices.

The SMarT programme exploits human tendencies, such as the tendency to maintain the status quo and to postpone future decisions. People tend to maintain the current state, so the programme automatically increases the savings rate, allowing people to increase their savings without having to actively make decisions, thus exploiting the power of default settings. This decision architecture helps people make better financial decisions without having to actively make decisions.

In their study, Pogarsky and Herman apply the principles of behavioural economics to influence criminal decision-making. For example, they use nudge techniques to try to reduce criminal behaviour by shaping the decision-making environment in such a way that people are less likely to commit crimes. In their research, they emphasise the importance of decision architecture in criminal decision-making. Decision architecture is the way in which the decision-making environment is designed to influence people's decisions. The authors examine how the decision-making environment can be shaped to encourage people to choose the desired behaviour. For example, to reduce criminal behaviour, they create an environment in which committing crimes is less attractive. These techniques help to influence people's behaviour in a positive direction in both areas.

Summary of research findings related to the SMarT programme

This summary presents the results of the SMarT programme and other related research, which highlight the effectiveness and importance of financial programmes based on the principles of behavioural economics.

Following the success of the SMarT programme, other researchers, such as Bland and Chambers, have examined the effectiveness of financial programmes based on behavioural economics principles. Their research has shown that pre-commitment to future tax refunds can increase savings, particularly for low- and middle-income households. People create mental accounts, which influence how they spend their money. A better understanding of emotional labels can help predict irrational behaviour and support better decisions.

Findley and Cottle Hunt first review the SMarT programme and then present a theoretical model that examines a representative household that hyperbolically discounts the future. The SMarT programme may increase retirement savings, but it may also reduce other financial assets. To evaluate the programme's effectiveness, the entire household balance sheet must be considered, not just retirement savings. In another study, individuals with short-term planning horizons benefit more from the SMarT programme. The programme automatically increases the savings contribution rate, which helps individuals save more without having to make active decisions. Individuals with longer planning horizons experience smaller but still positive benefits from the programme.

Chetty and his colleagues' study examines the effects of pension savings policies on wealth accumulation, with a particular focus on active and passive decisions. Systems based on active decisions are less effective at increasing savings, while those based on passive decisions, such as automatic employer contributions, significantly increase wealth accumulation. Automatic contributions are more effective at increasing savings rates, especially for passive savers.

Kast and Pomeranz found that access to formal savings accounts reduces participants' short-term debt and improves their subjective well-being. Automatic savings mechanisms can be effective in increasing savings and reducing debt. Reducing barriers to saving and introducing automatic mechanisms can have a significant positive impact on individuals' financial situation and well-being.

The Consumer Financial Protection study discusses the necessity and effectiveness of financial regulation, with a particular focus on consumer financial markets. It applies the principles of behavioural economics to improve financial decision-making, similar to the SMarT programme. It uses the power of automation and default settings to influence consumer financial behaviour. Both studies aim to improve the long-term financial well-being of consumers.

Finally, Pogarsky and Herman explore connections between behavioural economics and decision architecture in the SMarT programme. Both studies use nudge techniques that subtly influence people's decisions without restricting their choices. The SMarT programme exploits people's tendencies, such as the tendency to maintain the status quo and to postpone future decisions. Pogarsky and Herman apply the principles of behavioural economics to influence criminal decision-making, for example by using nudge techniques to try to reduce criminal behaviour. They emphasise the importance of decision architecture in criminal decision-making and examine how the decision-making environment can be shaped so that people choose the desired behaviour.

In summary, the results of the SMarT programme and related research clearly demonstrate the effectiveness and importance of financial programmes based on behavioural economics principles. Such programmes have proven effective not only in increasing savings rates, but also in improving financial decision-making, particularly among low- and middle-income households. Through the use of automatic mechanisms and nudge techniques, these programmes can promote long-term financial well-being and stability. Future research and development can further refine these approaches, ensuring that even more people benefit from the advantages offered by behavioural economics.

Conclusion

The SMarT programme and other research have examined the effectiveness and relevance of financial programmes based on behavioural economics principles. Following the success of the SMarT programme, other researchers, such as Bland and Chambers, have shown that pre-commitment can increase savings, particularly for low- and middle-income households. According to the theoretical model of Findley and Cottle Hunt, the SMarT programme can increase retirement savings, but may be accompanied by a decrease in other financial instruments. According to Chetty and his colleagues, automatic employer contributions are more effective in increasing savings rates than systems based on active decisions. Research by Kast and Pomeranz suggests that automatic savings mechanisms can reduce short-term debt and improve subjective well-being. The Consumer Financial Protection study discusses the necessity and effectiveness of financial regulation, while Pogarsky and Herman examine the use of nudge techniques to influence decision-making. Overall, these studies highlight the effectiveness and importance of financial programmes based on behavioural economics principles in promoting long-term financial well-being.

Their application is particularly important because people's short-sightedness has a significant impact on their financial decisions. Campbell and colleagues (2011) point out that many consumers have present-oriented preferences, which lead them to favour current consumption, even though they would be more patient if they could commit to a savings and future consumption plan. In addition, some people lack the cognitive abilities necessary to optimise their financial situation, even when all the information is available. The infrequency of financial decisions and the slow accumulation of experience further hinder learning. According to the 1992 Health and Retirement Study, 61% of Americans aged 50 and older have a short-term financial planning horizon, which explains their insufficient savings for retirement. The short-term planning horizon intuitively modifies the life cycle consumption and savings framework, predicting insufficient savings for retirement.

It is important to emphasise finding a balance between current and future financial goals. If we allocate too many resources to the future, we risk making unhealthy sacrifices in the present and possibly financing our needs with loans. This is not sustainable in the long term and can even lead to financial stress. To achieve balance, we need to find the reserves that are available but that we do not consciously use due to psychological and cognitive biases. These biases, such as present bias or mental accounting, often prevent us from managing our finances optimally. If we manage these reserves consciously, we have the opportunity to achieve positive medium- and long-term goals without significantly compromising our current quality of life.

The SMarT programme can help improve the well-being of short-sighted, limitedly rational individuals. According to Thaler and Benartzi (2004), hyperbolic discounting makes future savings opportunities more attractive than present ones. However, if credit markets function well, the impact of the SMarT programme may be limited, as individuals can offset savings contributions by reducing other assets or taking on debt. Therefore, short-sightedness may be the dimension along which the SMarT programme can improve individuals' well-being by helping them prepare for retirement.

Recommendations

The results of the SMarT programme and related research offer a number of important lessons for companies and policymakers looking to the future. These lessons and recommendations are explained in detail below:

- The importance of balance: Companies and policymakers need to recognise that financial strategies that focus too much on the future are not sustainable if they neglect current needs. Finding a balance is key to ensuring that individuals are not forced to make unhealthy sacrifices or finance themselves through credit. They should take into account that, when credit markets are functioning well, the impact of the programme may be limited, as individuals can offset savings contributions by reducing other assets or taking on debt. Financial programmes should offer mechanisms that help people manage their available reserves consciously and achieve positive medium- and long-term goals.
- Use of automatic mechanisms and nudge techniques: The success of the SMarT programme highlights that automatic mechanisms and nudge techniques can be effective in increasing savings and achieving financial stability. Government and private sector stakeholders

should apply these principles when designing financial programmes to promote long-term financial well-being. Automatic employer contributions and default settings can be particularly important for passive savers.
- Addressing psychological and cognitive biases: Psychological and cognitive biases, such as present bias and mental accounting, should be taken into account in financial decision-making. Policymakers should develop programmes that help individuals recognise and manage these biases so that they can manage their finances optimally. Financial education and awareness-raising can also play an important role in this regard.
- Accounting for short-term planning horizons: Employers and policymakers should take this short-sightedness into account and offer programmes that help individuals better prepare for retirement and other long-term financial goals.

Overall, the results of the SMarT programme and related research suggest that financial programmes should be designed to take into account individuals' short- and long-term needs, address psychological and cognitive biases, and promote financial stability and well-being. Future research and development can further refine these approaches, ensuring that even more people benefit from the advantages offered by behavioural economics.

The results of the SMarT programme and financial programmes based on behavioural economics principles may have wider implications for other areas, including the following potential impacts:
- Investment products and regulation: The success of savings programmes suggests that similar approaches could be applied to the design and regulation of investment products. Techniques that counteract cognitive biases can help investors make better decisions, reducing excessive risk-taking and promoting long-term financial stability. It may also be important for regulators to take these principles into account in order to increase the stability of financial markets.
- Reducing excessive risk-taking: Programmes based on behavioural economics principles can help reduce excessive risk-taking because they enable investors and consumers to manage their finances more consciously, reducing the likelihood of risky decisions. This can be particularly important in preventing financial crises and maintaining the stability of the financial system.
- Healthcare: Automatic mechanisms and nudge techniques can also be used in healthcare because they can help people lead healthier lifestyles, participate regularly in screening tests, or comply with medical prescriptions. When designing healthcare programmes, it is worth taking these principles into account in order to improve the health of the population.
- Education: These findings can also be useful in the field of education. The techniques mentioned can help students develop better study habits, attend classes regularly, and complete their assignments on time. When designing educational programmes, it is worth taking these principles into account in order to improve student performance.
- Workplace wellbeing: The principles of behavioural economics can also be applied to improve workplace wellbeing, as they can help employees develop healthier work habits, better manage workplace stress, and increase job satisfaction. When designing workplace programmes, it is worth considering these principles in order to increase employee wellbeing and performance.

Overall, the results of financial programmes based on the principles of the SMarT programme offer a wide range of applications in other areas as well. Companies and decision-makers should consider applying these principles in the areas of investment products, regulation, healthcare, education and workplace wellbeing to promote long-term stability and prosperity.

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Charting the Uncharted: A Critical Gap Analysis of Causal Inference and Counterfactual Analysis in Science using LLMs and RL on Scholarly Graphs

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Abstract: Scientific progress is fundamentally driven by the understanding of causal mechanisms and the exploration of counterfactual scenarios. The convergence of Large Language Models (LLMs), Reinforcement Learning (RL), and Scholarly Graphs presents a transformative paradigm for automating this process, promising a future of accelerated, predictive discovery. While state-of-the-art methods demonstrate the potential to extract causal knowledge from literature and navigate complex knowledge networks, a significant chasm remains between this nascent capability and a robust, reliable framework for scientific reasoning. This article presents a critical gap analysis of this emerging field. We synthesize the current state-of-the-art, where LLMs serve as semantic extractors, scholarly graphs provide a structural substrate, and RL agents act as exploratory hypothesis generators. Our analysis identifies three profound and interconnected gaps: (1) a gap in the fidelity and dynamism of knowledge representation, where current graphs fail to capture the uncertainty, context, and evolution of scientific knowledge; (2) a gap in the reliability and interpretability of AI-driven reasoning, where model hallucinations and opaque policies undermine scientific trust and verifiability; and (3) a gap in the evaluation and reward mechanisms, where the absence of ground truth for counterfactuals and ambiguous definitions of "novelty" hinder systematic progress. By articulating these challenges with depth and precision, we outline a concrete research agenda aimed at bridging this chasm, calling for dynamic probabilistic knowledge graphs, hybrid explainable models, and novel evaluation frameworks. This analysis provides a roadmap for the community, guiding the development of AI systems that can truly augment human intellect in the relentless pursuit of scientific truth.

Key words: Causal inference; Counterfactual analysis; Large Language Models (LLMs); Reinforcement Learning (RL); Scholarly Graphs; Knowledge representation
JEL code: I23, O33

1. Introduction

The history of science is an epistemological journey, a chronicle of humanity's collective effort to transcend the surface of mere observation and uncover the deep, causal structures that govern the universe. From the methodical experiments of Galileo that challenged Aristotelian dogma to the elegant elucidation of DNA's double helix by Watson and Crick, the most profound breakthroughs have consistently arisen not from the passive cataloguing of correlations, but from the active formulation and rigorous testing of hypotheses about cause and effect. This process, rooted in the hypothetico-deductive model and championed by philosophers of science like Karl Popper, is the very engine of empirical progress. This engine, however, is now facing an unprecedented and existential bottleneck. The exponential proliferation of scientific literature, with millions of papers published annually across an ever-increasing number of hyper-specialized disciplines, has created a landscape of knowledge so vast, complex, and fragmented that it exceeds the cognitive capacity of any single researcher, or even a large, well-funded team. The critical connections, the subtle causal links between disparate fields, and the promising counterfactual pathways that could unlock the next grand discovery are increasingly buried within an information avalanche, leading not to acceleration but to a state of knowledge saturation and siloed thinking.

In response to this escalating crisis, a powerful tripartite technological paradigm has emerged, offering a potential pathway through complexity. Large Language Models (LLMs), with their remarkable ability to parse, contextualize, and semantically distil knowledge from unstructured text, offer a master key to unlocking the latent insights within the global scientific corpus. Reinforcement Learning (RL), with its formal framework for sequential decision-making and intelligent exploration under uncertainty, provides the optimal control mechanism to navigate this immense knowledge space, balancing the exploitation of known pathways with the search for novel ones. And Scholarly Graphs, which meticulously structure the heterogeneous relationships between publications, authors, concepts, and methodologies, offer the formal ontological substrate—the computational scaffolding—necessary for rigorous reasoning and inference. The synergistic convergence of these three paradigms promises a new era of scientific discovery: one where AI systems can autonomously read, synthesize, and reason over the entirety of human scientific knowledge, building dynamic causal models of complex domains and proposing novel, high-impact hypotheses for human validation and experimental pursuit.

Initial forays into this interdisciplinary domain have been promising, yielding proof-of-concept systems that can identify causal claims in biomedical literature, predict promising material combinations, or recommend non-obvious citations. However, the transition from these impressive yet circumscribed demonstrations to a trustworthy, scalable, and widely adopted scientific instrument is not a foregone conclusion. A significant, multi-faceted chasm exists between the transformative potential of this integrated approach and its current practical realization. This chasm is not merely a collection of technical hurdles but a series of profound methodological and epistemological divides that must be bridged for the field to mature. This paper serves to map that chasm in meticulous detail. We move beyond a simple survey of existing methods to provide a critical gap analysis that dissects the fundamental limitations—conceptual as well as technical—that are currently hindering progress and threatening to relegate this paradigm to the realm of interesting academic curiosities rather than transformative infrastructure.

Our contribution is therefore threefold and is structured to provide both a critique and a roadmap. First, we synthesize the confluence of LLMs, RL, and Scholarly Graphs into a cohesive conceptual framework, articulating the specific role of each component and the nature of their synergy in the service of causal discovery. Second, and most centrally, we identify and articulate three critical gaps that must be addressed for this field to mature: The Representation Gap, concerning the fidelity, dynamism, and multi-modality of our knowledge bases; The Reasoning Gap, concerning the reliability, interpretability, and context-awareness of our AI models; and The Evaluation Gap, concerning the metrics, benchmarks, and incentives that truly guide and validate scientific discovery. Third, we chart a path forward, proposing a concrete and forward-looking research agenda to bridge these gaps. By illuminating these foundational challenges with academic rigor, we aim to focus the community's efforts, foster a deeper dialogue on the nature and methodology of AI-driven science, and ultimately accelerate the development of the next generation of discovery systems that can truly augment and reshape the scientific process for the challenges of the 21st century.

2. Background and Related Work: The Confluence of Three Paradigms

To fully appreciate the nature of the gaps that impede progress in AI-driven scientific discovery, it is essential to understand the constituent technological paradigms and the current state of their integration. The proposed integrated framework for causal inference and counterfactual analysis rests upon three distinct yet synergistic pillars, each addressing a unique and fundamental challenge within the discovery pipeline. We now delve into the historical context, core principles, and inherent limitations of each paradigm, setting the stage for our subsequent critique.

2.1. Traditional Causal Inference in Science: The Legacy of Structural and Potential Outcomes Frameworks

The formal study of causality boasts a rich intellectual history, long preceding the era of big data. Its modern computational roots are often traced to the pioneering work of Sewall Wright in the early 20th century, who introduced path analysis to model causal relationships in genetics. This lineage was profoundly expanded and formalized by Judea Pearl, whose development of Structural Causal Models (SCMs) and the accompanying do-calculus provided a rigorous, mathematical language for articulating causal assumptions, identifying confounding variables, and reasoning about the effects of interventions from observational data (Pearl 2009). In parallel, the potential outcomes framework, championed by Donald Rubin, offered a complementary statistical foundation for defining causal effects as the difference between observed and counterfactual outcomes, providing powerful tools for estimating treatment effects in fields like epidemiology, economics, and the social sciences (Rubin 2005).

Together, these frameworks constitute the gold standard for causal reasoning in quantitative disciplines. They provide a principled methodology for moving beyond the confines of statistical correlation to answer the critical "what if" questions that lie at the heart of scientific inquiry. However, their application to the vast, text-driven corpus of modern scientific literature has been severely limited. A fundamental epistemological chasm exists between the requirements of these frameworks and the nature of scientific knowledge as it is published. SCMs and potential outcomes models demand well-defined variables, structured datasets, and a clear pre-specification of the causal model under consideration. In stark contrast, scientific publications are predominantly narrative, unstructured documents. Causal claims are often embedded within complex prose, qualified by context, and contingent on a myriad of unstated experimental conditions. The variables are implicit, and the data is presented in heterogeneous formats—tables, figures, and text—that are not readily amenable to direct input into these traditional causal models. This "symbolic-linguistic divide" has rendered these powerful tools largely ineffective for large-scale causal discovery from the literature itself, confining their use to curated, structured datasets derived a posteriori from human expert labor.

2.2. Scholarly Graphs: From Bibliometrics to Semantic Knowledge Networks

In an effort to computationally tame the sprawling landscape of scientific literature, the paradigm of scholarly graphs has emerged as a necessary structural substrate. This represents a significant evolution from traditional bibliometrics, the foundational work of Eugene Garfield and others, which relied on relatively simple, aggregated metrics like citation counts or the h-index to quantify

scientific impact. While revolutionary for their time, such metrics fail to capture the complex, multi-faceted web of relationships that constitute scientific knowledge. Modern knowledge graphs address this limitation by modelling science as a complex network, formally defined as G=(V,E), where nodes V represent heterogeneous entities (publications, authors, institutions, concepts, methodologies) and edges E encode diverse relationships (citations, co-authorship, conceptual similarity, institutional affiliations).

This graph-based representation enables sophisticated multi-hop analyses that are impossible with traditional metrics. Large-scale, general-purpose projects like the Microsoft Academic Graph (MAG) (Sinha et al. 2015) and its successor, OpenAlex (Priem et al. 2022), have mapped hundreds of millions of publications and their interconnections, enabling macro-level analyses of scientific collaboration, knowledge flow, and disciplinary evolution. Concurrently, domain-specific graphs have demonstrated the power of semantic enrichment. In biomedicine, for example, projects like SemMedDB (Kilicoglu et al. 2018) extract semantic predications (e.g., "Drug X treats Disease Y") from PubMed abstracts, creating a richly annotated graph that goes far beyond simple citations. These structures have proven invaluable for tasks like trend analysis, expert finding, and literature-based discovery (LBD), where the seminal work of Swanson (Swanson 1986) demonstrated that indirect relationships (A → B → C) across disparate literatures can reveal novel, testable hypotheses. Yet, a critical limitation remains: even the most advanced scholarly graphs often represent a "shallow" understanding of the literature. They capture that one paper cites another, or that a concept is mentioned, but they struggle to represent the deep, conditional, and often counterfactual nature of the causal arguments embedded within the texts. The graph knows the connection, but not the why.

2.3. Large Language Models for Scientific Knowledge Extraction: A Revolution in Semantic Distillation

The advent of transformer-based Large Language Models (LLMs), initiated by the seminal "Attention Is All You Need" paper (Vaswani et al. 2017), has revolutionized natural language processing and, by extension, the potential for scientific knowledge extraction. Models such as GPT-4, LLaMA, and their successors, trained on massive and diverse corpora of text, possess an unprecedented ability to perform a wide array of language tasks. More critically, the development of domain-specific models like BioBERT (Lee et al. 2020), SciBERT (Beltagy et al. 2019), and the more recent Galactica (Taylor et al. 2022) has demonstrated the power of fine-tuning these architectures on focused scientific corpora, leading to a deeper understanding of domain-specific terminology, syntax, and latent conceptual relationships.

These models can be prompted or fine-tuned to perform sophisticated information extraction from unstructured text, including named entity recognition of scientific terms, relation extraction between entities, and, crucially for our purpose, the identification of potential causal claims, experimental parameters, and methodological details. The resulting contextualized embeddings are not merely word vectors; they are dense, high-dimensional representations that capture the semantic meaning of concepts, arguments, and entire passages within their specific scientific context. These embeddings can serve as rich, semantic features for nodes and edges in a scholarly graph, transforming it from a simple network of citations into a dense, knowledge-rich structure. However, this power is not without its perils. LLMs are known to "hallucinate" or generate

plausible-sounding but factually incorrect information, a critical flaw for applications demanding scientific veracity. Furthermore, their reasoning process remains largely a "black box," making it difficult to validate the provenance of an extracted causal claim or to understand the model's internal logic, thus posing a significant challenge to their deployment in a scientific context where interpretability and trust are paramount.

2.4. Reinforcement Learning for Exploration and Hypothesis Generation: A Framework for Goal-Directed Discovery

Reinforcement Learning (RL) provides the formal mechanism for active, goal-directed exploration within an LLM-enriched scholarly graph. An RL agent can be formalized as navigating this graph environment, which is naturally modeled as a Markov Decision Process (MDP), defined by the tuple (S, A, P, R, γ). Here, the state space S represents the agent's current position or context within the graph (e.g., a specific paper or a subgraph of related concepts). The action space A involves traversing citations, exploring related concepts, or even proposing hypothetical interventions or novel connections. The agent's objective is to learn a policy $\pi(a|s)$ that maximizes a cumulative reward R over time (Sutton & Barto 2018).

This framework is uniquely suited to the very nature of scientific discovery, which is inherently a sequential process of exploration: formulating a hypothesis, testing it, observing the result, and deciding on the next step. The core RL dilemma of exploration versus exploitation maps perfectly onto the scientific process. "Exploitation" involves following established, well-trodden research pathways, while "exploration" entails venturing into novel, high-risk, high-reward domains. RL allows an agent to learn efficient exploration strategies, prioritizing paths through the knowledge network that are likely to lead to novel or high-impact findings, rather than getting lost in the vastness of the space. The central, and perhaps most difficult, challenge in applying RL to scientific discovery is the design of the reward function. How does one quantify "novelty" or "impact"? The reward signal for a truly groundbreaking discovery is often sparse, delayed, and difficult to define, posing a significant hurdle to the practical implementation of this powerful paradigm.

2.5. Initial Efforts at Integration: A Nascent and Fragmented Frontier

Recent research has begun to explore the synergistic integration of these three powerful paradigms, recognizing that each can mitigate the weaknesses of the others. Studies have demonstrated the feasibility of using LLMs to automatically populate knowledge graphs with semantic relationships, including causal ones, extracted from text. Other works have employed RL agents to navigate citation networks for tasks like personalized paper recommendation or predicting future research collaborations. A few pioneering studies have begun to combine all three components, using LLMs to provide semantic guidance and state representations for an RL agent exploring a scholarly graph to generate novel hypotheses.

However, these efforts remain in their infancy, and the integration is often piecemeal rather than principled. They are frequently constrained to specific, well-defined domains (e.g., biomedicine), operate on small-scale graphs, or rely on simplified causal models that do not capture the full complexity of scientific reasoning. The connection between the components is often engineered rather than learned, and the critical challenges of hallucination, interpretability, and reward design

are only partially addressed. It is at this frontier, where the promise of integration meets the complexity of reality, that the critical gaps we identify in this paper become most apparent. The field lacks a unified, robust framework that can seamlessly blend the semantic extraction of LLMs, the structural reasoning of graphs, and the goal-directed exploration of RL into a coherent, trustworthy, and scalable instrument for scientific discovery. It is precisely this void that our analysis seeks to illuminate and fill.

3. The Critical Gaps: A Multi-Faceted Analysis of Foundational Limitations

Despite the elegant theoretical synergy of the proposed LLM-RL-Graph framework, its practical implementation and realization as a transformative scientific instrument are hampered by profound and interconnected gaps. These are not merely engineering hurdles to be overcome with incremental improvements; they are foundational challenges rooted in the very nature of scientific knowledge, the limitations of our current AI models, and the methodological difficulties of evaluating discovery itself. A failure to address these gaps risks relegating this promising paradigm to the realm of sophisticated but ultimately unreliable tools, incapable of earning the trust of the scientific community. Our analysis identifies three primary domains of deficiency: the Representation Gap, the Reasoning Gap, and the Evaluation Gap.

3.1. The Representation Gap: The Epistemological Failure of Current Knowledge Models

The first and most fundamental chasm lies in the very substrate of our analysis: the computational representation of scientific knowledge itself. Current scholarly graphs, while representing a significant advance over unstructured text, are fundamentally inadequate as a foundation for rigorous causal inference. They are brittle, static, and incomplete, failing to capture the nuanced, evolving, and multi-modal essence of the scientific enterprise. This is not a technical failing but an epistemological one; our current models of knowledge are too simplistic to reflect the complex reality of how science is known, debated, and advanced.

3.1.1. The Static Snapshot Problem: Failing to Model the Temporal Dialectic of Science

Science is not a static archive of settled facts but a dynamic, self-correcting, and often contentious conversation. It is a temporal dialectic where a causal claim (thesis) is subjected to scrutiny, refutation, or refinement (antithesis), leading to a more robust, nuanced understanding (synthesis). A causal assertion made in a 1950s paper on particle physics may be celebrated for decades before being superseded by a new model revealed by a more powerful accelerator. Similarly, a proposed mechanism for a drug's side effect might be initially accepted, then challenged by clinical data, and finally refined into a more accurate model of its metabolic pathways.

Current scholarly graphs, however, are overwhelmingly constructed as static snapshots. They are typically built from a fixed corpus and treat all extracted edges and nodes as equally valid in the present moment. They lack a robust mechanism for representing this crucial temporal evolution and the contested nature of scientific claims. An edge representing a causal relationship is rarely annotated with its full provenance—not just the source paper, but the subsequent literature that supports, refutes, or qualifies it. There is no "validity curve" that might decay over time as new evidence emerges or be strengthened by meta-analyses. The consequence is that any causal

inference performed on such a graph risks being based on outdated, superseded, or even long-refuted information, leading to the propagation of "zombie concepts"—ideas that have been scientifically killed but continue to walk in our computational models. Bridging this gap requires a paradigm shift towards versioned, temporally-aware knowledge bases that can model not just the state of knowledge at a point in time, but its entire evolutionary trajectory (Weis & Jacobson 2021).

3.1.2. The Unimodal Blind Spot: The Tyranny of Text in a Multi-Modal World

The overwhelming majority of scholarly graphs are fundamentally unimodal, constructed almost exclusively from textual content (titles, abstracts, full-text) and associated metadata. This represents a profound "tyranny of text" that systematically ignores the rich, multi-modal nature of modern scientific evidence. While the textual discussion in a paper provides interpretation and context, the core evidence—the primary data upon which causal claims are built—is often non-textual. In materials science, the causal link between a synthesis procedure and a material's superconductivity is evidenced by an X-ray diffraction pattern and resistivity curves. In computational biology, the assertion of a protein-protein interaction is supported by a 3D structural model from cryo-EM. In astrophysics, a claim about dark matter is substantiated by gravitational lensing effects in telescope images.

This unimodal blind spot means that the most critical components of the scientific argument are simply lost in translation to a graph-based representation. While LLMs are masters of language, they cannot directly "see" an image, "hear" an audio recording of a whale song, or "run" a block of simulation code. The result is a shallow, textually-mediated understanding of science. The graph might know that Paper A cites Paper B, but it will miss that the core reason is a subtle, unspoken similarity between two microscopy images that a human expert would instantly recognize. A truly comprehensive knowledge graph must be intrinsically multi-modal, integrating and deeply linking text, figures, tables, code, and datasets into a unified semantic fabric. This requires moving beyond current multi-modal models, which can often only associate modalities at a coarse level, to systems that can perform fine-grained, cross-modal reasoning to establish the true evidentiary basis for scientific claims (Peng et al. 2023), (Zhu et al. 2022).

3.1.3. The Illusion of Certainty: The Urgent Need for Probabilistic and Contextual Knowledge Representation

Perhaps most critically, current knowledge graphs project a dangerous illusion of certainty. In these structures, an edge either exists or it does not; a relationship is either present or absent. This binary representation stands in stark contrast to the reality of scientific knowledge, which is inherently probabilistic, contextual, and fraught with uncertainty. A causal claim derived from a small, observational study on a specific cell line carries significantly less epistemic weight than one established through a large, multi-centre, double-blind, randomized controlled trial. The hedged language used by scientists—"suggests a link," "is consistent with," "may play a role"—is not a weakness of writing but a deliberate and precise quantification of uncertainty.

Current graphs fail to capture this crucial nuance. They conflate correlation with causation, and a tentative hypothesis with an established law, representing both with the same unqualified edge. This leads to downstream reasoning that is built on a brittle, black-and-white view of science,

producing overconfident and potentially flawed conclusions. An AI agent might propose a novel experiment based on a causal link that is, in reality, highly speculative and context-dependent. To bridge this gap, we must move decisively from deterministic graphs to probabilistic and contextual knowledge graphs. Every edge should be associated with a confidence score derived from source credibility, study design, and community consensus. Furthermore, edges must be annotated with the conditions of their applicability (e.g., "valid in murine models under hypoxic conditions," "observed for polymers with a specific molecular weight distribution"). Without this explicit representation of uncertainty and context, any AI system built upon such a foundation will be a blunt instrument, incapable of the subtle, cautious reasoning that is the hallmark of genuine scientific expertise (Liu, Wang, Zhang & Li 2024), (Choudhary, Reddy & Hooi 2021).

3.2. The Reasoning Gap: The Reliability and Interpretability Crisis in AI-Driven Inference

Even with a perfect, dynamic, multi-modal knowledge graph, the AI models tasked with reasoning over it present the second major chasm: a profound crisis of both veracity and interpretability that fundamentally undermines the trustworthiness of the entire discovery pipeline. This gap represents the tension between the raw, impressive power of modern AI architectures and the stringent, uncompromising requirements of scientific reliability. It is a chasm that, if left unbridged, threatens to relegate these powerful tools to the status of intriguing but ultimately unusable black boxes, incapable of earning the trust of a community built on scepticism, evidence, and transparent reasoning.

3.2.1. The Hallucination-Veracity Dilemma: From Sophisticated Patterns to Scientific Fact

At the heart of the reasoning gap lies the inherent limitation of Large Language Models, the engines of semantic extraction. LLMs are not oracles of objective truth; they are sophisticated stochastic pattern-matchers, trained on vast corpora to predict the next most probable word in a sequence. This architecture, optimized for linguistic fluency and coherence, makes them inherently prone to "hallucinations"—the confident generation of plausible-sounding but factually incorrect, unsubstantiated, or contextually inappropriate information. In the context of automated causal discovery, this is not a minor flaw to be mitigated; it is a fundamental vulnerability. A hallucinated link between a gene and a disease, or a fabricated causal mechanism for a chemical reaction, is not a simple error. It is a potentially dangerous misdirection that could lead research teams down futile and costly experimental paths, misdirecting vast human capital and resources and eroding the very foundation of evidence-based reasoning.

The core challenge is therefore one of veracity. How can we build systems that can rigorously distinguish a genuine, subtle causal claim, buried deep within a paper's nuanced discussion, from a sophisticated, context-free fabrication by the model? This requires a paradigm shift from simple pattern matching to a deeper, verifiable understanding of scientific context, methodology, and the hierarchy of evidence. The system must learn not just what is said, but who said it, how they know it, and how the broader scientific community has received that claim. It requires the development of a meta-cognitive layer within the AI, one that can reason about the epistemic trustworthiness of its own inputs, weighing a claim from a seminal Nature paper against a speculative comment in a preprint, and understanding the profound difference between correlation and causation (Li, Zhang & Li 2025), (Liu, Wang & Li 2025).

3.2.2. The Opaque Policy-Interpretability Paradox: The Black Box of Discovery

This opacity is compounded and amplified by the integration with Reinforcement Learning. An RL agent navigating a vast, complex graph might develop a highly effective but completely inscrutable policy for discovering novel hypotheses. It may learn to prioritize certain nodes or citation paths that lead to high-reward outcomes, but the human scientist is left with a black-box recommendation, an unjustified edict delivered without explanation. For a researcher to trust, and more importantly, to learn from an AI-generated counterfactual—such as a prediction of the outcome of an unperformed experiment—they must understand the chain of reasoning. They need to inspect the provenance of the conclusion: which papers were consulted, what causal assumptions were made, how the LLM interpreted the textual evidence, and why the RL agent chose this particular path of inquiry over countless others.

The current state of integration often produces a final answer without a provenance trail, creating a critical interpretability gap. This is not merely a user-interface issue; it is a fundamental barrier to scientific collaboration. True scientific progress relies on a shared language of reasoning, where arguments can be dissected, challenged, and built upon. Without the development of Explainable AI (XAI) techniques specifically tailored for this multi-modal, graph-based context, these powerful tools will remain impressive but untrustworthy oracles, rather than the collaborative partners in the scientific process that they must become. This necessitates not just explaining the final output, but illuminating the agent's exploratory policy itself—providing counterfactual explanations for its choices and making its decision-making process transparent and auditable by human experts (Milani, Hamed & Veloso 2024), (Yu et al. 2023).

3.2.3. The Context-Dependency Challenge: The Universal Fallacy

A third, and more subtle, aspect of the reasoning gap is the challenge of context-dependency. Causality in science is rarely universal; it is profoundly contingent. The efficacy of a drug is contingent on the patient's genetics and disease state; the properties of a material are contingent on its synthesis conditions and post-processing; the outcome of a physical experiment is contingent on the environmental parameters and measurement apparatus. Current models, especially LLMs which are trained on vast, decontextualized corpora, often fall prey to the Universal Fallacy—the tendency to extract a general causal claim and strip it of its essential contextual qualifiers.

An LLM might correctly extract the claim "Protein X activates Pathway Y" but fail to link it to the specific experimental conditions under which it holds (e.g., "in the presence of ligand Z, in HeLa cells, under serum-starved conditions"). This leads to oversimplified and often incorrect causal models that are not actionable in a real-world laboratory setting. A robust reasoning system must be profoundly context-aware, not merely in a passive tagging sense, but as an active component of its reasoning process. It must be able to associate causal relationships with the precise experimental, temporal, and domain-specific contexts in which they are valid, to query for this context when making a recommendation, and to communicate this context alongside the claim itself. Without this capability, the system will generate hypotheses that are, while perhaps novel, fundamentally flawed in their assumptions, leading to experimental failures and reinforcing the perception that AI tools do not understand the real world of scientific practice (Buehler 2024), (Felin et al. 2024).

3.3. The Evaluation and Incentivization Gap: The Epistemological and Methodological Void in Measuring Discovery

The final, and perhaps most profound, chasm concerns the very metrics of success and the incentives that guide the discovery process. This is not a technical gap but an epistemological and methodological one. How do we evaluate a system whose primary purpose is to generate knowledge that, by definition, does not yet exist? How do we incentivize an agent to pursue truth when the very concept of a "ground truth" for its most important outputs is a philosophical contradiction? Without a robust solution to this problem, the entire enterprise risks becoming an exercise in sophisticated guesswork, lacking the objective criteria necessary for scientific validation and cumulative progress.

3.3.1. The Ground-Truth Vacuum: Evaluating the Unseen and the Unknown

The traditional machine learning paradigm, with its reliance on held-out test sets and objective ground-truth labels, finds itself on philosophically shaky ground when applied to the task of scientific discovery. In the world of counterfactual analysis and hypothesis generation, the very concept of a ground truth for the most valuable outputs is, by definition, absent. A counterfactual outcome for an unperformed experiment has no empirical reality to be measured against. A truly novel hypothesis is, at the moment of its generation, unvalidated. This creates a profound evaluation vacuum, an epistemological rupture that severs the link between model output and objective verification.

The consequences of this vacuum are severe. Without standardized benchmarks and universally accepted metrics, the field risks devolving into a fragmented landscape of impressive yet irreproducible anecdotes, where claims of progress are based on a handful of compelling case studies rather than systematic, evidence-based validation. This leads to a state of near-evaluative nihilism: how can we meaningfully compare two different discovery systems? Is one superior because it proposes a greater quantity of novel hypotheses, or because its proposals, while fewer, are more plausible or grounded in existing theory? We lack a common yardstick, a shared evaluative lingua franca, making it impossible to distinguish genuine methodological advancement from mere serendipity or a more eloquent user interface. This absence of a rigorous evaluation framework is the single greatest impediment to the field's maturation into a cumulative science. Moreover, the reproducibility crisis in AI for scientific discovery further exacerbates this issue, as many AI models are not transparent. Furthermore, the development of standardized benchmarks for causal discovery, such as the Open Causal Discovery Benchmark (OCDB) (OCDB 2024) and Causal Assembly (Göbler, Schölkopf & Janzing 2024), provides a foundation for evaluating algorithms on real-world datasets, but these are still insufficient for capturing the complexity of scientific literature.

3.3.2. The Ambiguity of Scientific "Reward": The Challenge of Incentivizing True Innovation

This evaluation problem is intrinsically and unavoidably linked to the challenge of reward function specification in Reinforcement Learning. An RL agent requires a well-defined signal to guide its exploration, but defining that signal for the open-ended task of scientific discovery is exceptionally difficult, if not impossible, with current frameworks. A naive reward function based solely on

proxies like future citation count would be disastrous, creating a feedback loop that perpetuates existing scientific paradigms and stifles true, paradigm-shifting innovation. It would incentivize the agent to propose safe, incremental work in fashionable fields, reinforcing the "rich-get-richer" dynamics of science.

Conversely, a reward based purely on novelty, perhaps measured by semantic distance from existing literature, is equally flawed. Such an agent might be rewarded for proposing connections that are novel but epistemically vacuous—scientifically nonsensical links that are formally different but substantively meaningless. The ideal reward must strike a delicate and elusive balance, balancing novelty with plausibility, and predictive utility with empirical grounding, often in a manner that is highly domain-specific. This reward ambiguity leaves researchers to design heuristics that may inadvertently inject their own biases into the agent's exploration policy. It becomes exceedingly difficult to assess whether an agent is being truly innovative or is simply learning to exploit patterns in the graph structure or the latent biases within its LLM's training data, gaming the system for reward rather than genuinely seeking truth (Reward Function Design 2024), (Hong 2025).

3.3.3. The Lack of Standardized Benchmarks: The Absence of a Shared Scientific Gym

To escape this cycle of ambiguity and anecdote, the field urgently needs the creation of standardized benchmarks, shared tasks, and simulated "scientific gyms." These are not mere niceties; they are foundational infrastructure for systematic progress. We need large-scale, expert-annotated benchmark datasets where causal relationships are explicitly tagged with their context, confidence, and provenance, providing a gold standard for evaluating the extraction and reasoning components of these systems.

More importantly, we require the development of simulated scientific environments—digital twins of complex scientific domains—where the ground truth for counterfactuals is known and can be queried. Imagine a simulated materials science laboratory where an agent can propose a novel synthesis procedure, and the environment, governed by known physics and chemistry, returns the material's resulting properties. Such a "gym" would provide a controlled, reproducible, and scalable environment for training and evaluating RL agents, allowing researchers to measure their performance on objective, quantitative metrics. Without these shared resources, the field will remain a cottage industry of one-off demonstrations, making it impossible to conduct controlled experiments, compare different approaches fairly, or measure the incremental progress of the discipline as a whole. The creation of such benchmarks is the critical first step toward transforming AI-driven scientific discovery from an art into a rigorous, cumulative engineering discipline.

4. Charting a Path Forward: A Research Agenda for Bridging the Chasms

The identification of these profound chasms is not an exercise in pessimism but a necessary and clarifying step toward building a more robust and transformative future for AI-driven science. Bridging these gaps requires a concerted, interdisciplinary effort that transcends incremental improvements and calls for a fundamental reimagining of our approaches, models, and metrics. We propose the following research agenda as a roadmap for the community, a set of ambitious but

achievable directions that, if pursued with vigor, can guide this field from a collection of promising prototypes to a cornerstone of modern scientific methodology.

4.1. Towards Living Knowledge Graphs: Dynamic, Multi-Modal, and Probabilistic

To surmount the Representation Gap, we must move beyond the paradigm of static, brittle knowledge graphs and forge a new generation of Living Knowledge Graphs. This is not merely an engineering challenge but a conceptual one, requiring us to treat the knowledge graph not as a database to be queried, but as a dynamic, evolving cognitive artifact that mirrors the scientific process itself. This involves a multi-pronged research thrust. First, we must develop new graph-theoretic models and annotation schemas where edges are not simple binary connections but are endowed with a rich, multi-dimensional metadata: quantified confidence scores derived from source credibility and consensus, explicit temporal validity curves that model how a claim's acceptance changes over time, and granular contextual dependencies that define the precise conditions under which a relationship holds. Second, these graphs must become truly multi-modal, moving beyond simple links between text and figures to achieve a deep semantic alignment. This necessitates advances in multi-modal foundation models capable of cross-modal reasoning—understanding not just that a figure exists, but how the data in a table proves the claim in a caption, or how a simulation's output visualizes a theory described in the text. Finally, this requires the creation of continuous, automated learning pipelines that can ingest the daily firehose of new publications, resolve entity and concept disambiguation, and revise the graph's structure and edge weights in real-time, ensuring that the causal model remains a living, breathing reflection of the current scientific consensus and its inherent uncertainties.

4.2. Forging Faithful and Interpretable Reasoners: Hybrid and Context-Aware Models

Addressing the Reasoning Gap demands a decisive move away from monolithic, opaque models towards a new generation of Hybrid, Faithful, and Interpretable Reasoners. The core of this agenda is the principled integration of neural and symbolic approaches, creating a neuro-symbolic synthesis that leverages the strengths of both. We envision a framework where Large Language Models act as powerful "hypothesis generators" or "intuition engines," proposing potential causal links and counterfactual scenarios from their vast pattern-matching capabilities. These proposals, however, are not taken at face value. Instead, they are immediately formalized and subjected to rigorous testing within a symbolic Structural Causal Model (SCM), which serves as a "logic engine" that checks for consistency, identifies confounders, and ensures adherence to causal axioms. This neuro-symbolic loop creates a natural and powerful guardrail against hallucination, forcing the LLM's intuitions to pass a formal test of veracity. Furthermore, the integration of Explainable AI (XAI) is not an optional feature but a non-negotiable requirement. Future systems must be designed from the ground up to generate not just an answer, but a complete, provenance-rich argument. This includes visualizing the inferential path through the graph, citing the specific textual snippets that support each step, and making the agent's policy transparent to human scrutiny. This must be coupled with Active Learning and Collaborative Refinement frameworks, where human expert feedback is not just used for error correction but is integrated into a continual learning process, creating a symbiotic partnership that refines the model's understanding and guides its future explorations. Finally, these reasoners must be explicitly designed for Contextual Grounding of Causality, moving beyond universal claims to learn and represent conditional causal

rules that are intrinsically linked to the experimental, temporal, and domain-specific contexts in which they are valid.

4.3. Constructing a Rigorous Evaluation Ecosystem: Benchmarks and Rewards

Finally, conquering the Evaluation Gap is the sine qua non for the field's maturation into a cumulative science. This requires a community-wide effort to construct a Rigorous Evaluation and Incentivization Ecosystem that provides the objective standards currently lacking. The most immediate priority is the development of standardized benchmarks. This includes the creation of large-scale, expert-annotated "gold-standard causal corpora" where relationships are tagged not just for existence but with rich epistemic metadata (confidence, context, provenance). More importantly, we must invest in the creation of Scientific "Gym" Environments—high-fidelity simulated scientific domains (e.g., a digital twin of a gene regulatory network, a physics-based materials synthesis simulator) where the ground truth for counterfactuals is known and can be queried on demand. These environments would provide a controlled, reproducible, and scalable platform for training and, crucially, for fairly comparing different discovery agents. In parallel, we must advance the science of reward function design for discovery. This involves exploring sophisticated, multi-objective functions that explicitly balance competing goals such as novelty, plausibility, and potential impact. It also requires research into intrinsic motivation techniques, where an agent is rewarded for reducing its own uncertainty about the knowledge graph, encouraging efficient exploration of truly unknown territory. Ultimately, we must envision a Closed-Loop System for Real-World Validation, where the long-term success or failure of experiments inspired by the AI's suggestions can be fed back as a delayed, high-value reward signal, creating the ultimate, albeit challenging, feedback loop that grounds the entire process in empirical reality.

5. Conclusion: The Future of Human-AI Symbiosis in Science

The confluence of Large Language Models, Reinforcement Learning, and Scholarly Graphs presents a transformative prospect for the future of scientific inquiry—a new epoch where the pursuit of causal knowledge is profoundly augmented by autonomous systems for reasoning and discovery. This vision promises to amplify human intellect, enabling us to navigate the ever-expanding universe of scientific knowledge with a speed and depth previously unimaginable. Yet, the translation of this compelling vision into a practical, trusted instrument of science is a journey across a formidable intellectual terrain, rife with conceptual and technical challenges.

This paper has systematically delineated a tripartite chasm that must be bridged to realize this future: the epistemological inadequacy of our current knowledge representations, the veracity and interpretability crisis in our AI reasoning engines, and the profound methodological void in how we evaluate and incentivize discovery. These are not insurmountable obstacles but rather the seminal research questions that will define the next generation of scholarship at the intersection of artificial intelligence and scientific methodology. They represent the frontier where true progress will be made.

By rigorously and dispassionately confronting these foundational gaps, and by channelling our collective efforts toward the research agenda outlined herein, we can begin to construct the

necessary bridges. In doing so, we will achieve something far greater than merely incrementally more powerful AI. We will inaugurate a new paradigm of human-AI symbiosis, where machine intelligence navigates the vastness of human knowledge to surface hidden causal pathways and generate novel counterfactuals, and human wisdom provides the critical context, validation, and ethical guidance. This partnership will transform scientific discovery from a process limited by human cognitive capacity into a more efficient, transparent, and profoundly impactful endeavour, accelerating our understanding of the natural and constructed world for generations to come. However, it is crucial that we address these gaps to ensure that the AI systems we build are reliable, reproducible, and do not contribute to the reproducibility crisis in science

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Mediterranean products in the Hungarian short food supply chains

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Abstract: The study investigating the possibilities of incorporating native Mediterranean plants and their fruits into production and sales explores which part of the short supply chain (SFSC) these relatively new plant species can be integrated into. Mediterranean plants (lemons, oranges, kumquats, pistachios, pomegranates, olive trees, and figs) can now be successfully cultivated much further north of their original growing areas due to climate change in recent decades. All V4 countries successfully cultivate these plants. There is a wealth of information available to consumers about fruits and vegetables, which has led to consumers becoming increasingly informed and conscious about their purchases. Environmental awareness, functionality, and sustainability are becoming increasingly important values for them, and these aspects are influencing demand. Most of the fruits of Mediterranean plants grown in Hungary and the products made from them are eligible for the "Hungarian Product" or "Domestic Product" designation. Processed and unprocessed plant products grown in Hungary support the local economy, reduce the distance between the producer and the place of sale in terms of transportation, allowing both producers and traders to sell more efficiently and quickly. Consequently, domestic production of these plants significantly reduces the ecological footprint compared to imports. Consumer needs are constantly changing, which forces businesses to continuously seek new avenues and solutions. During local sales, a mutual trust relationship develops between the producer and the consumer. The potential inherent in the production of Mediterranean plants is currently largely untapped. By capitalising on the potential within this segment of the industry, the increased production volume of crops that are currently not widely cultivated could lead to their inclusion in public catering in the future.

Keywords: Short Supply Chain, agritourism, sustainability, Mediterranean plants
Jel Codes: R11, Q13, Q18, Q56

Introduction

Global warming is one of the most impactful components of climate change. One of its most characteristic trends is that summers are becoming increasingly dry, precipitation distribution is extremely uneven, and winters are milder. The agricultural sector is increasingly challenged by the cultivation of traditional crops. In addition to continuous plant breeding activities, they are experimenting with introducing new plant species, including Mediterranean species that are suitable for the changing climate, into cultivation in Hungary. With plantations of new types of crops, it is not necessary to wait for the plants to bear fruit; they can be utilised from the moment of planting, provided we also develop them into tourist destinations from the outset. The tourism experience is also an important factor in creating a domestic consumer market, which, in addition to market creation, has significant marketing value.

In terms of Mediterranean plant cultivation, educating visitors also plays an important role, with a strong emphasis on the interconnected critical importance of economic, environmental, and social factors in achieving long-term stability. A key factor in the production of Mediterranean products will be the creation of a product that can meet the needs of future generations in order to achieve environmental sustainability (Singh, 2024).

Our current world is changing extremely rapidly, and in this changing world, it is of paramount importance that we closely monitor the increasingly close interconnectedness of various economic actors. In the production environment, the demand for local values is increasing, as is the importance of locally produced goods from local communities. That's why more and more people are choosing short supply chains, where the product reaches the customer faster, cheaper, and with less pollution from the producer or manufacturer. We can attribute this trend to consumers becoming much more conscious and prioritising quality over price in their purchasing decisions (Csíkné Mácsai and Lehota, 2013).

The impact of green marketing is also not negligible, as a result of which the number of consumers who prioritise environmentally conscious purchasing is increasing, meaning that the market trend is directing and shaping consumer behaviour towards more sustainable products (Naz, 2020; Pacsi et al., 2025).

The perception of domestic Mediterranean produce compared to imported goods is primarily more favourable due to the advantages arising from differences in product quality and plant protection practices, which consumers value in terms of food safety and health awareness. A survey conducted by Euromonitor in 2023 also shows that the eco-economic approach is gaining strength. Is it worth and sustainable to produce Mediterranean products in Hungary? What are the experiences of producers? How consumers react? These are the main questions to be examined by this study, which is the first stage of a comprehensive research project on the opportunities and threats of growing Mediterranean and exotic plants in Hungary.

Literature Review

Key characteristics of short food supply chains

A short food supply chain prioritises a direct, more personal relationship. Unlike the practices seen so far, a close relationship develops between the producer and the consumer, transcending anonymous wholesale food distribution. Instead of anonymity, being well-informed takes centre stage. The short food supply chain differs greatly from traditional long chains, where the relationship between the product and the producer becomes impersonal and obscure. SFSC is more personal; the producer will have a "face," and the product will carry the producer's personal presence, development path, and story, which inspires trust towards buyers (Marsden, Banks, & Bristow, 2000).

Over the last decades, numerous academic studies have examined the role of short food supply chains in the agricultural sector, focusing on their effects on the growth of small agricultural businesses and rural communities. Short or alternative food supply chains illustrate how new connections can be formed between agricultural production and society, as well as between producers and consumers, by allowing consumers to become closer to the source of their food and, in some cases, to participate more directly in the production process (Renting et al., 2003). According to Marsden et al. (2000), a short food supply chain is defined not by the number of intermediaries involved or the physical distance food travels, but by the fact that the product reaches consumers accompanied by meaningful information about its origin and production.

According to Renting et al. (2003) 3 primary types of short food supply chains exist:

1. face-to-face, involves direct physical interaction, where consumers purchase products straight from producers or processors through channels such as farm shops, farmers' markets, roadside sales, pick-your-own schemes, home delivery services, and e-commerce.
2. spatial proximity, refers to products that are produced and sold within the same region, with consumers valuing their local origin. This category includes specialist retailers such as bakeries, butchers, and grocers offering local goods, as well as hospitality businesses and initiatives like farm shop networks, community-supported agriculture (CSA), special events, thematic routes, and institutional catering.
3. spatially extended category, which applies when consumers are located outside the production region, but detailed information about the origin and production processes is conveyed to them, as seen with fair trade products or protected designations of origin.

Due to their complexity, short food supply chains can be grouped based on the principles of geographical proximity and structural simplicity, as the guiding principles include the physical distance and territorial connection of sales, as well as the low number of intermediaries involved in the chain (Kiss and Ruszkai, 2020). The main elements of SFSC is summarised in Figure 1.

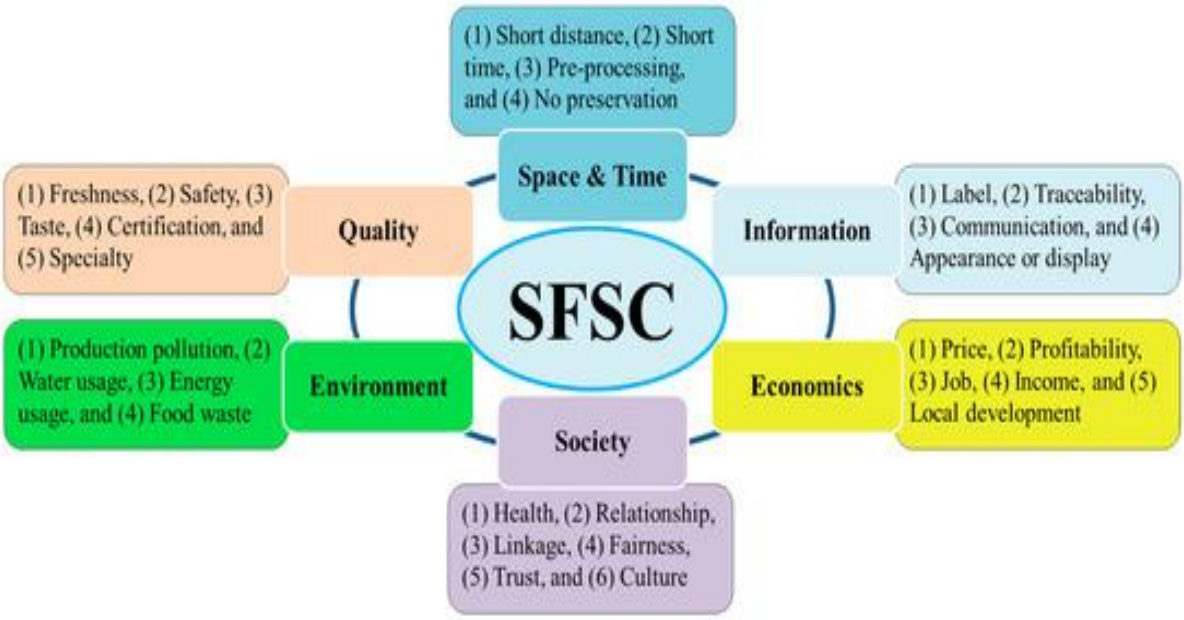

Figure 1. The framework of SFSCs
Source: Hoang (2021) https://www.mdpi.com/agronomy/agronomy-11-02408/article_deploy/html/images/agronomy-11-02408-g002.png

We can also examine how the form and nature of participation of the participants, as well as the various marketing channels and the physical form of the products, all determine the nature of the relationship between the producer and the consumer based on sales methods (Kujáni, 2014).

The definition of a short food supply chain was established by the EU's rural development policy for the 2014–2020 programming period. The regulation is based on European Parliament and Council Regulation (EU) No 1305/2013 (eur-lex.europa.eu, n.d.), which laid down the rules for

support from the European Agricultural Fund for Rural Development (EAFRD) along the following main elements:

- Collaboration (supply chain): A network involving producers, processors, and consumers.
- Limited number of actors: The number of intermediaries participating in the chain should be zero or minimal.
- Commitment: Participants are committed to supporting local economic development and maintaining social connections. The essence of SFSC is to restore the direct connection between farmers and consumers. The customer is committed because they know the origin of the product, and possibly the producer.
- Geographically, the product's journey from the producer to the consumer is short.

Short food supply chains (SFSCs) are characterized by a limited number of intermediaries between producers and consumers and are mainly classified according to the type of interaction involved. These include face-to-face exchanges (such as direct sales and farmers' markets), proximate systems (local retail outlets and box schemes), and extended chains (where added-value information connects distant consumers through virtual platforms or regional products). All SFSCs emphasize local relationships, trust, and shorter physical distances, distinguishing them from long supply chains that involve numerous intermediaries. Main Types of Short Food Supply Chains (SFSCs)

1. Direct-to-Consumer (Face-to-Face): This type offers the highest level of transparency through direct contact between producers and consumers.
   - On-Farm Sales: Includes farm shops and pick-your-own activities.
   - Farmers' Markets and Fairs: Regularly organized local markets.
   - Internet Sales: Direct online purchasing with home delivery options.

2. Intermediated (Proximate/Local): These systems involve one or a small number of local intermediaries.
   - Box Schemes and CSAs: Subscription-based models providing seasonal produce.
   - Local Retailers and Restaurants: Sales to small shops or HoReCa (Hotels, Restaurants, Catering).
   - Collective Sales: Producer cooperatives or solidarity purchasing groups.

3. Spatially Extended / Value-Added: This type links consumers outside the production area with the product's local origin and story.
   - Virtual Platforms: Online marketplaces offering regional or specialty products.
   - Geographical Indications: Products associated with a specific location, such as Parmesan cheese or Champagne.

The essential characteristics of SFSCs are: fewer intermediaries, that means a shorter path from producer to consumer; spatial proximity, that means reduced physical distance between production and consumption; trust and transparency, which is established through direct relationships or clearly communicated information, and finally, value-oriented which represents an emphasis on local identity, sustainability, and fair pricing.

The essence of SFSC is to reduce the distance between local producers and local consumers and to prioritise local markets. The grouping of SFCSs is summarised in Table 1, presenting the characteristic of traditional and modern channel forms.

Table 1. Categories of SFSC

Traditional SFSCs	**Modern SFSCs**
Contry hospitality	Box system
Pick yourself	Basket communities
Traditional markets	Farmers' market
Fair	Food ATMs
	Online home deivery
	Catering delivery

Source: own categorisation based on Dunay et al. (2018)

The literature distinguishes between traditional and modern SFSCs. Traditional farming and direct sales are supplemented with innovative methods in the case of modern or new types. In the traditional case, sales are built on immediate trust and personal interaction. In the case of the new ones, modern logistics and technological solutions are used to maintain the advantages of the short chain while also expanding the consumer base (Hampel et al., 2022).

It is important because it builds a relationship of trust between the producer and the consumer, allowing the producer to sell more quickly and in a more organised manner. And the customer gets the product directly, or at most through one intermediary. When the sale takes place, the profit generated from the transaction also stays local, which the farmer can use for development, and the consumer gains access to 100% local, quality food (Nemes et al., 2019).

Mediterranean plants grown in Hungary

In our study, we focused on the fruits of Mediterranean plants in Hungary and the products made from them. Therefore, we will also review the main characteristics of the most important plants involved below. Of course, in the next steps of our research, we wish to examine other mediterranean products such as persimmon or kiwifruit.

Lemon

Locally grown Mediterranean fruits have many beneficial effects. According to folk medicine, lemon is also an excellent ingredient, which is well-known to people. It is also used in the cosmetics industry, perfume manufacturing, food industry, and pharmaceutical industry. Lemons are a versatile natural source that contributes to maintaining health, strengthening the immune system, alleviating numerous minor health issues, and for beauty care thanks to their composition rich in vitamin C and flavonoids.

Vitamin C and flavonoids work together to strengthen the immune system. In addition to their antioxidant properties, these compounds contribute to improving blood circulation and maintaining the elasticity of capillaries, which could potentially play a role in preventing

cardiovascular diseases. Lemon also has antibacterial and anti-inflammatory effects. Due to its diuretic and detoxifying properties, it helps cleanse the body. Due to its vitamin C content, it soothes sore throats and reduces cough symptoms in cases of respiratory illnesses. Lemon juice stimulates the secretion of stomach acid and bile, aiding digestion.

The acids in the fruit can be converted in the body to help neutralise the acids that cause heartburn. The hesperidin flavonoid found in its peel, along with vitamin C, supports the elasticity of vein tissue and stimulates blood circulation, which has beneficial effects on haemorrhoids, varicose veins, and vasodilation. It is suitable for mineral supplementation and detoxification treatments in case of fatigue (Pichard, 2014).

Pomegranate
Pomegranate (Punica granatum), or the food of the gods, is an excellent immune-boosting fruit that has been cultivated for millennia. This crop is a true superfood with many beneficial effects. It contains numerous bioactive compounds that have significant positive physiological effects. Scientific findings support the fruit's cardiovascular disease-preventing effect. Pomegranate juice, which is currently becoming increasingly popular, is rich in antioxidants and lowers blood pressure (Stowe, 2011).

Olive tree
The beneficial effects of the olive tree are attributed to the polyphenols it contains, primarily oleuropein. Olive leaf extract significantly lowers blood pressure. For example, a 2011 study compared the extract to a medication and found similar blood pressure-lowering effects (Susalit et al., 2011).

Its fruit is extremely rich in monounsaturated fatty acids, which also contribute to lowering cholesterol levels, thereby reducing the risk of cardiovascular diseases (Estruch et al. 2018). A Spanish study provides an extremely detailed explanation of how to offer a unique agritourism experience to visitors (Parrilla et al. 2020). Currently in Hungary, there are two olive tree growers and olive oil producers in the Balaton Uplands and in Pécs. In terms of domestic varieties, the Pécs nursery is of the highest quality, and it is also involved in breeding olive tree varieties that are adapted to the domestic climate.

Pistachio
Pistachios contain a significant amount of dietary fibre and protein. Its consumption can positively influence the body's glucose levels, supporting blood sugar regulation. Its consumption reduces total cholesterol and blood pressure (Aldemir et al. 2020).
In Hungary, a dedicated professional is cultivating 400 Mediterranean plant species and 800 plants on 3 hectares of land in Köveskál. Several ecological plant protection research projects are currently underway on the estate, adapting to the demands posed by climate change. A prominent crop in culture is pistachios, which were first successfully cultivated in Hungary.

Materials and Methods

The aim of the research was to examine the relationship between domestic Mediterranean plants and the short food supply chain (SFSC) within a qualitative framework. In addition to a literature

review, we will use primary and secondary data collection methods to support the findings of the research.

The research methodology is qualitative, aiming to identify good practices and outline future research and development directions. The study focused on the fruits of Mediterranean plants grown in Hungary and the products made from them.

The first step of the research was to lay the theoretical foundations of the topic. A review of the literature related to short food supply chains, agritourism, sustainability, and domestic Mediterranean plant cultivation provided the basis for the research. Following this, the websites of domestic companies were examined.

A key element of the research was conducting expert interviews. These interviews were conducted with experts in the cultivation of Mediterranean plants. Their goal was to learn about good practices and identify potential areas for development. Examples of the businesses involved:

- Gizella Losonczi (Kivi Farm, Jobaháza), which is situated in Western part of Hungary (Győr-Moson-Sopron county),
- Zoltán Lakos (Mini Kivi, Dabas), which is situated in the Central Region not far from the capita, Budapest,
- and Zoltán Bakó (Citrus and Palm, Kunsziget), which is situated also in Western Hungary Győr-Moson-Sopron county).

This study is primarily based on previous professional experience and expert interviews; document and content analysis, as well as a deeper literature review, will be part of the next phase of the research.

Results

The fruits of lemons, oranges, kumquats, pistachios, pomegranates, olive trees, and figs have all been proven to have beneficial effects on the human body. Mediterranean products grown in Hungary and processed products made from them are considered 100% domestic products.
Businesses involved in plant cultivation can be found with pictures and videos on social media. An online presence and regular content creation are fundamental elements for the operational pillar aimed at tourism.

All three experts surveyed hold garden visit programs where visitors can learn about cultivation and the plants themselves. This allows them to build a relationship of trust with customers, which forms the basis for a future customer base for their products. These businesses were able to become tourist destinations beyond their production activities, which holds significant marketing value in terms of creating a domestic consumer market.

Everyone is a member of short food supply chain sales, which is why the products they offer are more environmentally friendly than those available in the traditional production model. Their customers prioritise being informed, and producers fully meet this need. All three farmers are committed to bit harvesting, which is partially or fully realised. At each business, educating visitors also plays a prominent role.

Producers from Dabas and Jobaháza have also joined the Open Door event series. In addition to 4 hectares of kiwis in Dabas, there are also Indian bananas, western strawberry trees, figs, persimmons, and Chinese dates on another 4 hectares. The area is under "eco" certification. They are not joining the "pick-your-own" movement because kiwifruit needs to ripen after picking, which cannot be controlled to the extent necessary for excellent quality fruit when harvested by hand. The majority of consumers are unfamiliar with the mini kiwi they grow; they view it as an exotic fruit. Most sales take place locally, directly from the producer, allowing the supply chain to remain as short as possible. In this case as well, it is clear that direct sales and distribution are extremely effective in the markets.

However, above a certain emission level, local sales directly from the producer become impossible, and in such cases, gaining access to the wholesale market is crucial because it provides recognition. Here, distributors, retailers, and restaurants can see the product. For a new, as-yet-unknown product, market introduction is a key marketing task. The interviewee said they took the product from their store to the local kindergarten, and since it was unknown to the staff, they threw it away. This case highlighted the paramount importance of early education, especially for products that have not yet taken root in the Hungarian public consciousness.

Joint marketing campaigns related to short food supply chains increase awareness and reduce marketing costs. Each business offers the option to pre-order on their website. The products of the two subjects from Győr-Moson-Sopron County are known to conscious consumers, and several hundred kilogrammes of untreated lemons or kiwis are sold, but according to their statements, there would be a demand many times greater.

Kunszigeti Nursery's young gardeners are leading pioneers in the cultivation and sale of Mediterranean plants. The business slogan is: Gardening with a pinch of magic. Lemons are grown in the soil under plastic sheeting over an area of over a thousand square meters. Last season, over a tonne of untreated lemons were snapped up within a week, perfectly illustrating the demand for high-quality horticultural products from conscious consumers, which far exceeded the supply. The lemons produced are sold both locally and online. The elderly owner of the Jobaházi farm used to take the kiwis to markets, and then joined the "Open Gate" initiative because it is physically easier for the customer to pick the product, and also because they don't have to store and sort the kiwis for immediate takeaway. The initiative was a great success. The company has been certified as "organic" since '1999, but has been growing organic kiwis for 18 years.

The Agrarian Chamber and the Small-Scale Association are assisting small-scale food producers, agrotourism providers, and market organisers. A SFSC EXPO is a meeting point where producers can connect and showcase their products. Here, innovative manufacturers and companies producing and providing sales tools and services, SFSC producer communities, and professional organisations can get to know each other.

Conclusion

Domestic Mediterranean plants can be successfully integrated into the short food supply chain. Prioritising local products over imports significantly reduces transportation distances. The direct sales model not only ensures higher product quality but also builds a relationship of trust between

the producer and the health-conscious consumer. The conscious consumer looks beyond the hedonic value of products and seeks their functional and nutritional benefits. Agritourism and educational programs support the local economy and help with the market acceptance and spread of new crops. Thus, SFSC offers a viable, modern alternative for domestic agriculture in the face of climate change challenges.

The next steps of our research will represent more interviews with the same structure, to focus on the opportunities and threats of producing such special products, and to explore how these specialities may be linked to agritourism or social activities, which could improve their performance and stability.

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Bridging Regional and Sectoral Gaps in Hungary's Digital Transformation: Challenges and Strategies for Labor Market Evolution

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Abstract: This study discusses the complex implications of automation on employment in Hungary, referring not only to the creation of new but also to the disappearance of traditional workplaces. In this respect, it has a holistic view that synthesizes both qualitative and quantitative perspectives, bringing attention to how technological changes may shift workplaces in Hungary due to automation. The results show significant disparities between Hungarian regions, where Central Hungary is much better prepared in terms of digitalization compared to others. Moreover, with automation growth, the workforce faces skill gaps, particularly in high-risk sectors like manufacturing and retail. This study discussed also the importance of aligning educational and policy efforts in enhancing the digital skills of the workforce in order to adapt to the new technological advancements. Policy suggestions are provided to promote upskilling activities and regional development in order to ensure that the Hungarian labour market undergoes balanced and sustainable transformation.

Keywords: Digital Transformation; Hungarian Labor Market; Regional Disparities; Workforce Skills Development
JEL Codes: O33, J24, J24

1. Introduction

As previously shown (Vadie & Lipták, 2023), the influence of automation on employment is complex (Jones et al., 2022), with its effects on job loss and creation varying based on industry and specific job functions. Automation may lead to the replacement of certain roles, simultaneously it may generate new opportunities in fields like in technology and engineering. These challenges are also represented within the small and medium enterprises in Hungary (Endrődi-Kovács & Stukovszky, 2022) where industry 4.0 (Nick et al., 2019) and the COVID-19 (Tóth et al., 2021) play a key role in the Hungarian economy (Karacsony et al., 2022). Report from the International Trade Administration, U.S. Department of Commerce (International Trade Administration, U.S. Department of Commerce, n.d.) shows that the digital economy represents about 6.7% of the country's total gross value added GVA, adding internal digital innovations would account for at least 10% of the Hungarian GDP. Stating the role of an agent for economic transformation enables one to discuss its implication on employment.

Notwithstanding the worldwide progress in digital transformation, Hungary encounters specific obstacles in capitalizing on these opportunities for equitable economic growth (Obermayer, 2022). The variations in digital preparedness among regions (E. Kiss & Páger, 2024), particularly as figure 1 shows with the number of investments in Central Hungary exceeding the performance of the other areas Transdanubia, Great Plain and the North, underscore the disparities in development throughout the nation.

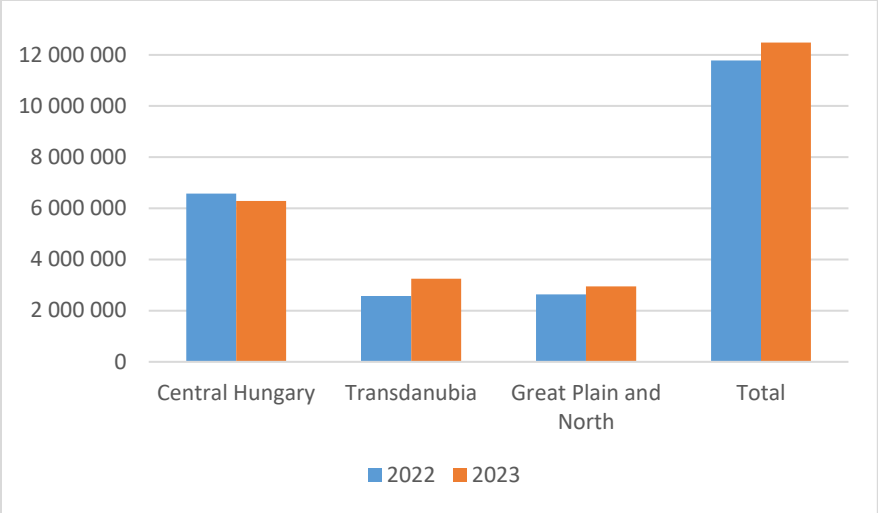

Figure 1. Investments by Hungarian Regions between 2022-2023 [million HUF].
Source: own compilation based on dataset from the Hungarian Central Statistical Office (Hungarian Central Statistical Office, n.d.)

Hungary rank 18 in EU – Digital intensity in businesses, in 2023, with 18% of the Hungarian businesses provide ICT training to their staff, in 2022, knowing that the range is between Finland, who is in the top 1 of the EU countries with 39.8% and Romania with 8.8% (Eurostat, n.d.-b). The Hungarian SME are facing also the challenge of digitalization especially in sales, while just 18% of the small and medium enterprises are selling online, and 7% of them are selling online cross-border, compared for example to Austria account 23%, and 16% respectively. Moreover, studies show (Tumiwa & Nagy, 2021) that population declining and other social, cultural, and political considerations have a negative impact on the Hungarian SMEs, where these SMEs represent the 99.8% of the total number of the enterprises have 68.3% of the total employed persons, contributing with 37.7 Billion euro (54.1% of the value added) in 2018 (Dyczkowska et al., 2021).

The existing literature on digital transformation mostly focuses on high-income EU countries, so there is a lack of attention to mid-tier economies like Hungary. Further, while earlier works (E. Kiss & Páger, 2024) (Gábor et al., n.d.) (Varró, 2019) (European Commission, n.d.) have shown the dynamics of labor market dynamics after automation, how digital transformation interacts precisely with pre-existing regional inequalities and the particular labor market challenges in Hungary is still little understood. Current frameworks also do not provide actionable strategies to remove barriers to the adoption of digital technologies by SMEs and bridge the skill gap.

This would, therefore, attempt to answer how digital transformation shapes the labor market of Hungary, with a special focus on given regional and sectoral disparities in Hungary. It aims at creating a framework linking the hypotheses on digital transformation with those concerning employment trends, identifying the main barriers to SME digitalization, and offering policy recommendations to foster equitable and sustainable growth.

2. Literature Review

For better understand Hungarian position over 40% of jobs currently automatable lead to job displacement and the creation new roles requiring different competences (innovációs és technológiai miniszter, n.d.), even though 58.9% of people in Hungary have a moderate level of basic or above basic digital skills in 2023 compared to the EU average (55.6%) (Eurostat, n.d.-c). For example, in terms of enterprises using cloud computing services, Hungary has the same medium level as EU in 2023 with 45.1% compared to the EU 45.2% (Eurostat, n.d.-a).

2.1. Link between education and technological innovation

How is technology and education related?
While the relationship between education and technological innovation is widely acknowledged, more in-depth research is required to understand the impact of educational reforms and policies on the innovation outcomes where the issue is not about a need to understand the current technological demands but also should predict future (Bambi & Pea-Assounga, 2024). Of particular note is the low comparative share of people with tertiary education, and the high rate of early school leavers among the 18-24-year-olds. The largest gap in the attainment of education required for a competitive workforce is further reduced within the age group 25-64, which makes Hungary face an important challenge with the 25th rank in the EU in terms (Csath, n.d.). Although the link between human capital and innovation has been very much in focus within the literature, there is considerable scope for further research with regard to specific skills and competencies considered most important within different types of innovation scenarios. In view of the fact that in this age of artificial intelligence, only 3.7% of businesses using AI technologies in Hungary ranked 24th between EU member states in 2023, well behind the average in the EU at 8% (Eurostat, 2024), the paper concludes with the final section. However, what really makes the relationship between human capital innovation and education complicated and not clear enough to understand, is the lack of any shared methodology to determine what type of competencies are in the highest demand from our labor market (Ministry of National Economy of Hungary, 2025).

2.2. The Challenge of Defining Digital Competency Expectations

According to the IMD Digital Competitiveness Report (IMD World Competitiveness Online, 2024), Hungary ranked 47th out of 64 countries for its digital readiness in 2023; this score is, incidentally, further tempered by an analysis of the digitally enabled firms where digital practices are shown to have low levels of adoption in Hungarian SMEs, enabled companies, noting a particularly low level of digital adoption among Hungarian SMEs. Moreover, only 49% of the population in Hungary has adequate digital skills, which is below both the EU and Visegrad averages (IMD World Competitiveness Online, 2024).

- *Lack of Consistency:* The very big challenge in planning effective interventions is that there isn't a common methodology in defining expectations of digital competence. Due to the non-homogenized nature of approaches followed by institutions and programs, this lack of clarity in the training processes subsequently creates confusion for participants (Sillat et al., 2021).
- *Barriers to Effective Interventions:* The lack of a standardized competency framework is really very challenging for ensuring the interventions address the most pertinent skills.

Such variability weakens the effectiveness of the training programs, hence participants cannot acquire the skills that the labor market requires (European Commission. Joint Research Centre., 2020).

- *Improved Integration:* There is, therefore, a clear need for multi-sectoral collaboration involving academia, industry, and government. The orchestration of actions to leverage current capacities and encourage innovation can become very complex and will require effective communication and collaboration (World Bank, 2024). Having a harmonized definition of digital competencies would ensure smoother transitions between different training programs (European Commission, 2020), and so motivate continuous skills development. The approach is therefore essential in preparing people to become competent in the digital economy (DQ Institute, 2024).
- *Standardized Frameworks for the Future:* The rapid development of AI technology requires the establishment of special regulatory frameworks for responsible use and the protection of users' rights, including ethical issues and transparency in data usage (innovációs és technológiai miniszter, n.d.). A very clear illustration would be with respect to the inequalities of participation, with precarious workers, such as those on temporary or fixed-term contracts, having fewer avenues to get involved and hence feeling like second-class citizens in such circumstances. This inequality points out that the participation rights still need to be improved, so that everybody involved gets the say in matters. For example, reinforcing the company-level co-determination rights concerning data protection and occupational health will ensure an employee's participation when addressing specific challenges linked with the digital transformation process (Pärli, 2022a). Establishment of a harmonized system of digital competencies would similarly help alleviate today's questions, shaping guiding lines for the days to come. This would ensure the training of digital skills keeps aligning with labor market needs.

Those considerations emphasize how important a shared framework is to define digital competence able to improve the effectiveness of the training programs and interventions.

3. Methodology

To explore the various impacts of digital transformation on the labor market in Hungary, this study employed a mixed-methods approach (Anderson & Fontinha, 2024), combining bibliometric analysis (Zhang & Wang, 2024), statistical data assessment (OECD, 2024), and policy analysis (Magyarország Nemzeti Stratégiai Ütemterve (HU), 2024). The method selected was in line with regional disparities, sectoral challenges, and skills gaps in order to fulfill the main aim of suggesting practical strategies for the transformation of the labor market.

3.1. Bibliometric Analysis

A bibliometric analysis was performed to ascertain research trends and to find the gaps regarding labor market dynamics and the process of digital transformation. The dataset consists of 1,061 articles published from 1993 to 2024, it was retrieved from the Web of Science database through the utilization of keywords including “Labor Market Dynamics,” “Digital Transformation,” and “Policy Interventions” (Dyczkowska et al., 2021) (Eurostat, n.d.-b). VOSviewer software was used in co-occurrence analysis of keywords, clustering them according to frequency and thematic

relevance into four clusters (Arruda et al., 2022), which put in focus the key research domains, including digital competencies, regional inequalities, and SME challenges. This clearly brought out the lack of region-specific digital transformation frameworks for mid-tier economies like Hungary.

3.2. Statistical Data Analysis

Quantitative data was downloaded from the Hungarian Central Statistical Office (HCSO) for the period 2009–2023, focusing on employment trends by regions and sectors (Hungarian Central Statistical Office, 2025). The analysis included:

Sectoral employment trends, July 2023 to July 2024, show clear contractions with high-growth industries like manufacturing and technology, according to HCSO Dataset, Figure 4. Regional disparities in employment rates: Central Hungary has a high density of employment due to the urbanization and industrialization processes. On the other hand, Transdanubia and the Great Plain are characterized by sluggish economic growth (E. Kiss & Páger, 2024). Data were visualized using clustering techniques to categorize regions according to their digital readiness and employment distribution. The data resulting from Eurostat's Digital Intensity Index (Eurostat, n.d.-c) were used to assess Hungary's performance compared to that of the European Union.

3.3. Policy Evaluation

A key part of data analysis in our study is the analysis of policy documents and strategic plans - i.e., "Magyarország Mesterséges Intelligencia Stratégiája 2020–2030" (innovációs és technológiai miniszter, n.d.) - to identify how national initiatives are aligned with the needs of the labor market. The study analyzed the following dimensions:

- Effectiveness of digital skills training programs on the problem of 58.9% Hungarians having basic or above-basic digital competencies compared to the EU average of 55.6% (Eurostat, n.d.-a).
- The analysis of geographical differences in digital readiness and its correlation with employment growth, based on data extracted from the IMD Digital Competitiveness Study 2023 (Eurostat, n.d.-b).
- One of the things to address also is the policy concerning the SME digital adoption gaps, such as the fact that only 18% of Hungarian SMEs are active in online sales, while in Austria this share is 23% (Tumiwa & Nagy, 2021). The analysis highlights how important is to target interventions to close such gaps.

3.4. Practical Application of Findings

The study used the IMD World Competitiveness Framework combined with bibliometric methods to produce meaningful findings. For example:The recommendations for bringing the educational practice in line with technological needs were based on the fact that Hungary had both low tertiary education enrollment rates and high rates of early school leavers (Eurostat, n.d.-c).Proposals for SME upskilling programs considered data on low cloud computing adoption (45.1%) and AI integration (3.7%) among Hungarian businesses (Eurostat, 2024). This approach combines quantitative rigor with qualitative insight, allowing for a deep dive into the transformation of the

labor market in Hungary. The study provides hands-on recommendations for decision-makers and practitioners to reduce regional disparities and enhance digital readiness in Hungary, based on extensive datasets and comparing the results against international benchmarks.

4. Results

These fast changes lead to the necessity of investigating the current publications in this research area. Bibliometric analyses have been an instrumental approach to mapping research trends related to employability, skill development and competitiveness and successful project performance (Abdi Khalife et al. 2021, Al-Hanakta et al. 2021). For instance, an examination of graduate employability research between 1986 and 2020 indicated that there was a considerable rise in publications, reflecting the growing importance of relating educational outcomes to labor-market needs (Csath, n.d.). Likewise, studies on Industry 4.0 had shown the requirement for new competencies while underlining the needs of change in education, with an emphasis on curriculum adaptation to address upcoming shifts in technology (Ministry of National Economy of Hungary, 2025).

4.1. Bibliometric Analysis

The collection of 1061 publications on Web of Science was based on the following keywords:
("Labor Market Dynamics" OR "Labor Market Evolution" OR "Workforce Skill Requirements" OR "Skills Mismatch" OR "Job Demand" OR "Skill Alignment" OR "Skills Gap" OR "Labor Market Trends" OR "Workforce Adaptability" OR "Occupational Shifts" OR "Employment Trends" OR "Skill Development" OR "Labor Supply and Demand" OR "Job Market Shifts" OR "Workforce Transition" OR "Occupational Dynamics" OR "Labor Mobility" OR "Talent Mismatch" OR "Workforce Skills Gap" OR "Future Skills" OR "Reskilling" OR "Upskilling" OR "Skill Transformation" OR "Career Transitions" OR "Changing Job Roles" OR "Economic Restructuring" OR "Workforce Planning" OR "Human Capital Trends" OR "Employment Mismatches" OR "Evolving Labor Needs")

AND ("Automation" OR "Transformation" OR "Industry 4.0" OR "AI" OR "Artificial Intelligence" OR "Digital" OR "data-driven" OR "Technological" OR "Advanced Tech" OR "Machine Learning" OR "Deep Learning" OR "Big Data" OR "IoT" OR "Internet of Things" OR "Cyber-Physical Systems" OR "Smart Manufacturing" OR "Digitalization" OR "Intelligent Systems" OR "Robotics" OR "Process Optimization" OR "Innovation" OR "Smart Tech" OR "Emerging Technology" OR "Cloud Computing" OR "Blockchain" OR "Predictive Analytics" OR "Augmented Reality" OR "Virtual Reality" OR "Autonomous Systems" OR "Edge Computing" OR "Next-Generation Technology" OR "IT Transformation" OR "Tech Revolution")

AND ("Policy" OR "Interventions" OR "Policies" OR "Regional" OR "Region" OR "Workforce Policy" OR "Economic Policy" OR "Government" OR "Public Policy" OR "Policy Making" OR "Governance" OR "Policy Framework" OR "Regulation" OR "Regulatory Framework" OR "Development Policy" OR "Social Policy" OR "Labor Policy" OR "Employment Policy" OR "National Policy" OR "Local Policy" OR "Policy Strategies" OR "Administrative Policy" OR "Economic Development" OR "Urban Policy" OR "Policy Innovation" OR "Legislation" OR

"Public Administration" OR "Policy Implementation" OR "Policy Evaluation" OR "Policy Reform" OR "Policy Analysis")

The selection of these keywords was related to the main research topic of "Labor Market" and the subdomains: "Skills Development", "Policy and Regulations", and „Technological Transformation"; These keywords were evaluated through open peer review method [5. of Bib paper].

In the resulting sample, the 1061 articles with 1656 keywords, after using the minimum number of occurrences 6, 145 keywords met the threshold.

In order to enhance reliability, some of the following keywords were removed:

Table 1. Removed Keywords using VOS viewer.

Panel A: Removed Keyword			Panel B: Selected Keyword	
ID	Keyword	Occurrences	Keyword	Occurrences
1	firm	6	firms	22
2	impacts	6	impact	52
3	intervention	6	interventions	11
4	models	8	model	23
5	policies	6	policy	39
6	service	6	services	7
7	systems	13	system	16
8	technologies	12	technology	45

That 137 keywords lead to 4 clusters where the minimum cluster size is 8 keywords, figure. 1 presents the results we found by using VOS viewer software based on the database files obtained directly from the Web of Science.

The findings show that our sample related to different research areas where 345 articles in Business Economics, 145 in Education Educational Research, and 122 in Environmental Sciences Ecology. In addition, there are 104 other areas of study (e.g. Public Administration, Computer Science, Engineering and Geography) related to our results. Thus, our final sample consisted of 1061 articles for 1993–2024. To provide a graphic description of the bibliographic results, the visualization software VOS viewer (Luo & Saeheaw, 2024) (Zhang & Wang, 2024) was used. This software compiles bibliographical data and displays the results.

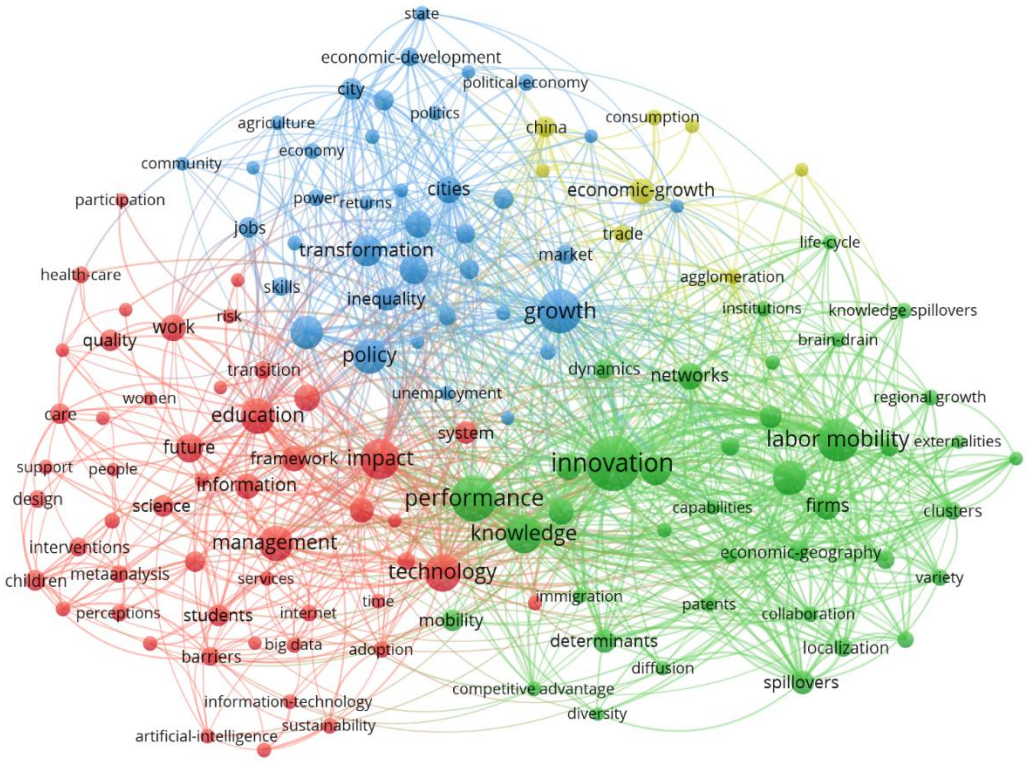

Figure 2. Co-occurrence of Web of Science Keywords on Labor Market using VOS viewer.
Source: Own compilation on VOSviewer.

According to figure 3, the evolution of publishing on our topic is obvious in the last years, where we found 41.2% of the total number of publications are in the last three years, and 60.5% of the total number of citations are just in the last ten years.

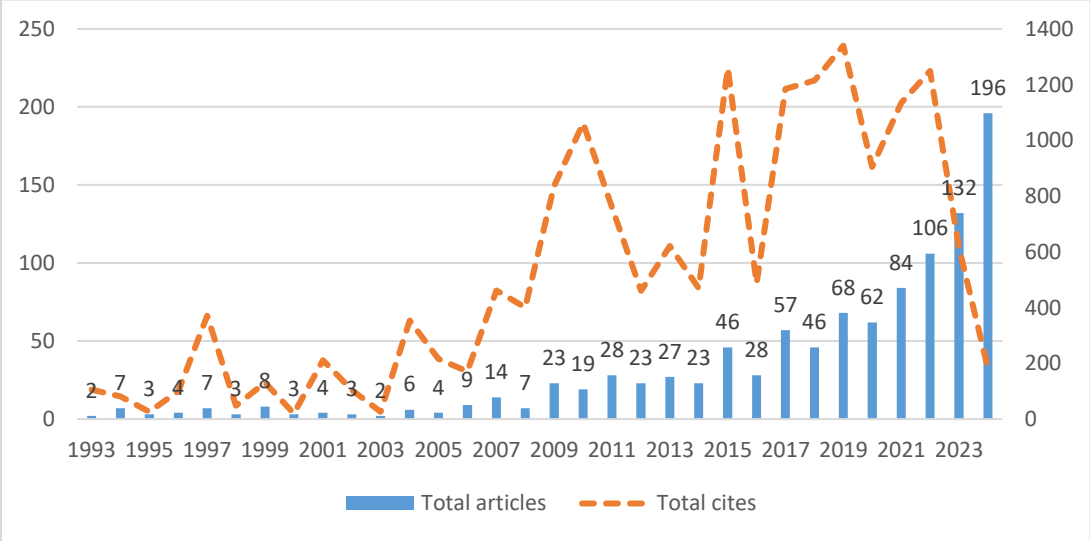

Figure 3. Articles and Citations.
Source: Own compilation based on dataset from web of science.

Table. 2 shows the top 15 keywords by the number of occurrences related to our research topic.

Table 2. The most relevant keywords by occurrences.

ID	Keywords	Occurrences
1	innovation	96
2	performance	67
3	growth	63
4	labor mobility	59
5	impact	52
6	knowledge	48
7	technology	45
8	education	40
9	management	40
10	policy	39
11	research-and-development	37
12	employment	36
13	transformation	32
14	productivity	30
15	governance	28

4.2. Quantitative Analysis and Findings

The top industry is Manufacturing, which had the highest employment with 17.54% (Figure 5.) of the employed persons in Hungary in the last year, indicating its continued dominance in Hungary's labor market. While Wholesale & Retail Trade and Education follow in employment levels, though their numbers are significantly lower than manufacturing with a slight increase, the same change for Public Administration & Defence, Administrative Services, and Health & social work activities show slight growth, more likely reflecting ongoing demand in Hungary's traditional industries and government-driven stability or small expansion in public employment.

Certain modern sectors, such as Information and Communication and Scientific and Technical Activities, show steady growth, indicating a gradual digitalization and technological advancement within Hungary's economy. However, this growth remains modest compared to traditional sectors, pointing to a slower shift toward a tech-oriented labor market.

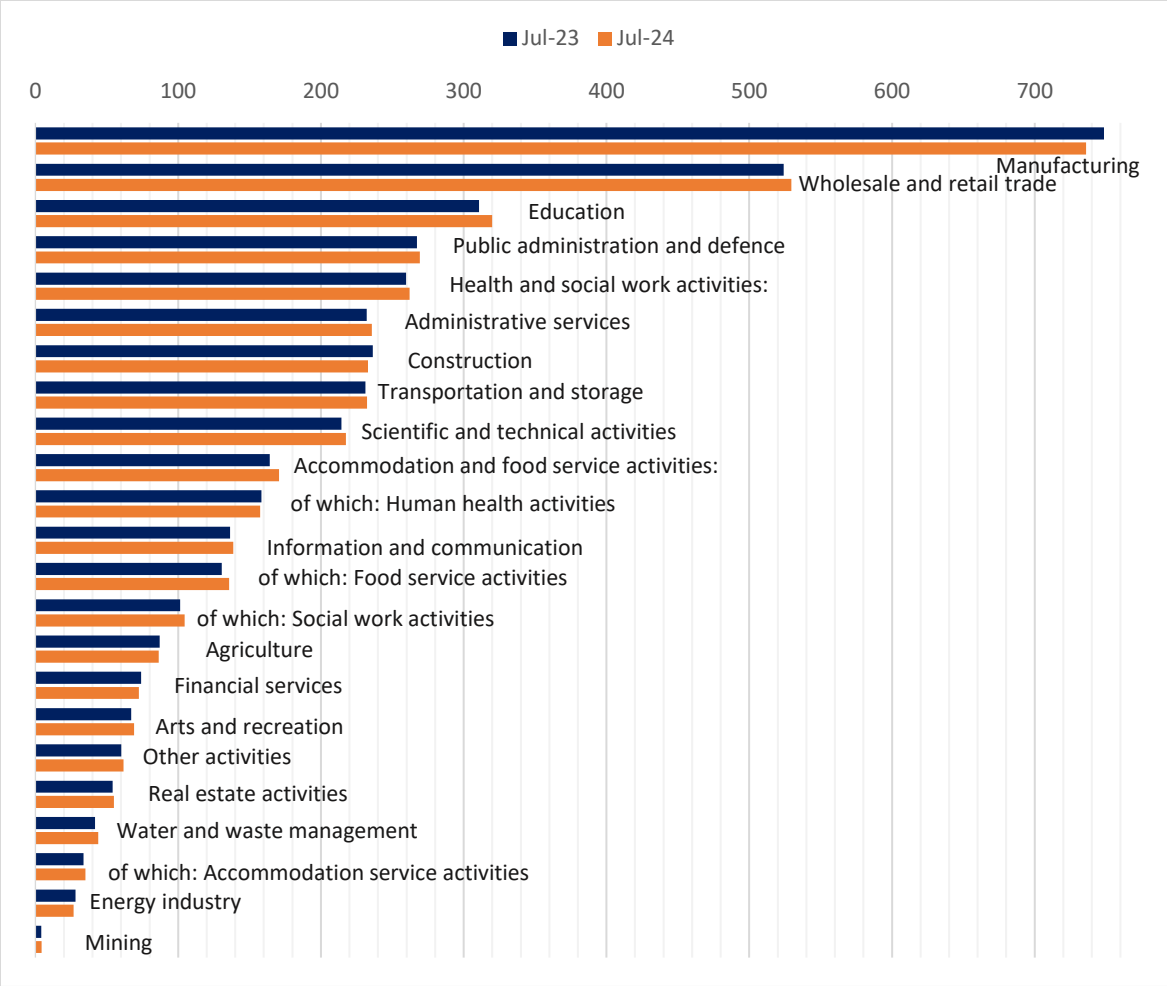

Figure 4. Employed Persons by Industry (thousand persons) - comparison between July 2023 - July 2024 in Hungary.

Source: Own compilation based on data from Hungarian Central Statistical Office Database (Hungarian Central Statistical Office, 2025).

Figure 4 also reveals low-growth sectors, for example, the arts and recreation industry, agriculture, and financial services—possibly reflective either of limited demand in those areas or problems in attracting workers possibly due to poor wages or conditions of service.

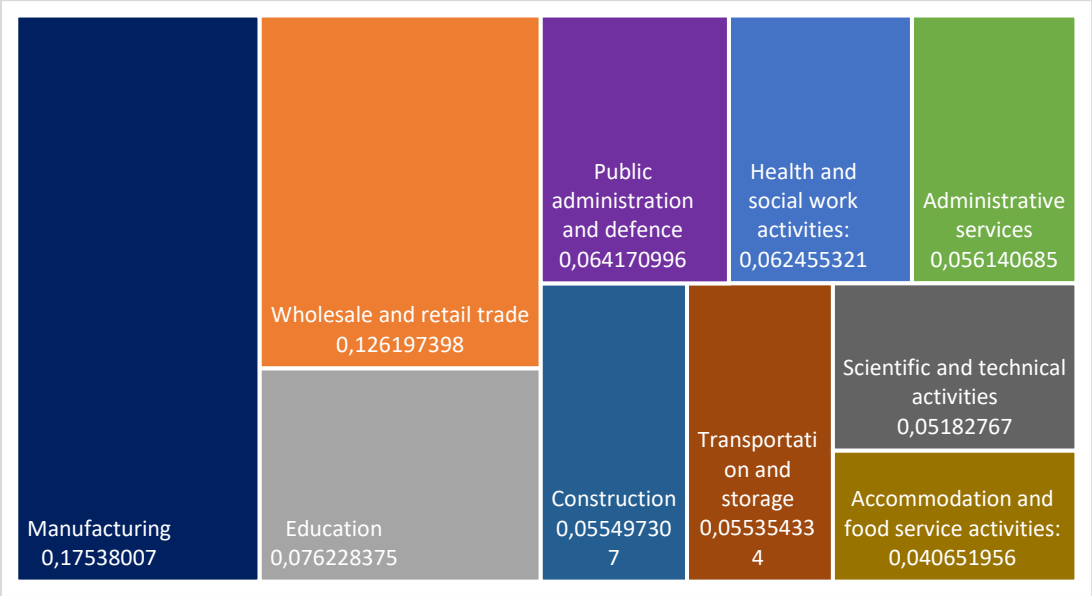

Figure 5. Employed persons by Top 10 industries.
Source: Own compilation based on data from Hungarian Central Statistical Office Database.

Figures 4. and 5. give, in summary, an overview of the sectoral employment trends in Hungary, showing moderate growth overall with strong performances in manufacturing and retail. However, to meet future labor demands, there may need to be a shift toward high-skill, tech-oriented sectors.

4.3. Regional Employment Trends

It would then be easy to put the regional trend in employment across Hungary into perspective with the historical trend of employment between 2009 and 2023 by assuming the distribution of 2023 employment (Figure. 7). The Great Plain and North region is always leading with a share in total employment in 2023 at 36%. This dominance can probably be explained by its agricultural and industrial activities, as suggested by recent labor market research (Kissné Nagy, 2016) (G. Kiss & Demeter, 2023). Central Hungary, including Budapest, contributes 34% of total employment (Figure 6).

While it underlines its role as the economic and administrative core of the country, driven by urbanization (Kok & Kovács, 1999), service industries, and commercial hubs (Eurostat, n.d.-b). Transdanubia, although with a slightly lagging 30% share, has followed a relatively stable growth path over time, which reflects regional economic development and diversification (Cunningham & Villaseñor, 2016; World Bank, 2024). According to the bar chart, over the period 2009-2023, the increase in employment has been continuous in all regions; it is somewhat exceptionally accelerated after 2015, which was consistent with the economic recovery of Hungary and deeper integration into European labor markets. These results give credence to the relative balance of the workforce distribution, where regional strongholds clearly impact employment opportunities. Further research into local factors and labor market dynamics might deepen the understanding of regional disparities and their implications for policy-making.

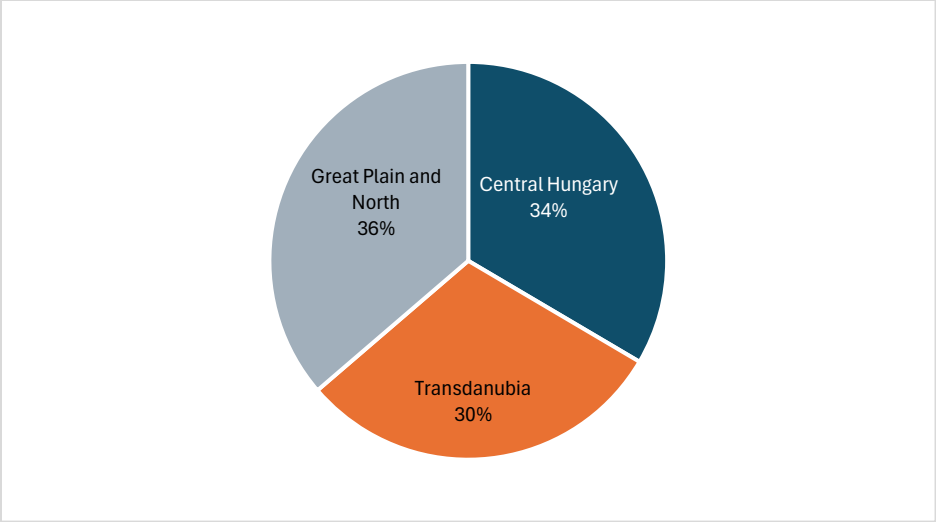

Figure 6. Employed Persons by Regions - Geographical Distribution in 2023.
Source: Own compilation based on data from Hungarian Central Statistical Office Database(Hungarian Central Statistical Office, 2025).

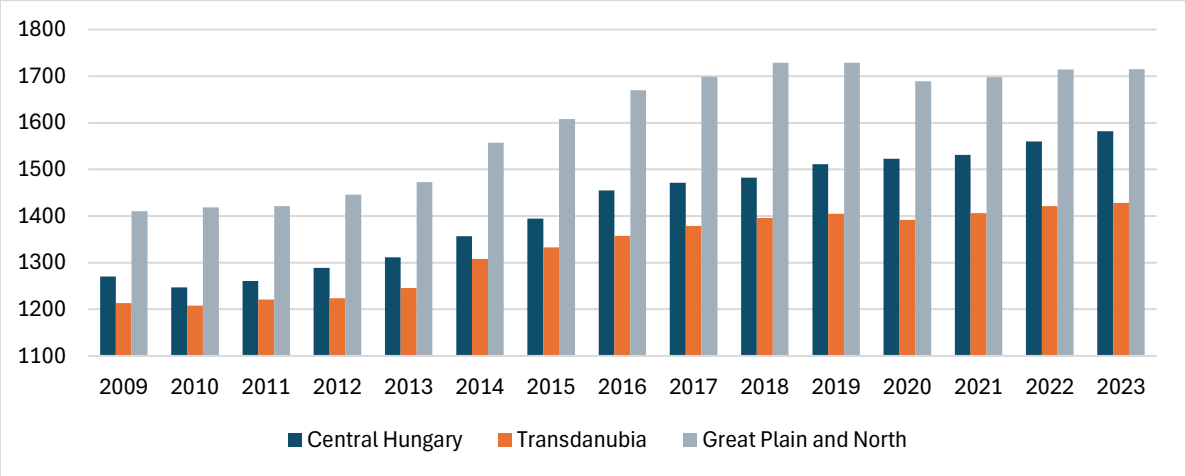

Figure 7. Employed Persons by Regions between 2009-2023.
Source: Own compilation based on data from Hungarian Central Statistical Office Database(Hungarian Central Statistical Office, 2025).

These trends might imply that while Hungary's economy is steadily growing in traditional sectors, there is a need for policies to foster growth in high-skill sectors like scientific and technical activities and information technology. This could better align Hungary's workforce with future digital transformation demands and support the gradual shift toward a more diversified economy.

5. Discussion

5.1. Improving the understanding of digital transformation in mid-tier economies

This study contributes to the understanding of digital transformation focusing on Hungary as a middle economy in Europe that — in general discussion driven by high-income countries — is

often little discussed. Previous research has mostly focused on digital transformation in economies with strong digital infrastructures, like Germany and Sweden (European Commission, n.d.; OECD, 2024). By focusing on Hungary, this study addresses a significant gap, exploring how the interplay between regional disparities, sectoral differences, and labor market dynamics can influence a country's digital trajectory (International Trade Administration, U.S. Department of Commerce, n.d.). This provides an advanced perspective on how digital transformation takes place in economies with unequal distribution of digital readiness.

5.2. Studying the Gap Between Regional Disparities and Digital Competency

Our research establishes a link between regional disparities and digital competence frameworks, e.g. Central Hungary has much higher indicators of digitalization and investment compared to both the Great Plain and Transdanubia. The detected difference confirms the findings of previous studies (e.g., Magyarország Mesterséges Intelligencia Stratégiája, 2020–2030 (innovációs és technológiai miniszter, n.d.)), which highlights the uneven economic impact of digitalization on different regions. Although these investment gaps have been identified in the literature (Bureau of Economic and Business Affairs, 2023), the current study contributes to the discussion because it shows the consequences of these investment gaps for labor market flexibility, for the skill distribution, and for growth in various sectors.

5.3. Addressing the challenge of defining Digital Competency

A major issue in the body of literature on digital transformation has been a lack of an in-depth framework for outlining digital competence (IMD World Competitiveness Online, 2024). This research highlights the disunity in expectations surrounding digital competency within Hungarian SMEs and relevant policy initiatives, mirroring global trends regarding the variability of digital training approaches (Pärli, 2022b). By creating a common framework, this research lays a conceptual ground for future policy-making and changes in digital education within similar economies. A harmonized approach to defining and teaching digital competences can reduce inequity in labor market outcomes, thus promoting equitable economic growth.

5.4. Comparative analysis of digital economies

Finally, this research contributes to the comparative study of digital economies, putting the Hungarian experience side by side with broader EU trends. It shows that digital intensity in businesses in Hungary is comparatively low: 18% of ICT training in SMEs, while 39.8% was the rate for Finland (Eurostat, n.d.-c). These findings could provide valuable insights into how the digital transformation strategies might vary across economies at different stages of readiness. This study, based on an overall framework that integrates regional, sectoral, and policy perspectives, lays the foundation for further cross-national comparisons, especially among transition economies in Eastern Europe.

6. Conclusion

While some strategies (János, n.d.) are significant for switching toward more digital transformation, this research points to the potential of digitalization to transform the labor market

in Hungary, and also underlining some critical challenges. Several of these can be identified as regional disparities and sectoral imbalances. The obvious contrast between high-scoring Central Hungary and lagging regions like the Great Plain and Transdanubia underlines the need for targeted intervention so that equitable growth can set in. Moreover, the slow adoption of advanced technologies on the part of SMEs and gaps in digital competencies bring about an urgent call for policy and practical measures.

In order to look after these challenges, our research recommends the following:
Regional Digital Development: Invest in underpinning digital infrastructure and people's training programs in less well performing regions to improve inequality for inclusive growth.
Digital Transformation of SMEs: Establish subsidies and incentives promoting digital technologies such as cloud computing and AI among SMEs, as well as ICT training of their workers.

- *Education Reform:* Update the educational curricula in accordance with the needs of the future labor market, including digital literacy, AI, and data analytics. Expand lifelong learning programs to support adult upskilling, particularly in low-digital-readiness regions.
- *Unified Digital Competency Framework:* A uniform framework regarding digital competencies training that should be developed and implemented in Hungary, harmonized with the demand of the labor market.
- *Sector-specific policies:* Promotion of R&D and digitalization in high-growth sectors, such as ICT and scientific research, is highly recommended, while the support of digital transformation in more traditional industries-manufacturing and retail-should be provided.
- *Sectoral Policies:* Incentivize R&D and digital adoption in the high-growth sectors like ICT and scientific research, and foster digital transformation in the traditional industries manufacturing and retail sectors.
- *Monitoring and Evaluation:* Establish monitoring mechanisms for reporting on the implementation of the Strategy on Digital Transformation, using specific performance indicators like rates of digital adoption, regional investments, and trends in employment in the technology sectors.

More than ever, addressing these issues in a coordinated effort by policymakers, educators, and industry leaders will enable Hungary to take up the challenges of digital transformation, reduce regional disparities, and build a resilient and adaptable labor market to technological changes.

Availability of data

The datasets analyzed in this study are publicly available from Hungarian Central Statistical Office (HCSO): https://www.ksh.hu, and Digital Economy and Society Index (DESI): https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts. These datasets and the derived data (e.g., regional employment graphs, bibliometric keyword clusters) are available from the corresponding authors upon reasonable request.

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AI-Enabled Business Intelligence for Managerial Decision-Making

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Abstract: As organizations increasingly embed AI into Business Intelligence (BI) platforms, BI has become a core capability for managerial decision-making by converting heterogeneous data into timely, decision-relevant insights.. This study examines how advanced analytics and artificial intelligence (AI) embedded in BI platforms support managerial decision-making by improving decision quality, timeliness, and confidence. Drawing on a systematic literature review, the paper synthesizes recent peer-reviewed evidence on BI evolution, decision-support effectiveness, and organizational enablers. The findings indicate that AI-enhanced analytics and visualization strengthen predictive and prescriptive decision support, but benefits depend on foundations such as data quality, data governance, appropriate data modelling, user-centred dashboard design, and analytical competencies. Overall, the review supports a socio-technical view: sustainable value arises when technology, data assets, processes, and organizational readiness are aligned.

Keywords: artificial intelligence, business intelligence, data governance, desision support systems, managerial decision-making, organizational performance
Journal of Economic Literature (JEL) code: M15, C88, D81, O33

1. Introduction

With the advancement of digital transformation, business intelligence (BI) systems have become a defining infrastructure for managerial decision-making, as they directly support decision quality and timeliness through the integration, processing, and analysis of relevant data. In practice, effective BI rests on the coherent interplay of enterprise data modelling to structure information, data quality frameworks to ensure accuracy and consistency, and management dashboard design principles that translate analytical outputs into interpretable managerial signals. The convergence of these elements largely determines whether BI tools can genuinely support strategic and operational decisions (Wieder & Ossimitz, 2015). Despite continuous technological progress, many organizations still struggle to transform data into a form suitable for decision support due to misaligned data architectures, inconsistent quality standards, and poorly designed visualization interfaces that undermine usability and trust (Gitzel et al., 2015).

In recent years, BI has evolved from basic reporting toward more sophisticated platforms that incorporate real-time analytics, predictive modelling, and interactive dashboards. This development has been driven by the increasing volume, velocity, and complexity of enterprise data, which requires advanced visualization and analytical techniques to extract insights that are actionable in managerial contexts. The practical relevance of this field is reinforced by recent statistics and studies suggesting that data-driven organizations are more likely to improve customer acquisition, retention, and profitability, thereby underlining the strategic role of BI in competitive business environments (Pendyala, 2024; Malla, 2025; Das et al., 2024). At the same time, substantial challenges remain in integrating analytics and visualization into BI systems in a way that reliably supports decisions, particularly regarding enterprise data modelling choices, sustained data quality management, and the design of dashboard interactions that fit managerial work practices.

A related and increasingly important debate concerns the appropriate balance between automated, AI-driven analysis and the human judgement required to interpret results and take responsibility for decisions (Alghamdi & Al-Baity, 2022; Shafa, 2025). In this context, the literature frequently characterizes generative artificial intelligence as a general-purpose technology, given its continuous improvement, broad applicability, and innovation complementarities, namely its capacity to amplify the value of other organizational and technological developments. This perspective is particularly relevant for BI and decision support because AI-enabled value creation is rarely determined by model performance alone. Instead, it tends to emerge from the combined maturity of data assets, analytical infrastructure, workflows, and competencies. In parallel, Industry 5.0-oriented research increasingly emphasizes a human-centred assessment of advanced technologies, where societal acceptance, perceived risks, and regional context shape adoption outcomes (Fási et al., 2025).

The aim of this article is to synthesize academic perspectives on the principles that improve managerial decision-making within BI systems, with a specific focus on data analytics and decision support tools. This review adds value by consolidating multiple research streams into an integrated account that can inform both effective BI implementation and meaningful managerial use. Methodologically, the study applies a rigorous literature review with explicit inclusion criteria that prioritize recent, peer-reviewed academic research on BI, data analytics, and decision-making support instruments.

2. Literature review

Research on the principles of improving managerial decision-making in Business Intelligence systems, with a particular focus on data analytics and decision-making support tools, is playing an increasing role in organizational environments due to the increasing volume and complexity of data (Duka, 2025, Mahajan, 2024; Moussas et al., 2024). The evolution of BI from the early data consolidation and reporting systems that emerged in the mid-20th century to today's AI-enriched, cloud-based and real-time analytics platforms reflects a trajectory characterized by technological innovation and expanding analytics capabilities (Chillara, 2025; Pavkov et al., 2016). This development underscores the practical importance of BI in improving strategic flexibility, operational efficiency, and risk management across various sectors (Didas et al., 2024; Whig et al., 2024). Effective implementation of BI can improve the speed and quality of decision-making, which directly impacts organizational performance indicators (Hurbean et al., 2024; Jim & Rauf, 2025). Despite these advancements, there remains a problem of how to use BI-generated data to improve managerial decision-making (Richards, 2016; Pourshahid et al., 2014). The focus of the knowledge gap is the integration of data analysis techniques, decision-making support tools, and organizational factors, which together influence the quality and effectiveness of decisions (Ali & Miah, 2018; Rahman et al., 2025; Ray & Deepanshi, 2025). While some research emphasizes technology enablers such as AI-driven analytics and extended analytics (Shafa, 2025; Odogwu et al., 2023; Sultana, 2025), others highlight human and cultural dimensions, including data analysis skills and data management (Hurbean et al., 2024; George et al., 2020). There are debates about the relative importance of technical advancement, organizational readiness, and user competence for unlocking the potential of BI (Jim & Rauf, 2025; Richards, 2016).

Advances in research aimed at improving managerial decision-making with BI systems show that core BI concepts and decision-support frameworks are gradually transforming into the integration of advanced data analytics and new artificial intelligence technologies. Early work focused on system architectures, optimization techniques, and the role of BI in improving decision quality. Over time, attention has expanded to big data analytics, machine learning applications, and the development of intelligent decision support systems that foster a data-driven culture and organizational capabilities. Recent studies emphasize human-AI collaboration, ethical governance, and the design of interactive analytics tools to support strategic and operational decision-making in a dynamic business environment. Human–robot collaboration research underscores a broader shift toward human-centred automation, where productivity gains depend on aligning technological capabilities with human adaptability, trust, and safe integration into workflows (Shina et. al. 2025).

Enterprise data modeling is the backbone of BI systems, which sets the framework for structuring, storing, and querying data. Shanks and Darke, in 1999, wrote that traditional models often prioritize technical efficiency over decision-making utility, which creates a disconnect between data structures and management needs. For example, entity relationship diagrams and dimensional modeling can optimize database performance, but they cannot capture the contextual nuances needed for strategic analysis (Jones & Song, 2008). At the same time, data quality, including accuracy, completeness, consistency, and timeliness, directly affects the reliability of BI outputs. Poor data quality undermines decision-making confidence, which leads to skepticism towards BI systems, despite their analytical capabilities (Chengalur-Smith et al., 1999). According to research, nearly half of BI initiatives face obstacles due to data quality issues (Scholz et al., 2010). Existing research has largely looked at these components, ignoring their interdependencies. Data modeling studies rarely address the usability of dashboards by influencing schema choices, while dashboard design research often ignores the inherent data quality limitations of real-world BI systems (Molensky et al., 2010). Furthermore, the rapid spread of advanced analytics and big data technologies has brought with it new complexities, yet their impact on traditional BI frameworks remains underestimated (Jin and Kim, 2018).

The integration of data analysis and visualization into business intelligence systems has developed rapidly. Early studies focused on the design of core BI dashboards and data quality management, and later focused on user experience, interactive visualization, and the use of artificial intelligence and machine learning to improve decision-making efficiency. Recent work highlights sophisticated architectures, real-time analytics, and AI-powered frameworks aimed at scalability, data modeling automation, and cognitive optimization for executives. Overall, the literature reflects the trajectory from core dashboard implementations to intelligent, adaptive, and context-aware business intelligence systems that holistically improve managerial decision-making. Dashboard design principles further convey the effectiveness of BI systems by defining how information is visualized and interpreted. Although guidelines such as Tufte's data-to-ink ratio or Few's perception principles provide theoretical foundations, their application in the management environment remains inconsistent (Sedrakyan et al., 2019). Decision makers often encounter dashboards that are full of irrelevant metrics or overly simple visualizations that obscure critical trends (Almasi et al., 2023). The cognitive load caused by poorly designed user interfaces can negate the benefits of even the most robust data models and quality controls (Cheng et al., 2024).

The conceptual framework on which this study is based defines Business Intelligence as a technology-based process that involves collecting, integrating, analyzing, and presenting data to support managerial decision-making (Mahajan, 2024; Vercellis, 2013). Data analysis and decision-making support tools are seen as integral components that transform raw data into actionable information, facilitating evidence-based decision-making (Steiger, 2010).

3. Methodology

This systematic literature review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The study uses a multi-database search strategy to capture a wide range of perspectives on enterprise data modeling, data quality, and dashboard design in the context of business and artificial intelligence. Scopus and IEEE Xplore were prioritized due to their extensive collection of technical studies on data architectures and BI implementations. The Web of Science was selected for its comprehensive coverage of disciplinary management and technology studies. And Google Scholar served as a supplementary source to identify essential works that were not indexed in other databases. The search strings combined keywords such as „enterprise data modeling," „data quality," „artificial intelligence," „business intelligence," „information systems," „dashboard design," „organizational performance," and „managerial decision-making." The advanced filter of each database has been limited to peer-reviewed journal articles, ensuring academic quality.
The review examines how enterprise data modeling and data quality principles connect with dashboard design to influence managerial decision-making in BI systems. The analysis is based on the following questions:

1. What principles, tools, and AI/BI technologies do organizations build on to increase the efficiency of decision-making?
2. What empirical surveys are available on the impact of business intelligence on organizational performance and decision-making outcomes?
3. What operational challenges hinder the effectiveness of the AI/BI system?

The first search returned 539 records, which were reduced to 295 after deduplication and preliminary exclusions. After filtering the title and abstract, 175 irrelevant studies were excluded, leaving 53 full-text articles for evaluation. In the case of the limitation of the research, the differences in the context, methodological rigor, industry focus and technological maturity of the studies must be taken into account, so the results obtained should be interpreted depending on this.

4. Results

The literature on improving managerial decision-making in business intelligence systems consistently highlights that integrating advanced data analytics and decision support tools is essential to improving the accuracy, speed, and organizational performance of decisions. Key topics include the transformative role of new technologies such as artificial intelligence, machine learning, and augmented analytics that promote predictive and prescriptive decision-making capabilities. Organizational factors such as data management, culture, and user competence are repeatedly highlighted as critical prerequisites or barriers to effective BI adoption.

In addition, methodological advances and the design of BI tools and frameworks underscore the increasing complexity and interdisciplinary nature of decision support systems in different business contexts. The analysis was carried out along the lines of the effectiveness of decision-making support, the assessment of technological infrastructure and organizational performance. Table 1 provides a structured literature review along the chapters on decision support effectiveness, technological innovation, and organizational performance, exploring the decision-making and organizational impacts of BI and AI-based analytics solutions.

Table 1. Summary of the Decision Support Effects of AI and BI based on the literature

Organizational Performance	Decision Support Effectiveness	Technology / Analytics Stack	Study	Year
Business problem-solving and adaptation	BI improves decision timeliness and quality	Data collection and analytical tools	Pavkov et al.	2016
Competitive advantage and innovation	Analytics strategies drive business value and growth	Emerging analytics technologies	Whig et al.	2024
Competitive advantage and performance gains	BI improves strategic and operational decisions	Data warehousing, OLAP, data mining	Moussas et al.	2024
Efficient data analysis for decisions	Neuro-computing and evolutionary algorithms enhance BI	Neural networks, genetic algorithms	Wu	2010
Empowers evidence-based decisions	Uses descriptive to prescriptive analytics	Data analytics techniques	Ray & Deepanshi	2025
Enhanced decision monitoring and impact	Iterative data and goal modeling improves decisions	KPI integration in BI models	Pourshahid et al.	2014
Enhanced decision outcomes	Balances adaptability and rigor for decision quality	Data-centric decision support tactics	Kowalczyk & Buxmann	2015
Enhanced decision-making and future readiness	Real-time, accurate insights improve decisions	AI, ML, cloud computing	Mahajan	2024
Enhanced management support	Covers modeling, data mining and knowledge management	Intelligent systems and expert systems	Turban et al.	2006
Enhanced managerial work performance	Positive impact on decision effectiveness and managerial performance	BI &AI tools adoption	Hurbean et al.	2024
Enhanced decision facilitation	Facilitates decision- making through design questions	Dashboard design best practices	Presthus & Canales	2015
Facilitates BI embedd-ing in businesses	Highlights technological and personnel capabilities	Information management integration	Ali & Miah	2018
Financial and process performance improvements	Improves decision quality, speed, and trust	Supervised, unsupervised, reinforcement learning, explainable AI	Shafa	2025
Fosters agility and responsiveness	Enables market trend anticipation and risk assessment	AI and big data analytics	Ramadhani et al.	2025
Gains in innovation and strategic agility	AI-driven BI fosters innovation and competitive advantage	AI, ML, augmented analytics, cloud computing	Chillara	2025
Guides BI&A system development	Identifies technical and non-technical BI dimensions	Work systems theory-based model	George et al.	2020
Improved competitiveness, risk reduction, operational efficiency	Enhances strategic flexibility and decision quality	Use of Power BI, Tableau, Python, R	Duka	2025
Improved data literacy and business outcomes	Reduces cognitive load, supports real-time decisions	AI, ML, natural language generation	Odogwu et al.	2023
Improved decision quality	Supports optimal business decisions	Data mining, classification, optimization	Vercellis	2013

Organizational Performance	Decision Support Effectiveness	Technology / Analytics Stack	Study	Year
Improved decision-making efficacy	Accuracy and efficiency support business decisions	Big data analytics tools	Didas et al.	2024
Improved decision-making quality	Enhances decision quality via mental model updates	BI techniques for knowledge discovery	Steiger	2010
Improved organizational decision insights	Highlights human cognition constraints in decision-making	Rules-based and heuristic decision support	Richards	2016
Improved decision accuracy and alignment	AI enhances interactive analytics and decision speed	AI-driven visualization and interaction	Sultana	2025
Performance uplifts in decision units	Higher AI-BI capability linked to better decision quality and speed	AI-BI workflow integration, automation, explainability	Jim & Rauf	2025
Supports responsible decision-making	Hybrid AI architectures improve strategic decisions	AI-augmented decision tools	Rahman et al.	2025

Source: own editing and compilation based on literature research

There is a general consensus in the literature under review that integrating advanced data analytics, artificial intelligence, and machine learning significantly improves managerial decision-making within BI systems by improving the quality, speed, and strategic flexibility of decisions. Data quality, governance, and organizational culture consistently emerge as key prerequisites or barriers to successful BI adoption across the studies. There is also a consensus that it is critical to integrate robust data modeling, maintain high data quality, and adopt user-centric dashboard design. However, there are differences in the extent of ethical considerations, the measurement of long-term impacts, and the practical implementation of governance frameworks in BI environments. Most studies emphasize the growing role of AI and real-time analytics in transforming traditional dashboards into dynamic, intelligent user interfaces that improve the speed and accuracy of decision-making. However, there are differences in the extent to which AI can fully replace human judgment, as well as in the challenges associated with the introduction of dashboards related to cognitive load and user insights. These differences are often due to the variety of study context, methodological approach and sector-specific applications.

4.1. Organizational performance

Several studies have linked BI-assisted decision-making to improvements in organizational metrics, such as operational efficiency, competitive advantage, financial performance, and managerial work performance (Duka, 2025, Hurbean et al., 2024, Whig et al., 2024, Moussas et al., 2024). They highlight cross-functional collaboration and a data-driven culture as performance drivers. Some studies report mixed or contextual performance outcomes, with varying effects depending on governance, data quality, and user competence (Jim & Rauf, 202, Richards, 2016). Of the literature examined, 29 studies demonstrate quantitative and qualitative improvements in business metrics, including financial performance, operational efficiency, and competitiveness, attributable to BI-assisted decision-making. Ramadhani et al., 2025; Based on the work of Whig et al., 202 and Pavkov et al., 2016, the introduction of BI promotes innovation, agility, and responsiveness in various sectors and is proven to improve managerial performance and improve strategic outcomes. Figure 1 summarises key concepts reflecting the impact of AI and BI-based solutions at the organisational level, with a particular focus on performance improvements, flexibility and competitiveness.

Figure 1. Key concepts of impacts on organizational performance
Source: Own editing in Power BI based on literature research

4.2. Effectiveness of decision-making support

Many studies report measurable improvements in the quality, speed and trust of managers thanks to BI tools. And AI-enhanced models in particular increase trust and accuracy (Shafa, 2025; Jim & Rauf, 2025; Ray & Deepanshi, 2025). Analyses show that the introduction of BI has provided better strategic flexibility, increased operational efficiency, and scenario planning in both tactical and strategic decision-making (Duka, 2025; Moussas et al., 2024; Kowalczyk & Buxmann, 2015). Some articles highlight the importance of human-AI collaboration and explainable AI to increase decision-makers' trust and reduce aversion to algorithms (Shafa, 2025; Rahman et al., 2025). More than half of the studies examined identified organizational culture, data quality, governance, and staff capabilities as critical drivers or barriers to successful BI adoption (Duka, 2025; Hurbean et al., 2024; Ali & Miah, 2018). Technical challenges include the complexity of integration, data governance and infrastructure limitations, while cultural resistance and lack of analytical skills are the main barriers to adoption (Didas et al., 2024; Jim & Rauf, 2025; Ali & Miah, 2018). Figure 2 shows the most frequently appearing concepts in the literature, which are related to the effectiveness and qualitative effects of the decision support role of AI and BI.

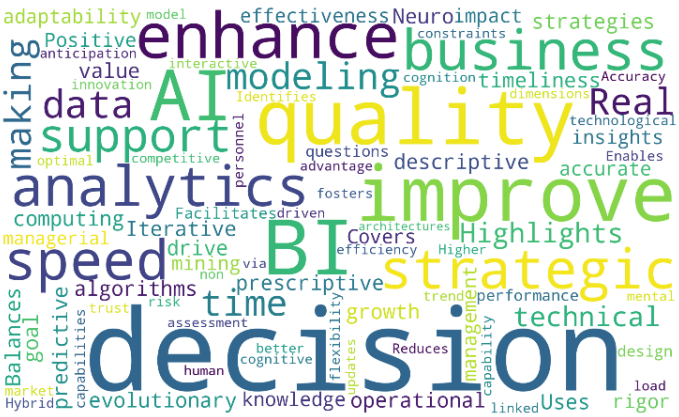

Figure 2. Key concepts on the effectiveness of BI and AI-based decision support
Source: Own editing in Power BI based on literature research

4.3. Technology / Analytics Stack

According to Chillara, 2025 and Shafa, 2025, the widespread incorporation of AI, machine learning, extended analytics, and cloud computing into BI frameworks will foster innovation by supporting data processing and decision-making. AI-driven visualization and interactive dashboards transform BI from static reporting to dynamic decision-making support environments (Sultana, 2025; Presthus & Canales, 2015). Challenges and solutions related to enterprise data modeling and data quality are of paramount importance, and they are essential to the issues that affect the reliability and efficiency of BI outputs. Another important topic is the interaction of dashboard design, which emphasizes AI-powered user interfaces to improve user experience, cognitive load, and decision-making efficiency. In addition, the incorporation of artificial intelligence and real-time analytics capabilities is being explored more broadly than a transformative solution for dynamic data integration and predictive capabilities. Figure 3 highlights the dominant technological and analytical solutions that determine the development, innovation potential and practical applicability of business intelligence systems.

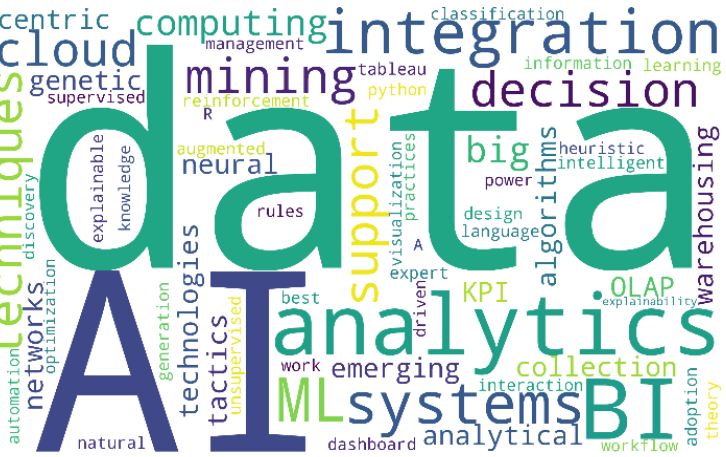

Figure 3. Dominant concepts of technological dimension
Source: Own editing in Power BI based on literature research

Based on the experience of previous general-purpose technologies, the economic and organizational impact of technological breakthroughs is often delayed. In the initial phase of adoption, additional investments, organizational transformation, new data strategy, and training needs will be expenses, while broad, measurable performance improvements will become dominant later in the ROI phase.

5.Conclusion

This study reviewed the role of BI and AI in supporting managerial decision-making, focusing on impacts on decision quality, speed, and organizational performance. The literature consistently suggests that advanced analytics and AI-enabled BI solutions can strengthen strategic agility and managerial performance, particularly when combined with real-time analysis and interactive visualization. Contemporary BI frameworks increasingly integrate machine learning, augmented analytics, and big-data technologies, thereby extending descriptive reporting toward predictive, prescriptive, and near real-time decision support. AI-assisted visualization and interactive

dashboards can reduce cognitive load and enable cross-functional coordination, provided that insights are translated into actionable decisions within well-designed processes.

At the same time, the evidence indicates that technological advancement alone does not guarantee effective BI-based decision support. Sustained value creation depends on the quality of data management and governance, robust data quality assurance, the development of user competencies, and the cultivation of a data-driven organizational culture. Implementation is frequently constrained by resistance to change, skills shortages, and fragmented governance structures that weaken adoption and long-term impact. In AI-enhanced settings, ethical and compliance considerations—especially privacy protection, fairness, transparency, and regulatory alignment—are becoming increasingly salient, while empirical research still addresses these issues unevenly. An integrated treatment of these factors is therefore essential for strengthening trust and accountability in BI–AI decision support.

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Who Fears Data, Who Trusts AI? Demographic Fault Lines in Privacy Behaviour and Platform Use

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Abstract: The rapid diffusion of AI-driven platforms and data-intensive applications has sharpened concerns about how demographic factors and regulatory literacy shape digital behaviour in Europe. This paper analyses how age, awareness of the General Data Protection Regulation (GDPR) and perceptions of artificial intelligence (AI) jointly influence screen-time patterns, privacy behaviours and platform choices in Hungary within an EU context. The empirical analysis integrates primary survey evidence (N = 218) with secondary Eurostat indicators capturing AI uptake and data-protection implementation at the EU level. Primary data were collected through a web-based questionnaire measuring sociodemographic characteristics, time allocation across major social media platforms, GDPR literacy, self-reported privacy practices, and attitudes toward AI-generated content. The dataset was pre-processed and visualised in Power BI, while additional statistical analyses were performed in Python.

Key words: artificial intelligence acceptance, demographic differences, data protection literacy, GDPR awareness, privacy behaviour, social media platforms
Journal of Economic Literature (JEL) code: D18, D83, K24, L86, O33

1. Introduction

The digital ecosystem has undergone profound transformations with the proliferation of social media platforms, smartphone applications, and AI-driven content delivery systems. These developments have reshaped user behavior while raising critical questions about data privacy, regulatory compliance, and ethical AI deployment (Hoven et al., 2021). The General Data Protection Regulation constitutes a pivotal initiative to standardize data privacy measures within the European Union, though its capacity to reduce privacy threats varies inconsistently among different population segments (Holt and Malčić, 2015). At the same time, AI algorithms are progressively shaping how content is consumed, which gives rise to conflicts between tailored experiences and individual self-determination (Iwuanyanwu, 2023).Prior research has examined digital behavior through isolated lenses, such as platform-specific engagement (Gawer, 2022) or regulatory compliance (Kira, Sinha and Srinivasan, 2021), but few studies integrate these dimensions with demographic variables. This gap is particularly salient in Central and Eastern Europe, where digital adoption patterns often diverge from Western EU norms (Lutz, 2019). Hungary, as an example, shows lower AI adoption levels than the EU average, which implies distinct socio-technical obstacles that require examination (Moravec et al., 2024).

This research addresses three interrelated questions:

1. How do age and GDPR awareness correlate with screen time allocation across social media platforms?
2. How does acceptance of AI differ across demographic segments, especially among highly exposed populations such as younger individuals?
3. How do regional disparities, such as Hungary's lag in AI adoption, reflect broader digital divides?

It is hypothesized younger users (under 35) devote more time to visually focused platforms such as TikTok but show less concern regarding AI-generated content, whereas GDPR-conscious individuals engage in protective behaviors (e.g., falsifying data) and steer clear of applications with high data collection, including those from Meta.

The study makes three key contributions. First, it empirically establishes demographic asymmetries in GDPR comprehension, showing that merely 35.27% of respondents correctly grasp its stipulations, a disparity that leads to measurable behavioral outcomes. Second, it classifies TikTok as the platform with the highest engagement and the lowest trust among Hungarian users, illustrating a contradiction where widespread adoption occurs alongside concerns about privacy. Third, it shows that AI tolerance decreases with age, which implies that younger generations accept algorithmic mediation as normal despite its potential dangers. These findings question established notions regarding digital competence and permission within changing legal frameworks (Nooren et al., 2018).

2. Literature Review

Digital behavior, data protection awareness, and AI adoption in social media have attracted substantial academic interest, but key gaps remain in comprehending their interplay among different demographic segments. Previous studies have shown that age plays a key role in shaping technology adoption behaviors, as younger individuals tend to show greater activity on image-centric platforms such as TikTok and Instagram (Khan et al., 2023). Nonetheless, this age group displays contradictory views on privacy, frequently valuing ease of access more highly than the protection of personal information (Arpaci, 2020). These results support theories of cognitive limitations, suggesting younger people may misjudge enduring privacy dangers because of insufficient life experience. GDPR awareness has been extensively studied in Western European contexts, where higher literacy rates correlate with proactive data protection behaviors, such as selective information disclosure or pseudonymization (Mühlhoff, 2023). Nevertheless, nations in Central and Eastern Europe such as Hungary show lower adherence levels, partially because of disjointed implementation and societal views on trust in institutions (Lutz, 2019). For instance, only 29% of Hungarian SMEs fully comply with GDPR requirements, compared to 67% in Germany (Kira et al., 2021). This difference highlights the necessity for analyses tailored to specific regions, taking into socio-economic and infrastructural factors. Findings from the gamification–digitalisation literature emphasise that sustained engagement is more likely when interventions are deliberately designed around user experience, including mechanisms that support flow and motivation over time (Kiss, 2023).

AI's role in shaping social media experiences has been examined through the lens of algorithmic personalization and user autonomy. Research indicates AI-powered content selection increases interaction while intensifying worries about echo chambers and the misuse of personal information (Iwuanyanwu, 2023). Despite regular interaction with AI-driven suggestions, younger individuals frequently remain uninformed about the data-gathering processes behind them, resulting in what is called "algorithmic resignation" (Moravec et al., 2024). This differs from older groups, who show greater skepticism but reduced engagement with AI functionalities (Sifaoui et al., 2024). The connection between risks tied to specific platforms and user conduct is still inadequately researched, especially in the context of newer applications such as TikTok. Although Meta's

platforms (Facebook, Instagram) dominate privacy discourse owing to their data-intensive architectures, TikTok's rapid growth has introduced novel concerns, including cross-border data transfers and opaque content moderation policies (Chung et al., 2021). Recent studies indicate that TikTok audiences are more prone to experience AI-selected material yet less inclined to grasp its data protection consequences, which results in a gap between engagement and comprehension (Kadhim, 2024).

Current frameworks frequently address demographic factors, regulatory knowledge, and AI exposure as separate variables, failing to account for their interdependent influences. For example, while (Oluoha et al., 2023) proposes a holistic approach to digital ecosystems, it does not account for age-related disparities in GDPR comprehension. Similarly, (Hoven et al., 2021) addresses ethical AI deployment but overlooks regional variations in technological adoption. While recent research reveals only gradual progress toward EU energy and climate targets across various industrial sectors (Takácsné Papp et al., 2023), similar sustainability challenges are emerging for data intensive digital services, including AI driven platforms reliant on large scale data processing.

This research extends existing scholarship by merging these aspects into a cohesive examination, with a specific focus on the ways age and GDPR awareness influence AI acceptance within Hungary's distinct socio-technical environment. In contrast to earlier studies that concentrate on individual platforms or broad user groups, our investigation identifies subtle behavioral tendencies, including the simultaneous presence of high TikTok activity and privacy skepticism, which contradict traditional views on digital literacy. Furthermore, by contextualizing Hungary's lag in AI adoption in 2025 (10.37% EU average of 19.95% (use at least one technologies, sector: all activities, except finacial, size: employed 10 persons or more), we contribute to broader discussions about digital divides and regulatory efficacy in transitional economies (Eurostat, 2025, Gawer, 2022). The conducted research stands out by empirically validating demographic disparities in GDPR understanding and AI acceptance, delivering detailed observations on how younger individuals assimilate algorithmic mediation even amid privacy concerns. These results not only support current theoretical frameworks but also furnish practical tools for policymakers seeking to address disparities in digital literacy and ethical governance.

3. Methodology

This paper employs a mixed-methods approach to examine the relationships between age, GDPR awareness, and AI tolerance in digital behavior. The research design merges quantitative survey data with qualitative findings from open-ended responses, which permits a thorough examination of user patterns across demographic groups. Our dual-methodology strategy integrates primary survey data (N=218) with supplementary examination of Eurostat reports and GDPR enforcement patterns. The survey documents appliance engagement, confidentiality perspectives, and interactions with artificial intelligence, categorized by demographic factors including age, sex, and educational background. Power BI supports the dynamic display of cross-sectional trends. Primary data were collected through a structured questionnaire distributed via Microsoft Forms between June 25 and October 10, 2025.

The survey implemented logical branching to guarantee relevance, and respondents were presented with an average of 26 questions (from a total pool of 119) depending on their device habits and privacy behaviors. The survey instrument consisted of four thematic sections:

1. Sociodemographic details (age, sex, educational attainment, occupational situation),
2. time spent on various social media platforms,
3. practices related to information security and awareness of GDPR regulations, and
4. experiences with content produced by artificial intelligence.

A variety of question types, such as Likert scales, multiple-choice, and open-ended formats, were employed to gather both quantitative metrics and qualitative insights.

The sampling strategy aimed at diverse demographic groups by disseminating via social media, resulting in 218 complete responses. The sample showed balanced gender distribution (49% male, 51% female) and a majority of younger participants (58.7% under 25 years old), which aligns with Hungary's digitally engaged demographic. Employment status and education levels were also recorded to control for socio-economic variables in subsequent analyses. Quantitative data were analyzed with Power BI, taking advantage of its connection to Microsoft's ecosystem for smooth data transformation and visualization. Power Query supported data cleaning by implementing filters to eliminate incomplete or inconsistent entries, whereas DAX (Data Analysis Expressions) permitted sophisticated modeling of relationships among variables. Interactive dynamic dashboards were built to display screen time trends, GDPR awareness metrics, and AI exposure data, featuring slicers that support cross-analysis by age, gender, and educational background. For deeper statistical analysis, Python scripts were embedded within Power BI to generate correlation matrices and regression plots. Key metrics included mean screen time per platform, GDPR comprehension scores (on a 6-point Likert scale), and AI concern indices stratified by age cohorts. To situate primary results within a broader framework, the research included supplementary Eurostat data (2025) on artificial intelligence uptake and General Data Protection Regulation adherence patterns in European Union countries.

4. Results

The subsequent section presents the principal results of the research, structured into four thematic subdivisions examining demographic trends, privacy issues, awareness of GDPR, and views on AI. These results yield empirical insights into the variations in digital behaviors among different age groups, levels of regulatory knowledge, and geographical settings.

4.1. Demographic Characteristics of Respondents

The research sample consisted of 218 respondents and showed a balanced gender distribution, with 49% male and 51% female participants. The age distribution displayed a majority of younger individuals, with 46.8% of participants between 18–25 years old and another 11.9% below 18. Together, individuals younger than 25 years comprised 58.7% of the sample, which indicates the study's substantial focus on students and younger participants. Middle-aged groups showed moderate participation rates: 25–35 (13.3%), 35–45 (8.7%), 45–55 (7.8%), 55–65 (6.4%), and over 65 (5%). Employment status figures showed that 61% of respondents were engaged in the labor market, whereas 54% held some type of student position, underscoring the commonality of

simultaneous employment and education among young adults. Only 15 individuals (6.9%) fell outside both education and employment systems.

4.2. Privacy Concerns and App Usage

The research uncovers essential findings on the influence of privacy issues on application engagement behaviors among different sample segments (Figure 1). Among the 207 valid responses analyzed, social media emerged as the dominant risk category, with 72.41% of respondents identifying it as their primary privacy concern. This was followed distantly by purchase-related apps (30.05% secondary risk) and financial applications, which registered minimal perceived threats. These findings align with prior research highlighting the paradox of high engagement with platforms despite recognized privacy risks (Barth & Jong, 2017). Platform-specific risk perceptions showed striking variations. TikTok achieved the highest primary risk attribution at 73.39%, exceeding Temu (67.53%) and Facebook (44.3%). This differs markedly from real-world metrics: TikTok and Messenger shared the top position in app prevalence (24.52% each), whereas YouTube dominated in daily interaction duration (68 minutes), with TikTok (60 minutes) and Instagram (48 minutes) coming next. According to (Ooijen et al., 2024), the dissonance between TikTok's risk perception and its usage dominance suggests a "privacy resignation" effect, where users continue engaging with platforms despite acknowledging their data vulnerabilities.

Figure 1. Data Protection Dashboard
GDPR Knowledge, Platform Use, Perceived Risk, and Privacy Behaviors
Source: authors' own editing in Power BI based on primary research(N=207)

Attitudes toward data collection showed distinct stratification by age. Although 36% of participants indicated feeling "yes it bothers me" by applications collecting their data, this unease was more pronounced in older age groups, with 55-65-year-olds showing 1.8 times greater

disturbance levels compared to those aged 18-25. In contrast, younger individuals showed more mixed feelings, with 52% expressing their unease "it depends on which app it is," an adaptability potentially indicating age-based distinctions in online interaction patterns (Maier et al., 2023). Defensive privacy behaviors showed similar demographic gradients. Falsifying information during registrations scored an average of 2.59 on a 6-point scale, yet standard deviations indicated substantial differences between younger individuals (1.34 for those aged 18-25) and older adults (0.29 for those over 65). This corresponds to the documented negative correlation between age and data manipulation(Montgomery et al., 2017), as younger individuals' greater proficiency in digital skills supports more deliberate privacy measures. In the digital economy, information increasingly functions as a core production factor alongside labour and capital, because it reduces uncertainty and underpins decisions from everyday consumption to strategic planning. Translated into data-driven platform markets, this implies that social media and AI-based services usually occupy the better-informed side of the exchange, while users remain only partially informed about algorithms and data practices, providing a powerful lens for interpreting demographic differences in privacy behaviour, risk perception and trust in AI-mediated content.

The dashboard visualization in Figure 1 underscores a number of pivotal relationships. Initially, respondents knowledgeable about GDPR (35.27%) showed 16% greater fabrication of information compared to the general mean, which implies that awareness of regulations fosters more dynamic privacy control. Second, the perception of risk showed an inverse relationship with frequency of engagement, as the most frequently accessed applications (YouTube, TikTok) were also those with the highest levels of distrust, which suggests that convenience frequently takes precedence over concerns about privacy. Third, age exerted a strong influence on both concern levels and protective behaviors, as older users adopted more consistent yet less sophisticated privacy strategies.

These findings challenge conventional assumptions about digital risk assessment. Although finance applications process confidential information, their relatively diminished perceived risk could be attributed to pre-existing confidence in the security measures employed by financial institutions. On the other hand, the elevated risk classification of social media stems from increasing recognition of behavior monitoring and precise ad targeting methods, especially by platforms such as TikTok which employ unclear artificial intelligence algorithms for content suggestions. The research also identifies a compelling paradox in younger individuals' privacy behaviors. Although they show greater acceptance of data gathering (the sample mean was $\bar{x}$=3.12 concern compared to $\bar{x}$=4.26 for older adults), they also adopt more proactive defensive strategies such as providing false information. This indicates a refined privacy calculus in which younger generations perceive surveillance as unavoidable yet adopt strategic countermeasures, an approach termed "privacy pragmatism" in recent scholarship (Berriman & Jaynes, 2022).

Comparisons of regional data with EU-wide figures highlight Hungary's unique standing. TikTok dominates privacy concerns (73.39% vs. Facebook's 44.3%), differing from Western European trends where Meta platforms usually lead the privacy discussion (Bruin, 2022). This could stem from TikTok's delayed introduction to the Hungarian market, which generates a novelty bias in perceived risks, or distinct cultural factors influencing trust in the platform (Durmishi, 2024).

4.3. GDPR Awareness and its Impact on Data Privacy Behaviors

The study identifies notable behavioral distinctions between GDPR-aware and unaware respondents, as the GDPR-aware group, which makes up merely 35.27% of the sample (n=71), shows more cautious data practices. As shown in Figure 1, individuals knowledgeable about GDPR indicated greater frequencies of submitting inaccurate details when registering online ($\bar{x}$=3.01 on a 6-point scale) relative to the general mean ($\bar{x}$=2.59), which implies that awareness of regulations promotes deliberate measures to safeguard privacy. This aligns with (Mühlhoff, 2023)'s findings on pseudonymization behaviors among regulation-conscious users.

App usage patterns diverged markedly between these groups. Although TikTok showed robust engagement in both groups (21.90% usage among respondents aware of GDPR), Meta's platforms experienced lower adoption, especially Facebook and Messenger, with GDPR-knowledgeable users reporting 18% fewer interactions. Instagram stood as an outlier, keeping 78% of its user base within the informed group, although the time spent daily dropped by 12 minutes. This targeted withdrawal implies that GDPR consciousness prompts evaluations of risk tailored to individual platforms instead of a generalized retreat from data-heavy services, aligning with (Garcia-Rivadulla, 2016)'s framework of situation-specific privacy decision-making. Risk perception data further underscored this dichotomy. Within the GDPR-conscious group, 83.33% cited social media as their foremost privacy issue, reflecting a 15% rise compared to the broader sample. TikTok's risk attribution remained high (65.79%) but showed a 7.6 percentage-point decline from the overall average, while Facebook's perceived danger increased by 9.8 points (54.2% vs. 44.3%). These changes suggest that regulatory instruction increases awareness of particular data operations, including Meta's cross-platform monitoring, while slightly reducing worries regarding emerging services such as TikTok, which contradicts expectations of consistent risk perception (Agboola, 2025). Age-stratified examination showed that younger GDPR-informed individuals (18-25 years) had higher fake data scores ($\bar{x}$=3.24) relative to their uninformed counterparts ($\bar{x}$=2.91), indicating that awareness of regulations intensifies preexisting youth privacy strategies instead of introducing novel behaviors. This group also showed the most refined data collection attitudes, with 77.78% indicating their concern "depends on the app", a 25% greater proportion compared to uninformed participants in the same age range. Such app-specific discernment reflects (Ma & Chen, 2023)'s observations about younger users' ability to differentiate between platform architectures.

The findings highlight the necessity for privacy education tailored to specific platforms, which tackles these conflicting behaviors. Although GDPR awareness seems to motivate protective behaviors, its low adoption rate (35.27%) indicates that the majority of users act without comprehending their rights, a disparity that is especially pronounced in older age groups, who show greater concern but possess less knowledge. Focused strategies can capitalize on young people's technological flexibility (Sas et al., 2023).while meeting older adults' requirements for straightforward privacy solutions

The dashboard in Figure 1 underscores three key GDPR-awareness outcomes:

1. a rise in false data submission among all age demographics, most notably for individuals aged 25-35 ($\bar{x}$=3.45);
2. greater perception of risk associated with well-known data aggregators such as Facebook and
3. continued interaction with image-centric platforms (TikTok, Instagram) irrespective of privacy apprehensions.

These trends indicate that GDPR instruction does not consistently diminish platform activity but instead restructures interaction patterns, which (Solove, 2021) describes as „privacy-conscious" participation. Qualitative insights from open-ended responses contextualize these trends. Participants conscious of GDPR often reported adopting „data minimization" strategies, including temporary email addresses for sign-ups or turning off ad tracking, while preserving essential platform features. A 24-year-old female participant stated: "I am aware that Instagram gathers my personal information, but I restrict what I post and employ a virtual private network." The platform's value outweighs the risk if managed properly. The research also uncovers an unexpected inverse relationship between GDPR awareness and blanket privacy rejection. Contrary to expectations that understanding regulations would lead to total platform disengagement, no respondents knowledgeable about GDPR stated they were "not at all concerned" by data gathering, which stands in sharp opposition to the 8.3% of uninformed participants who expressed this view. Hungary's regulatory context adds further nuance. Compared to Western EU averages where GDPR awareness exceeds 50% (Milošević et al., 2018), the study's 35.27% literacy rate reflects persistent educational gaps, likely exacerbated by limited local-language resources and lower corporate compliance pressures (Molnár-Gábor et al., 2022). This shortfall might clarify why even informed participants display varied actions, since incomplete comprehension could result in irregular adherence to privacy norms.

These findings carry implications for both policy and platform design. The relationship between understanding GDPR and engaging in protective privacy actions (e.g., supplying false information) indicates tailored educational initiatives may strengthen user agency, especially among older groups presently displaying less adaptive conduct. Nevertheless, the continued reliance on high-risk platforms suggests that mere regulatory awareness is insufficient to address structural dependencies on such platforms, calling for additional technical measures such as decentralized architectures (Mehta, 2023). The primary contribution of the study rests in showing that GDPR awareness functions as a behavioral modifier instead of a dichotomous mechanism, altering rather than removing interaction with data-heavy platforms. This contradicts dominant accounts of regulatory ability to prompt large-scale user shifts across platforms (Argenziano & Bonatti, 2023), emphasizing the necessity for more detailed digital literacy strategies tailored to distinct platform risks. Subsequent studies ought to investigate how these trends develop as TikTok and comparable platforms experience growing regulatory oversight in the European Union.

4.4. Perceptions and Concerns about Artificial Intelligence

The research's analysis of AI perceptions also reveals striking generational divides in both exposure and tolerance levels (Figure2). Out of 207 valid responses, younger users aged 18-25 years reported coming across AI-driven content most often, with 68% experiencing it daily or multiple times daily, which is 2.3 times greater than the 25-35 age group's 29%. This disparity aligns with platform usage patterns, as TikTok, whose core functionality relies on AI-powered recommendations, dominated youth screen time (63 daily minutes). The data corroborate (Iwuanyanwu, 2023)'s findings on algorithmic mediation's ubiquity in youth digital experiences, though our study highlights TikTok's outsized role compared to Meta's platforms.

Figure 2. Artificial Intelligence Dashboard

Source: author' own editing in Power BI based on primary research(N=207)

Concern levels showed an inverse age gradient as older respondents reported markedly greater anxiety ($\bar{x}$=5.36 for over-65s) compared to younger individuals ($\bar{x}$=3 for 18-25-year-olds). This disparity indicates that digital natives have become accustomed to algorithmic curation, while older users view it as invasive, which (Moravec et al., 2024) describes as „algorithmic unfamiliarity syndrome." The dashboard visualization in Figure 2 shows that concern increases linearly with age, whereas AI acceptance displays a U-shaped pattern: reaching its highest level among 25-35-year-olds ($\bar{x}$=5.04), declining abruptly at 45-55 ($\bar{x}$=3.35), and then recovering slightly among older individuals ($\bar{x}$=4.00). This nonlinear pattern suggests middle-aged users could form a pivotal transitional cohort, both conscious of AI risks and lacking adequate coping mechanisms.

Platform-specific AI awareness indicated TikTok had the highest perceived algorithmic presence (84% of users acknowledged its AI features), with Instagram (72%) and Messenger (68%) trailing behind. Facebook ranked lower at 53%, which could indicate either reduced awareness of its AI capabilities or diminished user interaction with its recommendation algorithms. These results contradict (Chung et al., 2021)'s premise of uniform AI perceptions across all Meta products, highlighting distinct algorithmic prominence for each platform. Remarkably, TikTok's AI detection stayed consistently strong among all age demographics, which implies its algorithmic influence is transparent enough to bridge differences in digital literacy between generations.

The interactive dashboard enables cross-tabulation of AI metrics by demographics. As illustrated, both the frequency of interactions and preferences for platforms change distinctly across different age groups. The primary engagement of younger individuals with TikTok accounts for their elevated interaction with AI, whereas older groups experience infrequent interactions primarily

within functional applications such as WhatsApp, where algorithmic elements play a minor role in essential operations. This interaction effect in the platform era supports (Kadhim, 2024)'s claim about AI perceptions being shaped by design elements of interfaces and specific contexts of application. The geographical context implies that the low local AI adoption in Hungary could amplify unease due to lack of exposure among elderly Hungarians, while younger generations gain advantages from worldwide platform standardization.

Behavioral data further illuminate this divide. Younger participants with regular exposure to AI showed a 42% greater acceptance of personalized advertisements ($\bar{x}$=3.89 vs. $\bar{x}$=2.74 for rare exposure). Nevertheless, even youth with substantial exposure continued defensive behaviors such as data falsification ($\bar{x}$=3.24), which shows that AI acceptance does not imply absolute trust, a subtlety frequently neglected in binary privacy paradox frameworks (Pozen, 2016).The paper also uncovers an unexpected gender dimension: women aged 25-35 exhibited 18% higher AI concern ($\bar{x}$=3.67) than male peers ($\bar{x}$=3.11), despite similar exposure levels. This corresponds with (Prophet, 2025)'s study on gender-based algorithmic skepticism but diverges from younger groups where no notable disparity was observed, which suggests the need for additional inquiry regarding life-stage effects on technology distrust. These results carry implications for AI governance and digital literacy programs. The ongoing worry among elderly users, along with Hungary's slower adoption rate, indicates that region-specific educational programs could reduce unease by clarifying how algorithms function. Given that young people are frequently exposed to AI yet show minimal concern, tools promoting algorithmic transparency are necessary to make the risks and advantages of AI concrete while avoiding habituation (Lindley et al., 2020).

The research's primary contribution consists in charting the interplay between app-specific AI experiences and demographic factors in influencing perceptions. In contrast to previous studies that view AI as a uniform entity, our results indicate that TikTok's recommendation-focused architecture generates different user behaviors relative to Meta's more varied algorithmic strategies. Overall, the results show pronounced demographic asymmetries. Younger users (under 25) devote substantially more daily time to TikTok and YouTube (around 60–68 minutes), yet report lower levels of concern about AI and data collection than older cohorts. Only 35.27% of the sample correctly understand core GDPR provisions, but this GDPR-literate segment exhibits more active privacy management, including a higher propensity to provide inaccurate registration data (mean score 3.01 versus 2.59), lower reliance on Meta's data-intensive applications and more app-specific risk assessments. Social media is overwhelmingly perceived as the riskiest application category (72.41%), with TikTok simultaneously identified as the most privacy-threatening platform (73.39%) and one of the most intensively used services, illustrating a form of privacy resignation. Linking these micro-level patterns to Hungary's below-average AI adoption rate relative to the EU highlights how demographic structure and uneven GDPR literacy reinforce digital divides.

5. Limitations

The research also identifies key constraints which temper its findings. The sample's demographic skew toward younger, educated Hungarians limits generalizability to older populations and other cultural contexts where digital behaviors may follow different patterns. Although the mixed-methods strategy bolsters internal validity, dependence on self-reported screen time and privacy

behaviors introduces possible response biases, as participants might inaccurately report sensitive actions such as data falsification. Furthermore, the cross-sectional design precludes causal inferences about how GDPR awareness develops over time or how AI tolerance shifts with prolonged exposure. These limitations imply the observed outcomes may reflect transient stages of changing actions instead of enduring attributes.

6. Conclusion

This article has systematically examined the intricate relationships between age, GDPR awareness, and AI tolerance in shaping digital behaviors across Hungary and the EU. The results indicate younger users show greater involvement with AI-powered platforms such as TikTok but display less awareness of algorithmic influence, whereas those familiar with GDPR employ more cautious privacy measures without abandoning platforms entirely. These patterns underscore the limitations of universal privacy frameworks and highlight the need for demographic-specific approaches to digital literacy and regulation. The study advances theoretical discussions by contesting the privacy paradox framework, uncovering a range of adaptive approaches individuals adopt depending on their technical proficiency and understanding of regulations.

Looking ahead, the study identifies critical gaps for future investigation, particularly the longitudinal tracking of how AI tolerance evolves across life stages and the development of platform-specific privacy education models. The enduring generational gaps in digital practices indicate that new technologies will keep transforming privacy standards in an uneven manner, calling for joint efforts among policymakers, technologists, and educators from diverse fields. As AI grows increasingly integrated into social platforms, this study establishes a basis for creating governance structures that harmonize progress with moral concerns, guaranteeing fair digital engagement among all population segments.

Hungary trails the EU average in the adoption of artificial intelligence, which indicates a more gradual assimilation of technology. These results underscore the intricate connection among age, awareness of regulations, and trust in digital technologies, highlighting the necessity for specific strategies to boost digital competence and ethical governance of artificial intelligence.
The study advances policy debates by empirically substantiating demographic differences in technology engagement and privacy perspectives, delivering practical guidance for stakeholders in education, regulation, and platform design.

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Navigating the Global Energy Revolution: Challenges and Opportunities in the Transition to Sustainability

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Abstract: The global energy sector is undergoing a significant transformation, driven by decarbonization, decentralization, and the adoption of digital technologies. As nations strive to achieve carbon neutrality by 2050, the demand for fossil fuels is declining, with renewables poised to supply nearly half of global electricity by 2030. The rise of "prosumers," localized microgrids, and smart energy solutions is challenging traditional utility models, while increasing reliance on digital infrastructure introduces heightened cybersecurity risks. Geopolitical tensions further complicate energy supply chains, with regions like Central and Eastern Europe facing unique challenges in transitioning from coal and nuclear power to renewable energy sources. The Energy Transition Index (ETI) highlights countries' progress toward sustainable energy systems, emphasizing environmental sustainability, energy security, and economic growth. Nordic nations lead in renewable adoption, while emerging economies encounter infrastructural and investment barriers. In Central and Eastern Europe, nations like Poland and Hungary are advancing solar energy adoption, though policy instability in the Czech Republic may hinder progress. Success in the energy transition requires embracing AI, modernizing infrastructure, addressing regulatory complexities, and fostering skilled talent. Consumers, increasingly empowered by energy transparency and renewable options, are reshaping the industry. Despite challenges, bold strategies and investments in clean technologies are essential to navigating this high-stakes revolution and ensuring a sustainable energy future.

Keywords: energy transparency, sustainability, Central and Eastern Europe, renewable energy, energy transition
JEL codes:

1. Introduction

The global energy revolution is undergoing an accelerated change, with the prediction that by 2030 the landscape will have undergone significant transformation. The dominance of clean energy sources is anticipated, with renewables projected to account for almost half of the world's electricity supply. This transformation is not confined to solar and wind energy; substantial investments are planned to exceed those in fossil fuels, thereby reshaping the global energy economy. This paper reviews contemporary researches to identify which are the main factors and forces that reshape the global energy platforms.

The first Net Zero Roadmap report by the International Energy Agency highlighted that the energy sector is responsible for about three-quarters of current greenhouse gas emissions. This means it has a key role to play in avoiding the worst effects of climate change, which is probably the most important challenge facing humanity. We can achieve net zero global CO_2 emissions by 2050 while limiting the long-term increase in average global temperatures to 1.5°C. This objective demands a transformation in the way energy is produced, transported and consumed (IEA, 2021).

The 2020s shall represent a massive clean energy expansion, which should not be considered as only a theory. The technologies needed for achieving the necessary reduction in global emissions

by 2030 already exist, but different further policies and measures are needed to be widely implemented (IEA, 2023).

The main goal of this study is to summarize the main drivers and desired steps of energy transition, focusing on the forces that shape energy industry, the critical success factors of the transition process. A special focus is set on Central and Eastern European countries, to show their present situation and their energy transition process using the Energy Transition Index introduced by the World Economic Forum.

2. Forces and directions reshaping energy industry

2.1. Drivers of energy transition

Climate change is a global emergency that requires international cooperation. To address the problem, world leaders agreed and signed the Paris Agreement in 2015, which set the common long-term goals about the substantial reduce of greenhouse gas emissions, to hold global temperature increase below 2°C and pursue efforts to limit it to 1.5°C above pre-industrial level. This could reduce the risks and impacts of climate change. periodically assess the collective progress towards achieving the purpose of this agreement and its long-term goals (United Nations, 2015a).

Recent studies highlighted that energy transition is not spontaneous process it is influenced by technological innovations, socio-cultural influences, market mechanisms (i.e. the players of business environment) and the different policies designed by national or international bodies (Stern et al., 2016; Geels et al., 2017; Geels, 2022). Yang et al. (2024) underlined the multi-dimensionality of the energy transition process and revealed that the interactions between technological innovations, market mechanism, policy design, and socio-cultural background are the key driving forces of the transition. These drivers influence each other; thus, they should be considered as a system (Fig. 1.).

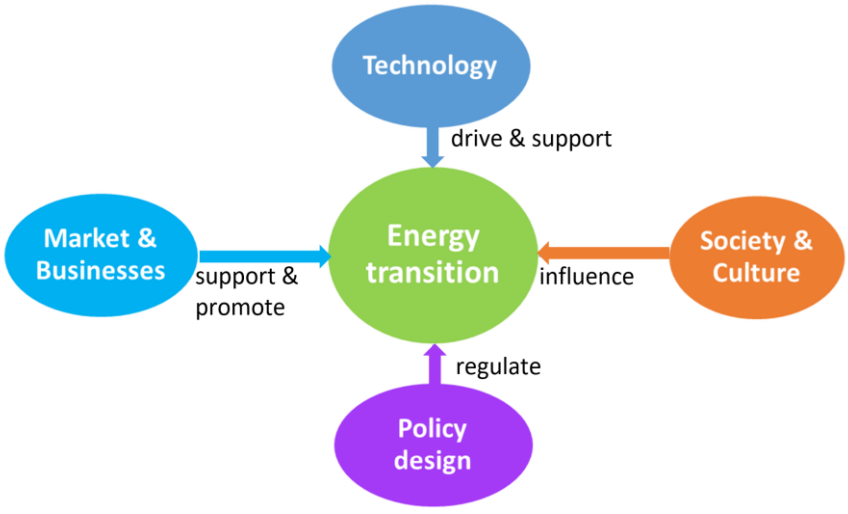

Figure 1. Drivers of energy transition process
Source: own, based on Yang et al. (2024)

Technological innovation in renewable energy is key to the success of the energy transition. Technological progress is driving this transition by innovating energy production, altering energy system elements and ensuring the integration of low-carbon technology. Innovation improves energy system structure and optimizes resource allocation, boosting production and efficiency. Conversely, renewable energy technology is increasingly integrated into modern information and smart grids, producing new products, patterns and business models of energy utilization. This will improve energy efficiency and promote low-carbon energy transitions (Yang et al., 2024).

The energy transition is also driven by market dynamics. Achieving net-zero emission targets will require phasing out fossil fuels, highlighting the role of market mechanisms. The declining cost of low-carbon technology is driving the commercialization of renewables, leading to low-carbon energy transitions (Adedoyin et al., 2020, Molnár & Horváth, 2025).

Effective policy design regulates energy transitions, and supports initiating and accelerating energy transitions, by formulating an appropriate environment and supportive framework for the transition process (Coenena et al. 2021, Horváth et al. 2023).

Finally, members of the society and their cultural factors and traditions (i.e. education and knowledge level, gender, family structures, habits, house building materials, heating systems, etc.) fundamentally influence local energy consumption habits and their technical solutions. These factors determine fuel choices and efforts to promote the energy transition (Stephenson et al., 2010, Sovacool & Griffiths, 2020; et al.).

2.2. Net Zero Emission by 2050 priority actions

As summarized by the International Energy Agency (IEA, 2021), achieving net zero emissions by 2050 requires the fast implementation of current technologies and the adoption of future ones. Significant innovation is needed in the next decade to ensure the introduction of these new technologies on time. By 2050, half of the reductions will come from technologies currently in the demonstration or prototype stage. In heavy industry and long-distance transport, emissions reductions from technologies still in development are even more significant. The most significant innovation opportunities are in advanced batteries, hydrogen electrolysers, and direct air capture and storage.

For the success of the process the priority actions are as follows:

- Supporting innovation: Government R&D spending should be increased and reprioritized. The critical areas (electrification, hydrogen, bioenergy and carbon capture, utilization and storage) presently count for only 30% of public R&D funding compared to the more established areas of low-carbon electricity and other energy-efficient technologies.
- Participation of citizens: Net zero pathway targets cannot be reached without the active support and participation of the society. The changes will have different impacts on the behavior and life of the citizens in different countries, regions, industries and jobs. According to estimates by the International Energy Agency (IEA, 2021), approximately 55% of emissions reductions may be attributable to human activity and consumer behavior. This includes energy-efficient home reconstruction and using alternative transport like

walking, cycling or public transport instead of cars. Energy transitions must consider the social and economic impacts on people and communities and treat people as active participants. The transition to net zero brings new employment opportunities thanks to new activities and investment in clean energy. But these opportunities are often in different locations, sectors and require different skills.

- Policy development, implementation and financing: Supportive policies must be created in order to unlock new business models and mobilize private spending, especially in emerging economies. Accelerated delivery of international public finance will be critical to energy transitions, especially in developing economies. The private sector will need to finance most of the extra investment required. Developers, investors, public financial institutions and governments must cooperate to provide available capital for large-scale infrastructure (IEA, 2021).

2.3. Key elements of decarbonization

The main principles of decarbonization within the global energy system encompass a range of key elements. They are a mix of hard (technological) and soft (human) issues, including energy efficiency, behavioral changes, electrification, the utilization of renewables, hydrogen and hydrogen-based fuels, bioenergy, and the strategic management of carbon through carbon capture, utilization and storage (IEA, 2021).

Energy efficiency: According to Net Zero Emissions scenario (NZE), it is vital to minimize energy demand growth through better energy efficiency. A range of efficiency measures can be quickly introduced and scaled up. These measures are key to reducing energy demand and emissions before 2030. After 2030, energy efficiency will keep improving but will do less to reduce overall emissions as other measures become more important.

Behavioral change: The energy sector is changing. This will only happen if citizens get involved. They are the ones who use and pay for energy. Their choices will be key to making the energy system sustainable. The adoption of low-carbon technologies, which constituted almost 40% of emissions reductions in the NZE, necessitated substantial policy support and investment (for example in steel industry and electricity production), but direct engagement from citizens or consumers was minimal. Further emissions reductions (55%) require low-carbon technologies and citizen/consumer involvement. This may include solar water heaters or electric vehicles. Behavioral changes and materials efficiency (8%) also reduce energy demand, e.g. less business flights and travel. Consumer attitudes can influence business investment decisions.

Electrification: Using low-emissions electricity instead of fossil fuels is key to the NZE, accounting for about 20% of the emissions reduction by 2050. Global electricity demand is set to rise sharply between 2020 and 2050, with the industrial sector leading the way. Electricity's share of the transport sector is set to rise from less than 2% in 2020 to around 45% in 2050 under the scenario. By 2030, over 60% of global passenger car sales are expected to be electric, up from 5% in 2020. The global car fleet will be almost fully electrified by 2050, with the remaining vehicles being hydrogen-powered.

Renewables: The key to reducing global electricity emissions is the use of renewable energy technologies. Hydropower has been a leading low-emission source for many decades, but wind and solar energy will triple renewables generation by 2030 and increase it more than eightfold by 2050. Dispatchable renewables are vital for electricity security, along with other low-carbon generation, energy storage, and networks.In the NZE scenario, the main renewables in 2050 are hydropower (12%), bioenergy (5%), concentrating solar power (2%), and geothermal (1%). Renewables have a significant impact on emissions reduction in buildings, industry and transport. They can be used indirectly (through electricity or district heating) or directly (for heat production). In transport, renewables also help reduce emissions indirectly by generating electricity for electric vehicles. They also contribute to direct emissions reductions through liquid biofuels and biomethane.

Hydrogen and hydrogen-based fuels: The main focus is on using hydrogen to convert existing fossil energy into low-carbon hydrogen, with no need for new infrastructure. This covers industrial use, refineries, power plants, and blending hydrogen with natural gas for distribution.

Bioenergy: In 2020, 90% of global primary demand for bioenergy was solid biomass. Around 40% of this was used in conventional cooking methods, which are inefficient and polluting. The use of solid biomass will end by 2030 as set out in the NZE in line with UN Sustainable Development Goal 7 (United Nations, 2015b). Household and village biogas digesters in rural areas are set to provide renewable energy and clean cooking for households by 2030 and total biogas use is projected to rise by in 2050. Half of total biomethane use is in the industry sector, where it replaces natural gas as a source of process heat, and its use is to be widened in building & construction and transport sectors.Bioenergy's key advantage is that it can use existing infrastructure: biomethane can use existing natural gas pipelines and end-user equipment, while many drop-in liquid biofuels can use existing oil distribution networks and be used in vehicles with only minor alterations.

Carbon capture, utilization and storage (CCUS): CCUS involves capturing CO_2 from power generation or industrial facilities using fossil fuels or biomass. If not used on-site, it is compressed and transported to be employed in various applications or injected into deep geological formations. The transition to net-zero CO_2 emissions can be achieved through tackling emissions from existing assets; providing a means to address emissions from some of the most challenging sectors; providing a cost-effective way to scale up low-carbon hydrogen production rapidly; and allowing for CO_2 removal from the atmosphere .

Focusing on the common goal of achieving carbon neutrality by 2050, there is a shared recognition of the need to transition away from fossil fuels (Yang et al., 2024). The development of renewable energy technologies, in conjunction with evolving regulations, is creating opportunities for new participants in the energy sector, including small companies and large tech and telecommunications firms. Additionally, large oil and gas companies are exploring opportunities to diversify their portfolios and direct funds into renewable energy, and the transition to cleaner energy sources is to be intensified.

Governments around the world are using green energy technologies in an effort to alleviate detrimental climate change impacts (Zeng et al., 2022). The massive dependence on traditional fuels is a root cause of environmental challenges. Several studies have examined consumers' desire

to adopt green energy technologies in emerging nations. Earlier investigations were performed in countries that had already formulated strategic policies to achieve net-zero carbon emission goals (Irfan et al. 2020).

3. Critical success factors for successful transition

3.1. Revision of the original Net Zero Emission strategy

The path to 1.5 °C has narrowed, but clean energy growth remained the main goal, the global energy system shall be transformed. Due to the external changes (environmental, political, technological and social) the original targets should have been modified. August 2023 was one of the hottest months on record, it is obvious that climate change is becoming more frequent and severe (IPCC, 2023). Global CO_2 emissions from energy hit a record high, 1% above pre-pandemic levels. The IEA has revised its projections, anticipating that demand for coal, oil and gas will also peak within this decade. While encouraging, this falls short of the 1.5°C goal (IEA, 2023a).

The implementation of clean energy policies is being accelerated on a global scale. A growing number of countries and businesses are demonstrating a strong commitment to achieving net zero emissions targets. Significant progress has been witnessed with 93 countries and the European Union having formally committed to achieving net zero emissions targets. In addition, governments worldwide, particularly in advanced economies, have introduced new measures to promote the uptake of renewables, electric vehicles, heat pumps, energy efficiency and other clean energy technologies in response to the pandemic and the global energy crisis.
The rapid increase in clean energy investment and deployment has been driven by market signals and financial incentives provided by governments. Mass-manufactured technologies, such as solar systems and electric vehicles have been identified as key drivers of this growth. In addition, sales of residential heat pumps and stationary battery storage are also increasing rapidly.

The 2021 IAE report relied on early-stage technologies to achieve net zero emissions by 2050. However, the updated report shows a drop in the proportion of emissions reductions due to these technologies. In 2021, technologies in the prototype or demonstration phase accounted for nearly 50% of the necessary emissions reductions, however, this is now decreased to about 35%. This shift is due to a combination of factors, including initiatives to advance and commercialize novel clean energy technologies, driven by government policies and the growing market value of the clean energy sector. There has been a significant increase in energy R&D spending by global companies' clean energy venture capital inflows persist despite the challenging macroeconomic environment (Fig. 2.)

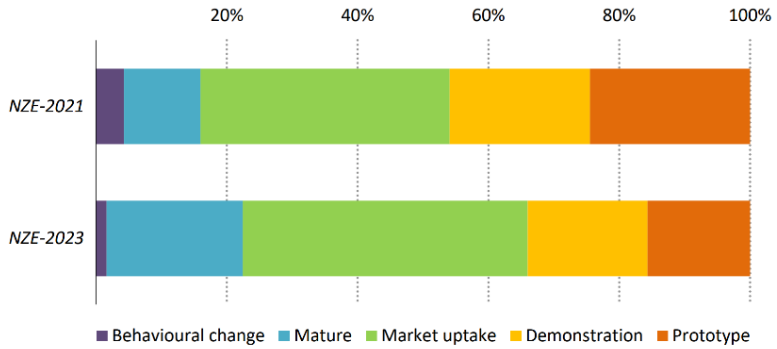

Figure 2. Comparison of CO_2 emissions reductions in 2050 compared to base year by technology maturity in the 2021 and 2023 NZE Scenarios
Source: IEA (2023b) p. 46.

3.2. Challenges in the transition to clean energy

The transition to clean energy affected fundamentally the energy sectors worldwide. The switch to clean technologies, the different elements of the transition process brought new challenges for the global supply chain and the players and consumers of the energy sector. Assumed by Rich & Rosenberg (2024) the top five forces of the transition are the following:

1. Decarbonization as a response to climate change: The development of renewable energy technologies, in conjunction with the evolution of pertinent regulations, has resulted in the attraction of new participants to the sector, including small companies and large tech and telecommunications firms. Furthermore, major oil and gas companies are diversifying their investment portfolios by allocating funds to the area of renewable energy. Consequently, the transition to cleaner energy sources is projected to accelerate.

2. Decentralization of energy production: The energy transition involves individual households and commercial enterprises generating electricity through renewable energy sources and localized microgrids including rooftop solar panels and electric vehicles. As an increasing number of individuals and businesses become energy producers, the conventional utility model is being confronted with significant challenges.

3. Cyber threats are increasing: Energy infrastructure is becoming more digital which makes it more vulnerable to cyberattacks. The reason for this is the integration of more and more connected devices and sensors. This increases potential vulnerabilities and complicates security measures.

4. Decentralization of energy production: The nuclear power industry is heavily reliant on foreign sources like uranium. This poses significant risks to energy security and stability. Current global geopolitical tensions, particularly with Russia, make this reliance particularly concerning. Other key players, such as Kazakhstan and Uzbekistan, may also be affected by regional instability.

5. Geopolitical turbulence continues: Geopolitical instability is also one of the major global challenges. International conflicts and political instability can disrupt access to vital resources such as oil, gas and raw materials for energy production, which can in turn threaten the global energy supply chain (Rich & Rosenberg, 2024).

3.3. New landscape, challenges, risks

The latest trend is clear: the provision of energy solutions as a service. This model provides energy management services, distributed energy resources and microgrid solutions to commercial and industrial customers (Kivimaa et al., 2022). The global energy landscape undergoes turbulent changes therefore the next five years may present certain challenges for energy leaders. As demand for fossil fuels reaches its peak and geopolitical turbulence reshapes supply chains, it may be advisable for leaders to consider prioritizing cybersecurity, fostering talent with cutting-edge skills and engaging with consumers who are increasingly empowered and eco-conscious (Gawel et al., 2019; Asif, 2022)

Mata Pérez et al. (2019) highlighted that energy security priorities of EU Member States vary due to differences in geography, natural resources, history and political traditions, and this in turn influences their positions on common European initiatives. They defined two rough clusters of EU Member States, which were defined in accordance with two principal indicators. Firstly, the degree of energy import dependency, in conjunction with the concentration of suppliers (Russia, in particular), secondly, the macroeconomic benefits of increased renewable energy penetration – in terms of electricity prices, low-carbon technology patents, market shares and turnover. The countries in the "green" cluster (basically the EU-15 member states) see energy transition as a way of combating climate change and a commercial opportunity in renewable energy. They also pursue policies to diversify their energy mix and increase their import dependency. "Blue" cluster includes member states accessing after 2004, there defend highly on imports and have a strong market concentration. Their most important (or only) supplier is Russia. It is clear that these countries shall build a different scenario for transition. In this environment where adaptability is key, those who are able to adapt may find themselves in a position of advantage.

In their model, Kivimaa et al. (2022) presented that the speed and nature of technological change is influenced by not only the technological factors, but by social elements, too, by the actors and their interactions in networks. Nevertheless, the impacts of informal and formal rules and institutions play also an important role, by balancing the two other elements. Technology covers resource and technology dependencies, infrastructure, risk of cyber-attacks, weather shocks etc. which should be managed closely. Actors or players are human-related challenges. Actors are linked to technologies, i.e. how they use new technologies and associated services. Those state actors who fail to face the advancing energy transition risk will represent a worse geopolitical position. These challenges may bring risks for technological adjustments and the global energy transition progress.

4. Energy Transition models

4.1. Energy Transition Index

The Energy Transition Index (ETI) is a measuring tool to show how countries perform in the transition to sustainable energy systems. ETI shows how countries manage their energy transition process, with a focus on sustainability, security and affordability. ETI represents a significant advancement in the field of energy systems benchmarking, offering a comprehensive and systematic framework to assess the performance of global energy systems in the transition process

towards a sustainable energy future. ETI utilizes a data-driven approach to evaluate the current energy system performance of 120 countries across three key dimensions: equity, sustainability, and security. It also assesses the readiness of the enabling environment concerning policies, regulatory frameworks, infrastructure, innovation, education and human capital, as well as finance and investment (WEF, 2024).

The original ETI framework evaluated the so-called energy triangle, i.e. the security and access to energy sources, the environmental sustainability and the economic development and growth related to the evaluated country. Other influencing factors were also taken into consideration: capital and investment, regulation and political commitment, institutions and governance, infrastructure, and innovative business environment, human capital and consumer participation, and the energy system structure (WEF, 2020).

The present methodology displays the system performance of the country and the transition readiness, accordingly. The country's energy system performance is assessed according to these three imperatives: 1) Equity, i.e. fair distribution, accessibility and affordability of energy for all citizens and players; 2) Security: i.e. ensuring supply security in the energy mix; 3) Sustainability: i.e. promoting responsible consumption in accordance with global energy transition goals by increasing the share of clean energy.
Influencing factors of transition readiness are regulations and political commitment, finance and investment, human capital and education, infrastructure and innovation (Fig. 3.).

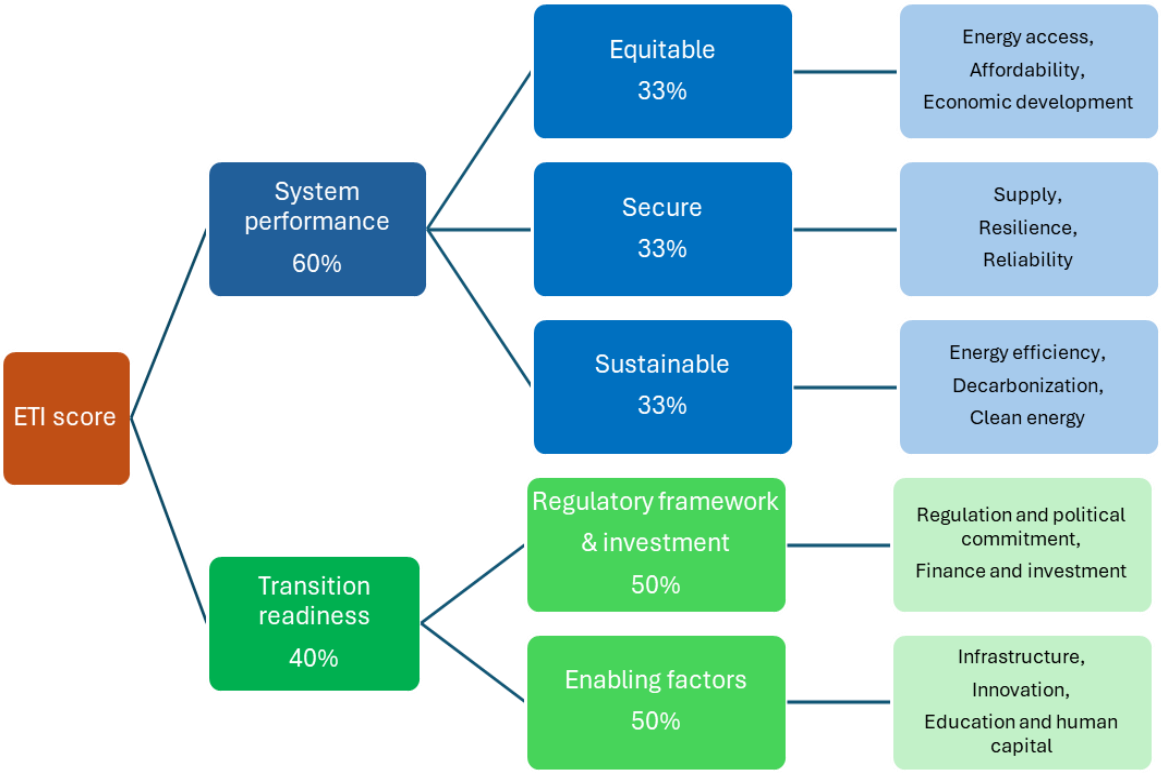

Figure 3. ETI methodology and indicators
Source: own figure based on WEF (2024) p. 44.

4.2. Global ETI rank

Global average ETI scores increased by 6% from 2015 till 2024, but the speed of growth has decreased in the past three years. The present global ETI average is 56.5. Countries are categorized according to their results into 7 groups:

- Advanced economies – average score is 64.8,
- Emerging and developing Europe – average score is 57.5;
- Middle East, North Africa and Pakistan – average score is 51.8;
- Sub-Saharan Africa – average score is 49.6;
- Latin America and the Caribbean – average score is 55.2;
- Commonwealth of Independent States – average score is 54.1;
- Emerging and developing Asia – average score is 53.9.

The top 10 countries are Sweden (78.4), Denmark (75.2), Finland (74.5), Switzerland (73.4), France (71.1), Norway (69.9), Iceland (68.0), Austria (67.9), Estonia (67.8), Netherlands (66.7). Hungary is the 28th (62.1), Poland is 31st (61.3).

The analysis of ETI data underscores the heterogeneity of national contexts, underscoring the necessity for nuanced global collaboration in the energy transition that transcends the implementation of uniform strategies. Analysis of ETI data shows the need for nuanced global cooperation in the energy transition. Key national characteristics include region, income level and local energy resources. (WEF, 2024).

The report highlighted 10 actions to improve the progress:

- The implementation of regulations to advance decarbonization is essential. Strong political commitment is required to ensure progress and continuity in decarbonization policies.
- It is vital to deliver energy equity for vulnerable households, such as social safety nets and compensatory measures, including cash transfers and temporary basic income initiatives to alleviate energy-related costs.
- There is a need to increase investments in clean energy infrastructure.
- Investments in energy efficiency solutions are crucial. Private companies must prioritize accelerated action, investing in energy efficiency and implementing robust governance processes.
- The upgrade of grid capabilities is essential for enhancing the efficiency of energy distribution.
- Enhanced collaboration between sectors and nations is crucial for the success of clean energy projects. The implementation of initiatives to attract capital for such projects and enhance the effectiveness of these investments (by inviting supporters, developing finance institutions, attracting private investors) is essential for driving growth in the clean energy sector.
- Lower emission intensity of fossil fuels.
- Drive R&D and adoption of new technologies.
- Accelerate decarbonization, for which technology, market and regulatory environments are needed to deliver cost reduction of green technologies.

– Prioritize the development of a skilled workforce for the energy sector. This includes reskilling workers affected by the energy transition and providing new skills and capacity building to those who will benefit from newly created jobs.

5. Energy Mix and Transition Efforts in Central and Eastern Europe

5.1 Traditions and challenges in energy mix of CEE countries

Poland and Czech Republic have historically relied heavily on coal. but recent developments indicate a shift toward renewable energy sources, mostly in solar systems. Poland has seen significant growth in solar energy production, becoming one of the key drivers of solar growth in Europe. Slovakia and Hungary are reliant mostly on nuclear power, but working toward integrating more renewable energy sources into its energy mix (Kochanek, 2021; Maguire, 2024; Moldicz, 2024).

Kochanek (2021) analyzed the energy transition in the Visegrad Group (V4) countries—Poland, Czech Republic, Slovakia, and Hungary—highlighting their dependence on fossil fuels and the challenges they face in shifting to renewable energy sources (RES) while aligning with the European Green Deal (2020–2030). The main findings show the following results:

Diverse Energy Approaches:
- Poland is the most coal-dependent and faces the greatest challenge in transitioning.
- Czech Republic, Slovakia, and Hungary have nuclear power, which helps their transition.

RES & Policy Implementation:
- Biomass is the primary RES in all V4 countries.
- Political ambivalence and reliance on fossil fuels slow down RES growth.
- EU policies drive change, but implementation varies.

Coal Dependency & Phase-Out Plans:
- Poland: Plans to phase out coal by 2049, faces the highest economic costs.
- Czech Republic: Aims for a 2030–2040 coal phase-out, investing in nuclear energy.
- Slovakia: Will exit coal by 2023, focusing on hydropower and biomass.
- Hungary: Targets a 2030 coal exit, with nuclear and solar as main alternatives.

Challenges:
- High costs of energy transition, especially for Poland (€240 billion estimated).
- Socioeconomic impacts due to coal job losses (90,000 in Poland, 20,000 in Czechia).
- Infrastructure changes required for integrating RES and nuclear.

The energy transition is crucial but difficult for the V4 due to economic, social, and infrastructural factors. While nuclear energy and RES play a growing role, coal dependency remains a key challenge. The speed and success of this transition will depend on EU funding, policy adjustments, and technological advancements.

The energy and climate policies of the Visegrad Group countries are shaped by multiple factors, including political, economic, social, security, and environmental concerns. The transition from fossil fuels to renewable energy sources (RES) is occurring at different speeds in each country due to varying levels of coal dependency, energy security strategies, and economic conditions.
The energy mix in each country reflects their different approaches to energy security and transition. Poland and Czech Republic rely heavily on coal, while Slovakia and Hungary depend primarily on nuclear energy. Natural gas imports are increasing in all four countries, and RES still play a relatively small role but are growing (Table 1.).

Table 1. Structure of net electricity generation in the Visegrad countries in 2019.

Energy Source	Czech Republic	Slovakia	Poland	Hungary
Coal	44.2%	8.5%	73.9%	11.6%
Natural Gas	6.8%	10.2%	9.3%	25.1%
Nuclear	34.6%	54.0%	0%	48.2%
Renewables (Total)	12.7%	23.3%	15.6%	13.9%
- Biomass	5.8%	3.0%	4.2%	6.1%
- Hydroelectric	2.7%	17.6%	1.4%	0.7%
- Solar/Photovoltaics	3.4%	2.6%	0.5%	4.9%
- Wind Energy	0.8%	0%	9.4%	2.2%

Source: own compilation based on Kochanek (2021)

In the progress in RES Development all V4 countries have incorporated EU policies on renewable energy into their national strategies, but implementation varies. Czech Republic & Hungary have met their 2020 RES targets (13%), Slovakia exceeded its target (14%) due to biomass and hydropower. Poland failed to meet its 2020 RES goal (15%) and had to buy "virtual" RES credits from other EU nations.

V4 nations are gradually reducing coal use, but at different paces, which depends on the traditions and coal resources of the countries. Slovakia will stop coal mining by 2023, replacing it with biomass and hydropower. Hungary plans a coal exit by 2030, relying on nuclear and solar energy. Czech Republic aims for a 2030–2040 coal phase-out, with nuclear playing a key role, and Poland will be the last to phase out coal, aiming for 2049 due to its strong coal industry.

5.2. Energy Transition Goals for 2030 in the V4 Countries

Each country has set specific targets for reducing CO2 emissions, increasing RES, and improving energy efficiency (Table 2.).

Table 2. Energy transformation goals for 2030 in V4 countries

Target	Czech Republic	Hungary	Poland	Slovakia	EU Goal
RES in final energy	22%	21%	21-23%	19.2%	32%
CO_2 Reduction (Non-ETS)	-14%	-7%	-7%	-20%	-30%
Coal Exit Date	2030/2040	2030	2049	2023	2040
Energy Efficiency Improvement	8% / 84 PJ	10%	23%	30.3%	32.5%

Source: own compilation based on Kochanek (2021)

Summarizing the main challenges and barriers of transition, the following key issues are to be highlighted. The main problems are listed as economic, social, technological and political:

Economic Costs
- Poland faces the highest cost (€240 billion), double the EU average.
- Energy price increases may cause public resistance, particularly in Poland and Hungary.

Job Losses in the Coal Sector
- Poland: ~90,000 coal jobs at risk.
- Czech Republic: ~20,000 coal jobs at risk.
- Additional employment in related industries also at risk.

Energy Infrastructure Issues
- Current electricity grids were designed for coal and nuclear power.
- Poland needs to redesign its system for offshore wind and nuclear in the north.

Political Resistance
- Poland & Czech Republic: Still provide government subsidies to coal.
- Hungary: Limits wind energy development through restrictive policies.
- Czech Republic: Seeks to classify nuclear as "green energy" for EU funding.

Public Attitudes Towards Green Energy
- Younger generations and urban populations support energy transition.
- Coal-dependent regions are resistant due to economic concerns.

Slovakia is leading the transition, with a clear coal exit plan by 2023. Hungary and the Czech Republic are focusing on nuclear and solar energy, and Poland lags behind, due to its heavy reliance on coal and high transition costs.

These findings are similar to the global challenges of energy transition and also in line with the WEF categorization and findings about the Visegrad countries. As a solution, EU funding and policy changes will be critical in shaping the future of energy in V4 countries.

5.3. Future challenges in Central Europe

In absolute generation terms, the five largest solar producers in Central/Eastern Europe still rank a distant third in the region behind the five largest solar producers in Western and Southern Europe.

Through the first seven months of 2024, Western Europe's largest solar producers generated 83.53 TWh of electricity, while Southern Europe's five largest solar producers - Greece, Italy, Portugal, Spain and Turkey - generated 76.12 TWh. The 25.2 TWh of solar electricity generated by Central and Europe's five largest solar producers looks small comparatively.

However, over the past three years the Central/Eastern European region has boosted solar generation by roughly 49% a year, which dwarfs the 19% annual growth pace for Europe as a whole, the 16% pace of Western Europe, and the 21% for Southern Europe. If those growth rates

were sustained for the rest of this decade, the generation total by the five largest Central and Eastern solar producers would surpass that of their peers in Western Europe in 2029 and those of Southern Europe in 2030.

Moldicz (2024) underlined, that the war in Ukraine accelerated the European Union's energy transition, prompting a strong focus on renewable energy investments to enhance energy independence. Despite a heavy reliance on foreign technologies, particularly from China, the EU remains committed to reducing energy import dependence and diversifying its energy mix. In 2023, the EU invested $360 billion in the energy transition, ranking second only to China. Solar energy capacity saw a 60% increase compared to pre-war levels, contributing to a 44% share of electricity generation from renewables. However, fossil fuel dependency continues to influence energy prices, posing economic challenges for the widespread adoption of renewable energy.

6. Conclusions

As a summary, we should put focus on the challenges of the next years. As it is a global experience, energy transition, clean energy production and utilization are complex processes all over the world. The most important issues to be considered are the continuity of energy, providing energy at acceptable prices to all consumers; and to produce and consume environmentally friendly energy not only at global, national and regional level, but also at individual level.

With a special view on Central and Eastern Europe, although specific rankings for these countries are presently not available in the provided sources, the information based on professional reports, statistical data and literature sources indicates a region in transition. Poland and Hungary are making significant strides in solar energy adoption, while the Czech Republic and Slovakia are also working toward diversifying their energy mixes. However, policy stability and clear support mechanisms are crucial to sustain and accelerate this progress. This research focuses on the impacts of energy transition in all three sustainability aspects: social, environmental and economic impacts are reviewed and summarized together with possible policy and managerial considerations.

The importance of socio-cultural issues also should be highlighted, as it represents important factors in the transition according to Net Zero Emission strategy and the Energy Transition Index methodology. Education, presenting good practices for the young generations are vital for the future of the process. Transition will generate new technologies, new jobs with special and new skill requirements, which should be taught by education institutions, special trainings. The transition is not only technological, but also social, without social acceptance and positive attitudes, the targets cannot be reached by 2050.

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The effect of entrepreneurial leadership on Performance of Micro and Small Enterprises: Evidence from Awi Administration, Northwest Ethiopia

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Abstract: This study investigated the effect of entrepreneurial leadership on Performance of Micro and Small Scale Enterprises in Awi Administration, Northwest Ethiopia. Entrepreneurial leadership plays crucial role in the growth and sustainability of enterprises. However in developing economy such as in Ethiopia this concept remains under explored. The study employed explanatory, descriptive and cross sectional research design with quantitative approach. The data were collected through structured questionnaire from 346 employees in selected MSEs and analyzed using descriptive statistics, correlation and multiple regression techniques. The findings revealed that innovation, pro-activeness, risk taking and visionary leadership positively and significantly influence enterprises' performance. Among the dimensions innovative skill demonstrated the strongest influence followed by risk taking and pro-activeness and Visionary leadership. The study recommended that, fostering innovation, encouraging calculated risk taking, developing pro-active and visionary leadership practices are critical for enhancing the performance of MSEs.

Keywords: Entrepreneurial leadership, Micro and small sized enterprise, MSE performance, Northwest Ethiopia
JEL Codes: L22, M12, M19,

1. Introduction

Micro and Small Enterprises (MSEs) are pivotal in the world socio economic development. Many highly-industrialized countries have based their industrial development on MSEs in which they are now a role model for less-developed countries on how to utilize their domestic resources, unemployed labor and domestic technologies (Gebremariam, 2017). Micro and Small Enterprises (MSEs) are the backbone for both developed and developing countries in improving their socio-economic condition, create employment opportunity, greater utilization of local raw materials, utilization of domestic technology and improve the economic growth of the country (Yaregal, 2018) and (Assefa, 2014). Consequently, in Ethiopia, Micro and Small Enterprise (MSEs) is prioritized as important means of economic diversification, job creation, income generation and equity distribution as in dispensable poverty reduction sector since 2006 (Teshome, 2018).This because MSEs have great value in Ethiopian socio-economic growth as it requires small capital, promote inter-sectorial linkages as it is a base for medium and large scale enterprises, increased domestic saving and investment (Gemechu & Teklemariam, 2016). MSES have significant roles in e Ethiopian economy in terms of employment generation, powerful instrument in economic growth, source of income, quick production response, and use of local resources, a means of realizing equitable income distribution and injecting a feeling of competition (Diriba, 2013).

As Gemechu & Teklemariam (2016) also argued that, micro and small enterprises (MSEs) in developing countries as engines through which the growth Objectives of developing countries as a means to sustain and grow economies. Small and medium-sized businesses (MSEs) played a significant role in domestic employment and inclusive GDP in developing countries such as Ethiopia (Abdissa et al, 2022). MSEs also, contribute to employment creation, income generation, and poverty alleviation, contributions to the local, regional and national GDP, stimulating

entrepreneurial climate and opportunities in the design, implementations, marketing opportunities, linkages, financial sources, dynamics, survival and policy land scape in developing world (Brixiova & Emerta, 2010; Hailai & Kibrom, 2019). Despite their importance, many micro and small scale enterprises failed due to poor leadership practices and limited entrepreneurial management approaches*(*Teka, 2022). Small businesses account for a large proportion of employment in Ethiopia, particularly in Ethiopia. However, their efforts have been futile due to administrative insecurity (Abdissa et al., 2022).

MSEs Today's turbulent competitive environment requires a strategic leadership approach to survive and thrive. Entrepreneurial leadership which combines leadership and entrepreneurship principles, is essential for navigating the challenge and crisis of modern organizational setting, in guiding enterprises towards sustainable growth, innovation and competitiveness (Arham, A and Muenjohn, N, 2012) Obiwuru, Okwu et al, 2011). Entrepreneurial leadership role on organizational performance well studied in developed countries, less could be said of in developing countries like Ethiopia (Bereket, 2015). Although, some studies conducted in developing countries context, most studies have focused either on leadership or on entrepreneurial orientation separately thus less is known on the two fields when merged as entrepreneurial leadership (Van Zyl, 2007). As a result, limited knowledge exists on the integrated construct of entrepreneurial leadership. Therefore, this study focused on entrepreneurial leadership, which conceptualize as a combination of leadership and entrepreneurial orientated behaviors. The main purpose of the study was to investigate the effect of entrepreneurial leadership on the performance of micro and small enterprise in Awi administration North West Ethiopia.

Objectives of the study and hypotheses

The major objective of the study is to investigate the effect of entrepreneurial leadership on performance of Micro and Small Scale enterprises in Awi administrations, Northwest Ethiopia. The specific objectives of the study are:

- To analyse the effects innovation on performance of selected micro and small scale enterprises.
- To examine the effect of risk taking on organizational performance of micro and small scale enterprises.
- To assess the role of vision on performance micro and small scale enterprises.
- To investigate the effect of pro-activeness on performance of micro and small scale enterprises.
- To identify which entrepreneurial leadership dimension has the strongest influence on micro and small scale enterprises.

Based on the above, the following hypotheses were formulated:
H1: Entrepreneurial leadership has significant positive effect on the performance of MSEs
H2: Innovative skill has significant positive effect on the performance of MSEs
H3: Risk -taking has significant positive effect on the performance of MSEs
H4: Pro-activeness has significant positive effect on the performance of MSEs
H4: Visionary leadership has significant positive effect on the performance of MSEs

2. Literature review

2.1. Overview and concepts of entrepreneurial leadership

Leadership and entrepreneurship are critical concepts in academic research. Leadership is considered a mature field .entrepreneurship is a relatively young field. However, the two are interconnected (Bhola, 2014).

The fields of leadership and entrepreneurship have under gone parallel developments in recent time. Although they are studied separately, some researchers have tried to combine entrepreneurship with leadership, defining entrepreneurship into a new form of leadership called Entrepreneurial Leadership. It entails influencing and directing the performance of group members to recognize and explore entrepreneurial opportunities for Entrepreneurial Leadership and business performance the achievement of organizational goals. In the dynamic, uncertain and competitive environment, entrepreneurial leader creates visionary or transformational scenarios of business as well as assembles and mobilizes a supporting cast of participants committed for the vision (Paudel, 2019).

In order to gain better understanding of both phenomena and utilizing the synergy in sake of improving the two disciplines, scholars integrated them into a new paradigm as ‘entrepreneurial leadership. Entrepreneurial leadership is the process of creating an entrepreneurial vision and inspiring a team to enact the vision in high velocity and uncertain environments. It has three main components of innovativeness, visionary, and risk taking (Bhola, 2014). Today, having just leadership or entrepreneurship qualities by business managers is not enough for success of enterprises. Managers need to have both leadership and entrepreneurship qualities in order to be successful. At this point, the concept of entrepreneurial leadership emerges. Entrepreneurial leadership is a new and modern type of leadership that is a combination of leadership qualities and spirit of entrepreneurship (Esmer & Dayi, 2016).In recent times, entrepreneurial leadership has become a new phenomenon in business management that needs to be discussed. It can be defined as the managers ability take risks, seize opportunities, pursue innovation and be innovative, producing, interchanging and strategic (Esmer & Dayi, 2018).

2.2. Theoretical Literature Review

Knowledge-Based View (KBV)

Knowledge base view identifies knowledge as a significant firm or business resource, it recognizes it as a strategic and vital resource to empower value creation, performance, growth, and success in business (Hussain N and Li B2022). Knowledge-Based View posits that an organization's ability to effectively create, acquire, share, and utilize knowledge is a primary source of competitive advantage and superior performance (Zack et al., 2009; Richey et al., 2010; Grant, 1996).

Resource Based View (RBV)

The resource-based view (RBV), often referred to as the "resource-based view of the firm" is a managerial framework used to determine the strategic resources a firm can exploit to achieve

sustainable competitive advantage (Graham et al., 1998). In the resource-based view, strategists select the strategy or competitive position that best exploits the internal resources and capabilities relative to external opportunities. Given that strategic resources represent a complex network of inter-related assets and capabilities, organizations can adopt many possible competitive positions Hooley et al, 2001).

2.3. Entrepreneurial leadership

Entrepreneurial leadership is organizing a group of people to achieve a common goal using proactive entrepreneurial behavior by optimizing risk, innovating to take advantage of opportunities, taking personal responsibility and managing change within a dynamic environment for the benefit of the organization (Penger & Dimovski, 2013). Entrepreneurial leadership defined by (Fløistad 1991) as a source of opportunity that revolves around achieving goals, creating chances in the job market and developing an environment for empowering people. EL can be differentiated among leadership and non-leadership skills, specifically entrepreneurial risk-taking behavior and innovative openness (Nicholas, 1998; (Hussain N and Li B2022). Business leadership has been described as "the dynamic process of presenting vision, making commitment among followers and risk acceptance when facing opportunities that cause efficient use of available resources, along with discovering and utilizing new resources with respect to leadership vision". Studies state that competent leadership should be able to achieve higher innovativeness through risk-taking. Some evidences how risk taking as one of the key characteristics to measure the innovativeness of leadership in organizations. Innovation culture is relatively at a slow pace compared to other countries of the world.

In an attempt to deal with the continuous dilemma in the manufacturing sector, the leaders of SMEs introduced `international based policies such as organizational restructuring and reengineering (Maladzhi, 2015). AS (H.J.C. Van Zyl, 2007), also state that the entrepreneurial leadership construct consists of different elements, namely risk-taking propensity (willingness to absorb uncertainty and take the burden of responsibility for the future), innovativeness (the ability to recognize changing needs and develop new ideas and solve new and old problems in new ways). (Gupta, 2004)Provide a two-dimensional model of entrepreneurial leadership. Entrepreneurial leadership is in their opinion distinctively different from other types of leadership behaviors in creating "visionary that are used to assemble and mobilize a 'supporting cast' of participants who become committed by the vision to the discovery and exploitation of strategic value creation". Also (Dhammika.K, 2016) Argue that Found that visionary leadership behavior of leaders improves the organizational citizenship of employees. Different studies confirm that the leaders who focus on firm vision are more successful (Çınar & Kaban, 2012).Similarly, Breevaart et al. (2014) confirm that different studies suggest that visionary leaders play a great role in improving the profit of their organizations.

2.4. Organizational performance

Existing studies suggested attempted to research on the impacts of entrepreneurial orientation on business performance have reported the existence of positive relationship between entrepreneurial orientation and business performance of SMEs (Almaz, 2019). Henceforth this study aims at testing the relation between entrepreneurial leadership style and business performance of SMEs in

Ethiopian context which previous studies have not been able to cover. This study is thus expected to bring a significant contribution to leadership and entrepreneurship literature.in addition this study is expected to bring an insight on how the combination of the leadership and entrepreneurial behaviors can influence business performance of SMEs (Mead & Liedholm, 2008). Previous studies indicate the presence of standard scale of business performance of organizations although there is still a long debate on how performance of SMEs can be measured due to lack of archival performance records and reluctance of the business leaders and managers to give such information to researchers. Several surveys, have reported on the difficulty to get data in the standard measures widely used in other parts of the world such as Profitability; Gross profit Return on asset (ROA), Return on investment (ROI), Return on equity (ROE), Revenue growth, Market share and stock price for financial business performance of SMEs . Non-financial measures are also included in the standard measure of non-business performance of SMEs which is said to include; achieving start up goals overall performance, innovation and product development, growth the size of the firm ,growth in market share and customer Satisfaction with company's performance. Most SMEs which conduct self-business performance for monitoring control use their own measures which most studies on the particular area-as shown in Figure 1-have summarized them to be, Turnover, Profitability, Cost of sales, Number of customers, Prices of products/services, Cost of inputs, Number of employees, Stock used, Equipment used and Loss (Mgeni, 2015).

2.5. Conceptual framework

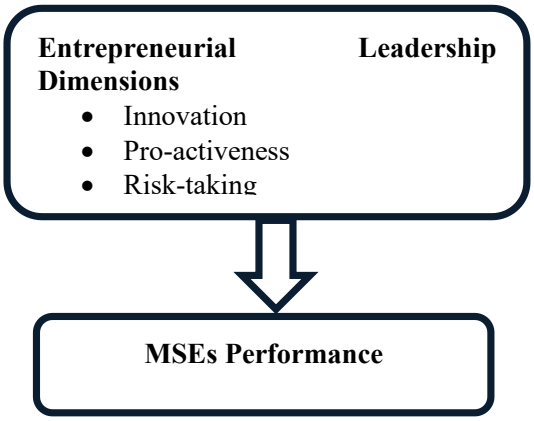

Figure 1. conceptual frame work

Source: Own research developed by reviewing literatures of Arham and Muenjohn (2012), Van Zyl (2007), Rao (2012).

3. Methods of the study

3.1. Research design

Descriptive and explanatory research designs were employed in this study. Descriptive research design was used to describe the existing status of entrepreneurial leadership practices and the performance level of micro and small scale enterprises in the study area. Explanatory research design was used to examine the causal relationship between entrepreneurial leadership dimensions (innovation, risk taking, pro-activeness and visionary) and the performance of micro and small

scale enterprises. Cross-sectional study design was adopted since data were collected at a single point in time using structured questionnaire.

3.2. Target population and Sampling Technique

The target population of this study comprised employees in all registered micro and small scale enterprises operating in three town administrations. Employees were selected as respondent because they are directly engaged in daily business operation and possess first-hand experience and knowledge of their enterprises leadership practice and performance. Combination of Random and stratified sampling technique employed to ensure representativeness of the sample. Stratified random sampling employed to ensure representation across different sectors___ while Simple random sampling was used within each stratum. Sample from each sector were proportionally selected using proportionate allocation method based on their share of the population. Sample size was determined using Taro Yemane, (1967).

$$n = \frac{N}{1 + N(e)2}$$

N= Designates the Total population in all MSEs, n= designates the sample size the researcher used, e=designates maximum variable or margin of errors (5%or 0.05) with 95% confidence interval, 1=designates the probability of events occurring. Therefore, the required sample size (respondents was) calculated as follows: $n = \frac{2535}{1+2535(0.05)2} = 346$ Respondents

Table 1. Descriptive data

Town	Sector	Total population	Proportion	Sample size	Total
Injibara	Urban agriculture	47	1.85%	6	161
	Manufacturing	237	9.4%	33	
	Service	274	11%	38	
	Construction	124	4.9%	17	
	Trade	493	19.45%	67	
Dangila	Urban agriculture	19	0.75%	3	109
	Manufacturing	154	6%	21	
	Service	212	8.36%	28	
	Construction	11	0.44%	2	
	Trade	409	16%	55	
Chagni	Urban agriculture	17	0.67%	2	76
	Manufacturing	145	5.7%	20	
	Service	139	5.5%	19	
	Construction	41	1.6%	6	
	Trade	213	8.4%	29	
Total		2535	100	346	346

Source: own compilation based on Awi Administration micro and small enterprise office

3.3. Data type and sources data collection, methods

Primary data collected from employees of micro and small scale enterprise through structure questionnaire.

During data collection, First the researchers provided detail instructions to the data collectors regarding the procedure to be followed in the field including how to administer the questionnaire and clarify the questions raised by respondents. Second the purpose of the study was clearly explained to the respondents to ensure their understanding and willingness to participate. Finally the questionnaires were distributed and administered by trained data collectors under the supervision of the researchers.

Structured survey questionnaire with Likert scale was used as the appropriate and convenient techniques of primary data collection. Structured survey questionnaire developed based on review literature and adapted to local context consists of two main sections: entrepreneurial leadership dimensions (innovation, risk taking, pro-activeness and visionary) and performance measures.

3.4. Reliability and Validity

Reliability

The reliability of the questionnaire was assessed using Cronbach's Alpha to examine internal consistency. All Entrepreneurial Leadership dimensions demonstrated Cronbach's Alpha value above 0.70, indicating a high degree of internal consistency (reliability) across items.

Table 2. Entrepreneurial dimensions

Entrepreneurial leadership dimensions	**Cronbach's Alpha**
Innovative skill	.721
Pro-activeness	.783
Risk taking	.747
Visionary leadership	.779
organizational performance	.721

Source: own research

Validity of the study

Content Validity was conducted to ensure instruments cover all relevant aspects by consulting experts in entrepreneurship and small business management to confirm the clarity, relevance and completeness questionnaire items. In additionally research validity was strengthen by formulating clearly defined questions, review of relevant literature ,and adopted valid instruments from previous studies to ensure the accuracy and credibility of research result aligned with study's objective.

3.5. Methods of data analysis

Both descriptive and inferential statistical techniques were employed using Statistical Package for Social Science software (SPSS: version 20). Descriptive statistical measures mean and standard deviation, percentage and frequency were used to summarize and describe the key characteristics of the study variables. Inferential analysis comprising Pearson correlation and multiple regression were employed to examine the relationships among variables and to test the proposed hypothesized influence of entrepreneurial leadership dimensions on the performance of micro and small enterprises.

Model Specification

To examine the effect of entrepreneurial leadership on the performance of micro and small scale enterprises multiple liner regression model was employed. The model was designed to assess how entrepreneurial leadership dimensions - innovation, risk taking, pro-activeness and visionary predict MSEs Performance. The corresponding econometric model was specified as:

$$Y=\beta 0+\beta 1X1+\beta 2X2+\beta 3X3+\beta 4X4+\varepsilon$$

Where:
Y = MSEs Performance
X1= Innovative skill
X2= Pro-activeness
X3= Risk-taking
X4= Visionary leadership
β_0 = intercept (constant)
B_1-β_4 = Regression coefficients represented the effect of each independent variable on Y.
ε= error term (capturing other factors not included in the model).

4. Results and Discussion

4.1. Descriptive statistical analysis of the study

Table 3. Descriptive Statistics

Descriptive Statistics			
Variables	N	Mean	Std. Deviation
Organizational performance	329	2.4043	.54871
Innovative skill	329	2.7799	.54991
Pro-activness	329	2.4359	.76751
Risk taking	329	2.5435	.66118
Visionary leadership	329	2.4991	.50513

Source: own research

The descriptive statistics presented in table 4.4 indicated that, the mean scores for all variables range between 2.40 and 2.7799 which are below the midpoint 3.0. This suggested that the

respondents perceive both entrepreneurial leadership and micro and small enterprises performance are below the average.

The mean score for Innovative skill: Mean=2.7799, SD= .54991) falls within the neutral range, indicated limited innovative or creative practices among MSEs. This suggested that, although some degree of innovation exists, Most MSEs lack sufficient institutional and leadership support to encourage employees to develop and apply innovative and creative abilities or skills. Therefore, managers of MSEs should adopt proactive strategies that embed innovation and creativity as core drivers of enterprise growth and competitiveness. The mean score for (Risk taking: mean=2.5435, S.d=.66118) falls within the neutral range indicated that MSEs demonstrate uncertain engagement in risk taking behavior. This implies that, managers or leaders relatively low willingness to take risk, to make uncertain decisions, which may constrain opportunities for growth and competiveness. The mean score (Pro-activeness: Mean=2.4359, S.d=.76751) falls within disagreement range indicated that, MSEs Managers are generally not proactive in anticipating future challenges and opportunities. This implies that, leadership practice exhibited with in the enterprises is largely reactive rather than forward looking, potentially limited adaptability and strategic responsiveness. The mean score (Visionary leadership Mean=2.4991, SD=.50513) lies between disagree and neutrality indicated that most respondents perceive lack of visionary leadership among MSEs Managers. This implies most managers lack a clear or inspiring long-term vision to guide their enterprises towards long -term success or sustained growth, which may negatively affect strategic planning and organizational sustainability. The mean score (MSEs Performance: Mean 2.4043, SD=.54871) falls within the disagreement range indicated that, respondents perceive the overall performance of MSEs as relatively low. This implies that, the enterprises haven't achieved satisfactory level of innovation and product development, market growth, profitability and firm's size growth. Overall the descriptive result revealed that, entrepreneurial leadership practices are remain weak among MSEs in Awi administration accompanied by poor over all MSEs Performance.

4.2. Inferential Statistics

Table 4. ANOVA of the Regression

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	107.509	4	26.877	242.704	.000[b]
	Residual	35.880	324	.111		
	Total	143.388	328			
a. Dependent Variable: MSEs Performance						
b. Predictors: (Constant), Innovative skill ,Pro-activness, Risk taking, Visionary leadership						

Source: own research

The ANOVA result indicated that the regression model is statistically significant in explaining or predicting variation in MSEs Performance. The calculated F-ratio ($F=242.704$, $P<0.05$) confirms that the model provides a significantly better prediction of MSEs Performance. The model as a whole statistically significant better prediction MSEs performance compared to the null model. The finding implies that the predictors' innovative skill, pro-activeness, risk taking and Visionary leadership jointly exert significant influence on MSEs Performance.

The total sum of squares is (143.388) represents the total variance in MSEs Performance of which the regression sum of square (107.509) reflects the portion explained by the model. The corresponding mean square for regression (26.877) indicates the average explained variation per predictor. While the residual sum of square (35.880) and mean square of (0.111) represent unexplained variance.

Overall ANOVA result confirm that, the regression model is statistically significant and provides strong fit to the data, demonstrated that, entrepreneurial leadership dimensions collectively have significantly effect on the performance of micro and small enterprises.

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.866[a]	.750	.747	.33278
a. Predictors: (Constant), Innovative skill ,Proactivness, Risk taking, Visionary leadership				

Source: own research

The model summary result demonstrated that the strength and explanatory power of the regression model predicting the performance of Micro and small enterprises based on entrepreneurial leadership dimensions.

The correlation coefficient(R= 0.866) indicates strong positive relationship between the independent variables and MSEs Performance. This implied that improvement in innovative skill, pro-activeness, risk-taking and visionary leadership are strongly associated with enhanced performance of micro and small scale enterprises.

The coefficient determination (R^2=0.750) reveals that approximately 75% of the variance in MSEs Performance explained combined influence of entrepreneurial dimensions. This indicated that the model possess strong explanatory power, meaning these predictors collectively account for substantial portion of performance variations among MSEs.

The Adjusted R^2=0.747 further confirmed, the model has strong explanatory power and stable, the minimal difference between R^2=0.75 and Adjusted =$R^2$0.747 demonstrating that the model generalize well and is not over fitted. Implies the number of predictors and sample size provide more accurate measure model fit.

The Std. Error of the Estimate (SEE= .33278) shows the Model's predictions deviate from actual values Performance value by an average of 0.333 units, implying that, only small portion of performance variance is attributable to other unobserved factors.

From the regression coefficient results, the constant $\beta_0 = -0.819$ shows that if all the entrepreneurial leadership dimensions are absent, the predicted performance of MSEs would fall below the expected level, meaning that without entrepreneurial leadership practices, the performance of an enterprise would substantially diminish.

Table 6. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-.819	.129		-6.333	.000		
	Innovative skill	.511	.040	.424	12.781	.000	.702	1.425
	Pro-activeness	.377	.036	.314	10.427	.000	.853	1.173
	Risk taking	.322	.027	.374	11.967	.000	.790	1.266
	Visionary leadership	.120	.042	.092	2.865	.004	.753	1.327
a. Dependent Variable: MSEs performance								

Source: own research

The unstandardized coefficients (B) explain the change in MSE performance that is expected for a one-unit increase in each of the predictors, while controlling for all other variables. More specifically, with every one-unit increase in innovative skill, performance increases by 0.511 units, while one-unit increases in pro-activeness, risk-taking, and visionary leadership lead to increases of 0.377, 0.322, and 0.120 units, respectively. This means that entrepreneurial leadership practices have a statistically significant positive effect on enterprise performance.

The standardized beta coefficients further reveal that innovative skills are the strongest predictors of MSE performance, with a β value of 0.424, followed by risk-taking at 0.374, pro-activeness at 0.314, and visionary leadership at 0.092, although smaller, still significant. All predictors were statistically significant at $p < 0.01$, confirming their collective contribution to explaining performance variations.

The t-test results also point to significant associations of entrepreneurial leadership practices with MSE performance. Moreover, multicollinearity diagnostics indicate that all the tolerance values are above 0.10, with VIF values ranging from 1.173 to 1.425, which are far below the threshold of 10, hence indicating no multicollinearity issues among the predictors.

4.3. The Effect of Entrepreneurial Leadership Dimensions

Hypothesis (H1) the findings revealed that, innovative skill has the strongest positive and statistically significant effect on the Performance of Micro and Small Enterprise (B=0.511, P<0.001). This implies that one unit increase in innovative capability leads to 0.511 unit improvement in MSEs Performance, holding other factors constant. The result suggests that, enterprises that actively fostering creativity, technological adaptation and continuous improvement are more likely to achieve superior performance.

Hypothesis (H2) the regression results indicates that pro-activeness has a positive and statistically significant on Micro and small enterprises performance (B=0.377, P<0.001). This suggested that holding other variables constant one-unit increase in pro-activeness leads to 0.377 unit improvement in enterprises performance. This implies that enterprises demonstrate higher level of pro-activeness by anticipating environmental changes, initiate timely actions and exploiting emerging opportunities tend to achieve superior performance compared these to adopt reactive approaches.

Hypothesis (H3) The finding reveal a positive and statistically significant relationship between risk taking and performance MSEs (B=0.322, P<0.001).This indicates that, holding other factors constant one unit increase in risk taking behavior results in 0.322 unit increase in MSEs performance. The result suggested that enterprises willing to take calculated risk -by exploring new opportunities and adopting innovative products or process tends to achieve higher performance compared to risk averse firms.

Hypothesis (H4) The regression result reveals that, Visionary leadership has positive and statistically significant effect on MSEs Performance ((B=0.120, P<0.004). This indicating that, holding other factors constant one unit increase in visionary leadership is associated with 0.120 unit improvement in enterprises performance. The finding indicates that, enterprises should leaded by managers who articulate clear vision, inspired commitment towards long term goals and align team effort with strategic objectives –tends to achieve superior performance.

The multiple regression results confirms, that all predictors have positive and statistically significant effect on the performance of MSEs at (P<0.05). Overall, the findings suggest that the four entrepreneurial leadership dimensions-innovative skill, pro-activeness, risk-taking, and visionary leadership-are jointly and significantly predictive of the performance of micro and small enterprises. The finding suggested that, fostering innovative, proactive, calculated risk taking behavior visionary direction, is crucial for the strengthening of competitiveness, adaptability, and sustainable growth within the MSE sector.

4.4. Correlational analysis of the study

Table 7. Correlations

Item		Innovative skill	Pro-activeness	Risk taking	Organizational performance	Visionary leadership
Innovative skill	Pearson Correlation	1	.314**	.361**	.698**	.436**
	Sig. (1-tailed)		.000	.000	.000	.000
Pro-activeness	Pearson Correlation	.314**	1	.274**	.554**	.051
	Sig. (1-tailed)	.000		.000	.000	.180
Risk taking	Pearson Correlation	.361**	.274**	1	.645**	.344**
	Sig. (1-tailed)	.000	.000		.000	.000
Organizational performance	Pearson Correlation	.698**	.554**	.645**	1	.421**
	Sig. (1-tailed)	.000	.000	.000		.000
Visionary leadership	Pearson Correlation	.436**	.051	.344**	421**	1
	Sig. (1-tailed)	.000	.180	.000	.000	

**. Correlation is significant at the 0.01 level (1-tailed).

Source: own research

The result revealed that innovative skill and MSEs Performance had the highest correlation at r = 0.698, P<0.01 followed by Risk taking and MSEs Performance at r = 0.645, p < 0.01, Pro-

activeness and MSEs Performance at r = 0.554, p < 0.01, and Visionary leadership and MSEs Performance had the lowest correlation (.421**). All the coefficients of correlation are positive and statistically significant at 0.01, suggesting a moderate positive relation of each entrepreneurial leadership dimension with organizational performance. These results therefore postulate that entrepreneurial leadership dimensions, especially innovative skill and risk-taking, significantly improve MSE performance and growth. This suggests further that strategies aimed at nurturing innovation, taking calculated risks, and promoting proactive and visionary behavior by leaders are critical in MSEs as a means of improving their competitiveness and sustainability.

5. Conclusions

This study examined how entrepreneurial leadership practices influence the performance of micro and small scale enterprises in Awi administration. The descriptive result demonstrated that all dimensions of entrepreneurial leadership were rated below the average scale, indicating limited engagement in innovative risk taking, pro-activeness and visionary leadership behaviors. Among these innovative skill record the highest mean score (M=2.7799), while pro-activeness reelected relatively low average. This suggested that although some degree of innovation exists MSEs largely luck the leadership commitment and institutional support necessary to foster creativity strategic foresight and calculated risk taking. Employees continue to express the need for entrepreneurial leadership practices that encourage innovation, visionary direction, proactive and adaptive risk management. The findings revealed that the overall implementations of entrepreneurial leadership practices among MSEs remains a weak with most enterprises still operating through traditional modes of business transaction rather than adopting innovative, proactive and strategic leadership approaches. Inferential analysis confirmed that statistically significant and positive relationship between entrepreneurial leadership dimensions and MSEs Performance. The regression model which demonstrate strong explanatory power (R2=0.75) indicates that improvement in innovative capability, pro-activeness and risk taking and visionary leadership collectively enhance enterprises performance. Specifically a unit increase in each entrepreneurial leadership dimensions corresponds to proportional improvement in MSEs Performance outcomes. The study conclude that, entrepreneurial leadership positively and significantly influence the performance of MSEs. Enterprises that cultivate innovation, foster proactive behavior, encourage calculated risk taking and exercise and operate under visionary leadership are more likely to achieve superior growth, competitiveness and sustainability. Accordingly for MSEs in Awi administration and similar contexts strengthen entrepreneurial leadership practices is essential for improving overall performance and ensuring long term viability increasingly competitive and dynamic business environment.

6. Recommendations

Based on the empirical findings and conclusions, the following recommendations are proposed for policy makers' development agencies enterprises managers to strengthen entrepreneurial leadership practices and enhance MSEs Performance in Awi Administration town administrations.

Promote culture of innovation and creativity: MSEs Managers should create enabling environment that encourage employees to generate, share and implement innovative ideas through offering

incentives, recognizing creative contributions and by investing in training programs that build innovative thinking, problem solving skills and adaptability.

Government, universities and development partners should collaborate to provide regular training, mentorship programs and workshops that enhance managerial skills and support adoption of global best practices.

Enhance pro-activeness: the managers of MSEs should adopt forward looking approach by continuously scanning the business environment to identify emerging opportunities, market trends, technological change, policy change and other potential treats by integrating this environmental awareness in to strategic planning and encouraging informed decision making will enhance proactive behavior across the enterprise.

Foster calculated risk taking: MSEs should develop supportive culture that embraces calculated risk-taking behavior other than risk avoidance. This can be achieved by providing managers enable to analyze risk, to assess potential outcomes systematically and make informed decision that balance opportunities with strategies to mitigate potential threats.

Enhance Visionary Leadership: managers should articulate a clear, inspiring vision that aligns with long-term business goals and objectives and effectively communication to motivate employees to work towards shared objectives. To support this, leadership development program should strengthen strategic foresight, vision formulation and team alignment to promote sustained growth and competitiveness.

MSEs should adopt regular assessments of leadership practice, employee feedback, and evaluation system to identify gaps, improve performance, and enhance adaptability, innovation and competitiveness.

Strengthen entrepreneurial support: Policy makers should integrated entrepreneurial leadership with broader national strategies for MSEs Growth and competitiveness. Development agencies better to provide financial, advisory, and technical assistance to promote innovation driven entrepreneurship.

MSEs in Awi administration and similar contexts strengthen entrepreneurial leadership practices is essential for improving overall performance and ensuring long term viability increasingly competitive and dynamic business environment.

Further studies should extend this research by incorporating longitudinal data to test for causal relationship and enable comparative analysis sectors and across industries. Integrating qualitative research insights of entrepreneurs or managers could further enrich the understanding of contextual and behavioral factors shaping entrepreneurial leadership and MSEs Performance dynamics. Furthermore, exploring additional dimensions of entrepreneurial leadership such as autonomy, competitiveness and opportunity and recognition – alongside moderate variables like organizational learning, Entrepreneurial orientation employee creativity and commitment, could help to develop more comprehensive model for explaining MSEs Performance in emerging economies.

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Application of Total Quality management. A Case study: Peacock Shoe Company

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Abstract: As quality is the duty of every member in an organization; the responsibility shouldn't be left only to the quality department of an organization. Total Quality Management (TQM) is the management philosophy and company practice that is aimed at harnessing the human and material resources of an organization in the most effective way to achieve the objectives of the organization. It is a combination of quality and management tools aimed at increasing business competitive advantage and reducing losses due to wasteful practices. The study is conducted at Peacock Shoe Company. The main focus of this paper work is to indicate the effect of TQM practices on improvement of business results and to suggest business improvement and implementation model of TQM which is appropriate to the company. Primary data are collected the first part relates to the extent to which employees are motivated to implement the TQM ideology, the second section focuses on customers' satisfaction. The final section focuses on operational effectiveness and general know how in total quality management. Data are analyzed to test quality practice levels of the company. The purpose of this analysis is to ascertain the relationship between TQM and business performance improvement. The results of these discussions approved that there exists a direct relationship between TQM and company's business improvement. Convenient secondary data are also collected and analyzed to understand what it seems the actual company's business results growth rate. These results are compared to the ideal continuous improvement of organization business results. Finally, step-by-step TQM implementation model and business improvement model is proposed. Moreover, general conclusions and recommendations are provided based on the findings of the study.

Keywords: Business improvement, Customer satisfaction, Implementation model, Operation effectiveness, Total quality management.
JEL Codes:

1.Introduction

Total Quality Management (TQM) is a management philosophy which focuses on the work process and people, with the major concern for satisfying customers and improving the organizational performance (Ahire et al., 1995). TQM is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs (Tadesse & Osada, 2010; Yusuf, 2007).

The culture requires quality in all aspects of the company's operations, with processes being done right the first time and defects and waste eradicated from operations (Juran & Gryna, 1993). It involves the proper coordination of work processes which allows for continuous improvement in all business units with the aim of meeting or surpassing customer's expectations. It emphasizes on totality of quality in all facets of an organization with the aim of reducing waste and rework to reduce cost and increase efficiency in production. TQM is applicable to any organization irrespective of size, and motives, even the public sector organization are fast adopting the ideology in order to make them effective in meeting public demands (M. Abraham, 1999).

TQM has been widely implemented throughout the world. Many firms have arrived at the conclusion that effective TQM implementation can improve their competitive abilities and provide strategic advantages in the marketplace (Anderson et al., 1994). According to Sila (2007), TQM

helps in improving the quality of products and also reduces the scrap, rework and the need for buffer stock by establishing a stable production process. He argued that TQM will reduce the cost of production and time of production. Many other TQM practices such as training, information system management, relationship with suppliers etc. have a positive impact on operational performance (Lagrosen, 2003; Illés & Szuda, 2015). It is evident from empirical studies that TQM positively impact on the performance of those organizations that implement its practices and principles (Taddese and Osada, 2010).

However, the adoption of the ideology by most organization has been hampered due to their noncompliance with the procedures and principles of TQM implementation. While some organization, run TQM like a program which they expect to function and perform the magic all by itself, others have used a halfhearted approach to it, by using some bits and pieces of the principles. This has accounted for the failure of most organization in meeting up to their expected target from implementing this ideology (Kiella & Golhar, 1997). There is a need to continue to buttress the benefits that accrue to organizations from the implementation of TQM, especially in developing economies, such as Ethiopia where the adoption of these principles seems farfetched to organizations. The aim of this study is to assess the implementation of TQM in peacock shoe factory and also to give guideline how to implement TQM.

1.1. Problem statement

TQM is a firm-wide management philosophy of continuously improving the quality of the products/services/processes by focusing on the customers' needs and expectations to enhance customer satisfaction and firm performance. During visit in peacock shoe there are problem like defect, rework and not using of sampling techniques that is inspecting all product. Since TQM started to help organizations to achieve their goals and produce high quality products, there have been many quality management tools that benefited different organizations worldwide. Practicing continuous quality improvement is not an option; it is rather a question of survival. Especially at the globalization era where the world is becoming like a small village, it surly is a question of survival, so the study focus on total quality management implementation in peacock shoe factory and to show if there are any barriers that hinder the implementation TQM.

1.2. Objective of the study

General objective
To investigate implementation of TQM in Peacock shoe factory and to see its impact on the business performance.

Specific objective

- To show if there are any barriers that hinder the implementation TQM.
- To investigate awareness of employee of peacock shoe factory towards TQM.
- To suggest possible guide lines in implementing TQM.
- To develop TQM model.

In order to achieve these research objectives, the following research questions were proposed as follows:

- What is overall business performance within TQM?
- What are the effects of TQM implementation on overall business performance?
- What kind of TQM implementation model should be developed in order to guide this firms in implementing TQM?
- How can this TQM implementation model be demonstrated in practice?

2. Literature review

Competitiveness can be defined as the ability of a firm or a nation to offer products and services that meet the quality standards of the local and world markets at prices that are competitive and provide adequate returns on the resources employed or consumed in producing them (Gadenne & Sharma, 2002). TQM is one of many acronyms used to label management systems that focus on quality which is the current need of the global market which includes continuous quality improvement for the creation of consistent business development (M.B.N.Q., 1999), (Samson & Terziovski, 1999), (Sedrani, 2005).

TQM's primary goal is to reduce costs and improve the quality of the company's product. It is commonly used as a program to help company's implement some sort of cost, or quality differentiation strategy, or even an overall lower cost strategy. Some of the proven benefits of TQM implementation listed by the majority of works are improved quality, improved customer satisfaction, reduced cost, efficient delivery of products and services, and higher performance (Kumar and Boyle, 2001). A data of 1,024 responses from Australian and New Zealand manufacturing organizations to examine the relationships between TQM practices and firm performance, the study showed that the relationship between TQM practice and organizational performance is significantly in a cross-sectional sense (Samson and Terziovski, 1999).

TQM has four main objectives: Better, less variable quality, quicker, less variable response to customer s needs, greater flexibility in adjusting to customers' needs, and lastly, lower cost through quality improvement and non-value adding work (Hassan et al., 2012; Szuda & Illés, 2024). While there is a long way to go, the first steps must be taken and TQM offers an effective strategic instrument toward the optimal goal of improved quality service delivery and organizational performance (Kehoe & Adebanjo, 1999). Thus, public, private, and non-profit organizations worldwide are up to a new challenge of adaptability, rigor and effectiveness, as well as responsiveness (Deming, 1996).

2.1. History of the concept of TQM

Over the past few decades, quality gurus such as Deming (1986), Juran (Juran and Gryna, 1993), Crosby (1979), Feigenbaum (1985), and Ishikawa (1985), the primary authorities of TQM, have developed certain propositions in the field of TQM, which have gained significant acceptance throughout the world (Ahire et al., 1995). Their insights provide a good understanding of the TQM philosophy, principles, and practices. After careful study of their work, it has been found that these quality gurus have different views about TQM, although some similarities can be found. Through development from simple inspection to an in depth inclusion of quality in all levels of divisions in organizations, these basic ideas become dominant in changing the features of manufacturing and service giving sectors (Feigenbaum, 1985).

2.2. Evolution of Quality Management

The concept of quality has existed for many years, though it's meaning has changed and evolved over time. The comprehension of the evolution of the quality movement differs between authors.

One common description of the development of quality management is the four-phase model towards the concept of total quality management. According to this model:

1. Quality Inspection Phase: in the early twentieth century (around 1910), quality management meant inspecting products to ensure that they met specifications.
2. Quality Control Phase: in the 1940s, during World War II, quality became more statistical in nature. Statistical sampling techniques were used to evaluate quality, and quality control charts were used to monitor the production process. This phase was developed by Walter A. Shewhart.
3. Quality Assurance Phase: In the 1960s, with the help of so-called "quality gurus," the concept took on a broader meaning. Quality began to be viewed as something that encompassed the entire organization, not only the production process. Since all functions were responsible for product quality and all shared the costs of poor quality, quality was seen as a concept that affected the entire organization.
4. Total Quality Management Phase: The term used in 1980s and beyond is the new concept of quality is TQM that is customer driven quality. It covers the whole understanding and implementation of quality management principles and concepts in every aspect of business and it has a clear system approach. It can be seen that the old concept is reactive, designed to correct quality problems after they occur. The new concept is proactive, designed to build quality into the product and process design (Juran & Gryna, 1993).

3. Methodology

3.1. Data collection instrument

Primary data are collected regarding the implementation of TQM. The respondents for the study were selected employees from various functional areas in the company. Data collected using structured questionnaires, the questionnaires consist of four major parts as shown in appendix, which focuses on the areas of interest of the research. The first part relates to the extent to which employees are motivated to implement the TQM ideology, the second section focuses on customers' satisfaction. The final section focuses on operational effectiveness and general know how in total quality management. Data are also collected through observation and from the company document and interview in addition to that Literature survey: surveying of related material on TQM.

3.2. Data analysis and interpretation

Data that gathered through observation and interview shows that no use of proper sampling techniques they inspect all shoe at each stage, so inspecting every product is costly and inefficient, but the consequences of shipping non-conforming product can be significant in terms of customer dissatisfaction this shows that no use statistical quality control. The company's working definition of quality. Producing a shoe whose conspicuous feature in the customer mind and quality

incorporated with a commitment of consistently meeting the customer and legal requirements of relevant standards.

The questionnaires consist of four major parts as shown below, which focuses on the areas of interest of the research. The first part relates to the extent to which employees are motivated to implement the TQM ideology, the second section focuses on customers' satisfaction. The final section focuses on operational effectiveness and general know how in total quality management. Evaluation was made based on the following scale levels: Extremely Satisfied 5, Satisfied 4, Indifferent 3, Unsatisfied 2, Extremely Unsatisfied 1

The questionnaire is distributed to each department that is cutting, stitching and lasting and finishing department from top management to shop floor level, based on the survey this are the response. Since in Peacock Shoe there are 337 employees so 10% is 34 employee assessed.

3.3. The questionnaire

The questionnaires consist of four major parts as shown below, which on focuses the areas interest of the research. The first part relates to the extent to which employees are motivated to implement the TQM ideology, the second section focuses on customers' satisfaction. The final section focuses on operational effectiveness and general know how in TQM.

Employee satisfaction

1. You are satisfied with the authority.
2. Management encourages and recognize team-work effort.
3. Management recognizes your suggestions.
4. Individual effort is recognized in delivering quality service
5. You view your job as being flexible

Organization: Replay the following as regards to your organization

1. Regular Training for workers is put in place?
2. How many times are you trained in a year?
3. There is continuous improvement in your organization?
4. Mistakes are seldom made while responding to customer's request?
5. Quality service delivery is due to worker's empowerment?
6. Employees are involved in decision making?

Customer satisfaction

1. Customers see high standard of quality in the service you render?
2. Customers do complain about your services?
3. Your customers recommend your services to others?
4. Your organizations respond quickly to customers complain?
5. Do your company honor his/her commitment and guarantee to all customers? Yes No

Effective operation: Replay the following based on the operational effectiveness of your organization

1. Your organization services are readily accessible to your customers?
2. Does the accessibility of services to customers' aids the efficiency in operation? Yes No
3. Management commitment to quality encourages effective operation?
4. Employees' commitment to quality encourages effective operation?
5. Your job flexibility does contribute to effective operation?

3.4. Research results

Interpretation from the collected data as shown in above figure that employee satisfaction with the authority, management encouragement and recognition of team-work effort, management recognition employee suggestions, and individual effort is recognized in delivering quality service almost all are not satisfied meaning the need improvement because total quality management require customer satisfaction , team work ,recognition and suggestion of employee are important aspect of total quality management to be properly functional throughout the Peacock Shoe factory.

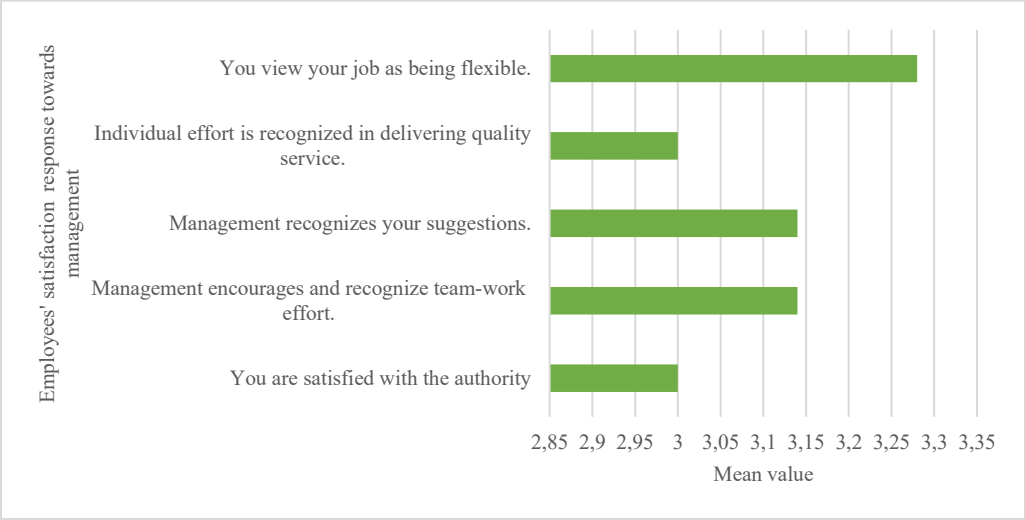

Figure 8. Employees' satisfaction
Source: own research

In general employee involvement improves quality and increases productivity, because:

- Employees make better
- Employees make better decisions using their expert knowledge of the process.
- Employees are more likely to implement and support decisions they had a part in making. Employees are better able to spot and pinpoint areas of for improvement.
- Employees are better able to take immediate corrective actions.
- Employee involvement reduce management friction by encouraging more effective cooperation and communication.

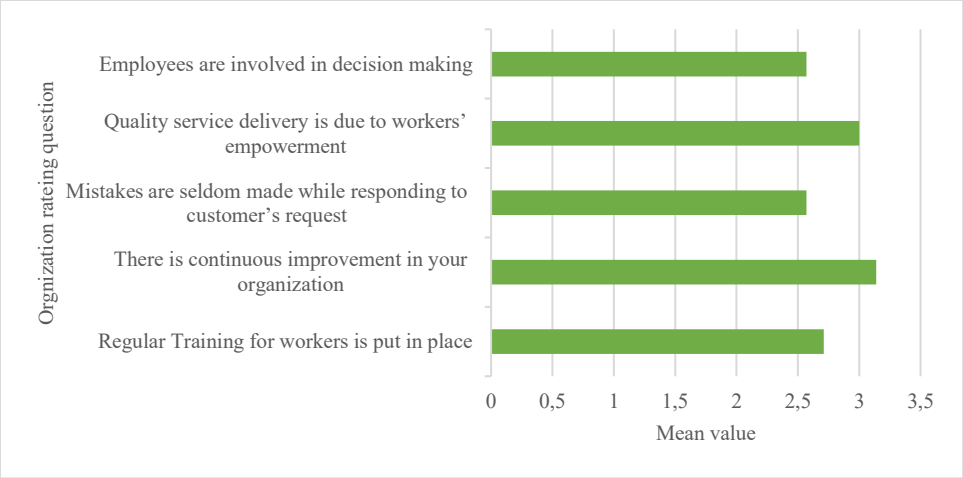

Figure 9. Employees' response towards their organization
Source: own research

Interpretation from the above figure such as regular training, employee decision making are not good enough but in total quality management regular training in how to do and education in what are basic things also employee involvement in suggestion and decision making are part of TQM. Participation and involvement in decision-making: - This refers to the extent to which jobs are delegated to the employees. The attitude to work by employees also go a long way to influencing the TQM implementation. If the attitudes of the workers are negative, it is not likely that the TQM will be successfully implemented.

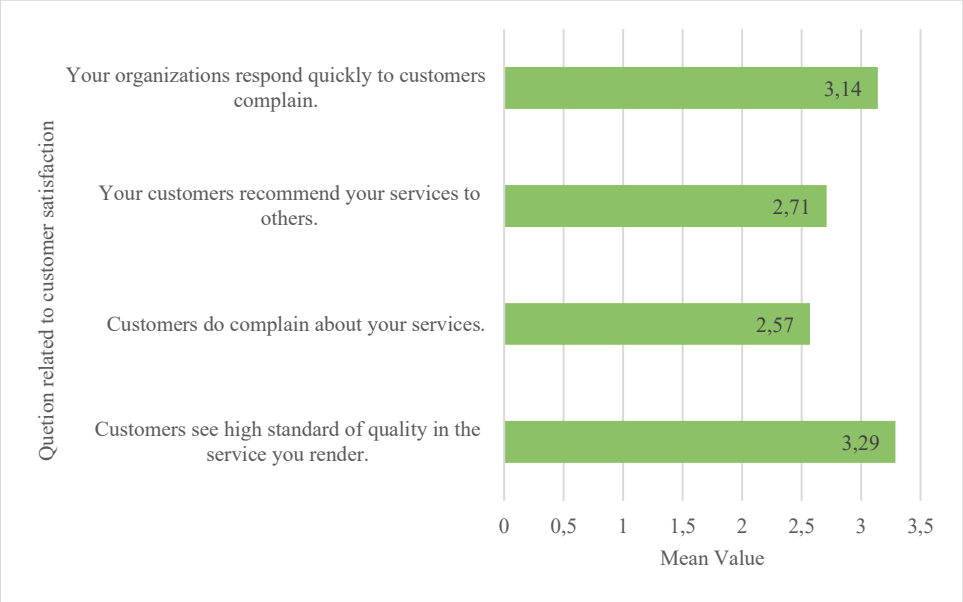

Figure 10. Customer satisfaction
Source: own research

TQM focuses on customer orientated approach so as to pursue strategically the continuous improvement of the results from all process. But in peacock shoe regarding customer satisfaction it need improvement, the basic thing in any organization is achieving customer satisfaction by

doing what they want. Reason for poor value Failure to network with customer–poor definition of needs and wants of customers. Design based on habitual thinking or mistaken beliefs (considering that they are smart enough).

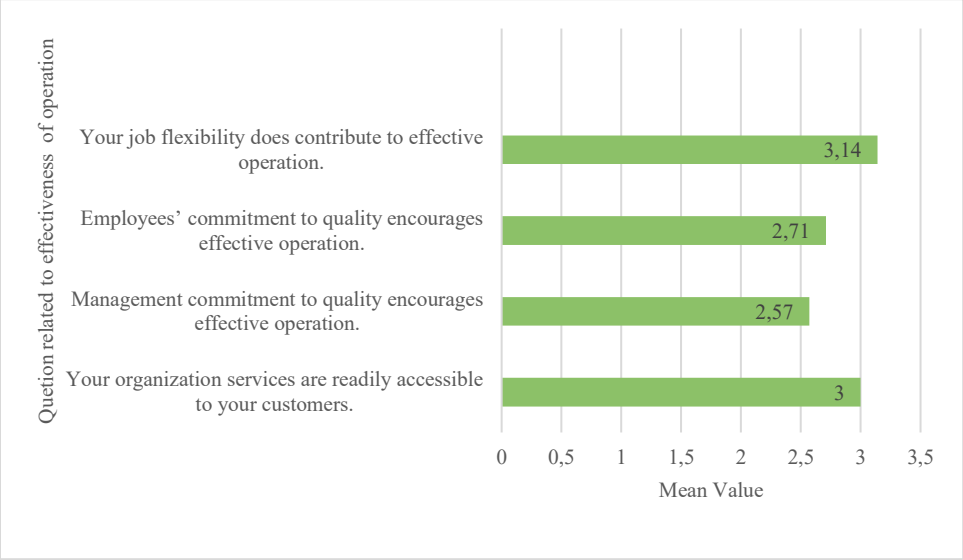

Figure 11. Effectiveness of operation
Source: own research

From the above figure it shows that management and employee commitment to quality needs improvement as part of total quality management, commitment starting from top management towards shop-floor is the means to make viable operational effectiveness.

Most of the employees replayed that training is given as once a year, but as part of total quality management regular training is very important that make the operation to be effective and also proper education. It is therefore necessary that the firms should create an internal quality awareness program aimed at training and educating employees within. The training program should aim at creating the quality awareness in the entire firm. Equipping all employees with the requisite skills and knowledge as well as influencing the attitude, values and behaviors of people is essential. Most of the workers believe that quality is the responsibility of every worker, so this is the essential point for the achievement of quality.

4. Proposed Implementation of TQM

4.1 Introduction

TQM is not an easy concept to introduce into the businesses particularly in companies who are not traditionally concerned about themselves too much with understanding customer needs and business processes. One of the main challenges of introducing the TQM concept is to make a significant impact on business, as TQM focuses on the activities that are closest to the customer satisfaction through meeting customer requirement. It also provides opportunity for management to focus on organizational culture during continuous improvement by empowering employees and involving them judiciously.

4.2. Approach

TQM is an approach to improving the competitiveness, effectiveness and flexibility of an organization for the benefit of all stakeholders, if combined with effective leadership, results in an organization doing the right things right, first time. It is a way of planning, organizing and understanding each activity, and removing all the wasted effort and energy that is routinely spent in organizations. It ensures the leaders adopt a strategic overview of quality and focus on prevention not detection of problems. All businesses have many types of customer. A customer can be someone "internal" to the business or the customer can also be "external to the business. This is the kind of customer **peacock shoe** factory are familiar with.

The implementation process step by step

Understanding: The exercise of finding out is often referred to as a diagnostic, which is simply a structured examination of how well the organization is suited to its tasks, in terms of its people, systems and technology. But the data that are gathered from peacock shoe through observation, interview and questionnaire shows that employee understanding towards ISO 9000, statistical quality control is not good enough.

Top management commitment: is the mobilization of all managers and the empowerment of workers and stakeholders to engage themselves into linked value-added activities for the purpose of achieving the greatest customer satisfaction at the lowest cost.

Company-wide awareness: A typical briefing session should explain what quality is, why it is important, and what the company is going to do about it. This is likely to take about two hours. If it goes on for longer, there is probably too much detail.

Planning: These will cover education and training on a more extensive scale than the briefing program, as well as the actions needed to realize the opportunities available.

Implementation: In order to build Total Quality into a continuous improvement process, each functional manager should have quality objectives that are set annually. Resource allocation must in turn be justified against the improvements demanded by the objectives, it is best to start with a pilot exercise.

Review: As every project reaches completion it must be reviewed to see if the objectives have been achieved and also to get means for improvement.

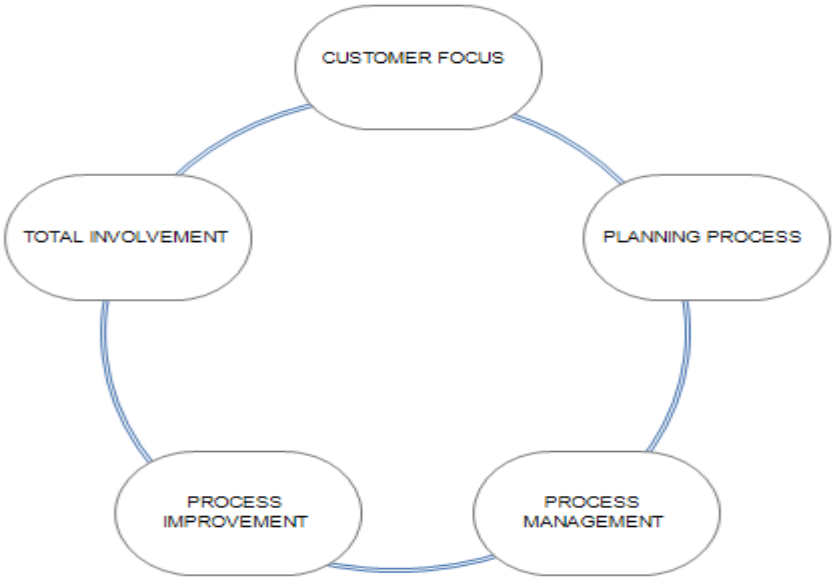

Figure 12. TQM Model
Source: own research

- Customer focus: the first key element of TQM is customer focus. **Peacock** shall focus on developing processes that identify todays' customer needs and try to anticipate customer needs in the future in addition, they require their competitive situation with respect to satisfying customer needs. One method to gain a better understanding peacocks' shoe customers is by conducting a customer satisfaction survey, proper education and training in how to asses for workers. After the survey, summary reports need to be created that can be used to gain an imaginative understanding of customer needs.
- Planning process: At strategic level, failure of management to plan for the future and to foresee problems have brought about waste of manpower, materials and machine-time, all of which raise the manufacturers' cost and price that purchaser must pay. Business planning translate customer needs into action that is essential for success. Proper education and train in planning.
- Process management & improvement: as a company peacock shoe shall manage their core and supportive process to consistently deliver high quality product and services, at a price the customer willing to pay, delivered when the customer wants it, and at a cost that allows the company to remain profitable, to manage the process use techniques like Plan-Do-Study-Act (PDSA), Statistical Process Control (SPC) etc. A key factor in process improvement is to reduce functional division and emotional pitfalls that set barriers to synergies. Proper education in why statistical quality is important for the company and train in how to use it.
- Total involvement: is system for direct participation of employee to organizational success, by letting them take responsibility. It enables every one deeply involved, using own brain power in problem solving, learning, continuous improvement activities and systematic search for opportunity. Educate on the skill need and train how to.

Six C's of TQM

For proper implementation of a TQM following Six Cs are required

1. Commitment: All employees of the organization must have quality improvement commitment. If a good TQM culture is to be developed in the organization, then quality improvement should become a normal part of everyone's job, a clear support and commitment from the top management must be provided. Without commitment all else fails. 'Quality' issue is not a responsibility of a single employee since this cannot create an environment for changing mindset and breaking down the barriers to quality improvement. Collective efforts can bring fruitful results.
2. Culture: Organization must develop and follow a modern culture for quality improvement on a regular basis. Training on regular basis is very essential for bringing a change in culture and attitudes. Management accountants, too often associate 'creativity' with 'creative accounting' and associated negative perceptions. It can be changed to encourage individual contributions and to make 'quality' a normal part of everyone's job.
3. Continuous Improvement: There must be continuous improvement in all policies, procedures and activities laid down by top management for the company. Recognition that TQM is a 'process' not a 'program' necessitates that we are committed in the long term to the never-ending search for ways to do the job better. There will always be room for improvement, however small.
4. Cooperation: Cooperation among employee and experience of employees must be utilized for improving strategies and enhancing performance. The application of Total Employee Involvement (TEI) principles is paramount. The on-the-job experience of all employees must be fully utilized and their involvement and co-operation sought in the development of improvement strategies and associated performance measures.
5. Customer: For long-term survival of the business, organization must focus on customers' requirements and satisfaction of their expectations. The needs of the customer are the major driving thrust; not just the external customer (in receipt of the final product or service) but the internal customer's (colleagues who receive and supply goods, services or information). Perfect service with zero defects in all that is acceptable at either internal or external levels. Too frequently, in practice, TQM implementations focus entirely on the external customer to the exclusion of internal relationships; they will not survive in the short term unless they foster the mutual respect necessary to preserve morale and employee participation.
6. Control: There must be effective control for monitoring and measuring the real performance of the business. Documentation, procedures and awareness of current best practice are essential if TQM implementation is to function appropriately. The need for control mechanisms is frequently overlooked, in practice, in the euphoria of customer service and employee empowerment. Unless procedures are in place improvements cannot be monitored and measured nor deficiencies corrected. Difficulties will undoubtedly be experienced in the implementation of quality improvement and it is worthwhile expounding procedure that might be adopted to minimize them in detail.

5. Conclusion and Recommendation

The finding shows that employee satisfaction in peacock shoe, in terms of satisfaction with the authority, management encouragement and recognize team-work effort, management recognizes employee suggestions, individual effort is recognized in delivering quality service, and job as

being flexible are indifferent, this show that it needs improvement since employee satisfaction is part of total quality management. Regarding commitment of management and employee towards quality also it needs improvement, it is absolutely fundamental to the company's way of working. If the senior management will not take the time to understand it, then no one else is going too. The training and education should focus on understanding quality requirements, knowing the methodology required to attain them. It should also stress doing things right the first time, every time, with no allowable error. People should understand how much it costs if small things go wrong. Training and education, should try thus to develop a vision for quality in everyone. Inspecting every product is costly and inefficient, but the consequences of shipping non-conforming product can be significant in terms of customer dissatisfaction but using statistical quality control can alleviate such problem.

There has been a growing need for firms to improve upon the quality of product to meet customer satisfaction. Total Quality Management is therefore one of the concept by which these objectives could be ascertained. The following recommendations based on the study have been suggested. Efforts should be made by the top management of peacock shoe to create a quality and TQM culture throughout the entire organization.
This can be achieved by

- The operating policy, procedure and processes of the business must all reflect an emphasis on quality.
- Everyone in the organization must have a clear understanding of the importance of quality in achieving their business objectives.
- People at every level must be aware of the requirements and needs of the customer.
- The structure of the organization should allow for continuous improvement.
- There should be integration of internal and external customer requirements in the business plan.
- Use of customer-based measures of performance is important.
- There is a need to develop strong communication lines.
- Customer commitment should be fostered.
- Emphasis on customer-oriented values and beliefs must be supported by top management.

The study also revealed that, top management commitment, education and training, supplier producer relation and employee involvement were the most challenging critical factors in the implementation of TQM. A predominant issue in quality management literature is that a strong commitment from top management is vital. Top management must therefore establish quality policy, establishing and deploying quality goal, providing the needed resources, providing problem-oriented training and stimulating improvement. Education and training have also been found to be most important elements in a successful implementation of TQM. There is therefore the need to equip employees with the needed skills and knowledge to handle their various roles during and after the change process, their anxiety of learning and changing would be reduced.

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Analysis of Sustainability Performance and ESG Data in the Food and Beverage Industry - A Case Study of HELL Energy Hungary Kft.

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Abstract: The food and beverage industry is a sector with significant environmental and social impacts, and its sustainability challenges are receiving increasing attention today. The aim of this study is to analyse the sustainability performance and ESG data of a Hungarian beverage company, HELL Energy Hungary Kft., for the period between 2020 and 2024. The research is based on a qualitative and quantitative analysis of the company's sustainability reports, as well as an examination of specific indicators. The results show that the company's environmental efficiency has improved, particularly in material and water consumption, while social responsibility and corporate governance practices have also evolved. The study highlights further opportunities for improvement, such as the use of renewable energy sources, a deeper integration of circular economy principles, and the independent assurance of reports, which could enhance transparency and credibility."

Key words*:* sustainability report, sustainability performance, ESG data
JEL code: M14, Q56

1. Introduction

The food and beverage sector is one of the most significant industries in today's global economy, or as Gallego-Álverez et al. (2025) put it, it is of strategic importance from the perspective of the world economy. This is supported by Silva et al. (2020), who describe this sector as operating one of the most complex and high-volume global supply chains. Its production and supply chain forms a complex system that spans from the cultivation of raw materials, their processing and packaging, to the distribution of the product and waste management. This industry goes far beyond merely satisfying nutritional needs, as it is one of the engines of the global economy, providing direct and indirect livelihoods to millions of people in agriculture, manufacturing, and logistics. For this reason, achieving sustainability is crucial for the food and beverage industry both socially and environmentally, also because the food and beverage sector is one of the most environmentally demanding industries today, having to face the complex requirements of sustainability amidst continuously growing global demand.

The most critical challenge for the sector is water usage: beverage production relies on significant amounts of freshwater both as a basic raw material and as a technological resource. This industry accounts for nearly 20 percent of global annual freshwater use and withdrawals (FoodDrinkEuropa, 2025). The energy demand of manufacturing poses another challenge: cooling, heating, bottling, and logistics operations consume a substantial amount of energy, directly contributing to greenhouse gas emissions. The entire food sector (including agricultural production, processing, storage, and transport) is responsible for nearly 30% of global energy consumption, more than 70% of which occurs 'off-farm' (IRENA - FAO, 2021). It is also responsible for nearly 30% of global greenhouse gas emissions (Sukman – Uwansri, 2024). Another major sustainability issue is the generation of packaging waste. Bottles made of plastic, glass, and aluminium constitute one of the largest portions of global packaging waste; according to Global Growth Insights (2024), this proportion was 45% in 2022.

Therefore, the industry's sustainability efforts include reducing water use and protecting local water supplies. In addition, it aims to minimize the energy demand of manufacturing and logistics processes and the resulting greenhouse gas emissions, as well as reduce packaging waste by implementing a circular economy (UN, 2015). Here, sustainability means that the company operates in a way that does not harm the environment, supports local communities, and ensures that the supply chain is economically sustainable.

Large companies like Starbucks, Nestlé, and Coca-Cola have already developed detailed sustainability plans to meet consumer expectations. These strategies aim to balance profitability with the long-term health of the planet (Kadam-Jeena, 2025). One of the leading companies in the domestic food and beverage industry, and an excellent example, is HELL Energy Hungary Ltd. (HELL), whose sustainability reports I used to examine its commitment to sustainability and sustainability performance in recent years.

2. Materials and Methods

I assessed HELL's sustainability performance primarily based on its official sustainability reports, but I also incorporated all other publicly available information. These included, among others, annual and management reports, as well as investor-targeted documents, such as materials related to HELL's Green Bond. The analysis was mainly conducted through a time-series comparison, meaning I tracked performance indicators over several years to determine development trends. I complemented this method, particularly when evaluating environmental performance, with intensity indicators. The latter help to understand actual efficiency in terms of unit revenue, independent of growth. Where data for subsidiaries were available separately, I focused solely on the parent company's data.

3. Results

The study presents Hell's sustainability performance in the form of a case study through the analysis of the company's sustainability reports from 2020 to 2024.

3.1. Hell Energy Hungary Ltd.

Hell Energy Hungary Ltd., which is entirely domestically owned, is one of the fastest-growing players in the global fast-moving consumer goods (FMCG) market. Founded in 2004, the company started producing HELL ENERGY in 2006 and had secured a market-leading position in Hungary's energy drink sector by 2010. By 2025, it will be present in nearly 60 countries internationally through its export activities, with its geographical reach continuing to expand. Beyond Europe, its products are also available in Asia, the Middle East, and Africa, and it has achieved a leading market position in seven countries. (Hell, 2024a). „*The company's mission is to offer a non-alcoholic beverage portfolio that meets diverse consumer needs by following trends, with a special focus on producing functional drinks that, in addition to the usual ingredients found in energy drinks, also contain additional components.”* (HELL, 2024b).

This is significantly contributed to by its modern, privately owned, state-of-the-art bottling plants, as well as its aluminium can production line, modern technology, and high bottling capacity. The

key to Hell Energy's success is the high quality of its products, the brand's favourable price-to-value ratio, its effective marketing communication strategy, and continuous adaptation to consumer needs.

Between 2020 and 2024, both the number of products sold, and the revenue generated from them showed continuous growth, clearly indicating the company's expansion. While the number of units sold increased from 892 million to 1,426 million, revenue grew even more dynamically, rising from 68,995 million HUF to 181,780 million HUF (Figure 1).

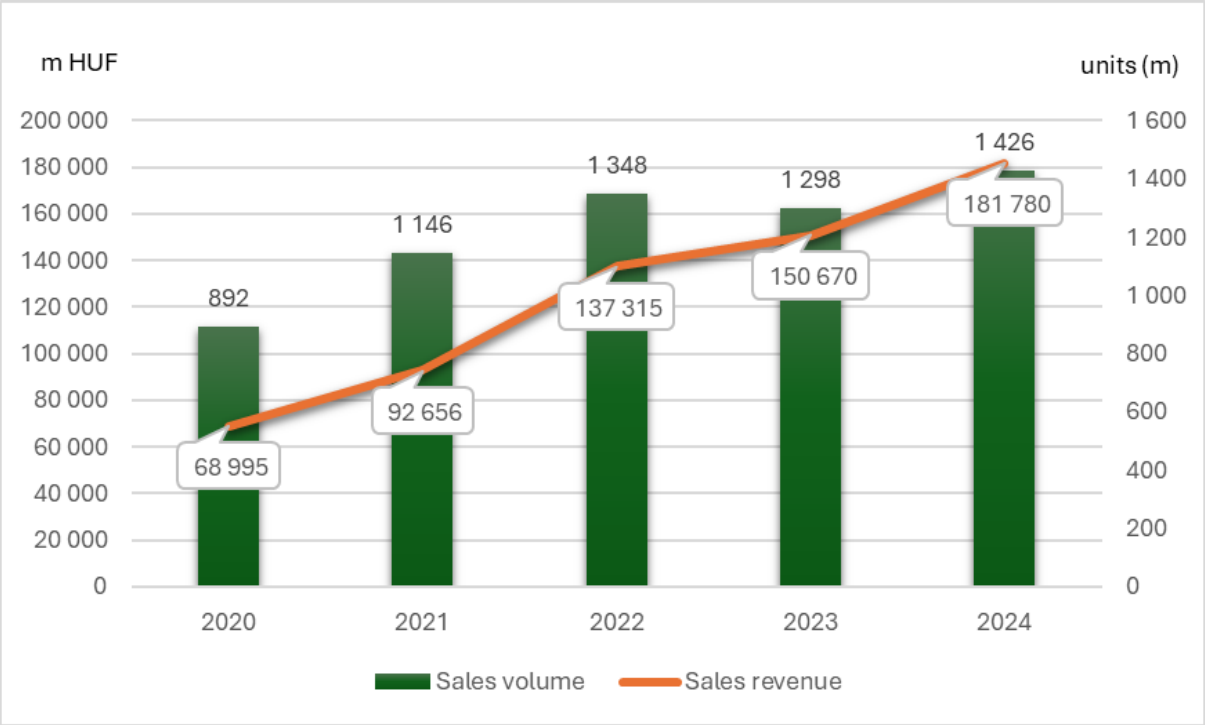

Figure 1. The company's sales data from 2020 to 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

3.2. The ESG performance of HELL

The company identifies the concept of ESG as a corporate-level approach to sustainability, although HELL uses the term 'sustainability report' and emphasizes in the management's foreword that the document presents the company's ESG performance (HELL, 2023). For the factory, sustainability means taking into account both the external and internal environment and community, both broader and narrower.

It is important to note that the company has only in recent years begun the uniform and systematic collection of data related to ESG aspects. Therefore, comprehensive, reliable, and comparable data for all key areas (responsible corporate governance, environmental protection, social responsibility) are available only from 2021 onward.

Accordingly, the analysis focuses on the period from 2021 to 2024. This ensures that the presented data provide a credible basis for assessing the company's ESG performance and illustrating development trends.

3.2.1. Responsible Corporate Governance

Although the company has had a sustainability report since 2020, environmental and social aspects only appeared in its strategy from 2022. In 2023, the company's main goal was to „*become the world's greenest energy and soft drink manufacturer*" (HELL, 2023). Its fundamental mission is „*to improve consumers' well-being with its products while emphasizing responsible consumption and production*" (HELL, 2023). In the 2024 report, this is expressed as „*operating not only successfully in business but also in an environmentally and socially sustainable way in the long term*" (HELL, 2024a). In other words, the company builds its financial/economic performance on an operational model that meets global expectations for ecological and social responsibility, thereby laying the foundation for creating dual value.

Table 1 contains the main points that the company has communicated over the years in the chapter on responsible corporate governance. The changes clearly illustrate the shifts in emphasis caused, on the one hand, by the annual changes in identified material topics, and on the other hand, by compliance with legislation, as increasingly aspects and focal points aligned with the CSRD are highlighted in the report. Initially, as part of corporate governance, economic performance was also addressed, but later this was completely removed from the report's content. (The factors marked with a grey check are included in the report, but not necessarily as subheadings; the relevant information is only found within the text.)

Another difference is that there are topics that do not appear in separate chapters but are only briefly mentioned. For example, the topic of conflicts of interest falls under legal compliance, discrimination under human rights, while product safety and responsible marketing have been moved to the section on society and the protection of our customers. The supply chain and supplier chain were previously presented in more detail, even tracking the proportion of local suppliers, but this was completely omitted from the 2024 report, and the topic is only briefly touched upon in the section on the general presentation of the report, rather than under the heading of corporate governance.

Two notable changes are that, in their most recent report, they do not separately indicate what the company's strategy is. While reading through the report makes it clear what the company's main goal is, it is not given separate emphasis, unlike in previous years when concepts like mission and main goal were used. However, an important step forward is that they have established an ESG committee, which helps the company achieve its sustainability objectives and comply with legal requirements. Although the report does not precisely list the company's main sustainability goals, capital is raised through green financing for projects related to these goals. In the documentation related to the issuance of green bonds for investors, these goals are clearly stated, such as Pollution prevention and control, Products, production technologies, and processes aligned with an environmentally friendly and circular economy, Sustainable water and wastewater management, Renewable energy, and Energy efficiency (Sustainalytics, 2021).

Table 1. Corporate Governance Topics in Sustainability Reports (2021-2024)

	2021	2022	2023	2024
Strategy - Key Values	✓	✓	✓	
Governance Structure		✓	✓	✓
Sustainability Topics			✓	✓
ESG Committee				✓
Conflict of Interest		✓	✓	✓
Ethical Guidelines	✓	✓	✓	✓
Implementation of Human Rights	✓	✓	✓	✓
Complaint Reporting System	✓	✓	✓	✓
Regulatory Compliance	✓	✓	✓	✓
Anti-Corruption	✓	✓	✓	
Awards		✓	✓	✓
Professional Organizations	✓	✓	✓	✓
Factory Development	✓	✓		✓
Responsibility in the Supply Chain	✓	✓	✓	✓
Green Financing		✓	✓	✓
Economic Performance	✓	✓		
Product Portfolio + Product Safety and Quality	✓	✓	✓	
Protection of Customer Data	✓	✓	✓	✓
Diversity, Fairness, and Avoidance of Discrimination	✓		✓	✓
Responsible Marketing and Communication	✓	✓	✓	

Source: own compilation based on Hell's sustainability reports (2020-2024)

3.2.2. Environmental Performance

The company's strategic goal is to reduce environmental impact and promote sustainable development, focusing on improving the efficiency of production processes, optimizing the use of raw materials, and reducing waste. A key role is played by the full life cycle analysis of products, which, from environmentally conscious design to environmentally conscious manufacturing, supports the selective collection of waste and, through the application of recycling technologies, facilitates its reprocessing. As the company states in its latest report: „*In the manufacturing and sale of products, we apply sustainability considerations throughout the entire value chain and actively support the realization of a low-carbon, circular economy*." (HELL, 2024a)

Table 2 contains the topics that the company has considered important to present in the environment chapter over the years.

Table 2. Environmental Topics in Sustainability Reports (2021-2024)

	2021	2022	2023	2024
Role in the circular economy		✓	✓	✓
Circular pallet management system		✓	✓	✓
Sustainable raw material sourcing			✓	✓
Materials used	✓	✓	✓	
Use of recycled raw materials				✓
Environmental awareness-raising	✓	✓	✓	✓
Waste management	✓	✓	✓	✓
Waste generation and significant waste-related impacts				✓
Managing significant waste-related impacts	✓			✓
Waste diverted from disposal				✓
Energy consumption	✓	✓	✓	✓
The organization's interactions with water				✓
Managing water-related impacts				✓
Water use, water withdrawal	✓	✓	✓	✓
Water discharges				✓
GHG emissions - Scope 1, Scope 2	✓	✓	✓	✓
GHG emissions – NOX, SOX, other air pollutants			✓	✓
Key environmental achievements	✓	✓		
Environmental compliance	✓	✓		
Product innovation - Packaging-free solution	✓	✓	✓	✓

Source: own compilation based on Hell's sustainability reports (2020-2024)

Some interesting points regarding the structure of the environmental section of the report. For example, in the 2024 report, the waste management data reporting is much more detailed than in previous years, now presenting waste generation broken down by composition across several pages. In contrast, the topic of awareness-raising has been removed from the standalone chapters, receiving only a brief mention in the document. An additional element is waste diverted from disposal, referring to recycling, as well as water emissions, which refers to wastewater. Furthermore, the 2024 report mentions that in the future they intend to measure Scope 3 as well, meaning they will also collect emission data related to the supply network, services, and consumers (HELL, 2024a). However, in previous years, in 2021 and 2023, they also calculated energy intensity for electricity and gas consumption, but this was omitted afterwards.

When examining environmental performance, I analyse in more detail the indicators related to material use, water consumption, energy consumption, and waste management. I do not specifically address greenhouse gas emissions, as they are closely related to natural gas and electricity consumption.

Material consumption

During the manufacturing process, the company strives to select raw materials and packaging materials that are more environmentally friendly. It is evident from Figure 2 that total material usage increased over the period under review.

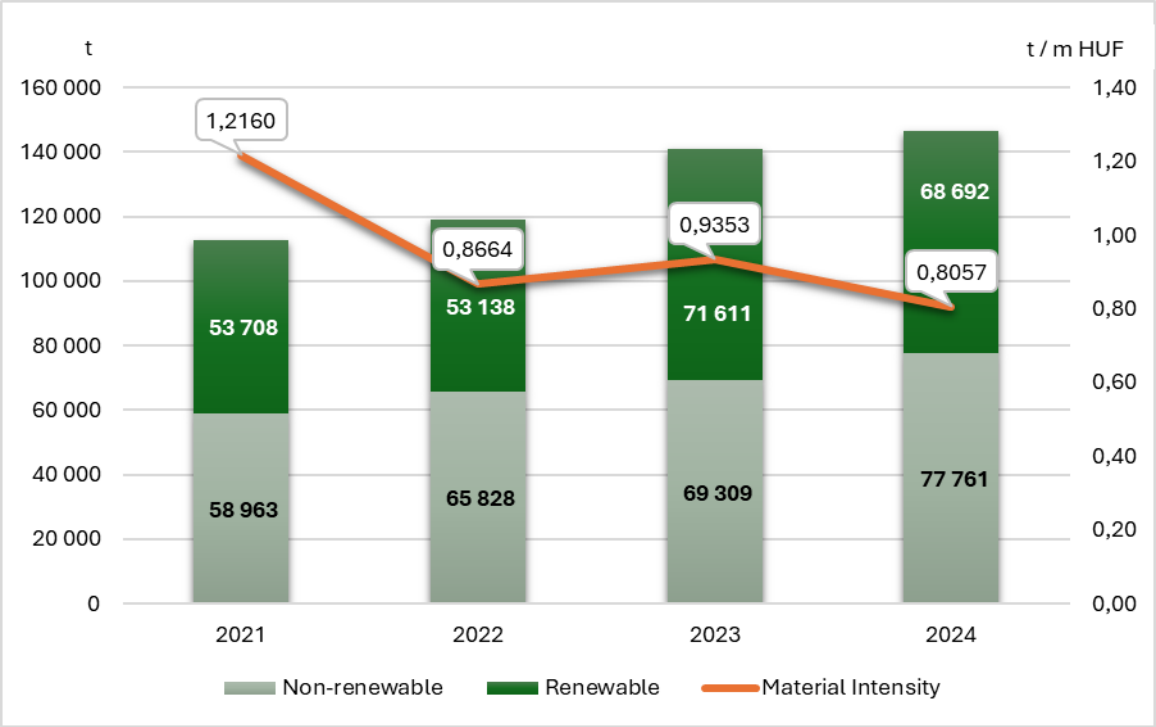

Figure 2. Material consumption between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

The main reason for this is the increased material usage associated with growing production capacity; however, while the proportion of non-renewable materials increased by 27.9%, the proportion of renewable materials rose by 31.9%, which is a positive development. In 2023, as part of a design project, the use of recyclable packaging materials was initiated. To support these goals, projects were launched to improve resource efficiency (e.g., reducing the weight of paper trays) and to introduce recyclable packaging materials to replace plastic films. As a result of these measures, by 2024 nearly 57.3% of the materials used were certified as recyclable.

Although the company's material usage was significant during the examined period (2021–2024) and showed a 31.7% increase, which was in line with the growth in production (sales) volume, different trends can be observed from the perspective of environmental efficiency. It can be considered a positive outcome that the specific material usage decreased from 1.216 to 0.805, a 33% reduction, indicating a significant improvement in the efficiency of production processes and a decrease in material requirements per unit of revenue.

Water consumption
The company's water consumption is significant, as one of the main raw materials of their products is high-quality, contaminant-free, potable water. The increase in the amount of water used is primarily the result of their capacity expansion. In 2021, this meant a production capacity of 1.5 billion boxes, 3 billion in 2022, and 6.5 billion boxes by 2024. The company's water management performance during the four-year period under review (2021–2024) showed a dual trend, as illustrated in Figure 3. The total annual water consumption increased significantly from 559,288 m^3 in 2021 to 747,664 m^3 in 2023, which can be explained by the growth in production volume

and the expansion of operating capacity. In 2024, a slight decrease was then observed (729,714 m³).

At the same time, the specific water consumption (m³/HUF), which is a critical indicator of operational efficiency, showed continuous and significant improvement: from 6.036 m³/HUF in 2021, it decreased to 4.014 m³/HUF by 2024. This reduction of 2.022 m³/HUF (approximately a 33.5% decrease) indicates that, because of intensive water management and technological optimization, water use efficiency has significantly improved, representing a positive performance in the environmental dimension.

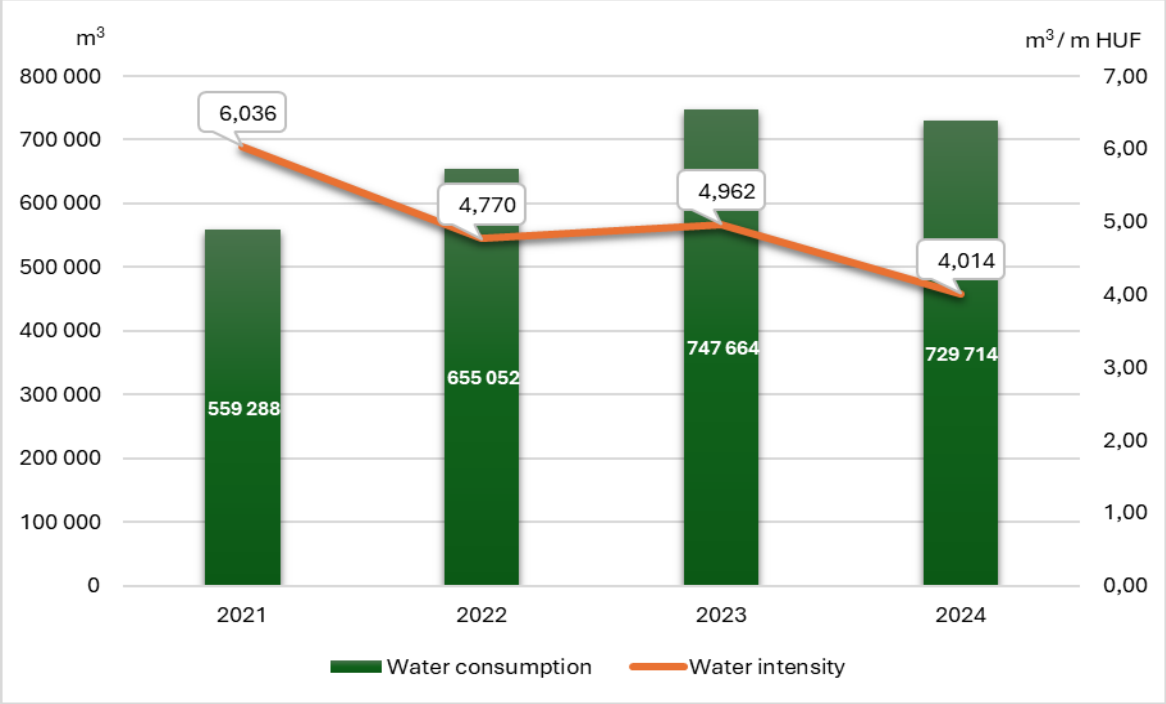

Figure 3. Water consumption between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

Energy consumption
In HELL's energy supply, natural gas plays the primary role, while electricity represents the other key element of its operation. During the four years between 2021 and 2024, significant growth could be observed in both energy types due to the expansion of the company's production and operational capacities.

The demand for electricity increased the most, with consumption rising by 39% in 2023 compared to 2021, and then increasing by more than 200% in 2024, reaching 34.084 million kWh (Figure 4). Natural gas consumption grew by 23.7% between 2021 and 2023, and in 2024 it saw a further 34.5% increase (Figure 5). These two trends clearly reflect the company's growing energy needs, which are closely linked to increased production and more intensive use of technological systems.

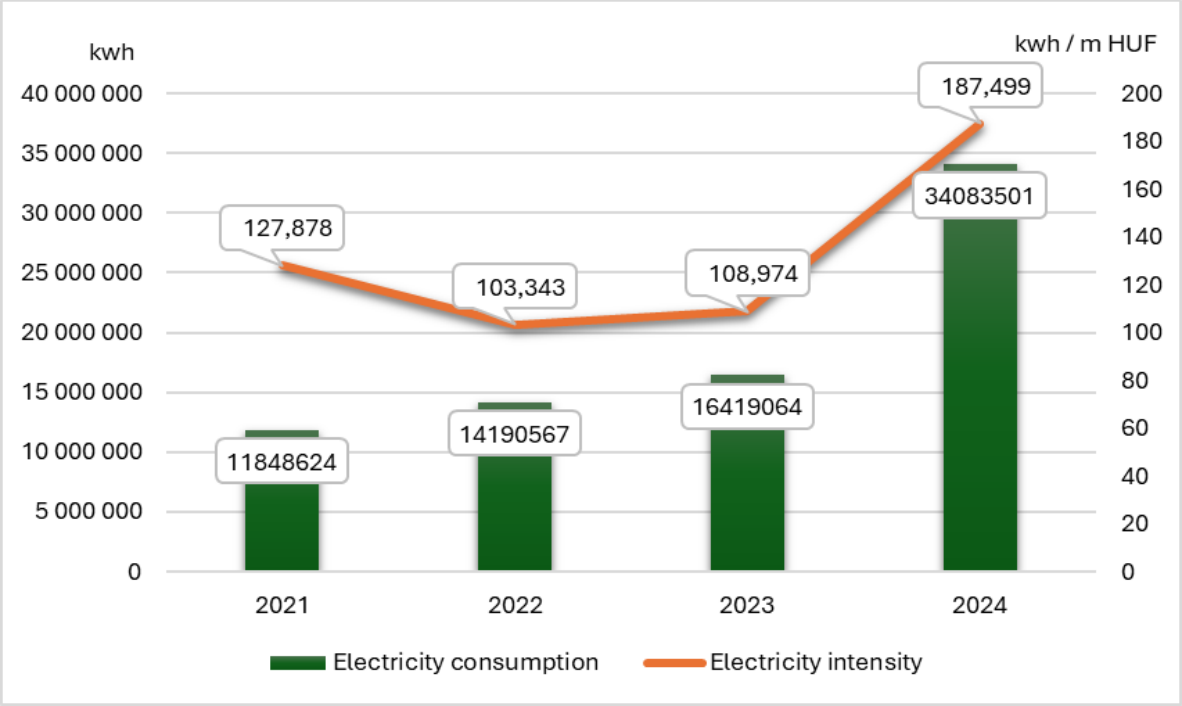

Figure 4. Electricity consumption between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

It is much more illustrative to examine specific energy consumption than actual usage. For electricity, the continuous increase in efficiency is also evident; the deterioration in the 2024 data may be related to the construction of production lines associated with capacity expansion, and once production starts, this ratio is expected to decrease. However, energy consumption is increasing, and although the company currently does not use renewable energy sources, future goals include transitioning to more sustainable operations, as part of which solar solutions will be introduced in 2025 (HELL, 2024a).

Fuel consumption also continued to increase (Figure 6). In 2021, diesel accounted for 56.7% of the total fuel mix, while by 2024, this ratio had risen to 72.6%. Although the 2021 and 2022 reports do not cover fuel usage, the 2023 report includes data for the past three years retrospectively; however, the reasons for the changes are not explained, and they could still be effects stemming from COVID. Despite a larger decrease during the period under review, fuel consumption had significantly increased by 2024 compared to 2022, but it still only slightly exceeded the 2021 level. This increase is directly related to the expansion of logistics, transportation, and processes supporting production. When examining fuel usage relative to revenue, it can be said that the company is nearly twice as efficient compared to 2021. This ratio has not changed significantly over the past three years, which is a favourable trend despite continuous growth.

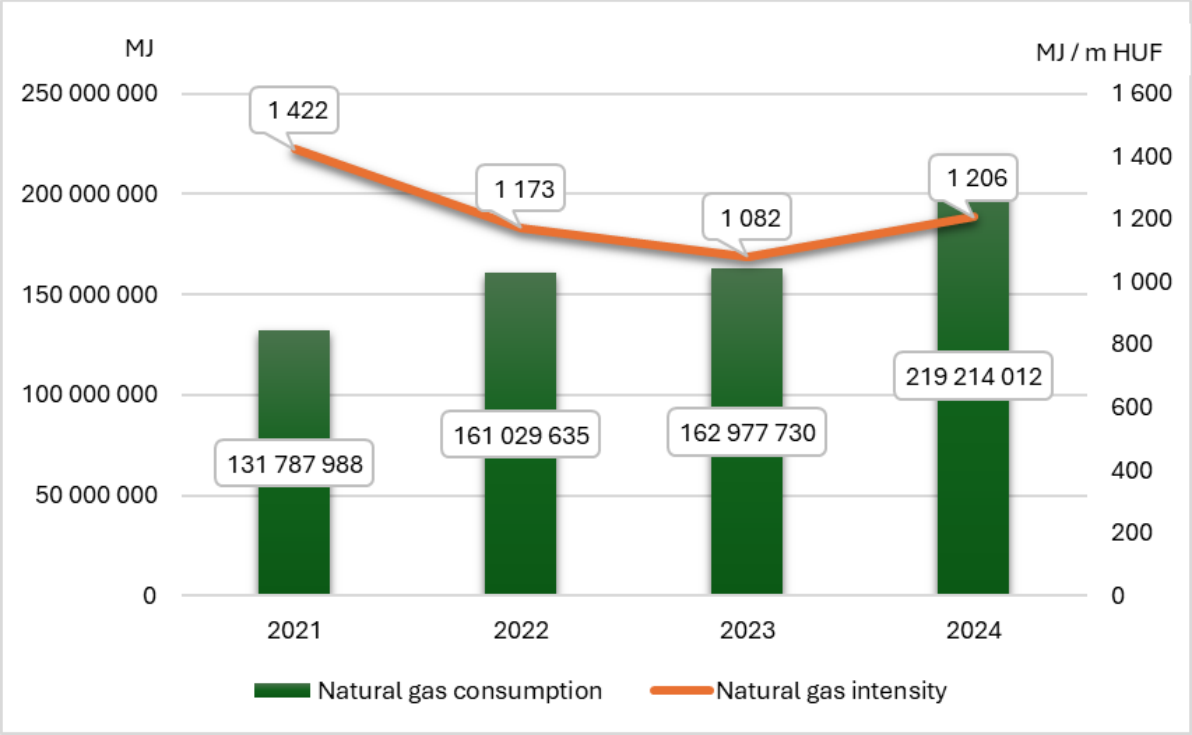

Figure 5. Natural gas consumption between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

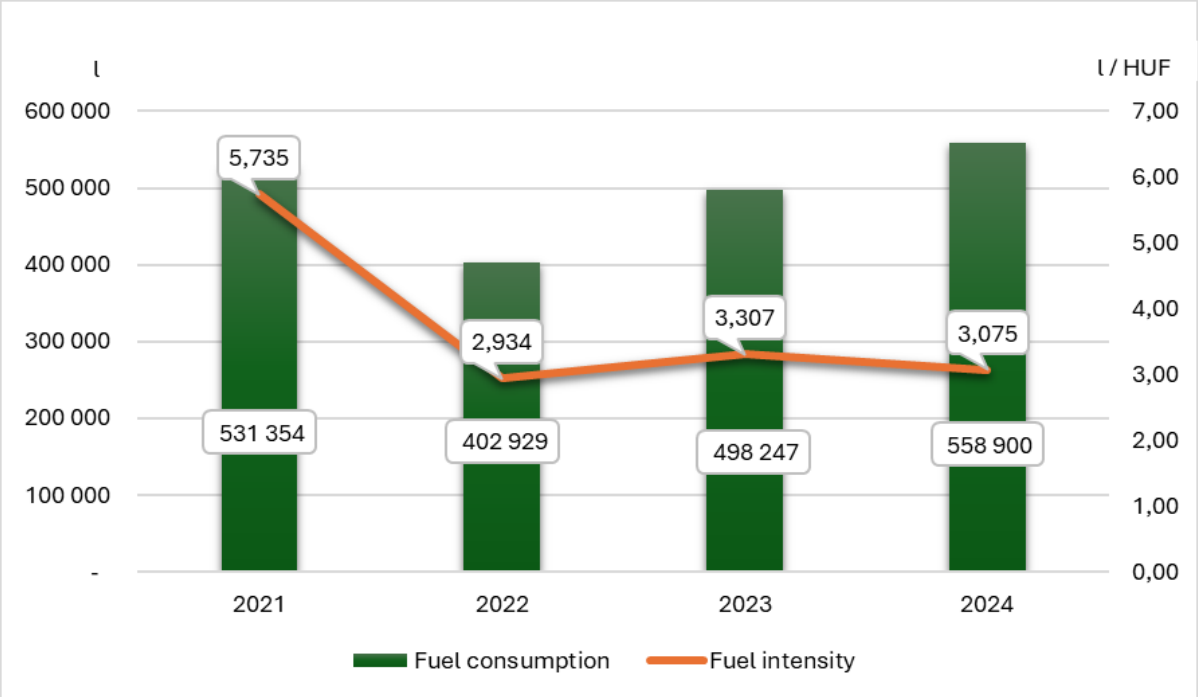

Figure 6. Fuel consumption between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

Waste management

Figure 7 shows the total amount of waste generated between 2021 and 2024. The total waste (hazardous and non-hazardous) increased from about 1,262 tons in 2021 to 2,426 tons in 2024, representing an increase of nearly 92%. This growth can be explained by the significant rise in production volume, as the manufacturing capacity quadrupled during this period. The amount of hazardous waste increased a hundredfold from 2022 to 2023 and a thousandfold by 2024. The reason for this was the washing liquid generated due to the commissioning of the new production line; this cleaning process began in 2023 and was completed in 2024. Therefore, for the sake of the realism and comparability of the analysis, data cleaning was necessary, and the quantities of washing liquids were subtracted in the study. In 2024, nearly 12,000 tons of washing liquid were generated, while in 2023, 90% of the total hazardous material was produced due to aluminium cans manufactured by Quality Pack, amounting to 1,110 tons (HELL, 2023 and 2024a).

The picture is a bit more nuanced when it comes to revenue, since even though the amount of waste has doubled, in relative terms it is still below the 2021 figure in 2024. The slight increase starting in 2022 can be explained by the capacity expansion, as it is expected that the commissioning of the production line will lead to an increase in the quantity sold and thus in revenue, which will bring back the value of the indicator representing the otherwise increasingly efficient waste management.

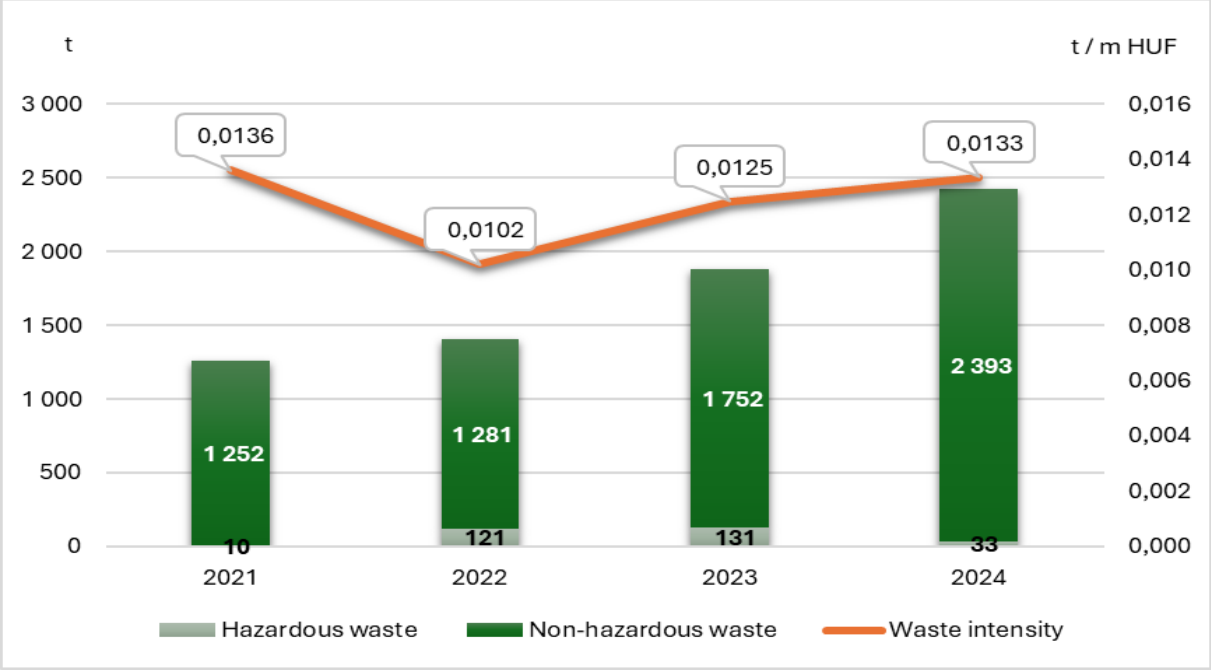

Figure 7. Waste generation between 2021 and 2024

Source: own compilation based on Hell's sustainability reports (2020-2024)

3.2.3. Corporate social responsibility

The main chapter of the report on social responsibility can be divided into three parts: employees, clients and consumers, and local communities. However, it is true for all four years that out of

these three areas, the greatest emphasis is placed on ensuring the health and well-being of employees, setting an example for industry players as a responsible employer. Consequently, this section is presented in the greatest detail in the report. HELL is committed to the well-being of its employees and maintaining a healthy work environment, placing great emphasis on work-life balance. The company's goal is to offer an attractive workplace to all its employees. They give particular attention to the professional development of employees, providing a wide range of training opportunities and supporting individual progress with regular feedback. The company's responsible employer approach is formalized in its Code of Ethics.

Table 3. Topics of Social Responsibility in Sustainability Reports (2021-2024)

	2021	2022	2023	2024
Employees of the HELL Group	✓	✓	✓	✓
Impacts on human rights				✓
Number of new employees and turnover	✓	✓	✓	✓
Remuneration and compensation		✓	✓	✓
Process of determining remuneration				✓
Annual total remuneration ratio				✓
Notifying employees of significant changes				✓
Training	✓	✓	✓	✓
Career development and performance evaluation opportunities	✓	✓	✓	✓
Digitalization	✓	✓		
Occupational Health and Safety Management System (EHS)	✓	✓	✓	✓
Hazard identification and risk assessment				✓
Work-related injuries and occupational diseases	✓	✓	✓	✓
Preserving employee health	✓	✓		✓
Employee occupational safety training		✓	✓	✓
Employee participation				✓
Workplace health services	✓	✓	✓	✓
Promoting a sustainable mindset	✓	✓	✓	✓
Responsible marketing	✓	✓	✓	
Product information and labeling	✓			✓
Customer satisfaction	✓	✓	✓	
Product safety and quality	✓	✓	✓	
Transparency in manufacturing communication				✓
Legal compliance and complaints management	✓	✓	✓	✓
Job creation	✓	✓	✓	
Corporate social responsibility - Supporting local communities	✓	✓	✓	✓
Supporting career opportunities for young people	✓	✓	✓	
Code of ethics and commitment	✓	✓	✓	✓

Source: own compilation based on Hell's sustainability reports (2020-2024)

Ethical and rule-abiding behaviour is a fundamental value in the operation of HELL, which includes consumer protection and full compliance with legal regulations. The company's main goal is to achieve the highest possible level of consumer satisfaction, which is ensured through accurate, transparent, and lawful product information. Since their products serve the end consumers directly, responsible and transparent communication is of great importance to them. In their marketing activities (advertising, packaging, sponsorship), they strive to ensure that every message is credible and clear.

Excellent product quality and safety are central aspects of their development and sales processes. Production is carried out according to international standards, ensuring that only flawless products reach the market.

HELL's complaint management system allows consumers to share their feedback directly. All written inquiries receive a response, ensuring transparent and professional handling (HELL, 2024a).

Table 3 lists the topics that the company has considered important to present in the corporate social responsibility section over the years.

It is generally true that the range of aspects presented expanded for 2024, but, for example, the number of topics affecting customers and the depth of their presentation decreased, and product safety, quality, as well as responsible marketing and communication were omitted from the latest report, although the latter appeared as product information and labelling. While previous reports included the proportion of local managers as an indicator of job creation, this was no longer considered important to present in 2024.

A positive change in recent years is that respect for human rights is included in the social chapter in 2024, whereas in previous years it was only mentioned under responsible corporate governance. EHS was referred to in the report every year, but as an important management system, it only appeared in 2024. Additionally, what used to be environmental awareness-raising, which was clearly aimed at consumers and was part of the environmental pillar, is now also available among social factors and applies to employees as well.

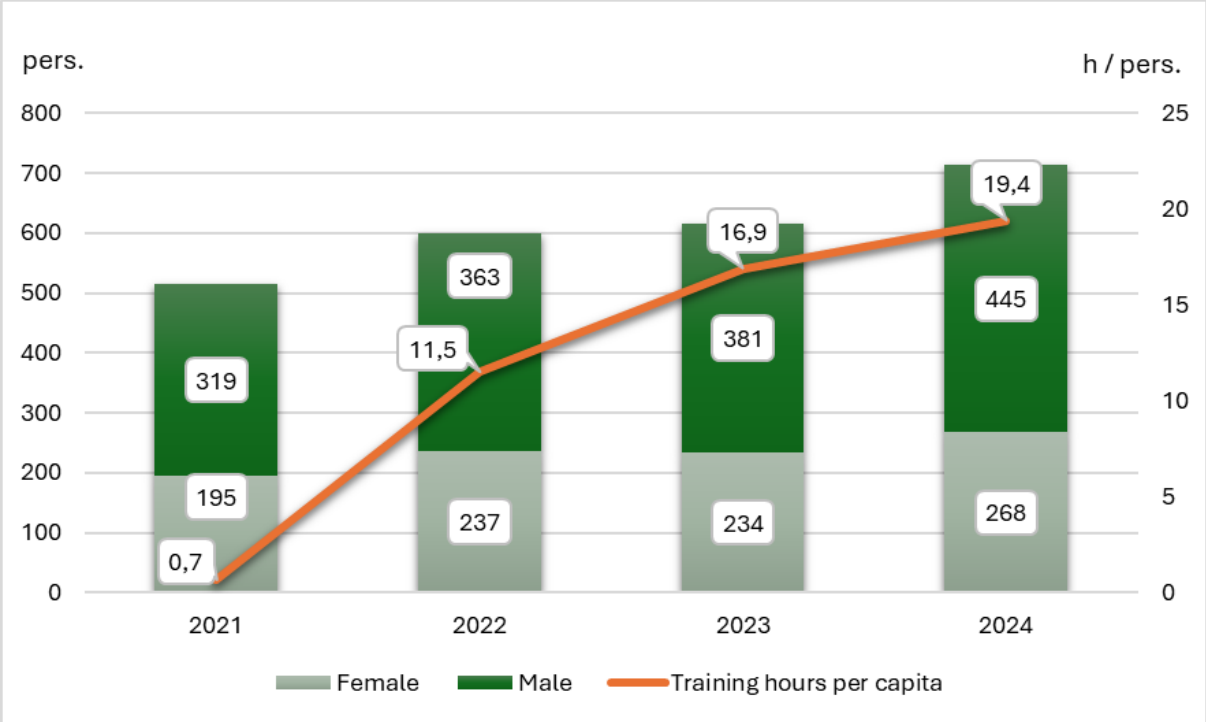

Figure 8. Number of employees and training hours per person between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

The number of employees at Hell has been increasing year by year; while in 2021 there were 514 employees, by 2024 this number had increased by nearly 39% to 713 (Figure 8). Additionally, a positive trend is that the proportion of new entrants each year is higher than the number of employees leaving the company. Moreover, turnover has decreased over the past four years from 26.8% to 17.4% (Figure 9), and the number of training hours per employee has also increased from 0.7 hours to 19.4 hours, all of which demonstrate that as a responsible employer, the company's social activities are improving year by year, and employee retention is becoming increasingly important. To this end, for example, the company strives to continuously involve its employees to achieve potential improvements and successes. Employee engagement and competitiveness are also supported by the fact that its remuneration policy is well thought out, structured, and aligned with the industry. The 2024 annual report already covers the process of determining remuneration and provides information on the total annual remuneration ratio, making the scope of benefits and performance evaluation more transparent. Another positive development is that the number of accidents per total hours worked improves year by year.

Hell Energy's commitment to local communities is also reflected in the fact that it supports the town of Szikszó with tens of millions of forints every year for sports and health preservation projects, and in addition, it donates around 50 million forints annually to various charitable causes.

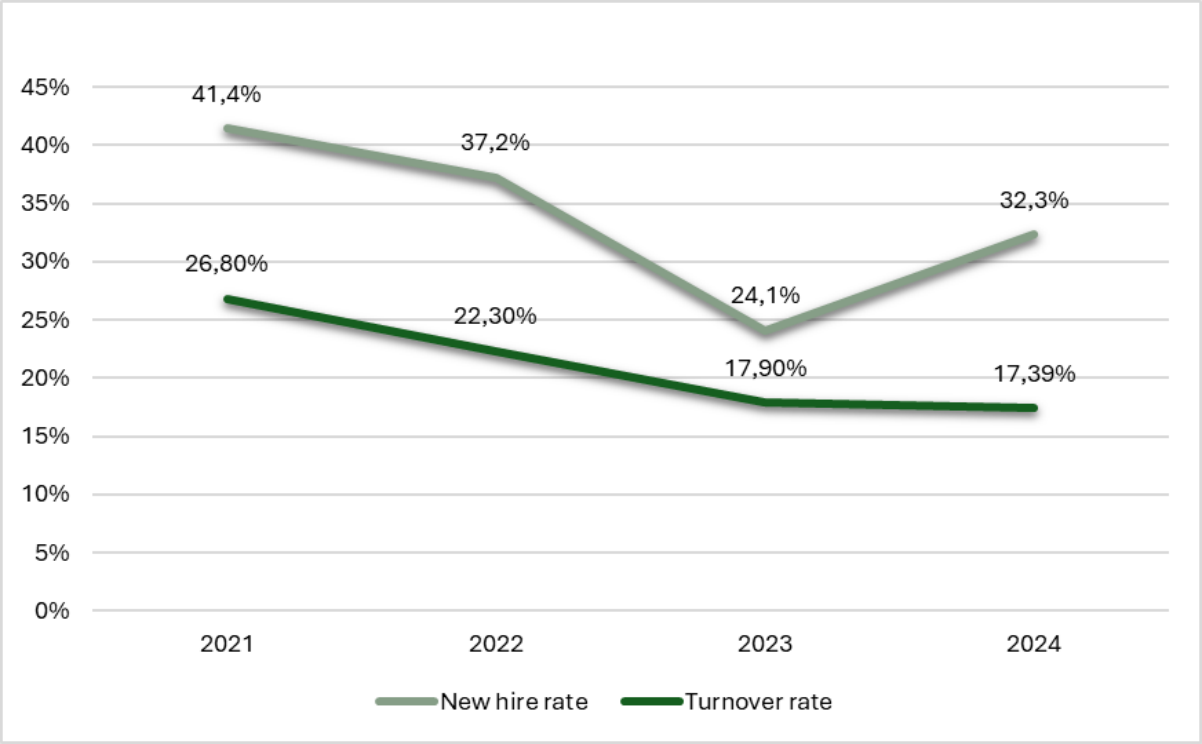

Figure 9. The ratio of new hire and turnover between 2021 and 2024
Source: own compilation based on Hell's sustainability reports (2020-2024)

3. Conclusions

In recent years, the strategic importance of sustainability has significantly increased in the industry, as the food and beverage sector thus plays a dual role in the sustainability transition. Consequently, it is particularly important to examine how companies in the sector report on their sustainability performance, what data they disclose, and how suitable this information is for objective comparison and assessing genuine performance. In other words, companies need to take real, substantial actions and credibly integrate sustainable practices into their entire business model.

Based on the analysis, it can be concluded that HELL Energy's sustainability performance and ESG data have improved positively in recent years. During the period under review, significant progress was made in environmental efficiency, particularly in indicators related to material and water use, as well as waste management. Progress is also noticeable in the social and corporate governance dimensions, for example through the establishment of an ESG committee and the expansion of employee training programs. However, the comparability and credibility of sustainability reports remain a challenge, making it particularly important to integrate renewable energy sources, further embed the principles of a circular economy, and ensure independent verification of reports. The example of HELL shows that sustainability is not just a communication tool, but a strategic factor that determines a company's competitiveness in the long term. Therefore, HELL, which has considered it important for five years to share with all stakeholders its contribution to achieving sustainability goals through presenting its sustainability performance, serves as a "best practice" not only for companies operating in the beverage industry but also for all domestic companies.

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Content and Structure Evolution in Sustainability Reporting in Light CSRD and ESRS: A Case Study of HELL Energy Hungary Kft.

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Abstract: In the food and beverage industry, the role of sustainability reports has significantly increased in recent years, reinforced by changes in the regulatory environment and growing societal expectations. The aim of the study is to examine the sustainability reports of HELL Energy Hungary Ltd. between 2020 and 2024, with particular attention to content and structural changes, as well as the emergence of the CSRD and ESRS standards. During the analysis, I evaluated the company's official sustainability reports and other publicly available documents. The results show that the reports initially followed the GRI guidelines, and by 2024 they were prepared considering the ESRS requirements, in line with the new EU regulations. The number and level of detail of the material topics in the reports have continuously increased, indicating the company's growing commitment to regulatory compliance and transparency. The study highlights that although sustainability reports are becoming increasingly complex, providing credible and comparable data remains a challenge. The research contributes to understanding domestic practices and exploring the impacts of regulatory changes, showing the significant content and methodological transformations resulting from these regulatory changes.

Key words*:* SDG, ESG, sustainability report, CSRD, ESRS
JEL code: M14, Q56

1. Introduction

Nowadays, there is an increasing emphasis on information that not only reflects financial performance but also provides a more comprehensive picture of the company's operations. (Gáspár et al., 2023). Companies that evaluate their own activities from a perspective, including sustainability, environmental, social and governance (ESG) aspects in addition to financial data, help to provide a transparent picture of the company's commitment to sustainability and its contribution to the Sustainable Development Goals (SDGs).

However, companies do not publish their sustainability information in a uniform way. Some companies publish ESG data exclusively on their websites, while others summarize their performance in a separate sustainability report, which allows stakeholders to get a more complete picture of the company's environmental and social performance, environmental and social responsibility achievements. As Bögöly and Wickert (2023) put it, thereby supporting transparency and responsible corporate behaviour. These reports can be in a simple, company-specific format, but increasingly, internationally recognized, standardized frameworks are also being used, such as the guidance of GRI (Global Reporting Initiative) or SASB (Sustainability Accounting Standards Board).

In recent years, commitment to sustainability has become an increasingly important expectation for companies operating in the food and beverage industry as well. This has been influenced partly by changes in the regulatory environment, such as the EU Green Deal, the EU Taxonomy, the emergence of the CSRD, and the CSDDD, and partly by shifting expectations from consumers and investors. As a result, an increasing number of companies are required to comply with these legal requirements, and accordingly, the number of companies preparing sustainability reports under

CSRD is growing. These reports must be prepared as part of the annual report, specifically within the business plan, and published in accordance with the rules for the publication of reports. The content requirements for reports prepared under CSRD are regulated by the European Sustainability Reporting Standards (ESRS), a package of EU-level delegated standards for uniform European reporting. All of this is also stipulated by the Accounting Act (Act C of 2000) as amended to include these contents. The adopted ESRS package contains a total of 12 standards, 10 of which address various ESG-related areas thematically (5 focus on environmental impacts, 4 on social impacts, and 1 standard focuses on corporate governance). While Standard 2 sets out the mandatory principles that must be considered when preparing sustainability information, both in terms of content and form, thereby establishing the basis for reporting, this framework provides clear guidance to companies on what and how to report, promoting the reliability and comparability of reports.

Its aim is to standardize company sustainability reports. Previous voluntary certified reports, such as those by GRI, although popular, often ranged in length from 10 to 100 pages and had varying content even within the same industry. This was because, out of the hundreds of possible indicators (KPIs), each company highlighted what it considered most important. The new regulation addresses this problem by introducing a mandatory section with fixed content, which every company must present in the same structure and format. This ensures that investors and stakeholders can measure and compare the sustainability performance of different companies on a real basis.

One of the leading companies in the domestic food and beverage industry, and an excellent example, is HELL Energy Hungary Ltd. (HELL), whose sustainability reports I used to examine its commitment to sustainability in recent years, as well as its sustainability reporting.

2. Materials and Methods

I assessed HELL's sustainability reporting practices primarily based on its official sustainability reports, but I also included all other publicly available information. These included, among others, annual and management reports, as well as documents intended for investors, such as materials related to HELL Green Bonds. The analysis was essentially conducted through a time-series comparison.

3. Results

The study presents Hell's sustainability commitment in the form of a case study through an analysis of the company's sustainability reports from 2020 to 2024.

3.1. Hell Energy Hungary Kft.

Hell Energy Hungary Kft., which is entirely domestically owned, is one of the fastest-growing players in the global fast-moving consumer goods (FMCG) market. Founded in 2004, the company started producing HELL ENERGY in 2006 and had secured a market-leading position in Hungary's energy drink sector by 2010. By 2025, it will be present in nearly 60 countries internationally through its export activities, with its geographical reach continuing to expand.

Beyond Europe, its products are also available in Asia, the Middle East, and Africa, and it has achieved a leading market position in seven countries. (Hell, 2024a). „*The company's mission is to offer a non-alcoholic beverage portfolio that meets diverse consumer needs by following trends, with a special focus on producing functional drinks that, in addition to the usual ingredients found in energy drinks, also contain additional components."* (HELL, 2024b).

This is significantly contributed to by its modern, privately owned, state-of-the-art bottling plants, as well as its aluminium can production line, modern technology, and high bottling capacity. The key to Hell Energy's success is the high quality of its products, the brand's favourable price-to-value ratio, its effective marketing communication strategy, and continuous adaptation to consumer needs.

Between 2020 and 2024, both the number of products sold, and the revenue generated from them showed continuous growth, clearly indicating the company's expansion. While the number of units sold increased from 892 million to 1,426 million, revenue grew even more dynamically, rising from 68,995 million HUF to 181,780 million HUF.

3.2. The structure of Hell's sustainability reports

Hell prepares its sustainability reports in accordance with the GRI requirements and using its elements, publishing them in Hungarian on its website every year since 2020. However, the report is not verified or certified by an independent party. Nevertheless, in anticipation of regulatory changes, for the year 2024, the material topics are presented taking into account the ESRS standards in line with the CSRD, thereby reflecting the company's sustainability performance as well.

An interesting change is that while in 2020 the content of the report was identified as sustainability performance, by 2023 it is referred to as ESG performance. This is also supported by the change in the structure of sustainability reports. In 2020, material information was published based on economic (financial), environmental, and social aspects. In 2021, corporate governance appears at the level of mention, but not as a separate chapter. In 2022, alongside environmental and social aspects, corporate governance aspects are also presented, and economic/financial performance is treated as part of the latter. In 2023, omitting the description of financial performance, the company presents its performance along the classic ESG lines. However, an important change is that the social part is split into two groups: employees and customers/local communities. In 2024, the report is structured according to the three parts of ESG: environmental, social, and corporate governance aspects.

However, in terms of content, the presentation of the impact on society provides a somewhat more nuanced picture, as from 2020 onwards it breaks it down into the categories of employees, consumers, and local communities. This shows that HELL's sustainability reports have become increasingly complex over the years; while the environmental and social dimensions have been consistently present from the beginning, corporate governance elements have gradually been incorporated, displacing financial performance (Table 1).

Table 1. The structure of HELL Ltd.'s sustainability reports between 2020 and 2024

	2020	2021	2022	2023	2024
Economic (financial)	✓	✓	✓		
Environmental-E	✓	✓	✓	✓	✓
Social-S	✓	✓	✓	✓✓	✓
Governance-G		✓	✓	✓	✓

Source: own compilation based on Hell's sustainability reports (2020-2024)

While in 2020 and 2021 the sustainability report only covered the two most important companies, Hell Energy Magyarország Kft. and Quality Pack Zrt., from 2022 the scope of reporting has expanded significantly, covering the entire group, including the other subsidiaries such as Avalon Park Kft., Hell Automata Üzemeltető Kft., and Hell Energy Promotion Kft. With this, the HELL Group provides a comprehensive overview of its sustainability performance across its entire range of activities. (HELL, 2024a).

3.3. Sustainability and ESG Information – Who Is It For?

In their research, Lippai-Makrai (2022) concluded that the primary drivers for preparing sustainability reports are to meet the information needs of stakeholders, although there are, of course, companies that are only compelled by regulation to disclose non-financial information. According to Chikán's (2021) definition, stakeholders are "any person or group who/which is in a significant, lasting, and mutual relationship with the company's operations." In practice, this means that stakeholders are interested in the company's performance since it directly affects them. Therefore, it is crucial for responsibly operating companies to consider the interests of stakeholders. The satisfaction and trust of stakeholders contribute to the company's long-term sustainability and success. Satisfied stakeholders enhance the company's reputation, stabilize operations, reduce business risks, and ultimately strengthen its market position.

In the 2020 and 2021 sustainability reports, HELL does not specifically name the stakeholders, only stating that the needs of internal and external parties are taken into account during report preparation. From 2022 onwards, however, as sustainability aspects are increasingly integrated into the strategy, the range of stakeholders also expands, as shown in Table 2. In its most recently published report, it again does not detail the stakeholders separately, only mentioning internal and external parties, and for the first time uses the terms environmental and social stakeholders.

Table 2. The stakeholders of HELL

	2020 -2021	2022	2023	2024
Internal stakeholders	Not specified individually, referred to only as internal stakeholders.	☞ Owners ☞ Senior executives ☞ Other employees	☞ Owners ☞ Senior executives ☞ Other employees	☞ Not specified individually, referred to only as internal stakeholders.
External stakeholders	Not specified individually, referred to only as external stakeholders.	☞ Partners and suppliers ☞ NGOs (Civil organizations) ☞ Professional organizations and consultants ☞ Local communities ☞ Media representatives	☞ Partners ☞ Buyers, customers, and suppliers ☞ NGOs (Civil organizations) ☞ Professional organizations and consultants ☞ Local communities ☞ Media representatives ☞ Government bodies and regulatory authorities ☞ Creditors ☞ Competitors	☞ Not specified individually, referred to only as external stakeholders. (Partners, Customers, Suppliers) ☞ Environmental stakeholders ☞ Social stakeholders

Source: own compilation based on Hell's sustainability reports (2020-2024)

3.4. Sustainability and ESG Information – What Content?

Involving the stakeholders is a critical point in identifying material sustainability and ESG topics. These are the focus areas about which external and internal stakeholders have information needs in relation to the company. Determining the materiality of sustainability and ESG information helps decide which topics the company should address when presenting its sustainability performance in its report, that is, which areas require special attention. This determination is based on double materiality, both financial as well as environmental and social materiality. Financial materiality examines the impact of opportunities and risks arising from climate change and social responsibility on the company. Environmental and social materiality, on the other hand, shows how the company's operations affect the climate, the environment, and society (European Commission, 2023).

The topics highlighted in sustainability reports have undergone significant changes over the past few years. The terminology has continuously evolved, new perspectives have emerged, while

others have faded into the background. From this year onwards, the material topics are identified according to the unified European standards (ESRS) defined by the CSRD. This new common regulation allows company reports to become reliable and easily comparable, whether over time or with other industry companies. The number of these topics was 9 in 2020, but by 2024 it had increased to 17. This expansion indicates that companies consider an increasing number of environmental (E), social (S), and governance (G) aspects as highly relevant to their operations.

The reports can also be examined in terms of how well they cover the areas that will later be defined by the ESRS under the CSRD. Table 3 contains the 10 thematic standards and their topics, compared to the material topics identified in HELL sustainability reports published between 2020 and 2024. The comparison was carried out solely based on the reports' "Our Material Topics" section, using the exact list provided. Therefore, the entire text of the report was not compared, as the company may have presented or achieved results in areas that were not highlighted as material during the materiality assessment.

The number of material (highly important) topics according to ESRS also shows a significant increase, reflecting the company's growing commitment to sustainability. In 2020, Pollution (E2), Resource use and circular economy (E5), Consumers and end-users (S4), and Business conduct (G1) were highly important, but topics related to Climate change (E1) and Own workforce (S1) standards were addressed, though considered less important. From 2022 onwards, in addition to the previous ones, the Climate change (E1) and Water and marine resources (E3) standards are also included. Among social topics, from 2023 the topic of Affected communities (S3) also becomes material, reflecting greater responsibility towards internal and external stakeholders. However, the standards on Biodiversity and ecosystems (E4) and Workers in the value chain (S4) are not addressed in any of the reports.

Table 3. Identification of material topics in Hell Energy's sustainability reports according to ESRS standards

	2020	2021	2022	2023	2024
Number of material topics (pcs)	9	10	15	8 (34)	17
E1 Climate change	✓		✓	✓	✓
E2 Pollution	✓	✓	✓	✓	✓
E3 Water and marine resources			✓	✓	✓
E4 Biodiversity					
E5 Resource use and circular economy	✓	✓	✓	✓	✓
S1 Own workforce	✓			✓	✓
S2 Workers in the value chain					
S3 Affected communities				✓	✓
S4 Consumers and end users	✓	✓	✓	✓	✓
G1 Business conduct	✓	✓	✓	✓	✓

Source: own compilation based on Hell's sustainability reports (2020-2024)

3.5. The company's commitment to sustainability – SDG goals

Hell Energy is also committed to the Sustainable Development Goals, paying particular attention to reducing environmental impact, increasing the sustainability of manufacturing processes, and

ensuring transparent operations. Accordingly, optimizing energy and resource use, using fully recycled packaging materials, and social responsibility are of paramount importance. Furthermore, the company is gradually incorporating the principles of a circular economy into its operating model. This change in approach extends to all stages of the value chain, from raw material procurement and the manufacturing phase to waste management (HELL, 2024a).

Table 4. The appearance of SDG goals in sustainability reports

	2020	2021	2022	2023	2024
SDG1 - No Poverty	✓				
SDG2 - Zero Hunger	✓				
SDG 3 - Good Health and Well-being	✓	✓			
SDG 4 - Quality Education	✓	✓			
SDG 5 - Gender Equality	✓	✓			
SDG 6 - Clean Water and Sanitation	✓	✓	✓	✓	
SDG 7 - Affordable and Clean Energy	✓	✓	✓	✓	
SDG 8 - Decent Work and Economic Growth	✓	✓			
SDG 9 - Industry, Innovation and Infrastructure	✓	✓	✓	✓	✓
SDG 10 - Reduced Inequalities	✓				
SDG 11 - Sustainable Cities and Communities	✓	✓			
SDG 12 - Responsible Consumption and Production	✓	✓	✓	✓	
SDG 13 - Climate Action	✓	✓	✓	✓	
SDG 14 – Life Below Water	✓				
SDG 15 – Life on Land	✓				
SDG 16 – Peace, Justice and Strong Institutions	✓				
SDG 17 - Partnerships for the Goals	✓	✓	✓	✓	✓

Source: own compilation based on Hell's sustainability reports (2020-2024)

In its 2020 sustainability report, the company only mentioned the support of the SDG goals in general terms and referred in a single sentence to contributing to the achievement of all goals but did not provide details on how this is implemented in practice. This initial approach therefore seems more like a formal statement.

Since 2021, the company's reporting method has significantly improved. In presenting its sustainability performance, it has precisely identified which SDG goals are supported by its activities. This specific reference is indicated on the report page with the pictogram of the respective SDG goal. This year, out of the 17 Sustainable Development Goals, the following 11 goals were highlighted as particularly supported: SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals).

In 2022 and 2023, only 6 SDG goals were identified. This includes SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action),

and SDG 17 (Partnerships for the Goals). By 2024, the company further refined its contribution to the SDG goals, focusing on just two goals: SDG 9 (Industry, Innovation, and Infrastructure) and SDG 17 (Partnerships for the Goals). At first glance, it may seem as if the company is less committed, its responsibility diminished, since it cited fewer SDGs in its report than before. In fact, this could be the result of a more deliberate, focused approach, identifying only those areas where it can have the greatest and most direct impact. The involvement of SDG goals is shown in Table 4.

4. Conclusions

In recent years, the strategic importance of sustainability has significantly increased in the industry, as the food and beverage sector thus plays a dual role in the sustainability transition. Consequently, it is particularly important to examine how companies in the sector report on their sustainability performance, what data they disclose, and how suitable this information is for objective comparison and the assessment of actual performance. In other words, companies need to take genuine, substantial actions and credibly integrate sustainable practices into their entire business model. For a company to build lasting customer trust and loyalty, it is essential that sustainability is not used merely as a communication tool, but becomes a fundamental element of strategic decision-making, risk management, and investor confidence. However, the practice of reporting faces significant methodological challenges, as the data provided by industry companies can vary greatly in both content and structure. In many cases, the information available is incomplete or difficult to compare.

Based on the analysis, it can be concluded that the structure and content of sustainability reports have undergone significant transformation in recent years. The example of HELL Energy Hungary Ltd. clearly shows that companies are increasingly integrating ESG aspects into their operations and adapting to the new regulatory environment. The introduction of the CSRD and ESRS standards allows for more uniform and comparable reporting, while in practice, providing comprehensive and reliable data remains a challenge. The study highlights that sustainability is not merely a communication tool but a strategic factor that influences a company's long-term competitiveness and stakeholder trust. Future research should focus on how ESG performance can be measured objectively and how data comparability can be ensured at the industry level.

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One Directive, Two Strategies: How France and Ireland Approach CSRD and ESRS

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Abstract: The study examines how the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) have been implemented in France and Ireland, and what impact this has on corporate sustainability reporting. France was among the first EU member states to transpose the directive, taking an ambitious approach with stricter national rules and active supervisory mechanisms, while Ireland opted for a "copy-out" strategy, integrating EU requirements almost without modification. The analysis presents the two countries' approaches to legal harmonization, their implementation timelines, content and format requirements, and the effects on companies. The French model offers the advantage of detailed regulation and strong action against greenwashing but faces technical and administrative challenges. Ireland's pragmatic solution provides a simpler legal framework, yet the lack of preparedness among mid-sized companies and limited ESG audit capacity pose significant risks. The study highlights that implementing the CSRD and ESRS is not only a legal obligation but also a major organizational and technological challenge that fundamentally transforms ESG data collection and reporting practices.

Keywords: CSRD, ESRS, sustainability report, legal harmonization, ESG
JEL Code: K32, M14, Q56

1. Introduction

In the European Union, the central legal source for corporate sustainability reporting is Directive 2022/2464/EU, the Corporate Sustainability Reporting Directive (CSRD). The Directive replaces the former Non-Financial Reporting Directive (NFRD) and significantly expands the scope of companies that must disclose environmental, social, and governance (ESG) information according to detailed, unified rules (Directive 2022/2465). The CSRD integrates the sustainability report into the annual reporting package, mandates the application of the double materiality principle, requires digital disclosure, and progressively introduces independent external assurance.

The implementation of the CSRD is ensured by the European Sustainability Reporting Standards (ESRS), which define mandatory and optional data points across 12 general and thematic standards (Commission Delegated Regulation 2023/2772). These include, among others, environmental topics (climate change, water and resource use, biodiversity), social issues (employee rights, supply chain, stakeholder rights), and governance areas (governance structure, risk management, ethics and compliance).

The Directive's application occurs in 'waves'. The first wave includes Public-Interest Entities (PIEs) that were previously under the NFRD, which must publish their first CSRD report in 2025 for the 2024 financial year (Directive 2022/2464). The second and third waves—large non-listed companies and listed SMEs—were originally obligated in 2025–2026, but the 'Stop-the-Clock' Directive, passed in spring 2025, postponed these obligations by two years (Directive 2024/1760). The fourth wave applies to non-EU parent companies with significant EU turnover, starting with the 2028 financial year.

EU Member States have transposed the CSRD into their national legal systems at different rates. Most countries, such as Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, and Sweden, have already fully implemented the directive. Some Member States, such as the Czech Republic, have only taken partial measures. At the same time, several countries, including Austria, Germany, Luxembourg, Malta, the Netherlands, Portugal, and Spain, have not yet announced their transposition, which has led to infringement proceedings being launched against them (Table 1.). This situation clearly shows that, although the EU deadline expired in July 2024, the process of legal harmonization is not progressing at the same pace everywhere.

Table 1. National transposition of the CSRD

National transposition of the CSRD	EU Member States
Full transposition completed	Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Sweden
Partial measures	Czech Republic
No transposition reported	Austria, Germany, Luxembourg, Malta, Netherlands, Portugal, Spain

Source: Own own compilation

The following sections will present the national regulations of France and Ireland, highlighting how the two Member States transposed the CSRD into their legal systems and how this is reflected in the sustainability reports of large corporations in practice.

2. France – The Early and Ambitious Transposition of the CSRD

France is one of the European Union's most active and earliest regulating Member States regarding sustainability reporting. Even before the introduction of the CSRD, a detailed and extensive large corporate reporting system existed, which had been mandatory for larger companies for years in the form of the "non-financial performance statement". This system covered a broad spectrum of environmental, social, and governance topics, making France particularly prepared for the CSRD's entry into force.

2.1. Legal Background and Precedents

France is traditionally a pioneer in corporate social responsibility (CSR) and non-financial reporting within the European Union. Compulsory extra-financial reporting obligations for large companies already existed before the CSRD, based on Article L.225-102-1 of the French Commercial Code. This system, based on the French transposition of the 2014/95/EU NFRD, already required a comprehensive CSR report from large PIEs.

France was one of the first, and indeed the very first, EU Member State to transpose the CSRD into national law. This was achieved by Decree No. 1142 of December 6, 2023, which regulates the disclosure and certification of 'sustainability' information, as well as the environmental, social,

and governance obligations of commercial companies. The implementing and ministerial decrees specify the reporting method, format, and audit rules in detail. The French regulation is organically integrated with pre-existing CSR and corporate responsibility legal institutions, such as the 'duty of vigilance' principle for large corporations, which requires the identification and management of human rights and environmental risks arising in global value chains (Law No. 399 of 2017). Thus, the CSRD sustainability report in France appears as part of a broader, responsibility-based corporate legal framework.

2.2. Scope, Thresholds, and Application Timeline

The fundamental principle of the French transposition is that the corporate scope defined in the CSRD is adopted at least at the same level, with specific national additions. Based on Decree No. 1142 of December 6, 2023, the sustainability reporting obligation applies, among others, to companies employing more than 500 employees and simultaneously achieving at least €40 million in net turnover or €20 million in total assets, or to listed large companies, or consolidated groups that meet the CSRD thresholds at the consolidated level. The French scope largely follows the criteria set out in the CSRD but builds on specific articles of the Commercial Code in detail.

The application timeline in France is also multi-staged. Large listed companies previously under the NFRD are obliged to publish their first CSRD sustainability report for the 2024 financial year in 2025. The obligation gradually extends to other large companies, listed SMEs, and third-country companies with significant EU operations between 2026 and 2029. Following the EU 'Stop-the-Clock' Directive, the deadlines for the second and third waves are pushed back by two years, which the French legislature is also aligning with.

Interestingly, in 2025, French senators initiated a proposal to partially delay or modify the application of CSRD obligations, arguing that the administrative burden on companies and issues of international competitiveness required further fine-tuning. Although this initiative did not revoke the CSRD transposition, it highlights that France simultaneously strives to lead sustainability regulation while also acknowledging its cost and competitiveness impacts.

2.3. Content, Principles, and Format of Disclosure

French law, like the CSRD, requires sustainability information to be disclosed as part of the management report, broken down according to ESRS standards. The report must cover the company's business model and strategy, sustainability risks and opportunities, the corporate governance structure, long-term goals (e.g., decarbonization, net-zero targets), and short- and medium-term action plans (L'Oréal, 2023).

The principle of double materiality is a central element, requiring the company to assess both the extent to which sustainability factors influence its financial position and the impact of its own activities on the environment and society. The French Financial Markets Authority (AMF), the supervisory body, has issued specific guidance on the practical interpretation of the double materiality analysis, climate risks, and taxonomy-related disclosures.

From a formal perspective, reports must be published in a digital format with XBRL-tagging, consistent with the European Single Electronic Format (ESEF), to ensure the data is machine-readable, comparable, and can be integrated into the EU's data service infrastructure. Disclosure is carried out through the national business registry system, ensuring free public access.

2.4. Assurance, Supervision, and Sanctions

One of the most significant novelties of the CSRD is that sustainability reports must be assured by an independent external party. France accordingly mandates that the sustainability information be reviewed by the company's statutory auditor or another authorized independent service provider at a level of limited assurance (Decree No. 1142 of 2023). Subsequently—based on the gradual application of EU rules—a higher level of assurance may also become mandatory.

French legislation includes a detailed sanction system against companies that are negligent or produce inaccurate reports. In addition to fines, personal liability may arise for directors and managers, especially if the reports contain consciously misleading, "greenwashing" statements. The significance of this is well illustrated by the fact that a French court has already convicted a major energy company for misleading climate communication in 2025 (BNP Paribas, 2023).

2.5. Successes in Legal Harmonization

France was the first Member State to fully transpose the CSRD in December 2023 (Decree No. 1142 of 2023). In practice, this meant that: the large corporate scope became immediately mandatory, the previous extra-financial report quickly aligned with the ESRS, and companies prepared mostly according to the CSRD logic in 2024. The French Financial Markets Authority (AMF) and French courts are more active than the EU average, often going beyond the EU's minimum requirements, for example, in tackling 'greenwashing'. Several companies were already sanctioned in France in 2023–2024 for misleading climate claims (BNP Paribas, 2023; TotalEnergies, 2023). In the area of mandatory external assurance, the French system enforced external audit faster, even before the CSRD. Furthermore, regarding the duty of vigilance, France has uniquely required large corporations since 2017 to identify human rights risks in the value chain (Law No. 399 of 2017), partially anticipating the themes of ESRS S2–S4.

2.6. Difficulties in Practical Application

While France is a leader at the political and legal level, corporate reports are often too heterogeneous, particularly among medium-sized companies (KPMG, 2023), and there is significant variation in data quality and consistency. Shortcomings include: differing methodologies for calculating greenhouse gases, varying deadlines, data collection cycles, and non-uniform terminology (a mix of DPEF and ESRS).

The French large corporate elite is strong, but a significant portion of non-listed companies with over 250 employees are still unprepared. They struggle with data gaps, the difficulty of mapping the supply chain, the conceptual interpretation of ESRS S2–S3 standards, and the technical requirements of the mandatory XBRL data submission. Disclosures related to the EU Taxonomy (revenue–CAPEX–OPEX ratio) are often incomplete at many French companies, insufficiently

substantiated, or lack a methodology (TotalEnergies, 2023). Although France was fast legally, it is technically slower to adapt to the new requirements. 60% of companies are not yet able to produce a national-level XBRL-compliant sustainability report, and digital reporting is progressing slowly. A significant portion of the French auditor community lacks ESRS-specific auditing capacity, and several companies submitted PDF-based, unstructured reports in 2024. The EU issued a specific call on this issue at the end of 2024, indicating France has a systemic technical lag (KPMG, 2023).

Overall, France operates an ambitious but not entirely consistent sustainability reporting system. The large corporate vanguard precedes EU norms, yet the mid-market segment and technical compliance lag EU expectations.

3. Ireland's Sustainability Reporting System Under the CSRD

Ireland adopted a 'copy-out' approach in transposing the CSRD, meaning it integrated the EU regulation into its corporate law with almost no changes (Directive 2022/2464). Although the country's corporate system previously had less of a comprehensive sustainability reporting tradition, reporting has developed quickly due to the sophistication of the financial sector and the large number of global companies. Large corporations had already published significant voluntary ESG reports even before the CSRD, especially in the banking and insurance sectors (AIB Group, 2023; Bank of Ireland, 2023).

3.1. Legal Background and Transposition Process

Ireland accomplished the CSRD transposition by amending the Companies Act 2014. The central legal instrument is the European Union (Corporate Sustainability Reporting) Regulations 2024 (S.I. No. 336 of 2024), signed by the competent minister on July 5, 2024, and effective from July 6, 2024. The Regulations—supplemented by minor amending instruments, such as S.I. No. 498/2024 and S.I. No. 309/2025—integrate the CSRD's sustainability reporting framework into Irish company law and transparency rules (S.I. No. 309/2025).

The primary goal of the Irish regulation is to transpose the CSRD expectations in a 'simplified but faithful' manner, using a so-called copy-out solution (Directive 2022/2464). The company law provisions mostly follow the wording of the EU Directive verbatim, with national specifics being more technical (e.g., procedural deadlines, supervisory powers, details of sanctions). Ireland completed the transposition in 2024, meeting the transposition deadline.

3.2. Scope, Thresholds, and Timeline

Under the Irish CSRD rules, sustainability reports must be prepared by all large companies and listed entities (excluding listed micro-undertakings) that qualify as large undertakings based on the size criteria defined in the CSRD (Directive 2022/2464). This practically means companies that meet at least two out of three conditions in a given reporting period, namely: at least 250 employees, at least €25 million total assets, or €50 million net turnover.

The application timeline in Ireland also follows the EU wave structure. Companies in the first wave, PIEs previously under the NFRD, are obliged to report in accordance with the CSRD for the 2024 financial year in 2025. For the second and third waves—the remaining large companies and listed SMEs—Ireland applies the EU 'Stop-the-Clock' Directive (Directive 2024/1760, 2024). S.I. No. 309/2025 postponed the start date of their sustainability reporting obligations by two years in the summer of 2025 (S.I. No. 309/2025). According to the Irish government's communication, this delay serves two purposes: first, it provides time for companies to build the necessary systems, data collection processes, and governance structures; and second, it mitigates the one-off 'rush' placed on the consulting and auditing market. At the same time, a significant part of the financial sector and the large corporate sphere had already published voluntary or NFRD-based sustainability reports, so for them, the delay means fine-tuning rather than an entirely new task.

3.3. Content Requirements and Reporting Principles

Aligning with the CSRD and the ESRS, the Irish regulation mandates that sustainability information must be disclosed as part of the management report (Commission Delegated Regulation EU 2023/2772). The report must cover the full spectrum of ESG topics: environmental (e.g., climate change, energy and resource efficiency), social (employee rights, diversity, customer and supplier relationships), and governance issues (governance structure, ethical rules, anti-corruption measures).

The application of ESRS standards is mandatory, meaning companies must present data points according to thematic and sector-neutral standards. The double materiality analysis plays a central role, where the company must identify which sustainability topics have a material effect on its business performance and what material impact the company has on stakeholders and the environment. The report must demonstrate the connection to economic activities under the EU Taxonomy and their revenue, CAPEX, and OPEX ratios (Taxonomy Regulation, 2020).

Regarding format, the Irish regulation also requires digital, machine-readable disclosure. The sustainability report—like the financial statements—must be filed with the Irish company registrar and, for capital market issuers, with the relevant supervisory bodies, ensuring free access for investors and other stakeholders.

3.4. Assurance, Supervision, and Sanctions

In Ireland, the CSRD extends auditor control to sustainability reports. The sustainability information is reviewed by the company's statutory auditor or other authorized assurance provider at a level of limited assurance. Specific provisions were inserted into the Companies Act 2014 in 2014 to regulate the specifics of sustainability report auditing. Following the subsequent adoption of the EU-level assurance standard, Ireland is expected to uniformly adopt the European requirements (Commission Delegated Regulation 2023/2772, 2023).

The sanction system primarily relies on fines and the liability of the company and its directors, like the provisions for financial statements. Irish professional organizations—the Institute of Chartered Accountants, accounting associations—are developing specific guidance to interpret the

CSRD expectations. However, several professional articles in 2024–2025 pointed out that some companies are awaiting further official guidance on the details of practical application.

3.5. Successful Legal Harmonization, Catching Up/Particularly Strong Rules

Ireland enacted the EU CSRD in July 2024 (European Union (Corporate Sustainability Reporting) Regulations 2024, S.I. No. 457/2024). The consequences of the copy-out method are that there is no 'gold plating' (no tightening of the rules), reporting obligations strictly conform to the EU, and the ESRS are fully adopted without national additions. Therefore, Ireland appears as the model most precisely aligned with the rules and the most legally harmonized in the EU.

Ireland's largest companies are highly globalized capital market players, so the banking and industrial sectors had been reporting based on international ESG standards years before the CSRD. For example: the AIB (Allied Irish Banks) Group's 2023 sustainability report uses a full TCFD structure, annually discloses sectoral emissions data for its loan portfolio, and the climate transition strategy is detailed with 2030 and 2040 targets (AIB, 2023). The Bank of Ireland's 2023 ESG report has a similarly high-level structure (Bank of Ireland, 2023). This significantly exceeds the basic requirements of ESRS E1. All this indicates that Ireland has caught up on a practical reporting level, especially in the banking sector.

Advancement in climate-focused industries: for example, Ryanair's 2023 ESG report presents detailed plans for fleet renewal and SAF (Sustainable Aviation Fuel) ratio, with well-structured emissions graphs and fuel efficiency indicators, including TCFD-based risk analysis. Ryanair is therefore one of the most transparent players in the European airline sector regarding ESG (Ryanair, 2023).

In the summer of 2025, Ireland postponed the application of the 2nd and 3rd CSRD waves by two years with S.I. No. 309/2025, in full alignment with the EU's reliefs (S.I. No. 309/2025). This eased the strain on the consulting market, the time pressure of data collection burden, and the compliance difficulties of medium-sized companies. Ireland is thus also closer to the EU's new direction in terms of timing.

3.6. Challenges and Difficulties to be Addressed

While banks and large corporations lead the way, a significant portion of medium-sized companies lag behind because the CSRD transposition was delayed until 2024, the Stop-the-Clock reduced the motivation for preparation, and little national guidance was produced for practical application (PwC, 2023). According to a 2024 Irish Chamber survey, 58% of medium-sized companies have not yet conducted a double materiality analysis, 72% are not yet collecting Scope 3 data, and 63% do not have a sustainability IT system.

This is a significant shortfall from EU expectations.
The sustainability culture in Ireland is sectoral: banks and global large companies are very strong, but SMEs in logistics, trade, services, and construction are very weak. This is supported by the fact that most Irish food industry medium-sized companies only issued 1–2-page CSR reports in 2023. In many cases, ESG goals and KPIs are not defined. Furthermore, many companies do not

publish Scope 3 data at all. This contradicts the ESRS requirements, which expect detailed data points regardless of sector.

Most Irish companies—even the large ones—often only provide partial or preliminary Taxonomy data: reports from several Irish energy companies state that "Taxonomy eligibility data is not available for the 2023 reporting cycle." This is a clear lag in applying the EU Taxonomy regulation practice.

Although the CSRD mandates Limited Assurance, the auditing market in Ireland is not yet fully developed. Limited assurance is the first, lower level of external, independent auditor review of sustainability reports. The auditor does not state that all data is demonstrably accurate, but rather that during the audit, they found no facts or evidence to suggest that the report:

- contains a material error (e.g., typos, incorrect calculations), or
- contains a material misstatement (e.g., intentional misleading).
- This type of opinion is also referred to as a negative statement in professional jargon.

However, the ESG-specific, local audit capacity and expertise are missing for this. Local auditors (especially for smaller companies) cannot perform the necessary audit in a timely manner, with adequate quality, or at an affordable price. They "import" expertise from the Big Four or other international consultants.

The Irish situation highlights that the successful introduction of the CSRD is not merely a legal challenge but also a market one. The inadequate level of ESG audit capacity, the lagging of medium-sized companies, and the shortfall in legal compliance endanger the EU goals of reliable and comparable ESG data.

4. Comparison of the French and Irish Models Regarding their Relationship to EU Norms

Both France and Ireland are committed to the EU's sustainability goals, but they started from different regulatory backgrounds, resulting in significant differences in the practical application of the CSRD (Table 2). France already operated an extensive CSR system during the NFRD period, which included important elements like the DPEF (extra-financial reporting) and the duty of vigilance (2017), i.e., the examination of human rights risks in the supply chain (Law No. 399 of 2017; Commercial Code, 2023). Consequently, large French companies—such as L'Oréal, BNP Paribas, TotalEnergies, and Suez—had already prepared materiality analyses, emissions data, and transparent sustainability reports based on ESRS logic in 2023–2024 (L'Oréal, 2023; BNP Paribas, 2023; TotalEnergies, 2023). The transposition of the CSRD in France thus effectively meant a 'change of form' rather than the introduction of a completely new system (Decree No. 1142 of 2023).

Table 2. Comparison of CSRD Adaptation in France and Ireland

COMPARISON ASPECT	FRANCE / AMBITIOUS MODEL	IRELAND / PURE LEGAL HARMONIZATION MODEL
LEGAL HARMONIZATION APPROACH	Ambitious Integration. Stricter, pre-existing national legal framework, exceeding the EU minimum requirements.	**'Copy-out' Method**. Almost verbatim adoption of the EU regulation by amending the Companies Act 2014.
PRIOR CSRD TRADITION	Strong and Mandatory. Detailed extra-financial reporting obligation already existed before the CSRD.	Weaker, Voluntary-Based. No comprehensive national regulation existed; large companies relied on global standards.
EXTERNAL ASSURANCE AND AUDIT	Prioritized. Mandatory external/limited assurance existed even before the CSRD. Strict supervision by the Financial Markets Authority (AMF).	EU-Rule Following. Introduction aligns with the CSRD; supervision follows the logic of financial reporting. Capacity is still under development.
SANCTIONS AND ANTI-GREENWASHING ACTION	Strict and Active. In addition to fines, managerial liability may arise; courts actively act against misleading climate communication.	Pragmatic. Primarily extended sanctions applicable to financial reporting; companies are still awaiting official state guidance.
APPLICATION OF THE 'STOP-THE-CLOCK' DIRECTIVE	Political Debates. Applied the EU delay for the 2nd and 3rd waves; initiatives also arose for further easing of obligations.	Quick and Pragmatic. Immediately and 'copy-out' applied the EU delay to alleviate the burden on medium-sized companies.
PREPAREDNESS FOR ESRS	Strong in the Large Corporate Sector. The double materiality principle has long been part of corporate practice; preparedness is high, especially among NFRD-covered companies.	Sectoral Discrepancy. High preparedness in the financial sector and global companies, but significant lag in medium-sized companies regarding Scope 3 data collection and materiality analysis.
DIGITAL REPORTING	Technical Lag. Despite legal speed, some companies were unable to produce the mandatory **XBRL-compliant (ESEF)** sustainability report in 2024.	Highlighted Requirement but Slow. Requirements regarding the format were also adopted, but the speed of practical implementation is slow.

Source: Own compilation

However, the disadvantage of the French model is the complexity of the regulation. The layering of national CSR requirements and EU rules causes a significant administrative burden for companies (Directive 2022/2464). This is reflected in the political debates that arose in 2024–2025 and the criticisms from corporate lobbying organizations, which argue that overly detailed and strict regulation may reduce competitiveness. Furthermore, France is more active in tackling greenwashing than the EU average, and the control of sustainability reports and the sanction system are also stricter than in many other Member States (AMF, 2024).

In comparing the two countries, two key dimensions can be distinguished. From the perspective of formal legal harmonization, Ireland is closer to EU norms, as it transposed the CSRD fully and without modification (S.I. No. 457/2024). However, in terms of substantive ambition and enforcement, France is ahead, as the auditing of corporate sustainability reports, the sanction system, and the existing CSR frameworks (DPEF, duty of vigilance) are significantly stricter and more deeply embedded in national law (Law No. 399 of 2017).

In contrast, Ireland chose a 'no gold plating' approach to legal harmonization in transposing the CSRD (S.I. No. 457/2024). 'Gold plating' is the practice in national legislation of transposing EU

laws more strictly than necessary, imposing an additional burden on domestic businesses. The amendments to the Companies Act 2014 adopted the CSRD provisions almost verbatim (Companies Act, 2014), resulting in a transparent, easily applicable system. Since few genuine CSR rules previously existed in Irish law, Irish companies—especially large, listed players like AIB, Bank of Ireland, CRH, or Ryanair—prepared for the ESRS requirements primarily by relying on international standards (TCFD, SASB, GRI) (AIB Group, 2023; Bank of Ireland, 2023; CRH, 2023; Ryanair, 2023). Ireland also pragmatically applied the EU Stop-the-Clock relief, which provided a two-year extension for smaller companies (Directive 2024/1760, 2024; S.I. No. 309/2025).

Overall, both countries contribute significantly to the practical realization of the CSRD's objectives. France does so through ambitious and detailed regulation, while Ireland does so through pure legal harmonization and pragmatic implementation. The quality of large corporate reports in both countries meets, and in several cases exceeds, EU expectations (L'Oréal, 2023; AIB Group, 2023), and the full application of the ESRS is expected to further reduce the differences between the two countries (Code de commerce, 2023; Loi n° 2017-399, 2017).

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Ecosystem services of urban forests, with emphasis on social functions and their interaction with global environmental risks

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Abstract: In urban areas, forest ecosystem services, especially their social functions, and interactions with global environmental risks play a key role in sustainable urban development and urban resilience. Forests have not only ecological and economic value but also social value, contributing to community well-being, psychological health and social cohesion. This social function is particularly strong for urban forests. Global environmental risks - like climate change, air pollution, extreme weather events and biodiversity loss - all impact on the health and functions of urban forests. This review article examines the interactions between forest ecosystem services and global environmental risks, with a particular focus on their presence in urban environments. By integrating findings from different disciplines (ecosystem services, sociology, urban development), the article presents the opportunities and challenges that affect the role and protection of urban forests in the context of global environmental problems. The study also aims to explore the linkages and make recommendations for improving the sustainability of urban forests.

Keywords: urban forests, forest ecosystem services, global environmental risks, climate change, social value
JEL codes: R58, Q57

Introduction

Global environmental challenges such as climate change, biodiversity loss, natural resource depletion, extreme weather events, air pollution and soil degradation are increasingly pressing challenges for cities around the world. The rapid pace of urbanisation, which has accelerated dramatically in recent decades, has led to the degradation of natural ecosystems, increased carbon emissions and dramatic deterioration of vital ecosystem services such as clean air. As the world continues to urbanise, the challenges of sustainable development will increasingly be concentrated in urban areas, particularly in lower and middle-income countries, where urbanisation has often occurred rapidly, spontaneously and with inadequate strategic planning, resulting in unsustainable land use patterns (FAO, 2016). The impacts of climate change, such as extreme weather events and ever-expanding urban heat islands, further exacerbate the challenges of sustainable urban development.

The role of urban forests is key to addressing these global environmental crises. The very concept of urban forest is now more than just a park forest: its functions cover a broader spectrum and its management requires cooperation between different disciplines and social groups. Well-designed and maintained urban forests not only protect local ecosystems, but also contribute to mitigating global climate change, for example by sequestering CO2, reducing air pollution and improving water management. In addition, urban green infrastructure, of which urban forests are the backbone, plays a key role in making cities more resilient to the impacts of climate change. Urban forests can help to mitigate the effects of the mentioned heat islands, while providing local communities with opportunities to access nature, thus improving quality of life and social cohesion.

In this overview article, I examine the ecosystem services provided by forests and the interactions between forests and global environmental risks, with a particular focus on their role in urban environments. By social functions of forests, we actually mean that the primary purpose of a forest is to provide social services such as recreation, tourism, education, research and/or preservation of cultural/intellectual values (FAO, 2020). These functions will be discussed in more detail later. However, it should be pointed out that, although the focus of this paper is primarily on social functions, the other ecological, economic (although in the case of urban forests the classic economic - i.e. timber production - function is rarely understood), ecosystem services of urban forests often have a direct and strong impact on these socio-social services, especially when considered in the context of global environmental problems.

A global environmental problem can be understood as all those social, economic and environmental issues and processes whose impact cannot be limited to the national, regional or sub-regional level, but which extend to the whole Earth and which may threaten the future of humanity with a series of disasters. The relevant environmental problems mentioned at the beginning of this chapter, such as climate change, biodiversity loss, natural resource depletion, extreme weather events, air pollution, natural resource depletion, will be discussed in more detail.

Thus, the aim of the study is to identify and even formulate the links to improve the sustainability of urban forests, taking into account global environmental crises.

Study background

Forest ecosystem services in the urban environment in general

Urban forests can be defined as networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint. (FAO, 2016).

Urban forest management is the management of the trees and forest resources in and around these communities for the environmental, social, economic and aesthetic benefits that trees provide to people. As I have already pointed out, in the case of simple park forests, among others, although it is primarily a social function, it can be seen as a very broad spectrum.

There are several approaches to group ecosystem services. In scientific research, the most widely used is the Millennium Ecosystem Assessment (MEA) categorisation, which is shown in Table 1.

Table 1. Cathegories of forest ecosystem services

Groups of ecosystem services	Ecosystem services
Supplying services	wood/timber
	wild mushrooms
	forest berries and other products
	forest honey
	game products
Cultural- social services	recreation, relaxation, rehabilitation (forest sports)
	landscape significance
	hunting (recreation and sport hunting)
	environmental education
	scientific research
	artistic inspiration
Regulatory (and habitat) services	soil erosion control
	wind erosion control
	water retention
	water purification
	air purification
	climate control (CO_2 sequestration)
	protection against noise
	protection against natural damage
	pollination
	habitat for plant and animal species
Supporting services	soil formation
	nutrient cycling
	primary production

Source: own compilation based on Kovács, Harangozó, Marjainé Szerényi, Csépányi (2015)

Global environmental problems

Before going into more detail on these functions, it is worth to explain a little more about the *global environmental problems*. The formal categorisation of global environmental problems is not always universal, as different literature and organisations may categorise them in different ways.

They are also highlighted by the scientific community and international organisations such as the United Nations:

- Climate change: changes in climate systems. Our activity is influencing the Earth's climate. Burning fossil fuels to produce energy, cutting down forests, farming crops and livestock, producing chemicals: in the course of all these activities, and many others, greenhouse gases such as the carbon dioxide (CO_2) are released. They trap heat in the atmosphere and amplify the 'greenhouse effect', which results in a temperature rise and major changes to the Earth's climate. (European Climate Pact, 2020)
- Biodiversity loss: the rapid loss of biodiversity, including the increasing rate of extinction of animals, plants and other organisms.

- Air pollution: Pollutants resulting from human activities that can cause air quality degradation, human health impacts and climate change.
- Water crisis: The decline in fresh water supplies, water pollution and unequal distribution of access to water.
- Natural resource depletion: depleting natural resources such as fossil fuels, minerals and other raw materials that are being depleted by human consumption.
- Waste and plastic pollution: the increasing amount of waste, especially plastics, is a major environmental burden on terrestrial and aquatic ecosystems.
- Deforestation: the loss of forest cover worldwide, with serious impacts on climate, biodiversity and people's quality of life.
- Soil degradation: Soil degradation caused by human activities, such as overcultivation, which reduces the quantity and quality of fertile soil. (UN 2015)

Economic and ecological benefits of urban forests

Economic benefits can be categorized as follows:

- The economic value of urban forests is reflected mainly in their intangible benefits. The most common benefit is increased property value, which takes into account the valuation of public goods provided by the local environment (Oleyar & Greve at al, 2008).
- Urban forests also contribute to energy savings by reducing air conditioning use in warmer seasons through evapotranspiration, which provides a natural cooling effect (Brack, 2002).
- Urban forests can also create jobs in the forestry companies that manages urban forests.

However, one of the most important advantages of urban forests is their *ecological services*

- As urban areas are hotspots for carbon emissions and urban forests act as carbon sinks, urban forests provide regulatory services by capturing and storing carbon (Amini & Salehi et al., 2019).
- Trees and shrubs absorb atmospheric carbon dioxide through photosynthesis and store it as other organic compounds in their biomass, including trunks, leaves and roots.
- The urban heat island effect (UHI) occurs when urban areas have higher temperatures than the surrounding rural areas or peri -urban areas. Urban forests, by allowing plants to evaporate water (evapotranspiration), can help cool the environment, thus reducing the heat island effect and creating a more comfortable microclimate. (Qiu & Li et al., 2013)
- The ability of forests to remove air pollution removes harmful pollutants, first ozone (O3), then PM10, NO2, SO2 and CO (Tyrväinen & Pauleit et al., 2005). Removing pollutants simultaneously ensures that urban populations adapt to climate change and protect their health.
- Urban forests can also help to protect biodiversity by providing habitat for different plant and animal species and by facilitating pollination, seed dispersal and pest control

Results – Mechanisms of interactions

How global environmental risks affect the social functions of forests in cities?

In short, global environmental risks have direct and indirect impacts on the ability of urban forests to maintain and provide ecosystem services, including social benefits, to urban residents.

Increasing urbanisation and global climate change are increasingly threatening negative impacts on our environmental, economic and social systems, which are having a major impact on forests, including urban woodlands.

Direct impacts: climate change, air pollution or water deprivation directly affect the condition, health and functioning of forests. For example, extreme heat waves can reduce the water availability of trees, while high levels of air pollution impair photosynthesis in trees, reducing their ability to purify air. Forest ecosystem services such as air purification, thermal insulation, water retention and carbon sequestration are directly dependent on forest health. If green space is reduced in response to these negative impacts, the provision of green space for recreation is compromised. And reduced biodiversity and the spread of invasive species further degrade the social and ecological functions of forests, reducing their recreational and educational value.

Indirect impacts: forests ecosystems may face disturbances due to increasing temperatures and extreme weather events (e.g. longer lasting droughts or heavy rainfall) as a result of climate change. For example, increasing concentrations of carbon dioxide may alter forest growth rates, and water scarcity may affect water retention and biodiversity maintenance.

Thus, global environmental risks not only directly affect the condition of urban forests, but may also threaten their long-term sustainability, leading to a reduction in ecosystem services or a decline in their availability (Seddon et al., 2022).

How urban forests can affect the resilience of cities?

In a dynamic environmental, economic and social space, characterised by increasing urbanisation and the growing impacts of global climate change, urban forests can play a crucial role in maintaining liveable cities (Borovics, Király, Lomniczi, 2023).

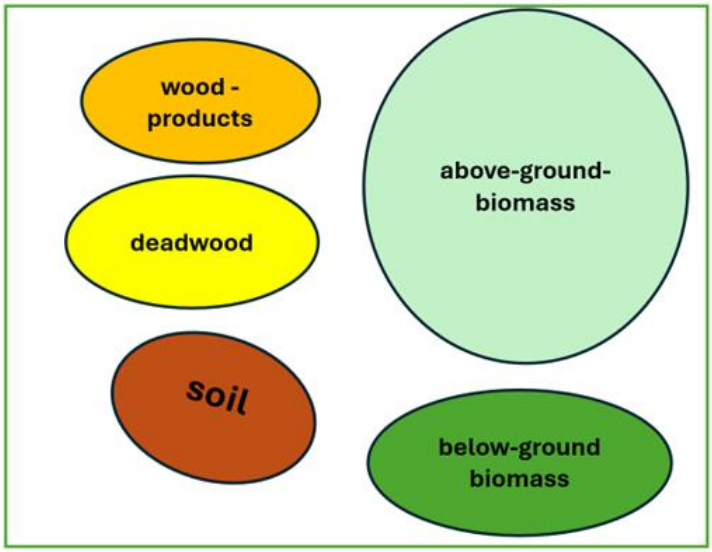

Figure 1. Carbon stores in urban forests
Source: own compilation based on Borovics, Király, Lomniczi (2023)

We present the details in a similar scheme to the global problems presented earlier:

- *Climate change:* urban forests play a key role in mitigating the urban heat island effect, as the cooling effect of plants, especially through evapotranspiration, reduces ambient temperatures and improves thermal comfort for people (Hiemstra et al. 2017). Increasing the spatial extent of urban and peri-urban afforestation projects can significantly reduce the intensity of the heat island effect in cities. A combination of green measures is most effective in reducing pedestrian thermal exposure on the street, with street trees, green walls and other green spaces being important elements, with large trees providing deep shade contributing significantly to improving pedestrian thermal comfort.
- In addition, urban forests help to sequester carbon dioxide, which contributes to mitigating climate change, in addition to the insulation effect. Also in urban forests, carbon sequestration takes place primarily in tree biomass and soil. Deadwood and mulch are also important carbon sinks.
- In addition, the iTree models (https://www.itreetools.org), developed by the US, are an excellent tool for assessing the climate change impacts of urban trees and forests. These models can be used to quantify the carbon sequestration capacity of urban trees and to express the monetary value of energy savings through shading and cooling and the associated emission reduction effects.
- *Biodiversity loss and protection:* urban forests and green spaces provide important habitat for urban ecosystems and help maintain local fauna and flora. Urban forests can promote biodiversity conservation, for example by providing habitat for pollinating insects, birds and other animal species. Managing urban ecosystems to enhance biodiversity is the basis for other ecosystem services, thus contributing to improving the quality of life of urban residents. In addition, the retention of decaying or dead trees plays an important role in biodiversity conservation, providing habitats and structural heterogeneity in the human-created and modified landscape of the urban environment (Borovics, Király, Lomniczi, 2023).
- *Air pollution:* urban forests help to clean the air, as trees and plants can trap air pollutants such as ozone (O_3), nitrogen dioxide (NO_2) and particulate matter (PM_{10}). This is especially important in urban areas where air pollution is a common problem.
- *Water crisis:* urban forests can help to absorb rainwater and prevent soil erosion, which plays an important role in water management, especially in cities where drainage systems can be overwhelmed. Forests can maintain water balance, reduce flood risk and improve water quality.
- *Waste and plastic pollution:* Although not directly the responsibility of urban forests, urban green spaces can help filter ecosystems and manage environmental pollution, as plants can absorb pollutants that are released into the soil and air.
- *Deforestation:* Although urban forests are not necessarily forests in the traditional sense, the loss of urban woodland can have equally serious consequences. Deforestation can also lead to a loss of urban green space, which can degrade the ecosystem of the urban environment, reduce the benefits of green space and increase the heat island effect.
- *Soil degradation:* Protecting and maintaining urban forests can help prevent soil degradation, as tree roots can strengthen the soil and reduce soil erosion. In addition, soil quality can be improved by maintaining adequate vegetation.

Table 2 provides a brief summary of the potential benefits of urban forests.

Table2. Potential benefits of urban forests

Urban issue	Potential benefits of urban forests
Food security	Provide food, clean water and woodfuel
Urban poverty	Create jobs and increase income
Soil and landscape degradation	Improve soil conditions and prevent erosion
Reduced biodiversity	Preserve and increase biodiversity
Air and noise pollution	Remove air pollutants and buffer noise
Greenhouse gas emission	Sequester carbon and mitigate climate change, improve local climate and build resilience
Extreme weather events	Mitigate local climate and build resilience
Energy shortage	Save energy through standing
Heat island effect	Cool the buiét environment through shade and evapotranspiration
Limited accessible green space	Provide more accessibleantural and green space
Public health	Improve the physical and mental health of residents
Flooding	Mitigate stormwater and stormwater runoff and reduce flooding
Limited recreation opportunities	Provide opportunities for recreation and environmental education
Exposure	Provide shelter
Limited water resources	Enable infiltration and the reuse of wastewater
Lack of community and social cohesion	Provide distinctive for formal and informal outdoor interaction

Source: own compilation based on FAO (2016)

Potential directions for development

Urban green infrastructure

In our environmental, economic and social systems, the design and management of urban green infrastructure plays a crucial role in maintaining the livability of cities, especially in the face of the increasing impacts of climate change and urbanisation. The backbone of green infrastructure worldwide is urban forests, which, together with other natural components of the urban environment, provide vital ecosystem services to local populations.

Plans for urban forest management and green infrastructure should set clear, practice-oriented objectives to improve the quality of ecosystem services and achieve the positive impacts listed above. These indicators, together with the availability of green spaces, are now commonly used criteria in urban planning. However, the actual planning of an urban green network takes place at very different scales: at the strategic level it may cover the whole metropolitan area or an urban region, and at the more operational level it may focus on individual neighbourhoods and green spaces (Borovics, Király, Lomniczi, 2023).

There is consequently a need for a comprehensive, ecological plan for the whole municipality, integrating green spaces and green areas, and for a major project(s) to lay the foundations for the sustainability of public space investments in action areas.

While the European Community and some Member States are increasingly promoting the role of trees in cities, the importance of this is not yet sufficiently understood by urban planners and the general public, and therefore, proper communication is crucial. Furthermore, the creation and management of green infrastructure in cities requires the involvement of a complex network of stakeholders, who may have very different expectations and approaches.

Continuous monitoring of the state of health of urban forests is important for their proper management. Nowadays, we can monitor the photosynthetic activity of trees on maps updated every 16 days using high-resolution space imagery, which can be used to assess their health and their exposure to drought and other abiotic and biotic stresses. (for example: Hungarian Forest Disturbance Monitoring) (Molnár et al., 2022). This allows for rapid and targeted interventions and provides the basis for a kind of precision urban forest management, through which we can effectively maintain and expand urban green infrastructure.

Conclusions

Urban forests are key elements of urban green infrastructure and provide ecosystem services of particularly high social value, including recreational, educational, and well-being services. This overview highlights how global environmental risks directly and indirectly threaten the health and functioning of urban forests.

Maintaining ecosystem services requires integrated, cross-sectoral planning that combines ecological knowledge with social expectations and urban development priorities. Increasing the resilience of urban forests should be based on nature-based solutions, enhancing structural and species diversity, improving water management, and continuous monitoring. In addition, stronger communication and stakeholder engagement are needed to improve public understanding and acceptance of urban forest management initiatives. Overall, the protection of urban forests is not only an environmental issue, but also a strategic prerequisite for sustainable and livable cities in the face of accelerating global change.

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Regional Differences in the Performance of Stable Players in The Fortune Global 500

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Abstract: The social, technological, environmental, political, and economic challenges of the past decade have substantially affected the functioning of the global economy, fundamentally reshaping international power dynamics. These transformations have also visibly influenced corporate performance. The revenue- and profit-based analysis in this study aims to determine whether regional affiliation plays a decisive role in shaping corporate performance. The analysis is based on data from 315 companies that have appeared in every edition of the Fortune Global 500 ranking over the past 10 years. The findings help illuminate which countries' firms have successfully adapted to the complex challenges of the 21st century. The results clearly indicate the dominance of U.S.-based companies, alongside the strengthening position of firms from emerging economies.

Keywords: Fortune Global 500, revenue, profitability, regional differences
Jel Code: L25, F23, R11

Introduction

The performance and competitiveness of companies are influenced by several external and internal factors that either reinforce or weaken each other. Due to the complex mechanism of influence, it is challenging to assess the impact of each factor on corporate performance separately. Typically, changes in performance and emerging differences can be explained by considering the existing synergy and spillover effects.

Numerous economic theories attempt to explain the sources of competitive advantage and differences in corporate performance levels. One of these is the theory of industrial organisation (IO), which places the factors influencing a company's performance outside the company, at the industry level. This was followed by the resource-based view (RBV), which seeks internal sources of sustainable competitive advantage and explains why companies' performance levels differ within the same industry (Wernerfelt, 1984; Conner, 1991; Hsu and Chen, 2024). A key economist in these approaches was Porter, whose models, the five forces model of industry competition (Porter, 1980) and the diamond model of factors determining national competitiveness (Porter, 1990), remain popular analytical frameworks today (Porter, 1980, 1990, 1993, Czakó 2000). Based on this, corporate performance is influenced simultaneously by the characteristics of the company's internal resource management and its external industry environment. Porter's diamond model (Porter 1990) emphasises that, in addition to these factors, the economic and competitive characteristics of a given country are also decisive in shaping corporate performance. The different resource endowments, institutional systems, and levels of development of countries significantly influence the competitive conditions under which companies operate, so that the different competitiveness characteristics of individual countries often drive differences in corporate performance.

The social, technological, environmental, political, and economic challenges of the past decade have significantly affected the functioning of the global economy. We are gradually witnessing a transformation in the international balance of power and economic poles. In addition to changes

in the relative positions of developed economies – the US, European developed countries, Japan, and South Korea – we are also seeing the dynamic rise of emerging countries (e.g., China, India, and several Southeast Asian countries). In addition, Russia's unique situation – as an energy- and raw-materials-based economy subject to sanctions – is also playing a role in the realignment. In addition to geopolitical tensions and armed conflicts in many parts of the world, trade war tools (e.g., tariffs, export restrictions) are also being used in the battle for position among economic powers (International Monetary Fund, 2022ab, 2023ab, 2024ab). Sustainability and climate policy pressures, international agreements – especially the Paris Agreement –, energy market shocks, and the challenges of the energy transition have also contributed to a rethinking of supply chains. The extraction of fossil fuels – primarily natural gas and crude oil – is concentrated in the hands of a few major exporters, and the market for raw materials needed to manufacture the batteries essential for electric cars is even more concentrated. The extraction of cobalt, lithium, nickel, graphite, and other critical raw materials is dominated by a few countries, creating serious global dependencies. The EU is particularly disadvantaged in this area, while China has a 70-90% share in the mining and processing of rare earth metals (Imre, 2025). In addition to all this, the socio-economic consequences of the COVID-19 pandemic (Bereczk et al., 2022, International Monetary Fund, 2020ab, 2021, Qlik-Fortune Global 500, 2021), as well as the explosive spread of digitalisation and artificial intelligence (Klinger et al., 2018, Csiszár, 2022, 2023, Brynjolfsson et al., 2025), have also placed significant pressure on economic actors to adapt. These changes have a noticeable impact on corporate performance. Therefore, examining performance differences between companies necessarily leads to exploring differences between countries.

This study aims to explore which companies among the stable players in the Fortune Global 500 ranking have been able to adapt (more) successfully to the complex challenges of the 21st century, and to examine what shifts can be observed in their performance over the past 10 years.

The research question of the study is: Is regional affiliation a determining factor in the development of corporate performance? The analysis by country (group) examines the differences in revenue and profit development between 2015 and 2024, based on data from 315 stable companies in the Fortune Global 500 ranking.

Chapter 2 summarises the data collection and methodology. Chapter 3 describes the results of the analysis. Chapter 4 contains the main conclusions.

1. Materials and methodology

The analysis is based on data from the Fortune Global 500 ranking between 2015 and 2024. The database publishes an annual list of the world's largest companies by revenue and key economic data, including revenue, after-tax profit, total assets, and number of employees. The data are available in a uniform format, enabling both time-series and cross-sectional analyses.
This analysis is based on data from 315 companies that have been included in the Fortune Global 500 ranking for each of the past 10 years. The methodological advantage of this approach is that the results are not distorted by the constant fluctuation of companies on the TOP 500 list, by the different sizes of companies entering and leaving, or by their industry and regional affiliations. By using a stable group of companies, the changes reflect the relative shifts between these companies and their actual performance differences.

The analysis is based on graphical representation and descriptive statistics, supplemented in places by statistical tests to explore correlations. I examine the relationships between nominal variables using cross-tabulation analysis, for which I used Pearson's chi-square test and Cramer's V index to measure the strength of the relationship. I used one-way analysis of variance (ANOVA) to examine differences in metric variables across nominal groups. The conditions for applying the standard one-way ANOVA were repeatedly violated when sales revenue was used as the dependent variable. The data show a strongly right-skewed distribution with several extreme outliers, and the condition of homoscedasticity is not met either. Therefore, in addition to analyses based on the absolute values of sales revenue, analyses using ln-transformed variables proved appropriate. Logarithmic transformation is a commonly used method for handling skewed data (Osborne, 2002; Feng et al., 2014; Willett, 2015), and although it does not guarantee normality on its own (Feng et al., 2014), in the case of the 315 companies examined, the transformation significantly reduced skewness and enabled the valid application of Welch's ANOVA by reducing skewness and mitigating the impact of extreme outliers (West, 2022). Since the assumption of homogeneity of variances was violated in several years according to Levene's test, it was appropriate to use the Games–Howell post hoc test, which is robust to heterogeneity of variances, to examine differences between groups (Games & Howell, 1976). The combined use of ln-transformed data and the Games–Howell procedure improves the reliability of Welch ANOVA analyses. Because negative values occur, I performed the transformation using the following formula: $\ln(\text{profit}+k_t)$, where $k_t = |\min(\text{profit})|+1$ and t denotes the given year. A significant part of the analysis is a two-dimensional quadrant chart in which companies were divided into four groups based on company size and return on capital.

2. Results

2.1. Analysis of stable giants by country group

Over the past 10 years (2015-2024), 315 companies have been stable members of the Fortune Global 500 corporate ranking. Table 1 shows the distribution of these companies by country group. Among stable players, the US (89 companies - 28.3%) and developed Europe (85 companies - 27%) have similar proportions in the ranking. Among developed European countries, French and German companies (21 companies each, 24.7%) dominate, followed by Swiss and British companies (10 companies each, 11.8%) and Dutch and Spanish companies (6 companies each, 7.1%). About one-fifth of the stable giants are Chinese companies. There are 60 companies from other developed countries: 60% (36 companies) are Japanese, 15% (9 companies) are South Korean, and 11.7% (7 companies) are Canadian. Approximately 5.7% (18 companies) of the companies come from emerging/developing countries, with Brazil and India standing out with 6 and 5 companies, respectively. Russia is represented by two companies among the stable players (Table 1).

Table 1. Distribution of stable players in the Fortune Global 500 corporate ranking by country group

Country (group)	Number of companies	Percentage (%)
USA	89	28.3
China	63	20.0
Developed Europe	85	27.0
Other developed countries	60	19.0
Emerging/developing countries	18	5.7
Total	315	100.0

Source: Own calculations based on the Fortune Global 500 database

2.2. Average sales revenue by country group

Figure 1 shows the average sales revenue of companies by country group between 2015 and 2024.

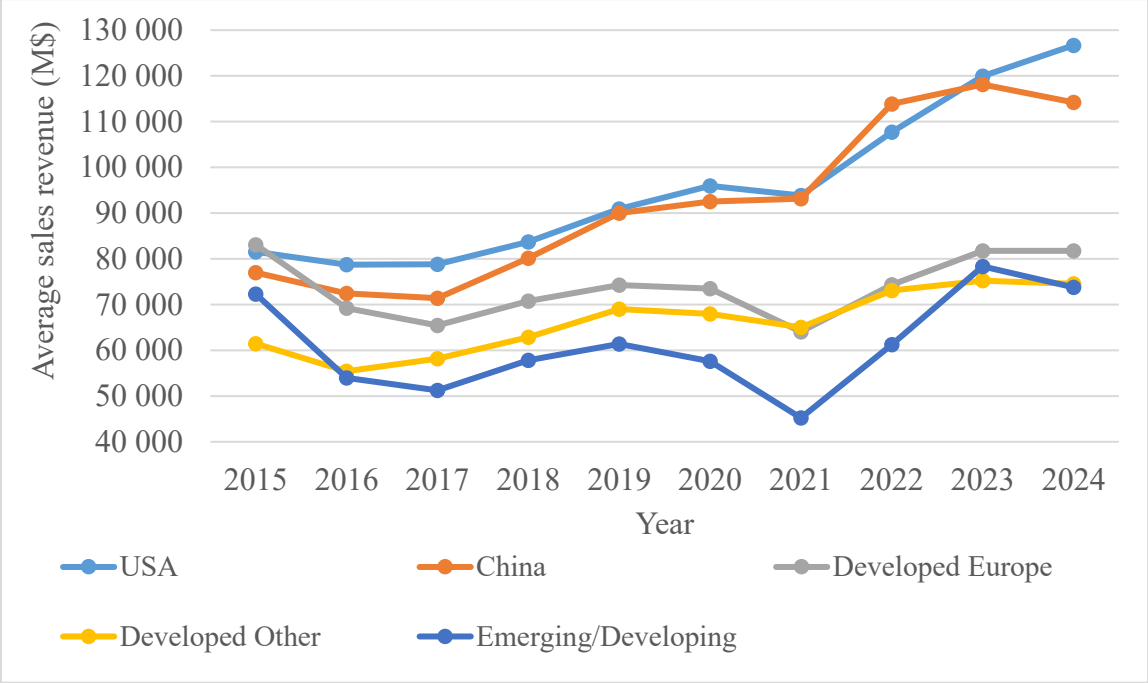

Figure 1. Average revenue of stable Fortune Global 500 companies by country group, 2015–2024

Source: Own calculations based on data from the Fortune Global 500 database

Figure 1 shows that between 2015 and 2019, there was no significant difference in the average sales revenue of companies belonging to different country groups. Still, after 2020, a divergence in the averages can be observed. The average sales revenue of companies in the US and China shows a greater increase, while developed countries and developing/emerging countries are moving roughly in tandem. The exception is 2021, when the average revenue of companies in developing/emerging countries shows a greater decline, thus lagging further behind companies in other country groups, but this gap will disappear by 2023.

The question arose as to whether this difference could be statistically verified. Based on the methodology section, I performed the analysis using ln-transformed data rather than sales revenue. The differences shown in the figure were examined using the Welch-ANOVA method, which confirmed that, before 2020 (except 2016), there was no statistically significant difference in the average ln-transformed sales revenue of companies across country groups ($p > 0.05$). In contrast, from 2020 onwards, the difference became statistically significant (2020: $p=0.004$; 2021-2024: $p=0.000$) and can be considered moderate based on the effect size values (Table 2).

Table 2. Welch-ANOVA results for ln-transformed sales revenue (2015–2024)

Year	F	df1	df2	p	η^2
2024	6.26	4	107.634	0.000	0.077
2023	6.355	4	99.009	0.000	0.075
2022	8.362	4	98.666	0.000	0.089
2021	10.662	4	102.817	0.000	0.090
2020	4.182	4	101.516	0.004	0.045
2019	2.272	4	100.313	0.067	0.026
2018	1.873	4	103.263	0.121	0.021
2017	2.229	4	102.141	0.071	0.024
2016	2.841	4	99.383	0.028	0.032
2015	2.121	4	97.132	0.084	0.023

Source: Own calculations using SPSS statistical software

(When examining the differences in absolute sales figures by country group using the non-parametric Kruskal-Wallis test, we obtain similar results.) All this suggests that average sales figures became more markedly differentiated by country group after 2020. Based on the Games–Howell post hoc tests, the differences are not significant across all country group pairs; they became more pronounced, mainly between the US and China, compared with the other country groups. From 2022 onwards, US companies achieved significantly higher sales than companies in all other country groups except China. The advance of Chinese giants, which began in 2021, appears to have stalled since 2023. There is no significant difference in average sales revenue across the other country groups, except for a lag in developing/emerging countries in 2021.

2.3. Average profit trends by country group

When analysing profits, it is essential to note that, each year, some of the world's largest companies by revenue close the year with a loss (Table 3). It can be seen that, in addition to the weaker year in 2016, the unfavourable trend in 2020-2021 is also evident in the increase in the number of loss-making companies.

Table 3. Number of loss-making companies

2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
21	35	23	17	13	29	50	14	22	23

Source: Own calculations based on the Fortune Global 500 database

Figure 2 shows the average profit growth of companies belonging to each country group between 2015 and 2024.

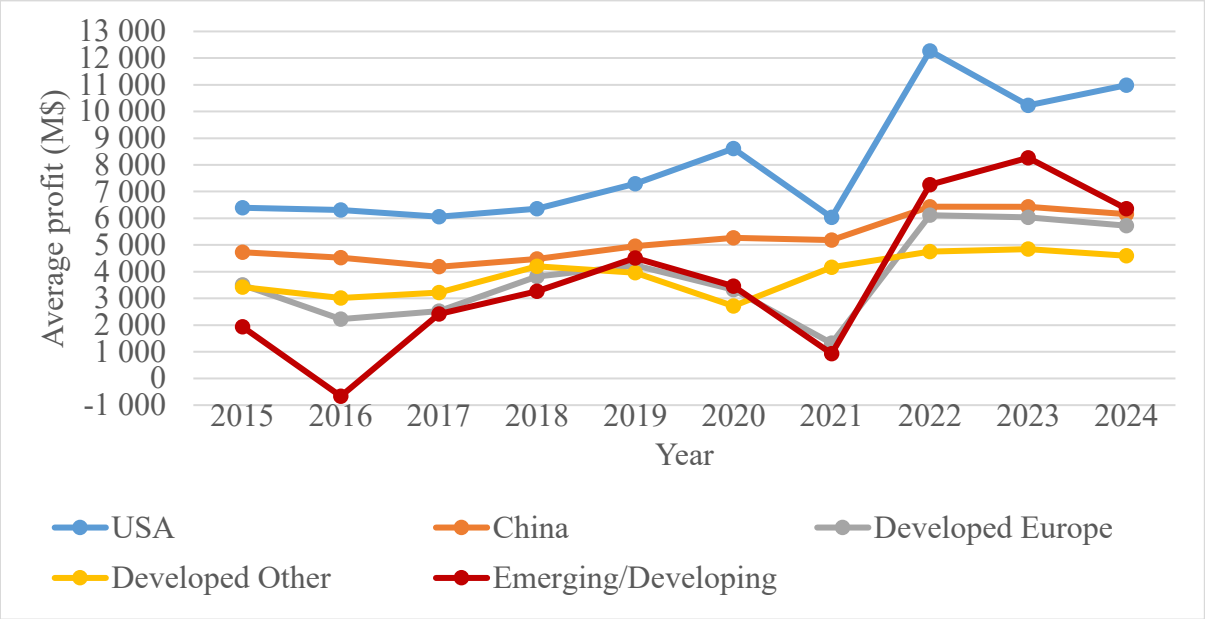

Figure 2. Average profits of stable Fortune Global 500 companies by country group, 2015–2024

Source: Own calculations based on data from the Fortune Global 500 database

Looking at the absolute data (see Figure 2), the superiority of US companies is evident, as is the lower profit level of companies in emerging/developing countries. But they will begin to catch up from 2021, and by 2022, they will rank second after the US average. The figure clearly shows a decline in almost all groups due to the COVID-19 pandemic in 2020-2021.

Based on the Welch-ANOVA test, the differences in average ln-transformed profits across country groups are significant, except in four years, and the effect sizes are small (Table 4).

Table 4. Welch-ANOVA results for ln-transformed profits (2015–2024)

Year	F	df1	df2	p	η^2
2024	1.190	4	88.251	0.321	0.024
2023	0.761	4	98.565	0.553	0.002
2022	3.370	4	85.146	0.013	0.037
2021	2.751	4	89.358	0.033	0.050
2020	6.088	4	86.929	0.000	0.059
2019	0.087	4	90.485	0.986	0.000
2018	0.999	4	86.542	0.413	0.045
2017	4.503	4	88.343	0.002	0.060
2016	5.707	4	87.925	0.000	0.060
2015	3.531	4	87.535	0.010	0.059

Source: Own calculations using SPSS statistical software

However, based on Games–Howell post hoc tests, the differences are only significant for a few country pairs, and this does not show as clear a trend as we saw in the case of sales revenue.

2.4. Comparison of stable giants based on sales revenue and profit by country group

The analysis aimed to present the combined results for stable companies in the Fortune Global 500 ranking, based on two essential criteria. The ranking is based on sales revenue, but high sales revenue does not necessarily mean high profitability. Based on the data available in the Fortune Global 500 database, two profitability indicators could be used: return on sales (ROS) and return on assets (ROA). In my analysis, I used ROA, a variable widely used in the literature, to assess corporate profitability. This indicator measures the company's after-tax profit in relation to its total assets. ROA is simple to calculate and can be considered relatively objective (Hsu and Chen, 2024).

When the 315 companies are displayed on a two-dimensional quadrant chart, four distinct groups can be identified. The horizontal axis of the quadrant shows the 2024 sales revenue (ln-transformed revenue for easier visualisation), while the vertical axis shows the 2024 asset-based profit ratio. Each point on the diagram represents a specific company, with the average values of the two variables marking the boundaries of the quadrants. In other words, values below and above the average determine the basis for classification.

The four quadrants are as follows:

1. High sales – high ROA
2. Low/medium sales – high ROA
3. Low/medium sales revenue – low ROA
4. High sales revenue – low ROA

The position of companies on the quadrant diagram is shown in Figure 3. Companies belonging to different country groups are marked with other colours.

Figure 3 shows that most of the companies with the highest sales and the highest return on assets are US companies. In contrast, most of the companies with high sales and below-average profitability are Chinese. Companies belonging to "other developed countries" are primarily concentrated in the lower left quadrant. The figure shows specific clusters by country group, so it is essential to examine whether there is a significant relationship between country group and quadrant classification. Based on the cross-tabulation analysis, there is a moderately strong, significant correlation between the quadrant classification of companies and their country group affiliation (Pearson Chi-square = 53.861, df = 12, $p < .001$, Cramer's V value 0.239 ($p < .001$).

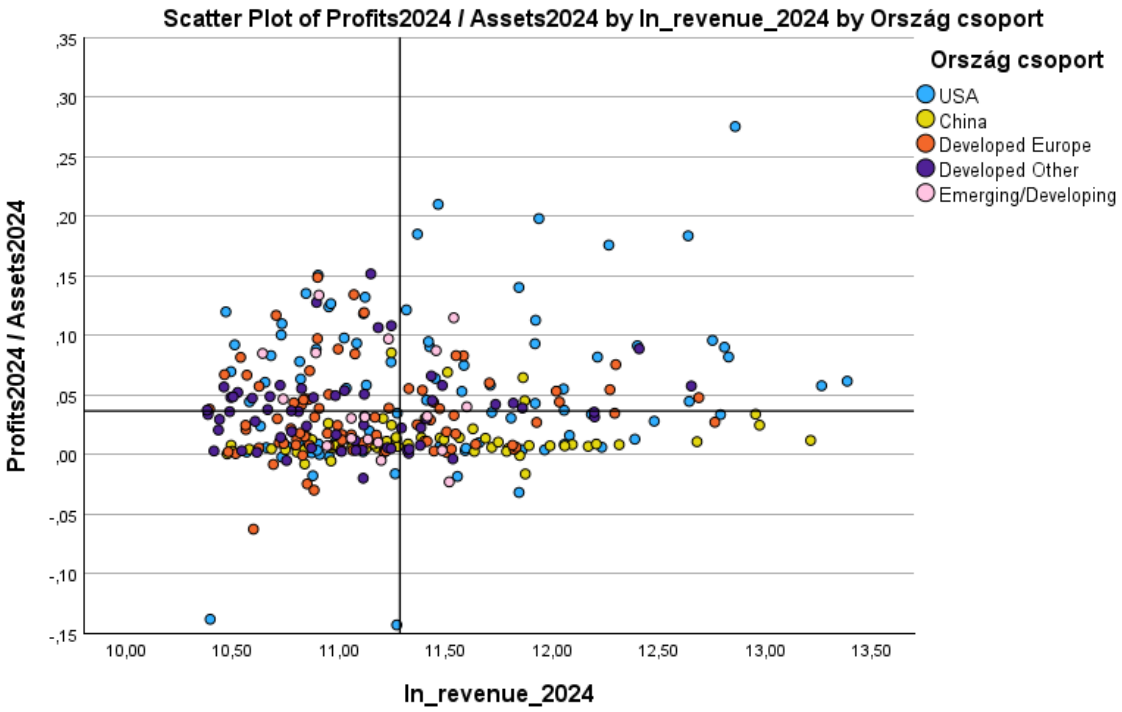

Figure 3: Quadrant classification of companies
Source: Own calculations based on data from the Fortune Global 500 database

Characteristics of the quadrants:

1. In the High Revenue – High ROA quadrant (54 companies), US companies are significantly overrepresented, accounting for 52 per cent, while Chinese companies are significantly underrepresented. Approximately one-third of all US companies and less than 5 per cent of Chinese companies appear in this segment.
2. Low/medium sales revenue – high ROA (68 companies): The segment with lower sales but high profitability is dominated by companies from developed countries, such as the US, developed Europe, and other developed countries (91.1%). Companies from China and emerging/developing countries account for a smaller share (8.9%).
3. Low/medium sales revenue – low ROA (117 companies): Chinese companies are overrepresented in the segment with lower sales revenue and low profitability, as are, to a lesser extent, companies from other countries except the US.
4. High sales revenue – low ROA (76 companies): The majority (approximately 37%) of companies with high sales revenue and low profitability are Chinese companies, while other country groups are underrepresented.

The analysis confirms that the majority of US companies (56%) are in the high-ROA quadrants. In comparison, Chinese (93.6%), advanced European (61.2%), other advanced (51.1%), and emerging-market companies (55.8%) are concentrated in the low-ROA quadrants.

3. Conclusions, recommendations

Based on the analysis, the following conclusions can be summarised:

- Their regional affiliation significantly influences the performance of companies.
- Average sales revenue became more differentiated after 2020, with the difference becoming significant (medium impact strength).
- From 2022 onwards, companies in the US achieved significantly higher sales revenue than companies in all other country groups except China. The superiority of US companies is also evident in terms of profits.
- Companies in emerging/developing countries showed significant growth in profits from 2021 (ranking second after the US average in 2022).
- The rise of Chinese giants starting in 2021 appears to be slowing down from 2023 onwards, and in terms of profitability, they tend to be less profitable.
- Most US companies are in the high ROA quadrants, while companies from China, developed Europe, other developed countries, and emerging countries are concentrated in the low ROA quadrants.
- The impact of the COVID-19 pandemic was clearly evident in all countries (groups), both in terms of revenue and profit development. This is consistent with the findings of Qlik-Fortune Global 500 (2021), Schwartz and Kay (2023), and Hsu and Chen (2024).

One limitation of the analysis is that the Global Fortune 500 database itself offers limited analytical possibilities. On the one hand, the ranking is based on sales revenue, which means many outliers distort the average. The use of the ln transformation helps to some extent. In addition, the database provides little information about the companies. In addition to sales revenue, data on taxable profits, the number of employees, and assets are available, as well as the company's headquarters and an industry classification. Based on this information, shifts and restructuring can be identified, but it is not possible to explore the reasons behind them. The study focused on analysing stable players, so it doesn't show the strong entry-exit dynamics reflected in the changes in the rankings – this is also an area for further research. In addition to analysing countries (or groups of countries), examining industry differences would also yield interesting results.

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The Situation of Acute Inpatient Care in Hungary

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Abstract: An aging society and increased life expectancy are driving up demand for healthcare, and with it, costs. Health-damaging habits typical of developed countries, such as smoking, alcohol consumption, and a sedentary lifestyle, have a negative impact on health, which is also reflected in the operation of the healthcare system. In my study, I examine the main component of the healthcare system, the performance of acute care, in the period 2019-2024. Covid-19 had a strong impact on the performance of the healthcare system.

Keywords: healthcare system, acute care, HBCS, COVID
JEL code: I10, I18

Introduction

Life expectancy at birth in Hungary is increasing, but still lags behind most EU countries, and socio-economic and regional inequalities have a significant impact on access and quality of care.

An aging society and increased life expectancy are driving up demand for healthcare, and with it, costs. Health-damaging habits typical of developed countries, such as smoking, alcohol consumption, and a sedentary lifestyle, have a negative impact on health, which is also reflected in the operation of the healthcare system.

The healthcare system in Hungary

Social security expenditures constitute one of the largest items in public finances (KSH, 2022). The essence of social security is that it creates a risk community based on the principle of solidarity at the societal level. Insured persons do not pay risk-based insurance premiums, but rather, as a general rule, contributions proportional to their earned income. Social security has a long tradition in Hungary. After Germany, Hungary was the second country to enact a law on social security in 1881, based on Bismarckian principles.

In Hungary, social security was part of the central budget until 1988 and was under the partial control and supervision of the National Council of Trade Unions (SZOT). On January 1, 1989, the Social Security Fund was established, and the National Social Security Administration was set up to manage it. Then, in 1993, the fund was split into the Pension Insurance Fund and the Health Insurance Fund. Healthcare institutions are financed from the latter, which was managed for a long time by the National Health Insurance Fund (OEP) and then by the National Health Insurance Fund Management Agency (NEAK) (Radics, 2018).

When examining healthcare expenditure in more detail, two indicators are typically used in analyses. One indicator is healthcare expenditure per capita. There are several variants of this. It is possible to examine total expenditure or only public expenditure. The difference between the two values represents private spending, the extent of which varies from country to country. The other indicator is healthcare spending as a percentage of GDP (Table 1).

Table 1. Total health expenditure as a percentage of GDP

Country	1990	1995	2000	2005	2010	2015	2020
Australia	6,8	7,3	8,1	8,5	8,4	10,2	10,6
Austria	8,4	9,6	10,0	10,4	10,2	10,4	11,5
Belgium	7,2	7,6	8,1	10,0	10,2	10,8	11,1
Canada	8,9	9,0	8,8	9,8	10,7	10,7	12,9
Chile	..	5,2	6,4	6,6	6,8	8,3	9,8
Czech Republic	4,4	6,7	6,3	6,9	6,9	7,2	9,2
Denmark	8,3	8,1	8,7	9,8	10,6	10,3	10,5
Estonia	..	..	5,3	5,0	6,3	6,6	7,8
Finland	7,7	7,8	7,2	8,4	9,1	9,6	9,6
France	8,4	10,4	10,1	11,0	11,2	11,4	12,2
Germany	8,3	10,1	10,4	10,8	11,1	11,2	12,8
Greece	6,7	8,7	8,0	9,7	9,6	8,2	9,5
Hungary	**7,1**	**7,3**	**7,2**	**8,4**	**7,4**	**6,9**	**7,3**
Iceland	7,8	8,2	9,5	9,4	8,4	8,1	9,5
Ireland	6,0	6,6	6,1	7,6	10,5	7,3	7,1
Israel	7,1	7,6	7,5	7,9	7,0	7,1	8,3
Italy	7,7	7,1	7,9	8,7	8,9	8,9	9,6
Japan	5,8	6,8	7,6	8,2	9,1	10,8	11,1
Korea	3,9	3,7	4,3	5,6	5,9	6,7	8,4
Luxembourg	5,4	5,6	7,5	7,9	6,7	5,1	5,8
Mexico	4,4	5,1	5,1	5,9	5,7	5,7	6,2
Netherlands	8,0	8,3	8,0	10,9	10,2	10,3	11,1
New-Zealand	6,8	7,1	7,6	8,4	9,6	9,3	9,7
Norway	7,6	7,9	8,4	9,0	8,9	10,1	11,4
Poland	4,8	5,5	5,5	6,2	6,4	6,4	6,5
Portugal	5,7	7,5	9,3	10,4	10,0	9,3	10,5
Slovakia	..	5,8	5,5	7,0	7,7	6,8	7,2
Slovenia	..	7,5	8,3	8,4	8,6	8,5	9,5
Spain	6,5	7,4	7,2	8,3	9,1	9,1	10,7
Sweden	8,2	8,0	8,2	9,1	8,3	10,8	11,5
Switzerland	8,0	9,3	9,9	10,9	9,9	11,0	11,8
Türkiye	2,7	2,5	4,9	5,4	5,0	4,1	4,6
United Kingdom	5,8	6,8	7,0	8,3	10,0	9,8	12,0
United States	12,4	13,7	13,7	15,8	16,2	16,5	18,8

Source:2010-től https://stats.oecd.org/index.aspx?queryid=30183
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In Hungary, after the change of regime, total healthcare expenditure as a percentage of GDP was around 7%, while after the turn of the millennium it rose to around 8%, but has been declining steadily since then. In 2019, it was only 6.4%, then in 2020 it was higher again, due to the pandemic situation. The figures for Hungary lag significantly behind those of developed European countries (OECD Statistics, 2022). These figures are even more unfavorable when we consider the size of the GDP in question.

Healthcare financing in Hungary

Since the change of regime, several reform plans have been drawn up. These have been implemented to a greater or lesser extent, with varying degrees of success. But the essence has not changed: according to Section 7 of Act XLVII of 1997 on Health Care (Eütv.), every patient has the right to appropriate health care justified by their state of health. The healthcare system must provide the population with appropriate healthcare services, while at the same time using the resources available to them through social security as efficiently as possible in the provision of services.

Healthcare systems around the world can be classified according to several criteria. The application of each method is determined by the healthcare system, historical traditions, and health policy objectives of the country in question.

1. Health systems by source of funding:
   - Beveridge model (Anglo-Saxon model)
   - Bismarck's social security model
   - USA model, (Medicare, Medicaid system) (Karner, 2008b).

2. Financing systems based on the principle of financing:
   a) on a cost recovery basis
   b) based on resource allocation
      - appropriation (input)
        - capacity
        - task financing
      - performance-oriented (output)
        - based on expected performance (normative): (head quota, HBCS, other)
        - based on services provided (itemized financing): (point system, tariff system).

July 1, 1993 was a milestone in the financing of the Hungarian healthcare system. On that date, the system switched from budget-based financing to performance-based, or output-based, financing, which has characterized the financing of Hungarian inpatient and outpatient healthcare institutions since July 1, 1993. Table 2 summarizes the advantages and disadvantages of the two main forms of financing.

Some of the items listed as disadvantages are more a consequence of input financing than output financing and should be treated as a given situation by performance-based financing.
In 2003, as in other European countries, there was talk of introducing a fixed element, a so-called availability fee, in outpatient and inpatient specialist care, which would have been a step towards base financing, but this was not implemented across the board, only in emergency departments.

Table 2. Advantages and disadvantages of healthcare financing models

Form of financing	Advantages	Disadvantages
Input (base) financing	• easy to plan	• source volume cannot be influenced, or can only be influenced with difficulty, • power and financial dependence, • characterized by subjective bargaining, • no one cared about the institution's performance, • gratuity system,
Output (performance-based) financing	• more economically efficient, • encourages cost savings, rational decisions, cost sensitivity, • reserves were discovered in farming, • resource allocation characteristic of a market economy, • the principle that money follows the patient, • The average length of hospital stays has decreased (for acute beds, 9.9 days in 1990 compared to 6.9 days in 2002). (Kincses, 2004) • Bed occupancy also increased slightly (acute: 1990: 74.9%, 2002: 77.8%; chronic: 1990: 84.6%, 2002: 86.3%). (Kincses, 2004)	• The problem of performance measurement must be solved. • "Fiddling" with performance accounting and coding (performance chasing) • Take on as many simple cases as possible, avoiding more serious ones (if possible) • low performance fees due to limited resources, • code system, continuous maintenance of intervention time required, • harmful bureaucratic traditions remain, • disproportionate structural situation, • No depreciation item is included in the performance fee.

Source: own editing (Karner, 2008a) (Kincses, 2004)

In my opinion, the cost reimbursement principle does not work in healthcare. Even among the forms grouped together in the previous classification, there are differences in terms of risk bearing. Risk sharing varies between the different forms of financing. In the case of services provided for a fee, the risk lies with the financier. In subsequent for- ms, the risk to the service provider decreases in parallel with the increase.

- the German points system (outpatient care))
- Diagnosis-Related Group (HBCS in Hungary) (acute inpatient care)
- daily allowance (chronic care)
- risk-adjusted per capita quota
- head quota (family doctor)
- annual budget (mother and child protection)(Boncz, 2004).

All forms of financing are currently available in Hungary at some level of care. Prior to the change of regime in Hungary, the global budget principle prevailed in healthcare financing. Although this shifted risk-bearing towards service providers, it did not allow financiers to implement performance-based financing.

The funding of institutions was based on a historically established "base," regardless of how many patients they treated and how they treated them. Deviations from the base were only possible by taking on new, additional tasks. A system of extra payments was developed for new tasks, which involved informal agreements. Then, as a result of the reform processes following the change of

regime, performance-based financing was introduced, i.e., the principle that money should follow the patient. (Boncz, 2004)

Previously, financing was administered by the Health Insurance Fund, but now it is administered by the National Health Insurance Fund Administrator. The financing rules are regulated by the current Government Decree 43/1999. (III.3) on the detailed rules for financing health services from the Health Insurance Fund.

Since 1993, when performance-based financing was introduced, the National Health Insurance Fund (OEP) and hospitals have demanded that hospital performance in various areas of care be measurable. In this study, I focus only on acute inpatient care. Inpatient specialist care refers to all care provided in clinics, hospitals, and specialist care institutions during which the insured person is admitted to the institution and stays there for at least 24 hours, or at least 6 hours in the case of day hospital care. Inpatient specialist care can be divided into two parts: acute and chronic care. Acute care accounts for the largest part of combined specialist care. Acute care is defined as care aimed at restoring health as quickly as possible. The duration and completion of such care can usually be planned and, in most cases, is short-term. Hospitals received a fixed annual budget for their ongoing operations, the amount of which was reviewed from time to time, but was based on the previous value (base funding). This method was gradually replaced by performance-based financing in active inpatient care from July 1, 1993, which has been considered complete since February 1998 (normative financing). Essentially, hospital revenues depend on the number of patients and the complexity of the care provided. Diseases with similar clinical characteristics and requiring similar treatment and care can be classified into groups that are expected to incur similar costs, known as homogeneous disease groups (HBCS). We adapted the system from the US. DRG (Diagnosis Related Groups) was originally developed at Yale University for quality control and statistical purposes. Since 1983, the US has been using it in the MEDICARE financing system, which provides health care for people over 65, and in the MEDICAID financing system, which provides care for the poor.

In Hungary, starting in 1987, the HBCSs and their corresponding values were determined through the detailed collection and processing of data from approximately 500,000 nursing events, representing about 40% of the country's patient traffic, with the participation of 37 hospitals over several years. Each HBCS has a weighting factor that is determined in a preliminary empirical analysis and then continuously maintained, which expresses the relative performance value and relative resource requirements of the nursing cases classified under that HBCS in relation to the average. The performance accounting of each institution is given by the total weighting of the HBCSs performed and reported, to which a nationally defined forint value is attached (Bodor et al., 2001).

When classifying individual diseases into HBCS, the main disease group is taken into account, which may then be modified primarily by accompanying diseases, the patient's further fate, the newborn's weight, age, etc., and secondarily by interventions which, together with the main diagnosis, clearly indicate a higher level of care. In addition to the weighting, each HBCS has predefined characteristics, such as the lower and upper limit dates, which represent the minimum and maximum care periods accepted for the care of a given disease group. The normative nursing time lies between the lower and upper limit days and is determined on the basis of the national

average. The lower and upper limit days are of great importance in financing. If a patient classified under a given HBCS does not spend at least the minimum number of days in the hospital specified by the code system as the lower limit for that HBCS, then only the proportional part of the specified HBCS is taken into account. The weighting for a lower limit day is multiplied by the number of days spent in hospital. This is referred to as a short care case. The example below illustrates the above information.

HBCS name	Pneumonia under 18 years
Main group	04M
HBCS	142C
Lower limit days	3 nap
Upper limit days	25 nap
Normative nursing time	8 nap
weight number	1,19089
surgical weight number	0,00214

The upper limit date is also important. If a patient exceeds the maximum number of days, even due to complications, the insurer will finance long-term care days, which is 75% of the chronic daily rate (currently HUF 6,600), except for intensive care units, where the multiplier is 400%. This amount is insufficient to finance a patient in an acute ward, which means that hospitals must strive to avoid long-term care cases.

Another important rule is that a certain amount of time must elapse between two hospital treatments—even if they are in different departments or institutions—otherwise the OEP will treat them as combined care and will only finance the treatment with the higher weighting.

These are the most important rules, but there are also numerous detailed rules that determine the financing of institutions. The base fee became uniform across the country in April 1998, at 56,250 HUF/weight number. Since then, there has been a slow increase. From November 2010, it slowly rose from HUF 150,000/weight to HUF 198,000/weight by March 2020 but then switched to average financing due to the virus situation (EMMI, 2020). This ended in February 2023 with performance-based financing and returned to performance-based financing (NEAK, 2023). However, the fees were not increased until April 2025, although service providers received the difference retroactively until November 2024, as the new value became HUF 210,000/weighting (PHARMINDEX Online, 2025).

Another area of inpatient care is chronic care. Chronic care is defined as care aimed at stabilizing, maintaining, or restoring health. Unlike the previous form of care, this type of care is difficult to plan in terms of completion and is typically long-term, but this is not the subject of this study.

Based on actual expenditure data for 2021, acute hospital care is the main focus of curative and preventive care. The insurer spends more than 60% of curative and preventive care on active care. Outpatient specialist care accounts for 22% and chronic care for 9%.

Examination of the performance of acute inpatient care

The COVID situation has had a major impact on social and economic life in recent years. At the same time, it has affected the healthcare sector in several ways. I examined how the number of active cases changed between 2019 and 2024 (Figure 1). By 2020, the number of cases had fallen by more than 18% compared to the previous year. By 2021, there was a further 2.5% decrease compared to 2020. Since then, there has been a slow increase year on year, but it has still not reached the 2019 level.

Figure 1. Changes in the number of acute cases in Hungary between 2019 and 2024
Source: own editing based on NEAK

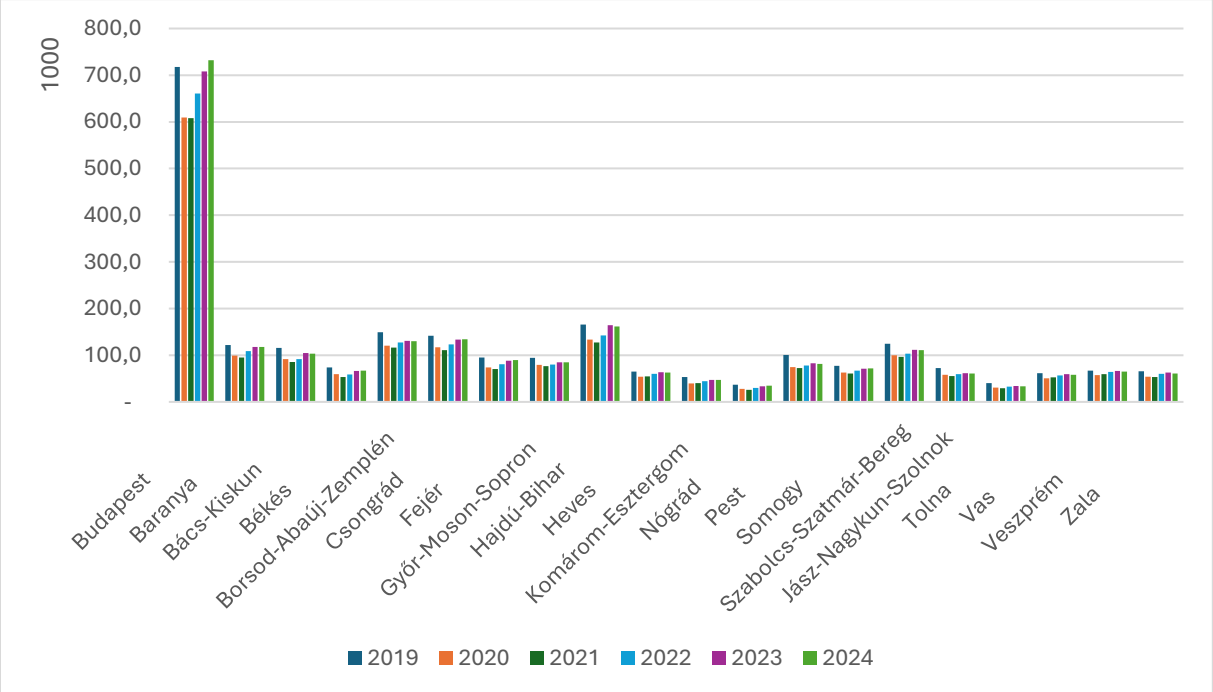

Figure 2. Number of acute cases by place of care
Source: own editing based on NEAK

Based on the NEAK database, Figure 2 illustrates the distribution of acute cases by place of care, and Figure 3 by patient reference number. Figure 2 clearly illustrates Budapest's predominance and central role. Healthcare facilities in Budapest treat around 700,000 cases, while in other counties the number typically does not reach 100,000, exceeding it in a few cases but not reaching 200,000.

In contrast, if we examine acute cases by place of residence, Budapest has fewer than 400,000 cases, and the difference appears in Pest County. Over the six-year period, there are no significant differences compared to other counties.

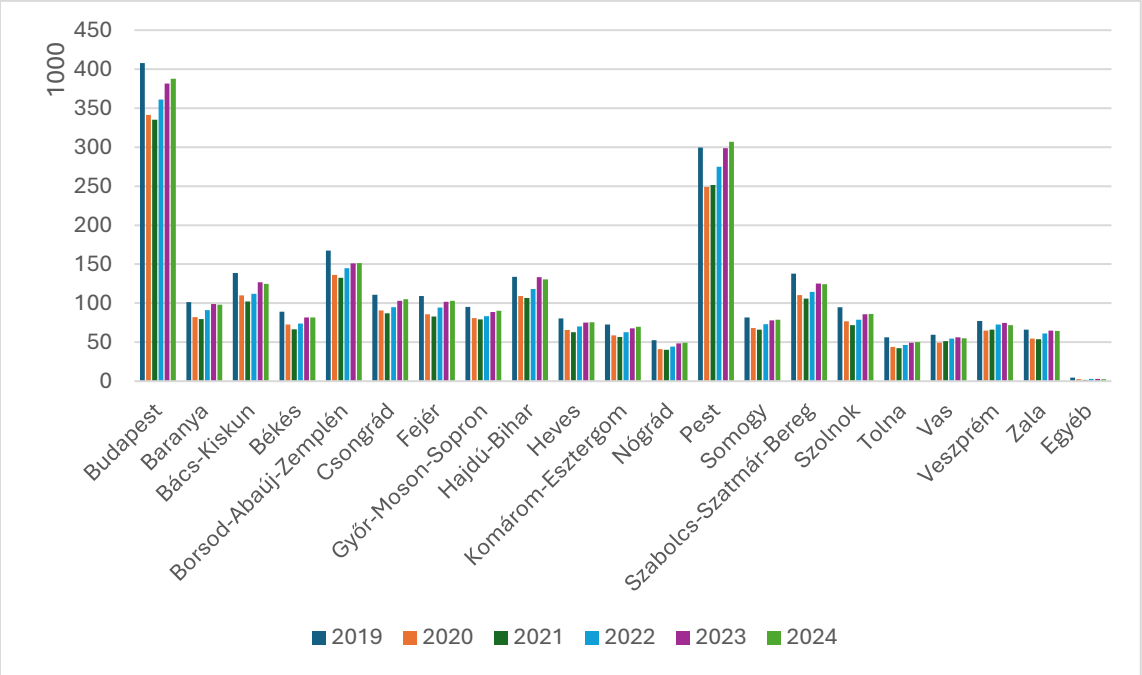

Figure 3. Number of acute cases by patient control number in Hungary
Source: own editing based on NEAK

At the same time, examining the ratios in 2024 by patient referral number and place of care, it is more evident that residents of Pest County typically use healthcare facilities in Budapest. There is still some difference in the case of Csongrád, Baranya, and Hajdú-Bihar counties, where the number of treatments is higher than the number of patients. The attractiveness of the clinics is well reflected in the numbers. At the same time, it can also be seen that the proportion of patients from Borsod-Abaúj-Zemplén County is higher than the proportion of those treated at county healthcare facilities. This must include the proximity of the Debrecen clinical center and, of course, the role of Budapest (Figure 4).

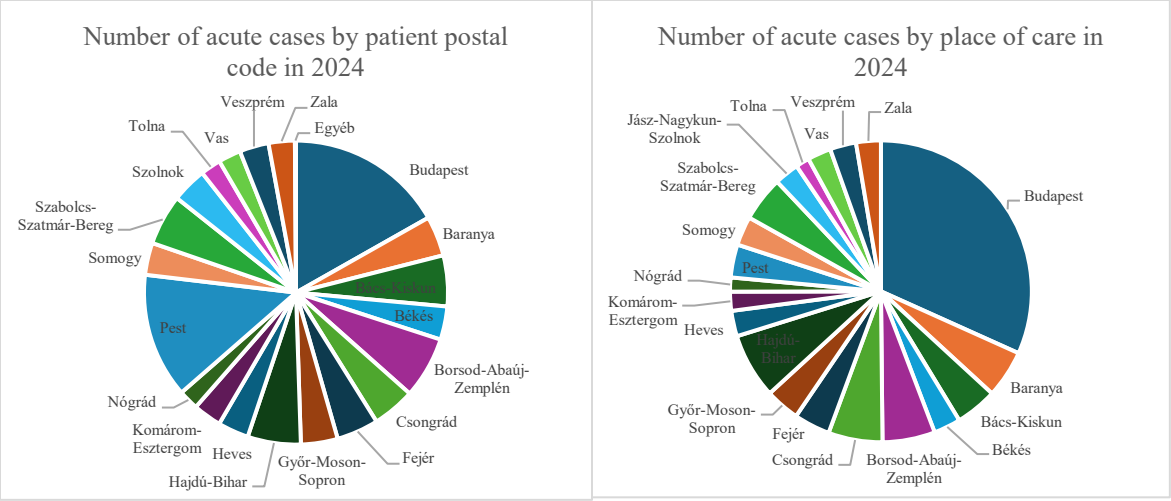

Figure 4. Distribution of acute cases in 2024 by patient postal code and place of care in Hungary

Source: own editing based on NEAK

Figure 5 shows the distribution of the population by county in 2024. Similar proportions can be seen on the left side of Figure 6. Based on the two pie charts, it can be concluded that the distribution of active cases corresponds to the distribution of the population by county.

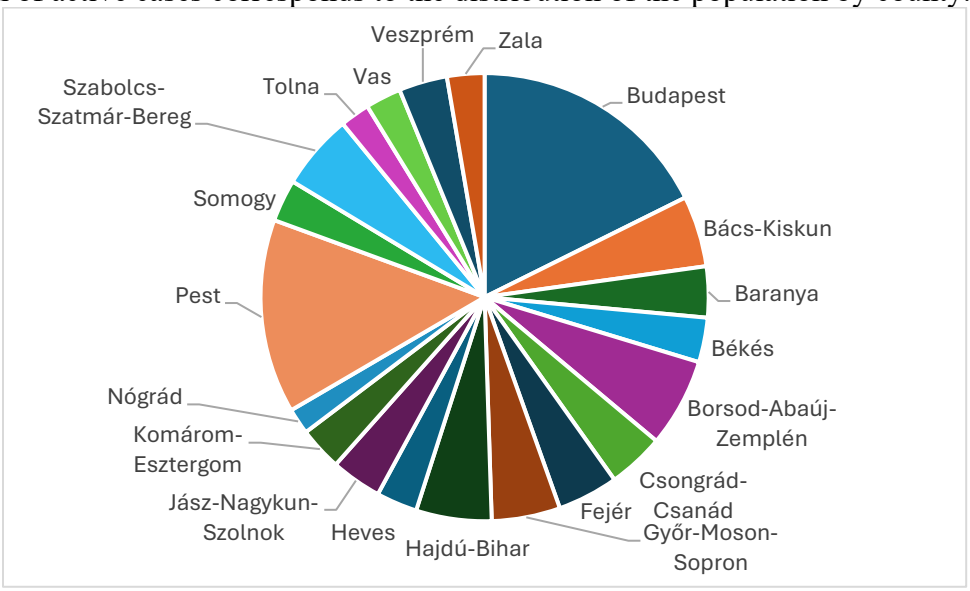

Figure 5. Population distribution by county in 2024

Source: KSH

Earlier in this study, I showed that HBCS plays a key role in financing active care, which is reflected in the weighting. That's why I looked into this in my study. After all, the number of cases alone doesn't form the basis for financing. The severity of diseases is reflected in the weighting. The treatment of more costly diseases requiring surgical intervention is reflected in a higher weighting. This is why the Case Mix Index (CMI), which is an average patient severity indicator, is also examined. Of course, these values vary by profession and even over time.

Figure 6 shows the change in weighting between 2019 and 2024. Performance fell by 12.5% in 2020, followed by a further decline of 1.9% in 2021 compared to 2020. Figure 1 showed that these figures were 18% and 2.5%, respectively. The smaller decrease in weighting suggests that fewer but more seriously ill patients were treated in 2020 and 2021.

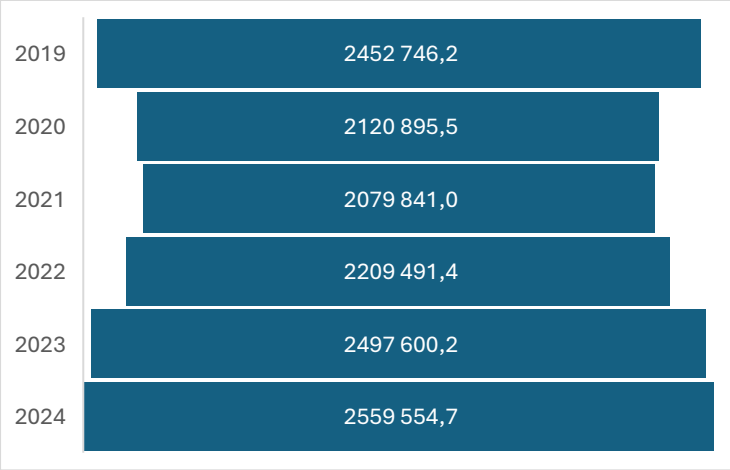

Figure 6. Changes in the weighting factor (including long days) in Hungary between 2019 and 2024
Source: own editing based on NEAK

The number of active cases showed that even by 2024, the value had not reached the 2019 level. In contrast, the weighted sum at the national level already exceeded the 2019 value in 2023. This may be related to the fact that, from February 2023, we can once again talk about performance-based financing in the sector with the abolition of average financing.

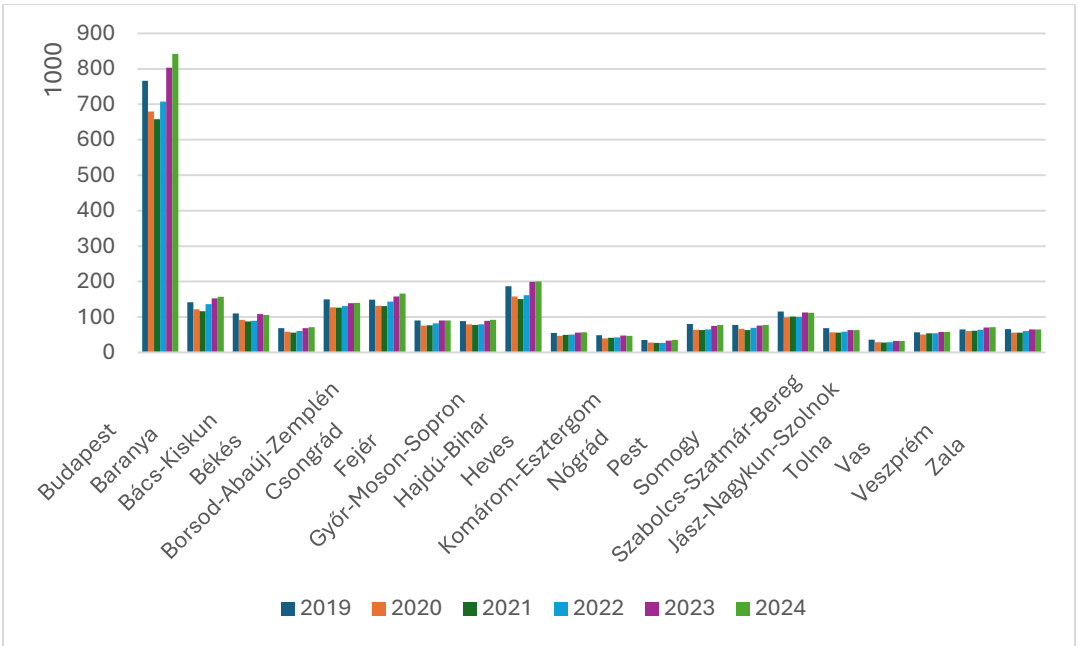

Figure 7. Weighting by place of care
Source: own editing based on NEAK

Figure 7 shows the distribution of weight scores by county according to the place of care. Figure 8 shows the weight scores according to the place of residence of the patients. A similar conclusion can be drawn as in the case of active cases.

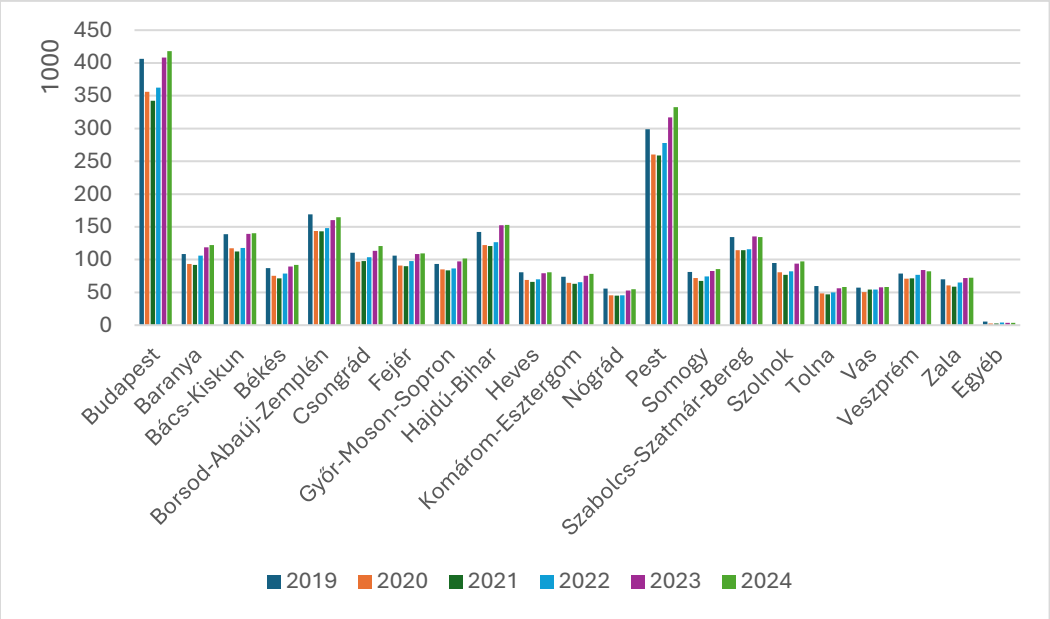

Figure 8. The weight scores according to the place of residence of the patients
Source: own editing based on NEAK

The role of Budapest's city center is decisive, to a greater extent than would be justified by its population share. This confirms the theory of regional inequalities.

Conclusions

Today, a very serious problem in healthcare is the disproportionate structure of the healthcare system. The process of reducing the disproportionately high number of hospital beds inherited from socialism is underway. The closure of individual active departments provokes enormous resistance among the population, even if it is economically justified. A good example of this was Miskolc, where, in addition to a county hospital, there were three city hospitals with many active beds. Thanks to the reforms, rationalization has taken place. The main goal of the reform efforts in 2006, 2010, and after Covid was to rationalize the unjustifiably high number of hospital beds and encourage progressiveness in the system. To do this, the appropriate resources must be available. Performance-based financing is currently the best option available, but it will probably need to be fine-tuned, as has been the case several times during its 30 years of operation, most recently in May 2025 with the HBCS coding system. Demands on the healthcare system have also undergone significant changes. An aging society, the treatment of chronic diseases, and longer life expectancy place new demands on the healthcare system. There is now a need for chronic care and nursing wards. For the treatment of diseases in the developed world. For fast and reliable healthcare. These demands affect several levels of the healthcare system. But as we have seen, acute care is a key element, which explains the focus of my study, while also providing

opportunities for further analysis. Further studies at the level of acute care, as well as at other levels of care or private providers, can be based not only on in-kind benefits, but also on cost allocations.

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The social discount rate applicable to cost-benefit analysis

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Abstract: In examining the social discount rate presented in Hungarian and international theoretical and practical literature and applicable to cost-benefit analysis, the paper looks for the answer to the question of how the rates used in practice are related to the definitions in the theoretical literature. The essential element of the analysis is the determination of the correct discount rate. Clarifying the rates applied to investment tenders is extremely important. The rates recommended in the practical guides differ from country to country. Mainly used by the local government sector, cost-benefit analysis is a method used in the evaluation of community investment projects.

Keywords: cost-benefit analysis, time preference, discount rate, social discount rate
JEL code: D61

Introduction

Cost-benefit analysis is a decision support method that differs from other similar methods in that it places great emphasis on accounting for social costs and benefits. The method is mainly used in the evaluation of community investment projects. Many factors must be taken into account when examining investments. Examples include the lifetime of the investment, financial costs and revenues, social costs and benefits, etc. Since the lifetime of the investment spans several years, it is essential to consider time preference. In the framework of the cost-benefit analysis, the social discount rate is usually applied, which is a complex rate made up of several elements. Time preference is an essential element of the social discount rate. The rate is a composite indicator. Several studies deal with the definition of the social discount rate. Research on cost-benefit analysis and on the social discount rate began approximately at the same time.

The main objective of the study is to present the characteristics of the main versions of the social discount rate in the theoretical literature and those used (recommended to be used) in practice, and then compare them to one another, based primarily on the processing of specialist literature. Regarding the rate recommended for application, recommendations can be found primarily in the practical guides issued for community investments. In the case of some community investment tenders announced by the Union, the relevant guides also contain the applicable social discount rate. On the other hand, EU sources also contain social discount rates that were developed for some European countries based on the theoretical definition.

Cost-benefit analysis is a complicated procedure in itself. Since the analysis is used to base community investment decisions, it is mainly used by the local government sector. In 2019, I conducted research on the knowledge of the method of cost-benefit analysis and its application. Several elements of the research results are included in this paper.

The theoretical background of the definition of the social discount rate

Cost-benefit analysis is a method mainly used during the decision-making process of community investment projects. Investments are made in order to bring benefits continuously, possibly in the long term. The assessment of advantages and disadvantages also applies not only to the appearance of monetary effects but to social costs and benefits as well. Community investments can contribute to the long-term well-being of the society. Costs and benefits do not arise at the same time, they must be brought to the same time with the help of time factors (e.g. discount rate). That is, taking the time value of money into account should not be neglected.

When evaluating community investment projects, thus when determining the results of calculation procedures (such as present value calculation) to be used in cost-benefit analysis, the examination of time preference is of prime importance. Later on, some calculation procedures will appear in the paper.
In essence, time preference means that we value a unit of today's currency more than a unit of future currency (Illés, 2008).

The paper mainly deals with the social discount rate, which is used when determining the above-mentioned calculation procedure, and whose essential element is social time preference.
Choosing the right discount rate is crucial when evaluating community projects. At the same time as the cost-benefit analysis appeared in the theoretical literature, the first research on the social discount rate (SDR) was published (Tabi – Csutora, 2012). Several researchers have dealt with its definition (Figure 1.).

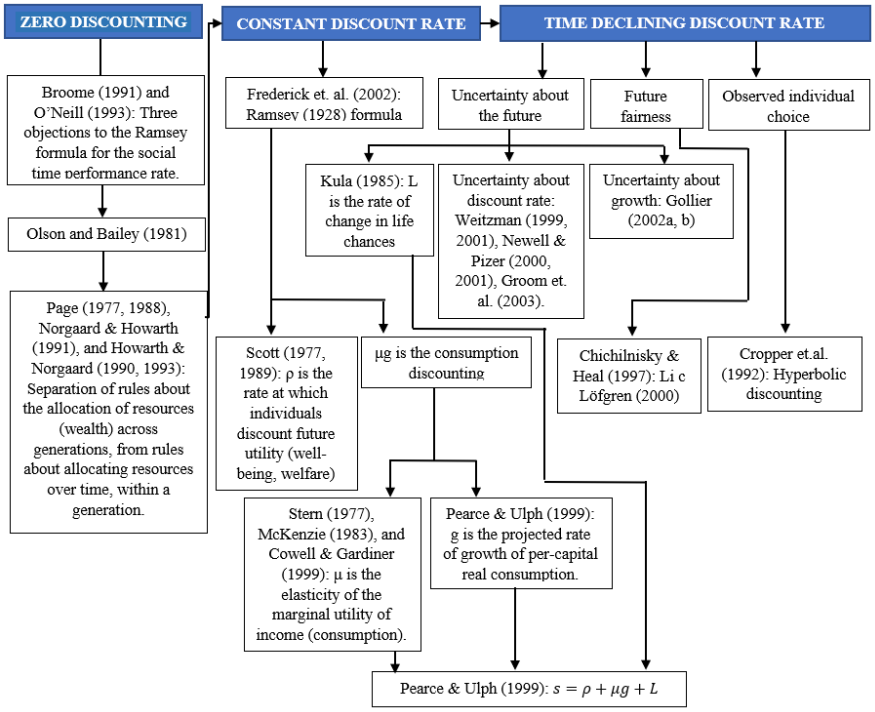

Figure 13. The social discount rate in the literature of economics
Source: based on the Supplementary guide of the National Development Agency (Nemzeti Fejlesztési Ügynökség, NFI) (2007)

Figure 2. illustrates the historical development of the definition of the discount rate used to examine business and community projects:

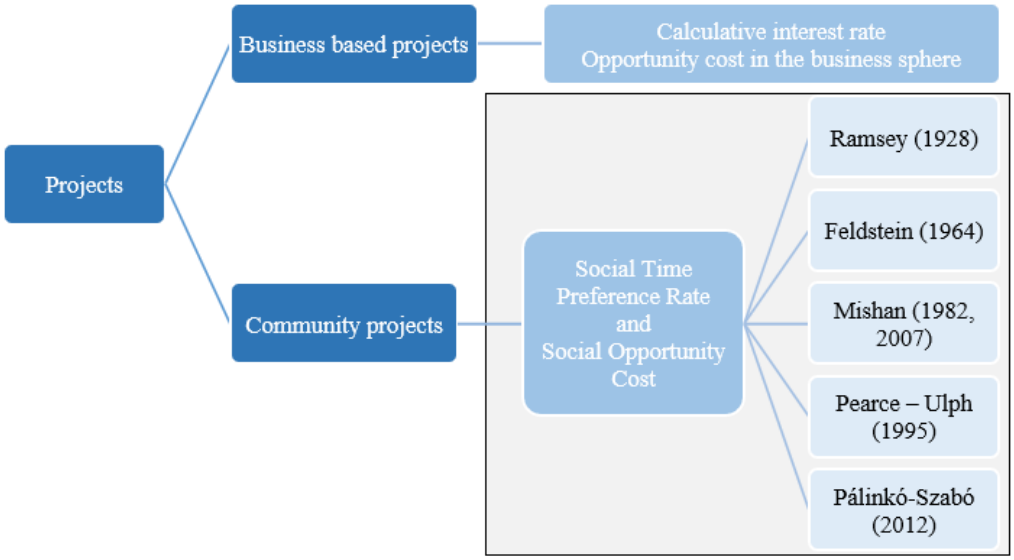

Figure 14.: Research on determining discount rates for business and community projects
Source: own editing based on the Author's PhD thesis submitted for workshop discussion

Several researchers, such as Somogyvári (2018), Tabi – Csutora, (2012), mention four methods in their studies to determine the discount rate to be used in the cost-benefit analysis for community investment decisions:

1. Social Time Preference Rate (STPR)
2. Social Opportunity Cost (SOC)
3. Weighted Average Method (WAM): the rate calculated according to the two methods mentioned above
4. Shadow Price of Capital (SPC): "the full price of the resource, also containing the external impacts" (Somogyvári, 2018: p 115.).

The practical guides mainly use the social discount rate as a suggestion for application.
The definition of the social discount rate was first dealt with by Ramsey in 1928. Ramsey's definition is of decisive importance to this day.

$$Social\ time\ preference\ rate\ (STPR) = \delta + eg$$

where

δ= pure time preference rate
e = elasticity of marginal utility of consumption
g = growth of per capita real consumption.

One half of the elements included in the calculation is based on individual time preferences, the other half on the expected future growth of consumption.
Several researchers have dealt with the definition of the social discount rate, however, the formula developed by Ramsey prevails in later publications as well regarding the primary structure of the rate (Figure 3.).

Author	Applied calculation
Frank P. Ramsey (1928)	$STPR = \delta + e * g$
Pearce – Ulph (1995)	$s = \delta + \mu * g$
Pálinkó – Szabó (2012)	$S = \rho + \mu * g$
Freeman, Groom, Spackman (2018)	$SDR(\text{STP}) = \rho + \eta * g$

Pure time preference rate

Elasticity of marginal utility of consumption

Growth of per capita real consumption

Figure 15. Publications on the definition of the social discount rate
Source: own editing based on the Author's PhD thesis submitted for workshop discussion

Determining the social discount rate in practice

Regarding the practical application of cost-benefit analysis, the guidelines are the guides prepared by the European Union. According to the guides, the comparison of decision variants is based on economic estimates, which proceed along two main lines:

- financial performance, and
- economic performance.

A calculation procedure applicable in both groups is, for example, the present value calculation. The formula used to evaluate community investments is very similar to this calculation method of investment-economic calculations used in the business sector (Table 1.). In each of the formulas, due to the importance of time preference, a rate appears (financial and social discount rate, as well as calculative interest rate). In addition to the present value calculation, it is also recommended to define additional calculation procedures when evaluating community investment projects, but these are not part of this paper.

Table 3. Comparison of present value calculation formulas used in community investments and in the business sphere

Cost-benefit analysis		Investment economics calculations applied in the business sphere
Financial analysis	Economic cost-benefit analysis	
Financial Net Present Value – FNPV	Economic Net Present Value – ENPV	Net Present Value – NPV
$FNPV = \sum_{t=0}^{n} \frac{X_t}{(1+i)^t}$ where, X_t – the difference between year t's revenues and the expenditure-based costst	$ENPV = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$ where, C_t – the difference between benefits in year t, and adjusted costs and social costs	$NPV = \sum_{t=0}^{n} \frac{H_t}{(1+i)^t}$ $H_t = P_t - (E_t + k_t)$ where, H_t – year t return P_t – year t income E_t – investment-type expenditure of year t k_t – non-investment type expenditure in year t i – calculative interest rate

Source: own editing based on the Author's PhD thesis submitted for workshop discussion

The European Union recommends the application of different discount rates for the tender opportunities announced in each tender cycle. Table 2. contains the discount rates recommended by the EU for the analyzes (for the period since Hungary's accession in 2004).

Table 4.: Development of discount rates recommended by the Commission (EU) for analyses

		European Union programming periods			
		2004-2006	2007-2013	2013-2020	2021-2027
Financial discount rate		5 %	5 %	4 %	based on SAMO[1]
Social discount rate	For cohesion countries	5.5 %	5.5 %	5 %	3%
	For other countries	3.5 %	3.5 %	3 %	3%

Source: own editing based on the Author's PhD thesis submitted for workshop discussion

In the 2013-2020 application period, Member States may also apply a financial discount rate other than 4 percent if they demonstrate its justification and ensure that this reference value is consistently applied to similar operations in the same sector. A reference value other than 4 percent can be justified on the basis of the following aspects:

- unique macroeconomic conditions characteristic of the Member State, as well as international macroeconomic trends and situation; or
- the nature of the investor or implementation structure, such as a public-private partnership; or
- the nature of the sector concerned.

The discount rate to be used for financial analysis must reflect the return opportunity cost of capital for the investor. The Commission recommends that a financial discount rate of 5 percent calculated in real terms be applied for public investment projects receiving co-financing. There have been cases where member states applied values reflecting unique socio-economic circumstances[2].

The social discount rate plays a prominent role in the cost-benefit analysis. In addition to theoretical approaches, many studies (guides) also deal with the implementation of the rate in practice. In practice, the Ramsey formula is the most widely used to determine the rate. As defined in the guides prepared by the EU:

$$r = eg + p$$

According to the formula used in practice

r = social discount rate of public funds
p = rate of pure time preference
e = elasticity of marginal social welfare with respect to public expenditure
g = growth rate of public expenditure

[1] The current discount rates that can be used for the analysis are published by the State Aid Monitoring Office (SAMO). (https://tvi.kormany.hu/referencia-rata).

[2] According to a guide prepared in 2006, the Commissariat Général du Plan in France reduced its reference to 4 percent. In the same period, the Department of Finance of the United Kingdom (then a member state) applied a social discount rate of 3.5 percent for investments in the public sector (European Commission, 2006).

Among the studies of the European Community, there are those prepared for the cost-benefit analysis of community investment projects. These studies detail the most important information and proposals required for the analysis, as well as the determination of applicable social discount rates.

With the help of the social discount rate, future impacts defined in monetary value are discounted to the present during the economic analysis, i.e. their value can be determined for the present (which can also be aggregated) (European Union Regional Policy, 2008). The rate was determined on the one hand for the Cohesion countries,[3] as well as for the other (non-Cohesion) member states (but only for a few of these countries).
Table 3. contains the social discount rate proposed for some EU member states for the year 2008.

Since the Union makes proposals regarding the application of the social discount rate, albeit different for each country group (Table 2.), it also determines the size of the rate for some countries with the help of the Ramsey formula proposed in the theoretical literature. Knowing these, it can be seen which return the EU expects from the individual countries, and how much it differs from the rates actually recommended in the guides.

Table 5. Social discount rate in some EU member states, 2008

Country	Rate of pure time preference	Elasticity of marginal utility of consumption	Growth of per capita real consumption	Social discount rate (%)
Cohesion countries (simple arithmetic mean)				**6.7**
Hungary	**1.4**	**1.68**	**4.0**	**8.1**
Czech Republic	1.1	1.31	3.5	5.7
Poland	1.0	1.12	3.8	5.3
Slovakia	1.0	1.48	4.5	7.7
Non-Cohesion countries (simple arithmetic mean)				**3.5**
Austria	1.0	1.63	1.9	4.1
Denmark	1.1	1.28	1.9	3.5
France	0.9	1.26	2.0	3.4
Italy	1.0	1.79	1.3	3.3
Germany	1.0	1.61	1.3	3.1
The Netherlands	0.9	1.44	1.3	2.8
Sweden	1.1	1.20	2.5	4.1
Simple arithmetic mean (countries examined together)				**4.65**

Source: own editing based on the Author's PhD thesis submitted for workshop discussion

[3]Cohesion member states (1993): Greece, Ireland, Portugal, Spain (Mogyorósy, 2006)
Cohesion countries (2007-2013): Ireland, Greece, Spain, Portugal, Bulgaria, Czech Republic, Estonia, Lettland, Latvia, Hungary, Poland, Romania, Slovenia, Slovakia (Farkas, 2012).
Cohesion countries (2014-2020): Greece, Portugal, Bulgaria, Czech Republic, Estonia, Lettland, Hungary, Poland, Romania, Slovenia, Slovakia, Croatia, Cyprus, Latvia, Malta (https://www.europarl.europa.eu)

In a study published in 2008, the European Community determined a social discount rate of 8.1 percent for Hungary, which is extremely high compared to other European countries (Germany: 3.1 percent, etc.). The elasticity values of the marginal utility of consumption were calculated using Stern's tax-based model.[4]. The value of the pure time preference component was influenced by life expectancy and other individual characteristics.

The study prepared by the European Community for the 2014-2020 programming period also includes estimates of the social discount rate (Table 4.).

Table 6. Estimate of the social discount rate in 20 EU member states, 2011

Country	Rate of pure time preference	Elasticity of marginal utility of consumption	Growth of per capita real consumption	Social discount rate
Cohesion countries (simple arithmetic mean)				**3.66**
Hungary	**1.29**	**1.25**	**1.90**	**3.67**
Czech Republic	1.02	1.44	2.58	4.75
Poland	0.97	1.09	3.16	4.43
Slovakia	0.91	1.38	1.69	3.25
Greece	0.98	1.47	0.96	2.39
Portugal	0.97	1.86	0.38	1.67
Spain	0.84	1.45	0.86	2.09
Ireland	0.63	2.31	1.55	4.21
Estonia	1.14	1.19	4.53	6.52
Non-Cohesion countries (simple arithmetic mean)				**2.41**
Austria	0.91	1.45	1.20	2.65
Denmark	0.94	1.28	0.63	1.75
Belgium	0.96	1.53	0.71	2.05
France	0.84	1.27	0.71	1.74
Italy	0.98	1.50	0.10	1.13
Luxembourg	0.74	1.84	0.77	2.17
Germany	1.04	1.33	1.36	2.84
The Netherlands	0.81	1.55	0.96	2.30
United Kingdom	0.88	1.53	1.13	2.61
Finland	0.94	1.70	1.46	3.42
Sweden	0.95	1.65	1.73	3.80
Simple arithmetic mean (countries examined together)				**2.97**

Source: own editing based on the Author's PhD thesis submitted for workshop discussion

Table 3. and Table 4. clearly show the size of the social discount rate in each country. These are a kind of norms.

[4] Stern's tax-based model: an approach to the elasticity index of the marginal utility of consumption, i.e. a method based on the declared social values of governments (Stern, 1977).

By applying the Ramsey formula, which is included in theory and recommended in practice, discount rates of different sizes occur in individual EU countries.

In the case of Hungary, there is a higher discount rate compared to the arithmetic mean of both Cohesion countries and non-Cohesion countries (for both periods). If these rates were taken into account for the examination of community projects, the EU would expect a higher yield requirement than the average from the investment projects that can be tendered in Hungary.

According to the 2008 calculation, compared to the 3.5 percent social discount rate of non-Cohesion countries, the difference is 4.6 percentage points. The application of the rate would put Hungary in a disadvantageous position and give the opportunity for a significantly narrower range of tenders. In the guides, however, a uniform system of requirements prevails in the financial analysis as well as in the economic cost-benefit analysis, but in the latter case only by country group.

Cost-benefit analysis in practice

Several researchers deal with cost-benefit analysis, as well as with the social discount rate. Table 5. contains the main literature recommendations that discuss cost-benefit analysis from a theoretical point of view.

Table 7. Main literature recommendations for theoretical approaches to cost-benefit analysis

Kapcsolódó forrásmunkák	
McKean (1958)	Efficiency in Government through System Analysis
Krutilla-Eckstein (1958)	Multiple Purpose River Development
Pearce (1968)	Cost-benefit Analysis. McMillan Studies in Economics
Mishan (1982)	Cost-benefit analysis
Dréze and Stern (2005)	The theory of cost-benefit analysis
Adler and Posner (2006)	New Foundations of Cost-Benefit Analysis
Mishan and Quah (2021)	Cost-benefit analysis, sixth edition

Source: own editing based on the version of the PhD thesis submitted for workshop discussion

Ideas based on cost-benefit analysis in today's sense were partly induced by practical applications.

The analysis is a very complex process, which is mainly applied in the local government sphere. Since the accession to the Union, municipalities have encountered, and continue to encounter, many tender opportunities. The present study examines the local government specificities of the cost-benefit analysis related to community investment tenders up to, and including, the year 2020.

In 2019, I conducted research (questionnaire survey) among domestic municipalities on the knowledge of cost-benefit analysis and its application. 140 municipalities participated in the survey.

The responses to the questionnaire revealed that the majority of municipalities (60.7 percent) are familiar with cost-benefit analysis (Figure 4.).

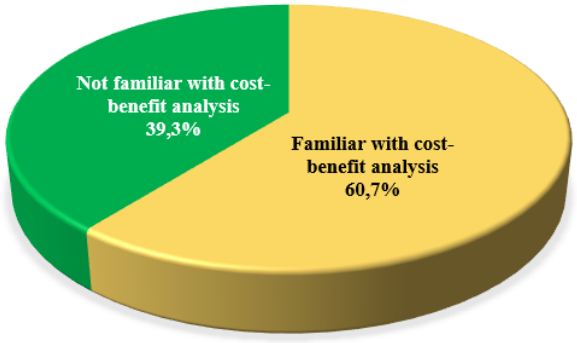

Figure 16. Knowledge of the method among domestic municipalities
Source: own editing based on the Author's PhD thesis submitted for workshop discussion

Regarding knowledge of the method, broken down by county, all regions except one county (Nógrád County) have respondents who know the method. This procedure is mostly known among municipal governments, but it is also true that most of the feedback came from here. It can be assumed that the municipalities are related to each other (this is even more typical for municipalities operating in the same region), which may contribute to the spread of the method. In Hungary, the number of municipal governments is the most decisive, and it follows that several of them are familiar with the procedure, but it can be said to be worse in proportion. The most stable knowledge of methods is typical for municipalities located at a higher level (in the case of capital districts and cities with county rights). Knowledge of the method is most common in Pest County (14 of the respondents know it), Zala, and in Szabolcs-Szatmár-Bereg County.

There are guides for preparing the cost-benefit analysis (several of them is available online as well), which also contain recommendations for the social discount rate. Knowledge of the guides is believed to contribute to the spread of the method. Figure 5. summarizes the responses to the question whether the Municipality has any guides for preparing a cost-benefit analysis. There were 135 responses to the question.

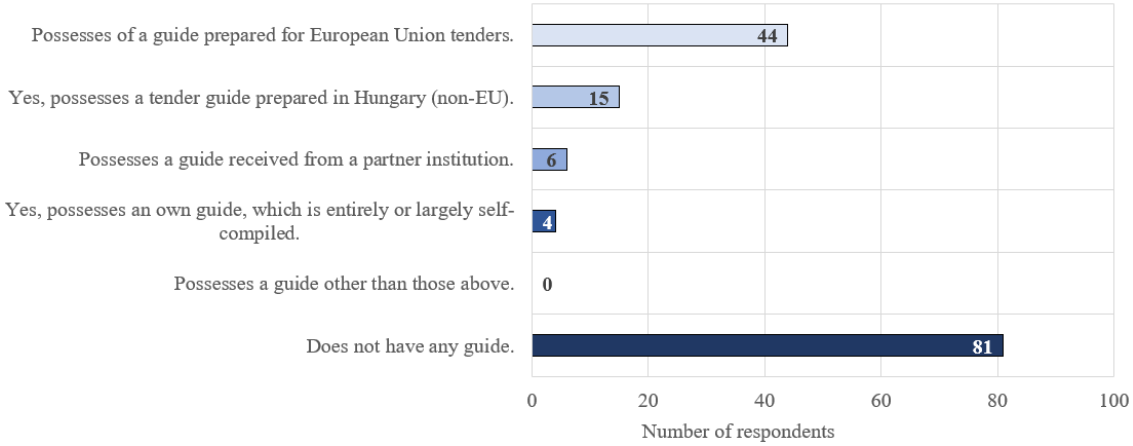

Figure 17. Guides for the preparation of cost-benefit in the possession of the Municipality
Source: own editing based on the Author's PhD thesis submitted for workshop discussion

The responses of the municipalities revealed that the majority of them (approximately two-thirds of the respondents) do not have any kind of guide. This may also be the reason why nearly 40 percent of respondents do not know the method. This is also related to the fact that knowledge of the social discount rate is also uncertain among local governments.

The responses to the question of the questionnaire in which the degree of difficulty of the cost-benefit analysis had to be evaluated on a scale from 1 to 6 are detailed in Figure 6.

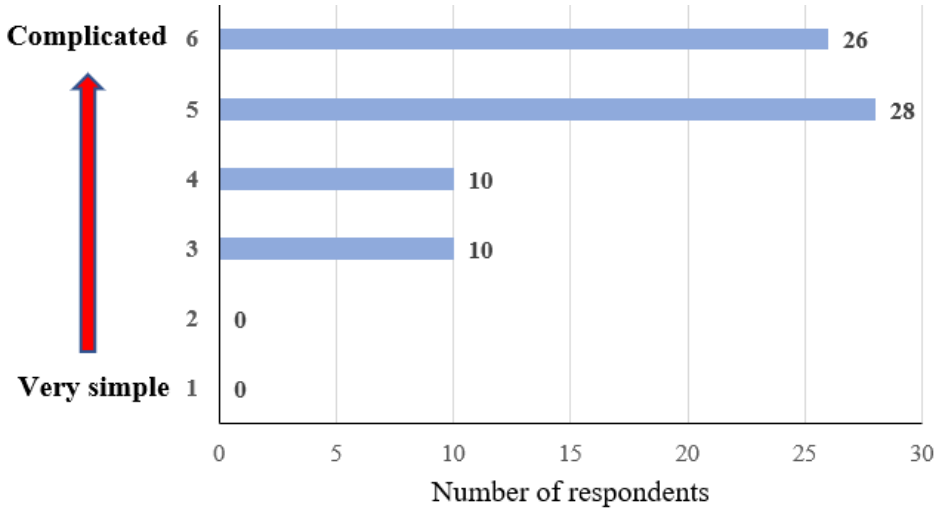

Figure 18.: The degree of difficulty of cost-benefit analysis for local governments
Source: own editing based on the Author's PhD thesis submitted for workshop discussion

74 out of 140 respondents answered this question. The majority considered the analysis complicated, in addition to the fact that several of the respondents are familiar with it.

Summary

Cost-benefit analysis is one of the methods used to base the decision between community investment projects. All costs and benefits are to be determined during the analysis, including social costs and benefits. This last requirement makes the method more complicated. This is also shown by the results of the questionnaire survey conducted among local governments, as the vast majority of respondents consider it very complicated. In addition, knowledge of the method is not so widespread among local governments. The survey also confirms that only 61 percent of respondents know the method.

Guides are available for a significant part of community investment projects. They contain a detailed definition of the calculation procedures required for the analysis, as well as the information required for them. It was also revealed from the responses of the local governments that most of them do not have any kind of guide. This also contributes to the fact that a significant number of local governments are not familiar with the method.

As with cost-benefit analysis, research related to the social discount rate goes back several decades. The formula developed by Ramsey is an indicator used to this day, both in theoretical literature and in practice.

The guides contain recommendations for both the financial and the social discount rate, but in the latter case, they differ in size for each country group. Using the Ramsey formula, the value of the social discount rate differs from country to country. If these rates were used during the analysis, i.e. for the examination of community projects, a higher yield requirement would be met for several countries, including Hungary. There is a higher discount rate for several European countries than the arithmetic mean (2008: 4.65 percent, 2011: 2.97 percent) of both Cohesion countries (2008: 6.7 percent, 2011: 3.66 percent) and non-Cohesion countries (2008: 3.5 percent, 2011: 2.41 percent).

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From reverse logistics to circular manufacturing

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Abstract: The aim of this Communication is to present the strategic role of reverse logistics in the implementation of a circular economy. The paper underlines that the traditional linear economic model is not sustainable in the long term, as it depletes natural resources and increases environmental pressures. In contrast, the circular economy seeks a closed cycle of materials, products and energy, in which reverse logistics plays a key role. This article analyses the economic and environmental importance of reverse logistics processes such as recycling, reuse, repair and reclamation and how they contribute to achieving sustainability goals. The paper stresses that the circular transition can only be achieved through cooperation between governments, businesses and consumers. In the future, the development of digital technologies, innovative business models and industrial symbiosis networks will be key to the effective operation of the circular economy.

Keywords: reverse logistics, circular economy, sustainability, recycling, supply chain management
Jel Code: Q20; Q56

Introduction

Reverse logistics (also often called reverse, inverse or inverse logistics) involves the opposite processes of conventional logistics. Narrowly defined, it refers to the flow of products, materials and related information from the consumer or place of use back to the manufacturer or supplier, typically for after-sales, usually recycling, purposes. The primary objective of reverse logistics is to use resources rationally and efficiently, reducing costs. The emphasis is on meeting environmental requirements, promoting sustainability and minimising the waste generated by recycling it.

Return logistics is typically organized around the following key activities:

- reverse logistics: receiving, sorting, and handling returned goods from customers, including warranty management and refunds;
- recycling: collecting and processing unused or defective products, packaging materials, and secondary raw materials;
- reuse: reclaiming and recirculating products, parts, or transport units (such as pallets and containers) in their original role;
- repair and refurbishment: restoring defective goods to a functional state for resale or continued use;
- waste management: the disposal of non-recyclable materials in compliance with environmental regulations.

The role of reverse logistics is growing day by day. This is because the volume of returned goods has increased dramatically due to the requirements of sustainable development, tightening environmental regulations and changing consumer demands. This phenomenon is particularly noticeable in e-commerce, where the volume of returned goods is considerable (Rubio at al, 2008).

In addition to those already mentioned, sustainability and the EU Green Deal reinforce the topicality of the issue. The principle of sustainability and sustainable development is an approach

that guarantees that our current needs are met without compromising the needs of future generations. This approach is based on three pillars:

- environmental sustainability, which focuses on the conservation of natural resources;
- social sustainability, encompassing welfare, cultural diversity, health, and education;
- economic sustainability, which relies on economic models that remain viable in the long term;

As an integrated approach, sustainability addresses economic growth, social development and environmental integrity simultaneously.

The EU Green Deal is the European Commission's universal and ambitious strategic package to make Europe the first climate-neutral continent by 2050. Rather than being just an environmental program, it represents a structural transformation process affecting industry, energy, transport, agriculture, and the financial sector. The strategy aims to reconcile economic growth with environmental sustainability by reducing carbon emissions, increasing energy efficiency, and promoting a circular economy that minimizes waste. To ensure a successful transition, the Commission employs various financial and regulatory instruments, such as the Investment Plan for a Sustainable Europe and the Just Transition Mechanism, serving as a global model for green economic growth (European Commission, 2025).

None of this can be imagined without reverse logistics, which, in addition to supporting strategic objectives, can provide a company with significant cost savings and competitive advantage by creating an efficient reverse logistics system. The key objectives of my research are to analyse the linear and circular economy, identify the economic and social impacts, explore future directions and understand how logistics thinking is evolving from reverse flows to the circular economy.

This study is based on desk research, utilizing a systematic literature review of current academic sources and policy documents. The research analyzes existing frameworks of reverse logistics and their integration into the circular economy to identify key strategic synergies.

Theoretical background

The theoretical background of reverse logistics covers many disciplines and concepts. Like logistics, reverse logistics is an interdisciplinary science. Methods and procedures are heavily influenced by integrated supply chain management, optimisation requirements, circular economy theory, sustainable development requirements, cost optimisation, risk management, operations research and inventory management.

Supply chain management theory is the traditional 'forward' supply chain organisation theory of logistics. Its theories provide the basic framework for managing flows. Reverse logistics is not an isolated function but is integrated into the forward chain. The theory emphasises the importance of coordination between the different links in the chain (suppliers, manufacturers, distribution centres, consumers) in order to manage the backward flow efficiently. Models derived from operations research and logistics help to determine the optimal location and capacity of take-back points, sorting centres and processing plants. This is essential to optimize the logistics network (Mentzer at al, 2001).

The doctrine and manifestation of the circular economy provides one of the most important modern justifications and purposes of reverse logistics. A concept often referred to in this context is the so-called "Cradle to Cradle" (C2C) approach. Its method and process are fundamentally different from the traditionally applied, typically linear "take-away-drop-off" model. Under the C2C doctrine, the life cycle of products must be designed so that their constituent parts can be continuously recycled as raw materials. As a result, it is possible to minimise waste and conserve resources. For this closed-loop system, the material flow is provided by reverse logistics (McDonough, & Braungart, 2005).

The circular business model theory advocates business models in which the producer remains the owner of the product and therefore has an interest in taking it back and preserving its value. It is a sustainable economic approach that focuses on maximising the lifetime of products and materials and minimising waste, rather than the traditional linear 'produce-manufacture-dispose' model. Its basic aim is to transform production and consumption cycles into a closed loop in order to ensure a continuous flow of resources. The basic principles of the circular model are centered around three strategic goals. First, it aims to eliminate waste and pollution at the design stage by creating products and processes that inherently minimize emissions and material loss. Second, it seeks to keep products and materials in use for as long as possible, shifting the focus from one-off consumption to extending product lifecycles through repair, reuse, refurbishment, and remanufacture. Finally, the model strives to regenerate natural systems by prioritizing the use of renewable resources and actively restoring ecosystems (Antikainen, & Valkokari, 2016).

Business model types can be found in many forms in business practice. Without being exhaustive, one can mention life cycle extension, so-called resource recovery, circular supply chains, or sharing platforms that allow sharing and renting products.

Lifecycle extension is essentially the extension of the life and usability of products through repair, refurbishment or replacement of parts. In a broader sense, lifecycle extension is a circular business strategy to keep products and their components in use for as long as possible. It is a way of ensuring that a product does not become waste immediately after failure or obsolescence, but that its durability is increased through various methods. This results in a radical reduction in the amount of raw materials, energy and waste generated (Den Hollander, & Bakker, 2012).

Resource recovery recovers valuable materials from waste and discarded products for recycling or remanufacturing. The waste or by-product is collected, processed and recycled back into the production and supply chain or value chain as a secondary raw material or new product. This method minimises materials going to landfill and maximises the rational use of available resources. The model is based on the principle that the materials generated at the end of the production process or after consumption are not considered as worthless waste, but as a valuable resource to be recovered. This approach shifts the focus from traditional waste management (disposal) to waste recovery. There are several methods.

Recycling is a physical or chemical process that transforms waste into raw materials for new products, such as the recovery of PET bottles. For materials that cannot be recovered materially or economically, energy recovery through incineration or heat generation serves as a secondary solution. Although this lies at the lower end of the circular model, it remains a superior option to

landfilling, provided it complies with relevant environmental regulations. Furthermore, waste can be broken down through specialized chemical processes - such as solvent regeneration - to recover valuable compounds or feedstocks.

Often, a by-product or waste from one company is used as a raw material or energy source for another company; this process is known as industrial symbiosis (Gaur et al., 2022). Another key approach is the use of platforms to share or rent products (such as cars or tools), which significantly increases asset utilization. This latter model is a central pillar of the sharing economy

In essence, they act as an intermediary between the provider of the service or asset and the user who needs it. They enable the use of infrequently used assets or spare capacity. They provide a so-called peer-to-peer (P2P The circular supply chain is nothing but the use of renewable, recycled or biodegradable materials in production. It is a sustainable version of the traditional linear supply chain. The concept goes beyond the traditional produce/manufacture-distribute-dispossess method. The basic aim is to keep products and materials (including resources) in the economic system for as long as possible, minimising waste and environmental impact. A circular supply chain is not a straight line to an end, but a closed loop system. In addition to delivering products to the consumer, it involves the collection, recycling, reuse, refurbishment or remanufacture of products and materials. Logistics plays a critical role in this process to ensure a reverse flow. The most striking difference from the traditional supply chain is that reverse logistics is integrated into the supply chain. This allows for the return of used products or by-products to the 'front end' of the supply chain or to other recycling points (Lahane et al, 2020).

Sharing platforms facilitate direct relationships between individuals by bypassing traditional service providers, often utilizing rating and feedback systems to build trust and reduce risk. These platforms are closely linked to the principles of the circular economy, as they extend the lifecycle of assets through more intensive use. By maximizing the utility of existing goods, the need for new production is significantly reduced (Huang et al., 2025). A prominent example of this model is the MOL Limo car-sharing service, which demonstrates how shared mobility can increase asset utilization and decrease the overall environmental footprint of urban transport.
The circular business model has many advantages: it reduces waste, energy use and raw material demand. This supports the fight against climate change and the protection of the environment. It leads to cost savings and increased revenues. It improves the efficiency of resource use. It enables the development of new markets and customer relationships, which can lead to a competitive advantage. It makes companies more resilient to fluctuations in commodity prices and supply chain disruptions, increasing competitiveness and resilience (Oghazi & Mostaghel, 2018).

With an understanding of the theoretical background, it can be seen that backward flows of materials, products and information are not independent processes. They are intrinsically linked to the functioning of the entire supply chain. It is therefore easy to accept the view that inverse logistics is not only an operational activity but also a strategic management function that creates value in economic, environmental and social terms.

The theoretical background of the concept has been developed at the intersection of several disciplines, including logistics, supply chain management, operations research, sustainable development and the circular economy. Research in recent years (2022-2025) shows that inverse

logistics is no longer just a tool for cost reduction or waste recycling, but part of a multifaceted and complex sustainability strategy. The integration of these factors has opened up new research directions and practical applications that further strengthen the role of reverse logistics. The next chapter will examine the scientific basis of this concept, the models and theoretical approaches that underpin its operation and its contribution to the development of circular and sustainable economic systems.

From linear to circular economy

The linear economic model is an unconventional economic philosophy. In the extreme, it means that it is organised along the logic of "produce/manufacture - use - throw away". This world view has been the basis of industrial and economic development for a long time. It was, in fact, the sole dominant one during the period of mass production and the emergence of the consumer society. This economic conceptual system involves three main steps: resource extraction (production of raw materials), production and consumption (raw materials are transformed into products and consumed by consumers) and waste treatment (landfilling, possibly incineration). It is crucial that there is no feedback or reuse in this model. Once consumed, materials and resources exit the economic cycle (Sariatli, 2017).

The model is characterised by a one-way material flow, which means that the economic process moves in one direction from the source of the raw material to the waste. It does not seek to reuse materials or energy and is therefore highly wasteful and resource intensive. The environmental burden is enormous. Production and waste management contribute greatly to pollution, climate change and the depletion of natural resources. In addition, economic vulnerability is considerable because the limited availability of raw materials and energy resources increases economic risks and, of course, costs in the long run (Upadhayay & Alqassimi, 2018).

The linear model is unsustainable. This finding is made because the system ignores finite resources, the environmental impact of the waste produced, the life cycle of products and their reclamation options. It must be acknowledged that this philosophy brought significant economic growth in the 20th century, but it is now clear that it is no longer sustainable in the 21st century. This is because the global economy is producing huge amounts of waste and greenhouse gases that could prove fatal for future generations (Gale, 1989).

The linear economic model is highly efficient in the short term, but unsustainable in the long term because it depletes natural resources and increases environmental pressures. Today's economic thinking - such as the EU Green Deal and the circular economy strategies mentioned earlier - seeks to reconcile economic growth and environmental responsibility and to replace the linear model. The so-called circular economy offers a good opportunity to do so (Fetting, 2020).

Circular is an economic philosophy that aims to preserve the value and usability of products, components and materials for as long as possible. This model breaks with the linear theory detailed in the previous paragraph. It seeks to create closed systems, so-called loops. Taking into account the theoretical background discussed in the chapter on the theoretical background and comparing the linear theory, the main difference is in the approach: the linear model consumes resources, produces waste and the product ends its life cycle in the waste bin. In contrast, an economic system

based on a circular philosophy creates value by keeping products and materials in the economic system for as long as possible: waste becomes a valuable input to another process (Geissdoerfer et al, 2020).

Practical applications of the model can be envisaged at micro, meso, and macro levels. At the micro level, focus is placed on using closed-loop production processes within individual firms. At the meso level, this occurs in industrial parks or at a regional scale, where firms utilize each other's by-products (as discussed in detail in the "Theoretical background" sub-chapter). Finally, at the macro level, the circular approach is implemented across the entire national economy, integrated into economic policy and the regulatory environment.

Alapvető fontosságú, hogy a körforgásos gazdaság ne csak környezeti, hanem gazdasági és társadalmi előnyökkel is járjon. Az erőforrás-hatékonyság növelésével és a hulladék csökkentésével a költségek mérséklődnek, és új üzleti modellek jönnek létre. Ez a folyamat új munkahelyeket teremt a javítás, a karbantartás, az újrahasznosítás és az innováció területén – ahogy azt az "Elméleti háttér" fejezetben tárgyalt megosztásos platformok is példázzák. A körforgásos gazdaság tehát egy rendszerszintű szemléletváltás, amely a fenntartható fejlődés alapját képezi: itt a gazdasági növekedés már nem a nyersanyagfelhasználás növelésén, hanem az erőforrások hatékony és felelős kezelésén alapul. (Linder & Williander, 2017).

The transition from a linear to a circular economy requires multiple and complex changes and systemic interventions. To guarantee this, government action and social cohesion are needed. Business, consumers and civil society must all play their part in the changes. Concerted and coordinated action is needed. There are a number of areas where action is needed. Government has a key role to play in setting the framework. A prominent example is the need to create laws that embrace durability, repairability and recycling (e.g. banning planned obsolescence) (Geissdoerfer et al, 2023).

Businesses need to change their operating models, introducing circular processes. They need to shift from selling products to providing services or supporting sharing platforms (Lacy & Rutqvist, 2015))

Design products that are durable, easily disassembled, repaired and recycled. Modular design helps to replace parts and extend lifetime. Reverse logistics should be developed. The efficient collection and processing of used products or by-products should be organised. An industrial symbiosis should be established, working with other companies to reuse by-products (Michelini et al, 2017).

Despite its many benefits, the transition to a circular economy faces significant challenges. It can be argued that these may slow down the full diffusion of the philosophy. These barriers include economic, technological, regulatory and social factors. Among the economic and financial constraints, it should be mentioned that they have an impact on both profitability and costs. This is because processing secondary raw materials and repairing or refurbishing products can often be more expensive than using cheap raw materials and producing new products. So-called planned obsolescence is still very much part of many companies' business models, still based on short product life cycles. Producing long-life products is contrary to the goal of continued sales and growth. The investment risks are significant because the construction of new circular infrastructure

requires a substantial initial investment, the return on which is also uncertain (Garcés-Ayerbe et al, 2019).

Technological and infrastructural constraints arise because modern products are often composed of multiple materials that are difficult to separate, making efficient recycling difficult. Typically, the necessary logistical and processing capacity to efficiently recover and recycle products and materials is lacking. A serious limitation is that secondary raw materials are not of the same quality as primary materials, which can limit the potential uses. In addition, different regulations in different countries or regions complicate the efforts of companies operating in global supply chains. Although the EU is taking action, there are still legal loopholes or loopholes that slow down the transition. In some cases, it has also been observed that manufacturers limit repairs by making spare parts unavailable or by blocking them with software (Neves & Marques, 2022).

We as consumers must also do our part to change. Unfortunately, we are used to the convenience of cheap, disposable products. Buying more consciously or repairing is time consuming, which discourages many. Although awareness of the issue is growing, many people are still not aware of the benefits of the circular economy or how they can actively participate in it. This is due to a lack of awareness. There is also a significant lack of confidence in second-hand, refurbished or recycled products, which is often not unfounded due to quality concerns. To overcome these barriers, concerted action is needed by all actors in the economy, including innovation, regulation and awareness-raising (Grafström & Aasma, 2021).

These constraints show that the transition to a circular economy is a complex process that requires long-term commitment, innovation and collaboration between all actors in the economy to overcome the challenges.

Socio-Economic Impacts and Systemic Synthesis

The shift to a circular economy is expected to have significant economic and social impacts, fundamentally transforming current systems and practices. While the transition is likely to be a positive one, conscious and coordinated government and business collaboration and strategic action is needed to address the negative impacts and ensure social justice. By optimising resource use and using secondary raw materials, companies can reduce their production costs, which will increase their competitiveness. Companies that have already adopted circular practices often report increased profits, as the circular model stimulates innovation, creating a market for new sustainable products and services. The EU and individual Member States will be less dependent on imports of raw materials, which will increase economic stability. It is important to note that some challenges may arise during the transition period. Building new infrastructure and technologies will require significant initial investment. Traditional industries based on linear models will have to transform, which may lead to disruptions in the short term (Tan et al., 2022).

Society may benefit from the circular economy creating new local 'green jobs' in repair, refurbishment, recycling and reverse logistics. A major benefit for local communities can be that these can be less automated than traditional manufacturing. Extending the life of products and recycling locally supports businesses that build on local communities and economies. Corporate and consumer social responsibility increases, which improves the achievement of community and

environmental goals. Although new jobs will be created, workers in traditional industries may need to be retrained, which could lead to social tensions. Changing consumer habits may in some cases inconvenience consumers (Bera, 2025).

Despite the clear advantages, the implementation of circular manufacturing faces significant practical hurdles. One of the primary issues is the quality and consistency of secondary raw materials, which often fluctuate compared to virgin resources. This technical uncertainty requires companies to invest in more flexible production technologies and advanced testing systems. Furthermore, the current legal environment sometimes acts as a barrier; for instance, the classification of certain by-products as 'waste' rather than 'resource' can create administrative burdens that discourage cross-industry collaboration. Overcoming these barriers is essential for reverse logistics to transition from a mandatory compliance task to a value-generating strategic function (Oghazi and Mostaghel, 2018).

This transition implies a comprehensive transformation of economic, technological, social and environmental mindsets. Unlike the linear "production-consumption-waste" logic, the circular approach seeks to preserve the value of products and resources within closed systems, where waste effectively becomes the raw material for another process (Gaur et al., 2022). Ensuring this transition requires the government to create a legislative and institutional environment that encourages durability and repairability while prohibiting planned obsolescence. Companies need to introduce new business models such as service-based sales, modular product design and industrial symbiosis to facilitate the cross-use of by-products. The interconnectedness of these socio-economic impacts and the strategic role of reverse logistics is synthesized in Figure 1.

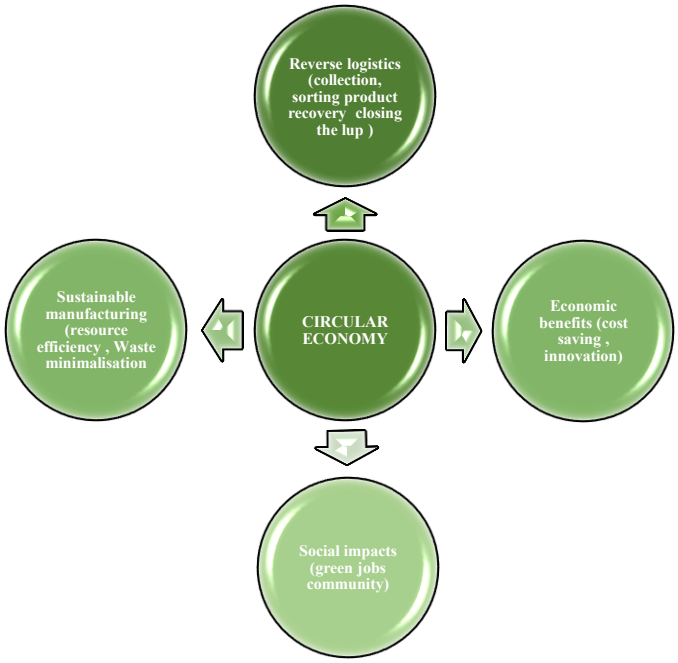

Figure 1. Synthesis of Socio-Economic Impacts and Reverse Logistics in the Circular Economy.

Source: Own elaboration based on Gaur et al. (2022) and Oghazi and Mostaghel (2018).

Conclusions and future orientations

After analysing the sources, it can be said that reverse logistics is not only a means of managing waste or returned goods, but also a strategic element in the implementation of a circular economy. It is key because it ensures the closed-loop flow of materials, products and information necessary to achieve sustainability goals, in particular the climate-neutral future set out in the EU Green Deal. The study points out that the linear economic model is unsustainable in the long term because it depletes natural resources and increases environmental pressures. In contrast, a circular economy is based on minimising waste, recycling resources and extending the life of products. It can be concluded that reverse logistics has become a strategic management function that creates economic, environmental and social value. The circular economy is the sustainable development model of the future, based on closed material flows and new business models (e.g. sharing platforms, life cycle extension, industrial symbiosis). The transition is complex and can only be achieved through cooperation between governments, businesses and consumers.

The development of integrated reverse logistics systems will presumably not be without digital technologies. IoT solutions and artificial intelligence are likely to be used to support the return of products, just as they are already being successfully applied to support service-based sales, rental and sharing platforms. The results of the research point in the direction of a shift in product design towards durability, repairability and recyclability.

Further research could focus on the economic efficiency of reverse logistics, the integration of digital solutions and the harmonisation of regulatory frameworks.

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Integrating ESG Metrics Into Business Analytics Frameworks: The Future of Data-Driven Sustainability

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Abstract: The growth in need for sustainability and corporate responsibility has necessitated the need to integrate the Environmental, Social, and Governance (ESG) metrics into business analytics. This has revolutionized the ESG data from the separation era where ESG data was reported separately from the financial and operational performance. This paper examines the rationale, structure and challenges of embedding ESG metrics into business analytical framework to create a system with unified data-driven sustainability. It proposes a conceptual model that can align ESG objectives with business strategy through data standardization, integration and reporting. Moving from compliance to data driven sustainability is the future of every business in the light of Global sustainability goals. The study shows that the future of business intelligence lies in its capacity to synthesize sustainability and profitability, to achieve transparency, resilience, and stakeholder trust through data-driven insights. The study discussed that the use of technology is the future of data-driven sustainability.

Keywords: ESG metrics, Sustainability, Business Analytics, Business framework
JEL codes:

Introduction

The growing need for sustainability in businesses has necessitated the need for businesses to provide greater accountability to their consumers and other stakeholders. To achieve this accountability businesses have incorporated Environmental Social and Governance (ESG) metrics in their performance measures. ESG metrics quantify how organizations manage the impact of their activities on environment, social factors, and governance practices. Environmental measures include carbon emissions, waste reduction, and resource efficiency. Social metrics capture workforce diversity, employee well-being, and community impact, while governance indicators focus on transparency, ethics, compliance, and board accountability (Karthik, Sujithra, & Senthilkumar, 2025).

Evolving business operations from the compliance of ESG principles to sustainable data-driven operations requires the organization to integrate the ESG measures into its operations. ESG metrics influence business decision-making by integrating environmental, social, and governance factors into operational frameworks, enhancing sustainability initiatives, reducing risks related to social and environmental challenges, and promoting long-term value creation through advanced analytics and AI-driven processes. These metrics help align economic decisions with environmental policies, fostering commitment to sustainability in various industries. Integration of the ESG metrics into the operational framework can help in the transformation of sustainability from goals to actionable and measurable activities for the company. ESG integration has provided a strategic competitive advantage for the company through its merits such as risk management, operational efficiency, accurate performance measurement and good reputation for the business.

Literature Review

The integration of sustainability data into business analytics has been widely discussed across fields such as corporate governance, accounting, and information systems. The availability of ESG data is no longer a challenge for businesses as measures have been employed to collect this data from the three aspects (Social, Environmental and Governance) of the business (Gaurav & Aman, 2022). The challenge lies in integrating this data into the business performance measurement. In the operational procedures some companies have integrated the ESG goals into key performance indicators that should be used to measure how organizations are attaining their goals (Peixoto, Machado, & Richter, 2022). The integration of ESG metrics into the business analytics is important in measuring the overall performance of the business and is instrumental in depicting an all-around performance for investors and other stakeholders. Studies show that firms that have structured sustainability metrics benefit from stronger long-term financial performance and stakeholder confidence (Olanrewaju, Daramola, & Babayeju, 2024).

Data-driven analysis integrated with ESG metrics for businesses can enable especially, retail organizations to develop sustainable strategies that improve operational efficiency and long-term financial performance (Kalyanam, 2024). There exists a positive correlation between financial performance and ESG metrics for organizations and thus using ESG metrics in analysis can be a strategic competitive advantage (Handoko, Afifudin, & Holili, 2024). Integrating ESG considerations into strategic management practices is crucial for enhancing transparency, building stakeholder trust, and fostering sustainable decision-making processes within organizations.

Businesses can effectively integrate ESG metrics into their existing analytics frameworks by adopting a structured approach that leverage advanced analytics and data-driven insights (Galvani, Carloni, Bocconcelli, & Pagano, 2025). This integration involves aligning ESG factors with business strategies, utilizing robust measurement and reporting mechanisms to enhance transparency and compliance, to foster stakeholder engagement (Karthik, Sujithra, & Senthilkumar, 2025). Empirical data analysis plays a crucial role in identifying significant ESG factors, particularly in sectors like payment services, where tailored methodologies can elevate ESG performance. Changing the use of ESG metrics from mere compliance to value creation involves integrating robust frameworks that enhance stakeholder trust, improve regulatory compliance, and drive superior long-term financial performance, ultimately transforming merger evaluation processes and post-merger strategies (Puente De La Vega Caceres, 2024).

The increasing use of data-driven methodologies in management has resulted in the integration of technological techniques for analyzing (ESG) indicators (Saxena, et al., 2022). ESG metrics influence business decision-making by enabling data-driven strategies through Executive Support Systems (ESS), which facilitate multi-source data aggregation, predictive analytics, and real-time monitoring, thereby enhancing alignment between sustainability initiatives and strategic objectives (Sorathiya et al., 2024). This provides a two-way solution through improving performance tracking and stakeholder engagement. The use of analytical tools such as clustering algorithms and time-series forecasting models to evaluate ESG trends and predict future sustainability outcomes is a current trend in sustainability measurement. Data integration and business analytics are important in linking ESG efforts to strategic objectives(Agyekum et al., 2025). Emerging research emphasizes that data integration and analytics play a decisive role in linking ESG efforts to

strategic outcomes. Predictive analytics, machine learning, and natural language processing can process large ESG datasets to uncover correlations between sustainability actions and operational efficiency.

The need for comparability and compliance of performance reports from various organizations by regulators is a key factor in the integration of ESG metrics. The use of measurement parameters such as the emission 3, Digital passports for manufactured goods, carbon footprint reports and carbon credits has become key to the measurement of performance. The availability of Standardized frameworks such as the Sustainability Accounting Standards Board (SASB), Global Reporting Initiative (GRI), and Task Force on Climate-related Financial Disclosures (TCFD) have contributed to the development of comparable ESG indicators (Sharma, 2024). These standards, however, have a primary role in guiding disclosures instead of analysis which is key to decision making.

Evolution of ESG metrics from a compliance-focused approach to one cantered on value creation can significantly enhance organizational performance and stakeholder satisfaction. Integrating human capital metrics into ESG reporting, can help companies improve the importance of employee well-being and diversity, which are crucial for long-term sustainability and competitive advantage (Anawadhi , Jahnvi, & Akhila, 2025) . ESG ratings can serve as strategic tools for investor indicators and risk management, encouraging organizations to embed ESG considerations into their key performance indicators and governance frameworks. This shift not only aligns with the growing demand for transparency and accountability in ESG practices but also fosters a broader understanding of value that encompasses social and environmental dimensions alongside economic performance (Patmanegara & Nainggolan, 2025). Additionally, developing ESG value creation metrics can clarify the relationship between ESG strategies and financial outcomes, enabling better decision-making and investment strategies that prioritize long-term value creation (Glassman, Potoski, & Callery, 2017).

A major barrier to integrating ESG metrics into business analytics frameworks is the persistent challenge of data quality, comparability, and assurance. ESG information often originates from diverse internal processes, voluntary disclosures, third-party ratings, and unstructured sources such as surveys or sustainability reports, which lack standardization (Anna, et al., 2024). This decentralization leads to inconsistencies, missing values, and subjective interpretations of indicators, particularly in social and governance domains where measurement practices are more subjective. (Li et al., 2024). Assurance of ESG data also remains uneven, with many organizations lacking formal audit procedures or robust data governance mechanisms to verify accuracy (Berg, Kölbel, & Rigobon, 2020). These issues erode analysts' and decision-makers' confidence, making it difficult to incorporate ESG metrics into predictive models or enterprise dashboards. Addressing these data challenges is essential for creating credible, analytics-ready ESG datasets that support meaningful, data-driven sustainability decisions.

Conceptual Framework: Integrating ESG into Business Analytics

The availability of practical frameworks that merge ESG data into existing analytics infrastructure is still underdeveloped and even less available for use by businesses (Kalyanam, 2024). This study proposes that organizations ought to build business analytics that tailored to meet their individual

strategic priorities and industry-specific sustainability requirements. Successful integration of ESG metrics into business operations requires understanding five integral framework formulation sequence processes.

The first step involves establishing the organization's ESG objectives in alignment with its broader strategic goals and the environmental, social, and governance expectations of its sector. Clarifying these priorities enables firms to determine which ESG indicators are most relevant and ensures that data collection efforts remain focused and meaningful. This step helps the to understand which ESG data and metrics are most relevant to the organization.
The second step concerns systematic data collection and integration. ESG data may come internally from organizations systems or externally from regulatory bodies, sustainability databases, and stakeholder reports. Systems such as Enterprise Resource Planning (ERP), Human Resources Information Systems (HRIS), and IoT sensors collect internal environmental and social data used in the business analytical framework to evaluate the performance of the organization.

The third step requires adopting an appropriate standardization or governance framework to ensure data comparability, reliability, and transparency. The organization should identify the applicable standard and apply to its framework for consistency which can ensure transparency, quality control, and ethical practice in the organization. Applying internationally recognized ESG reporting standards such as the Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), or the Task Force on Climate-Related Financial Disclosures (TCFD) enhances data consistency and embeds ethical and quality controls within the analytical process (Eccles & Klimenko, 2019).

After selecting a governance framework, the fourth step involves choosing analytical models that best support organizational needs. Firms may apply descriptive, predictive, or prescriptive analytics, while advanced AI-driven and machine-learning techniques enable deeper pattern recognition and allow organizations to link ESG outcomes with financial, risk, and innovation indicators (Wamba, Akter, & Collins, 2017).The final step involves the use of visualization and reporting tools. Platforms such as Power BI, Tableau, and cloud-based dashboards help generate interactive scorecards and visual summaries that present ESG performance alongside financial and operational metrics, thereby supporting evidence-based decision-making across organizational levels.

Recent literature highlights that integrating ESG metrics into business analytics extends beyond data availability; it requires embedding ESG considerations within broader digital transformation and data governance strategies. (Mahmoud Shaltout et al., 2023). Moreover, standardization frameworks such as GRI, SASB, and the more recent ISSB standards (IFRS S1 and S2) provide critical structure for aligning ESG metrics with analytical processes by improving cross-industry comparability (IFRS, 2023). Organizations with strong data governance practices are also shown to be more capable of embedding ESG metrics into enterprise-wide analytics systems, leading to improved transparency, enhanced performance insights, and stronger strategic alignment (Olanrewaju, Daramola, & Babayeju, 2024). Collectively, these findings highlight the importance of coupling ESG initiatives with robust analytics infrastructures and governance mechanisms to support credible, data-driven sustainability management. The availability of practical frameworks

that effectively integrate ESG data into existing business analytics infrastructure remains limited and insufficiently developed for widespread corporate adoption.

Discussion

Changing the use of ESG metrics can shift focus from mere compliance to value creation by emphasizing transparency, avoiding greenwashing, and ensuring senior management accountability, fostering long-term understanding of value that integrates economic, social, and environmental factors. This transformation requires a commitment to robust ESG frameworks and senior management involvement to ensure effective implementation and stakeholder engagement (Figure 1).

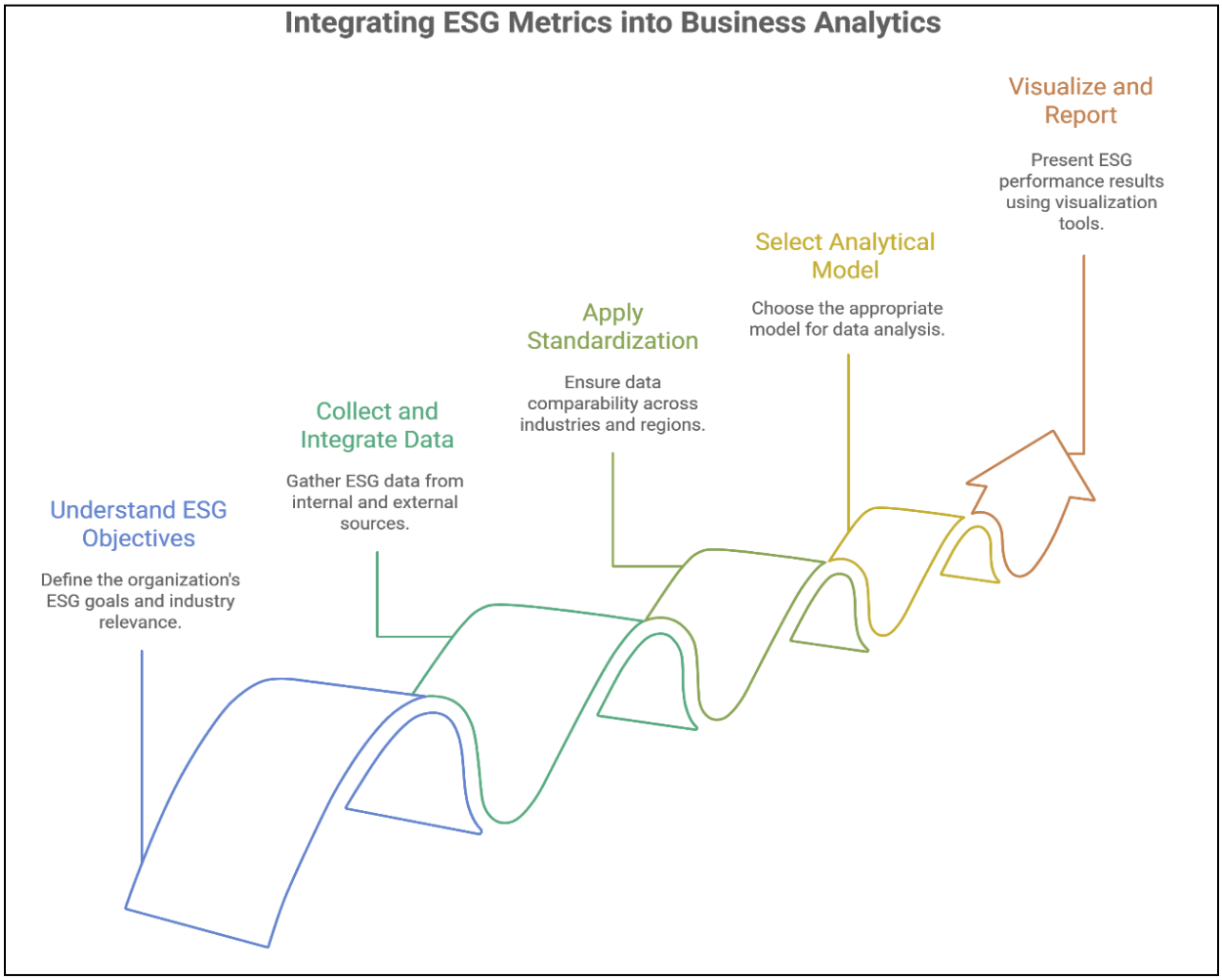

Figure 1. Integrating ESG metrics into business framework
Source: Authors own

The integration of ESG metrics into business analytics systems offers substantial benefits but also presents notable challenges. By addressing challenges such as data quality and expertise gaps, businesses can create a sustainable framework that not only drives profitability but also enhances their long-term value creation efforts (Sharma, 2024). Some of the challenges include, data

inconsistency, as ESG data may lack accuracy and frequency that exists in empirical performance data. Technological limitations may hinder support of the unstructured ESG data resulting in incomplete or unusable data being collected. Some cultural barriers such as the view of sustainability as a compliance rather than a strategic driver may hinder the integration of ESG metrics into analysis (Trubetskaya, Ryan, & Murphy, 2024). Addressing these challenges require investment in advanced data infrastructure, continuous employee training, and leadership commitment to a data-driven sustainability culture.

The integration of ESG metrics into business evaluation processes is important in driving long-term financial performance and improving reporting and regulatory compliance. Other benefits associated with the adoption of ESG metrics into business analytics include enhanced transparency, improved risk management, cross-functional collaboration and improvement of strategic alignment.

The Future of Data-Driven Sustainability

The next generation of business analytics will be deeply intertwined with sustainability performance (Chandrakala & Kamal, 2024). The shift in ESG from a compliance to a more dynamic, data-driven, and proactive management approach is largely powered by cutting-edge technologies such as Artificial Intelligence (AI), machine learning, the Internet of Things (IoT), and big data analytics (Solaimani, 2024). These technologies are allowing predictive monitoring of ESG risks while providing updated data. Technology tools like Internet of Things will enable real-time measurements of environmental factors like carbon emission, energy consumption and waste production, integrating environmental performance directly into operational dashboards. The data collected with the aid of these technologies is of higher quality thus enhancing efficiency and accuracy in reporting. Regulatory technology (RegTech) solutions will automate ESG compliance, reducing reporting burdens and improving data quality. The use of these solutions will enhance transition from reflective ESG reporting to real-time ESG management, where analytics continuously inform decision-making (Tavanti, 2023).

Future business analytics trends indicate a shift towards greater stakeholder engagement, integration of sustainability into core business operations, and the adoption of big data analytics to reconcile profit maximization with sustainable practices (Deloitte, 2022). The organization must view the future of data-driven sustainability as a core analytical factor of business performance rather than an external one. Firms that successfully integrate ESG data into their analytics frameworks will not only meet compliance demands but also gain strategic foresight and competitive advantage. The increasing use of data driven approaches will enhance operational efficiency and environmental stewardship for the organizations. Development of maturity models for evaluating sustainability management will facilitate the continuous improvement of practices across various sectors, ensuring that sustainability efforts are both transparent and strategically aligned with business objectives. (Anna, et al., 2024).

Conclusion

Integrating ESG metrics into business analytics frameworks is a strategic evolution beyond compliance. By embedding sustainability indicators within data-driven systems, organizations can

uncover insights that drive both social responsibility and financial success. Integrating financial, operational, and sustainability data, organizations can move from isolated reporting toward comprehensive, data-driven decision-making. In a world where corporate value is judged not just by profits but by purpose, the companies that leverage analytics to combine ESG with business performance will lead the next era of sustainable growth.

Organizations will need to formulate analytical frameworks that support their individual operations, industry sustainability requirements and strategic sustainability goals. As business environments become increasingly complex, the ability to derive actionable insights from ESG data will define leaders in the current era of sustainable value creation. The future of business analytics is therefore inseparable from the pursuit of data-driven sustainability. By measuring, monitoring, and managing ESG performance, companies can make better-informed decisions, enhance risk management, attract investment, increase customer satisfaction, improve employee engagement, and comply with regulations.

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Historiography as Data: Computational Methods for Studying the Evolution of Scientometric Concepts a thematic literature review

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Abstract: This article synthesizes three strands of scholars to examine how scientometric concepts evolve over time. First, it reviews the development of scientometrics from its origins in the work of Nalimov, Mulchenko, and Price to its consolidation in journals such as Scientometrics and the Journal of Informetrics, showing how citation analysis, growth models, and network mapping became core analytical tools. Second, it situates scientometric historiography within broader historiographical debates, highlighting how internalist, externalist, and communication-oriented perspectives inform the reconstruction of scientific knowledge. Third, using a thematic literature review, the study maps computational methods used to trace conceptual change, including co-citation, bibliographic coupling, direct-citation clustering, main-path analysis, co-word mapping, topic modelling, and embedding-based semantics. The review identifies methodological gaps—limited use of full text, separation from AI/LLM approaches, and lack of benchmarking—and proposes deeper integration of large language models for concept extraction, citation-function analysis, and hybrid historiographic modelling.

Key words: Scientometrics; Computational historiography; Citation networks; Thematic literature review; Concept evolution.
JEL codes: O33, C80, I23

Introduction and literature review

Scientometrics emerged in the 1960s as a quantitative "science of science," when V. V. Nalimov and Z. M. Mulchenko defined it as the study of the development of science as an information process, building on earlier growth models of scientific output (Nalimov & Mulchenko, 1969; Price, 1963). Their work crystallized a research tradition inaugurated by Price's *Little Science, Big Science*, which argued that science itself could be measured and modeled using bibliographic data (Price, 1963). Subsequent reconstructions of this early phase, most notably Granovsky's analysis of Nalimov's scientometric program, underline how probabilistic thinking, growth curves, and citation statistics became core analytical tools of the field (Granovsky, 2001). As the community grew, it became institutionalized through specialized journals: *Scientometrics*, launched in 1978, positioned itself as an outlet for quantitative studies of science and technology (Hood & Wilson, 2001; Marx & Bornmann, 2010), while Elsevier's *Journal of Informetrics* (JOI), founded in 2007, explicitly framed scientometrics and informetrics as a coherent research area (Egghe, 2012; Garfield, 2009; Wei, 2025).

Over time, the scientometric literature has mapped its own evolution. Hood and Wilson (2001) offered a classic review of "the literature of bibliometrics, scientometrics, and informetrics," showing how research clusters formed around citation analysis, mapping of science, and research evaluation, and documenting the changing use of the three "metrics" labels across Web of Science data. Garfield (2009) used the HistCite software to visualize the historical development of scientometrics itself, linking it back to the interwar "science of science" and to figures such as Bernal and Price. Egghe's (2012) five-year overview of *Journal of Informetrics*, together with Wei's (2025) retrospective analysis of JOI's 2007–2023 output, demonstrate how the field has diversified both methodologically (network analysis, advanced indicators, altmetrics, and topic

modeling) and thematically (evaluation, policy, interdisciplinarity). Complementary work by Mejia et al. (2021) explores topics in bibliometric research through citation networks and semantic analysis, while Szydlowski (2025) applies critical bibliometric methods to library science literature, showing how scientometric tools can also be mobilized for reflexive and normative assessment of fields. Recent comparative studies confirm this diversification: Chang and Nabavi (2024) compare disciplines, topics, and methods in *Scientometrics* and *Journal of Informetrics* from 2016 to 2020, and find a strong methodological core around citation-based indicators, network models, and algorithmic mapping techniques. Together, these studies position scientometrics as a mature, Web of Science–indexed domain that not only measures science but increasingly reflects on its own conceptual and methodological history (Bornmann & Haunschild, 2018; Haunschild & Bornmann, 2022).

Historiography of science, in the broad sense, concerns the methods, categories, and narratives used to write the history of scientific knowledge (Kragh, 1987; Nyhart, 2016; Liu, 2024). Kragh's *An Introduction to the Historiography of Science* remains a foundational reference, distinguishing internalist reconstructions of ideas from externalist analyses of social, institutional, and political contexts, and discussing issues such as periodization and the role of ideology in scientific narratives (Kragh, 1987). Nyhart (2016), in her chapter "Historiography of the history of science" in Lightman's *A Companion to the History of Science*, traces how historians have moved from "great men and discoveries" to accounts emphasizing social practices, material cultures, and communication systems. More recently, Liu (2024) has argued that historiography is not only an internal concern of historians, but also a key theoretical resource for science communication, because the ways histories are written shape how publics understand science and its authority. Within science studies and philosophy of science, this historiographical debate has interacted with broader reflections on scientific change, including Kuhn's paradigm model and its critics (Kuhn, 1962; Lakatos, 1970; Bird, 2000; Hoyningen-Huene, 1993; Radder, 1997; Kuukkanen, 2007; Sankey, 1993; Wray, 2011; Fuller, 2000; Small, 2006; Chen, 2016; Nickles, 2017).

Within scientometrics, historiographical questions have increasingly been tackled with quantitative tools—what we may call scientometric historiography. Garfield's (2009) work on HistCite demonstrated how citation networks can be used to reconstruct the intellectual lineage of a field and to identify canonical works and turning points. Citation-based historiography has since been extended and systematized through reference publication year spectroscopy (RPYS), a method designed to detect the "historical roots" of topics and influential authors by analyzing peaks in cited reference years (Bornmann & Haunschild, 2018; Haunschild & Bornmann, 2022; Bornmann, 2023). Bornmann and Haunschild's (2018) RPYS study of Eugene Garfield's publications, and Haunschild and Bornmann's (2022) software tutorial in *Scientometrics*, codified RPYS as a standard method for bibliometric historiography. Later applications of RPYS—from studies on academic efficiency and scientific subfields to Bornmann's (2023) RPYS analysis of Loet Leydesdorff's oeuvre—show how citation-based historiography can make explicit the seminal contributions and conceptual milestones in a research specialty. These developments bridge qualitative historiography and quantitative scientometrics, and motivate treating historiography itself as structured data that can be explored with computational methods (Mejia et al., 2021; Szydlowski, 2025; Chen, 2016; Small, 2006).

In methodological terms, the present study builds on the growing literature that treats the literature review not just as a narrative introduction, but as a systematic research method (Snyder, 2019; Jain et al., 2022; Cioppi et al., 2023; Szydlowski, 2025). Snyder's (2019) widely cited article in the *Journal of Business Research* distinguishes different review types—systematic, semi-systematic, integrative and others—and outlines procedures for rigorous searching, screening, and synthesis. Within this typology, a thematic literature review organizes the corpus around recurrent themes, concepts, or methodological approaches rather than chronology or individual authors, which is particularly suitable when the aim is to map a heterogeneous body of work, clarify how different methodological strands relate to each other, and reveal under-studied themes and conceptual gaps. Snyder's (2019) guidelines emphasize transparent search strategies (e.g., using Web of Science and Elsevier's ScienceDirect), explicit inclusion criteria, and systematic coding as prerequisites for a trustworthy thematic synthesis. Recent thematic and "systematic-and-thematic" reviews across Web of Science–indexed fields illustrate how this approach is implemented in practice. For instance, Jain et al. (2022) use a systematic and thematic review of fashion rental consumption in the *Journal of Business Research* to cluster studies into conceptual themes, map theoretical lenses, and identify under-examined constructs, while Cioppi et al. (2023) adopt a similar combined systematic/thematic design in the *Italian Journal of Marketing* to synthesize research on digital transformation and marketing. Szydlowski (2025) likewise combines critical bibliometrics and thematic coding to chart research in library and information science. In the context of scientometric historiography, a thematic literature review allows the present article to group studies by methodological approach (e.g., RPYS, co-citation networks, topic modeling, critical bibliometrics), compare their assumptions and analytical choices, and systematically identify where computational historiography of scientometric concepts remains under-developed—thereby clarifying the specific gap this study addresses (Bornmann & Haunschild, 2018; Haunschild & Bornmann, 2022; Mejia et al., 2021; Chang & Nabavi, 2024).

Thomas Kuhn's philosophy of science, articulated in *The Structure of Scientific Revolutions* (Kuhn, 1962), redefined scientific development as a cyclical process of "normal science," crisis, and paradigm shift, rather than a cumulative progression of facts. Normal science unfolds under a paradigm that structures accepted problems, methods, and standards until accumulating anomalies lead to revolutionary change and the establishment of a new, partially incommensurable framework (Kuhn, 1962; Hoyningen-Huene, 1993; Bird, 2000). This model places scientific communities, disciplinary matrices, and shared exemplars at the center of knowledge production, highlighting the social and conceptual structures that shape scientific inquiry. Kuhn's ideas became foundational across the history, sociology, and philosophy of science, and bibliometric analyses of Web of Science data consistently show *Structure* to be among the most influential works across the humanities and social sciences (Marx & Bornmann, 2010; Small, 2006; Chen, 2016). Scholars have extended and critiqued Kuhn's framework: Bird (2000) clarifies the metaphysical and methodological implications of paradigms; Hoyningen-Huene (1993) systematizes Kuhn's conceptual apparatus; Lakatos (1970) contrasts Kuhn's paradigm cycles with his own "research programme" methodology; Sankey (1993) and Kuukkanen (2007) revisit Kuhn's changing concept of incommensurability and the implications for rational theory choice; Wray (2011) and Fuller (2000) discuss Kuhn's evolutionary and sociological legacy; and Nickles (2017) surveys the philosophical debate on scientific revolutions. More recent empirical applications—such as Marx and Bornmann's (2010) bibliometric reconstruction of paradigm change in cosmology—demonstrate how Kuhnian concepts continue to guide theoretical and computational studies of

scientific evolution, and thereby provide a conceptual frame for scientometric historiography of paradigms and research fronts (Chen, 2016; Small, 2006; Szydlowski, 2025).

Thematic Literature Review as a Methodological Approach

Conceptualising the Thematic Literature Review

A thematic literature review synthesises research by organising studies around themes rather than individual findings or chronological development. It adapts the logic of thematic analysis, where Braun and Clarke (2006) define analysis as identifying and interpreting patterns across a dataset. When applied to published studies, this approach moves beyond summarising results and instead constructs higher-order patterns, conceptual categories and theoretical linkages (Thomas & Harden, 2008).

Thematic reviews sit between narrative and systematic approaches. Snyder (2019) describes literature reviews as methodological designs ranging from interpretive to highly structured forms. Thematic reviews typically use systematic search and transparent selection procedures while retaining the interpretive depth of qualitative analysis. This combination is well suited for fields requiring conceptual clarification and theory-building.

The approach is grounded in developments in qualitative evidence synthesis. Thomas and Harden (2008) demonstrated how coding and theme development can translate qualitative findings into integrated interpretations. Later contributions emphasise reflexivity, coding transparency and the interpretive role of the reviewer (Ahmed, 2025; Purssell & McCrae, 2021).

Methodological Foundations and Procedural Phases

A thematic review typically progresses through five linked phases. First, the reviewer defines the scope and research question, tailoring database searches and selection criteria in line with Snyder's (2019) emphasis on transparency. Searches usually use Web of Science, Scopus and ScienceDirect, as demonstrated in higher-education review methodology studies (Chong, 2022), and in methodological analyses of review formats (Hamel et al., 2021).

The second phase involves identifying and selecting studies through systematic or semi-systematic searches. Screening titles, abstracts and full texts ensures reproducibility and reduces selection bias. Methodological work on rapid reviews shows that even accelerated formats require documented search and selection procedures to maintain integrity (Hamel et al., 2021).

The third phase is coding. The reviewer treats published research as qualitative data and applies line-by-line coding to relevant sections. Braun and Clarke's (2006) framework guides familiarisation, coding and theme generation, while Thomas and Harden (2008) show how coding supports descriptive and analytical theme formation. Coding practices increasingly stress reflexivity and explicit documentation (Ahmed, 2025; Purssell & McCrae, 2021).

The fourth phase is theme development. Codes are grouped into descriptive themes that summarise recurring patterns. Studies such as Sezgin et al. (2019) on frailty and Salm et al. (2021) on global

health illustrate how thematic clustering clarifies conceptual ambiguities. Themes are refined to ensure fidelity to underlying data, eventually leading to analytical themes that extend or reinterpret existing knowledge (Thomas & Harden, 2008).

The fifth phase turns themes into a structured synthesis. The review is organised around thematic clusters rather than individual studies. Ward, House and Hamer (2009) exemplify this approach by deriving a framework for knowledge translation from recurring patterns in the literature. Uttley et al. (2023) similarly used thematic synthesis to identify structural weaknesses in systematic reviews and propose improvements.

Applications Across Domains: Thematic literature reviews are widely used across health, social sciences, management, education and technology. In health research, they help clarify complex concepts and synthesise qualitative evidence. Ward et al. (2009) produced a multi-domain framework for knowledge translation through thematic analysis. Salm et al. (2021) mapped key conceptual dimensions of global health, while Sezgin et al. (2019) identified major definitional variations in frailty research. Thematic synthesis is also used to integrate experience- and implementation-focused studies. Newington et al. (2021) examined the impacts of clinical academic roles; Warr et al. (2021) mapped beliefs and practices related to obesity care; Howard and Bartholomew (2024) synthesised intersectional barriers to physical activity among Black women; McMahon et al. (2022) reviewed shared musical experiences in dementia care. In public health and community research, Lee et al. (2020) analysed community exchange systems through thematic review, while Metsis et al. (2025) examined how young people conceptualise health. In management and marketing, Cioppi et al. (2023) created thematic clusters around digital transformation, and Li (2023) used a thematic review to explain academic help-seeking behaviour across individual, interpersonal and institutional themes.

In methodological research, Chong (2022) applied thematic analysis to systematic reviews in higher education, highlighting recurring methodological issues. Hamel et al. (2021) used thematic analysis to clarify the concept and use of rapid reviews. Uttley et al. (2023) synthesised themes related to weaknesses in systematic reviews, pointing to persistent methodological challenges. In technology and computing, Cooper et al. (2022) used reflexive thematic analysis to examine community-centred approaches, identifying themes such as participation and accountability that shape algorithmic systems.

Thematic Reviews and the Identification of Research Gaps: A primary value of thematic reviews is their ability to expose research gaps through thematic patterning. Because the method maps which themes dominate and which are underdeveloped, gaps become visible within conceptual, methodological and contextual dimensions. Ward et al. (2009) used thematic mapping to identify domains in knowledge translation that were conceptually rich but empirically thin. Salm et al. (2021) identified neglected perspectives in global health definitions. Thematic reviews draw attention to under-represented populations and contexts. Howard and Bartholomew (2024) demonstrated that mainstream physical-activity research lacked attention to Black women's experiences. Metsis et al. (2025) revealed how young people's own views on health were often overlooked. They also highlight conceptual ambiguities. Sezgin et al. (2019) exposed inconsistent meanings of frailty, while Salm et al. (2021) documented competing narratives within global health discourse. They reveal methodological imbalances as well: Chong (2022) found over-reliance on

narrative synthesis in higher-education reviews; Uttley et al. (2023) catalogued systematic weaknesses such as publication bias and limited stakeholder engagement. Thematic reviews also guide future research agendas. Cioppi et al. (2023) used thematic clusters to propose directions for work on digital transformation. Li (2023) turned thematic findings into propositions for empirical testing. Cooper et al. (2022) used thematic insights to articulate a research agenda for community-centred computing. Hamel et al. (2021) and Uttley et al. (2023) used themes to suggest improvements in evidence-synthesis practice.

Through these capacities, thematic literature review provides a methodological foundation for identifying conceptual gaps, neglected populations, unresolved debates, and methodological shortcomings, allowing a study to position itself clearly within the knowledge landscape.

Results of the Thematic Literature Review: Computational Methods for Studying the Evolution of Scientometric Concepts

This chapter synthesizes findings from a focused thematic review of Elsevier-indexed research (especially Journal of Informetrics, Information Processing & Management, and Expert Systems with Applications) and methodological descriptions from Web of Science (Clarivate). The aim is to identify and organize the computational methods that have actually been used to detect, map, and explain how scientometric concepts (e.g., impact, novelty, interdisciplinarity, research fronts) emerge, evolve, and diffuse over time (Börner, 2009; Garfield, 2009; Web of Science, 2021–2025).

Citation-Network Methods: Tracing Concept Lineages and Research Fronts

Co-citation clustering and research fronts

Co-citation analysis is widely used to delineate "research fronts"—cohesive clusters of highly cited papers that are frequently cited together—providing a dynamic proxy for the socio-cognitive evolution of concepts (Calero-Medina & Noyons, 2008; Chen et al., 2024). Clarivate operationalizes this logic in Web of Science's annual Research Fronts by first identifying top-cited papers and then clustering them by co-citation to reveal evolving fronts and their trajectories (Web of Science, 2024). In scientometrics, this approach explicitly links conceptual change (for example, the introduction of a new method or indicator) to shifts in co-citation structures that reveal how knowledge communities form, expand, or decline (Garfield, 2009; Leydesdorff, 2011).

Bibliographic coupling (BC)

Bibliographic coupling (BC) connects contemporary papers that share references and is particularly useful for early detection of topical convergence before heavy citation accumulates (Jarneving, 2007; Weinberg, 1974). Foundational work and subsequent refinements in Elsevier venues, including refined weighting schemes for shared references, show that BC can yield sensitive and timely delineations of emerging specialties and research fronts (Jarneving, 2007; Shen et al., 2019). Empirical applications confirm BC's value for science mapping and project-level knowledge organization in large-scale evaluations of research and projects (Li et al., 2020; Sun et al., 2016).

Direct-citation clustering (DC)

Where co-citation and BC infer relatedness indirectly, direct-citation (DC) clustering relies on observed citation links to assemble publication-level clusters and has been argued to produce more precise, large-scale maps of knowledge flow (Yun et al., 2020). Using Web of Science data, DC has been evaluated against co-citation and BC, with results showing robust clustering quality and interpretability for tracking topic evolution and domain structure (Ruiz-Castillo & Waltman, 2015; Wang et al., 2016; Yun et al., 2020). For scientometric concepts, DC provides a structural backbone on which further semantic and temporal analyses can be layered (Bornmann et al., 2022; Tian et al., 2023).

Main-Path Analysis (MPA) and knowledge-diffusion paths

For narrating conceptual lineages, main-path analysis (MPA) extracts the backbone of a citation network and yields interpretable "paths" of knowledge diffusion across decades (Liu et al., 2012; Xiao et al., 2014). Variants such as global, local, key-route, forward search path count, influence-difference, and structure-and-content-aware MPA enrich the original framework and allow for multiple developmental trajectories to be compared (Jiang & Liu, 2019; Yu et al., 2021, 2023). Recent studies show how MPA can be enhanced with prestige-aware edge weights, semantic information, and heterogeneous entities (for example, authors, venues, and keywords) to reconstruct how scientometric ideas mature, branch, or converge (Chen et al., 2017; Chen et al., 2022; Mei et al., 2022).

Quantifying conceptual novelty and disruption

In addition to clustering and path-based approaches, quantitative indicators have been proposed to capture conceptual change itself. Novelty indices, including those based on question–method recombination, quantify how far a contribution departs from prior knowledge configurations (Luo et al., 2022; Ponomarev et al., 2014; Savov et al., 2020). Complementary work on disruption indices uses Web of Science data to calculate the degree to which a paper restructures citation patterns and reduces reliance on prior literature (Leydesdorff & Bornmann, 2021). For scientometric concepts, such measures support the identification of contributions that function as conceptual turning points or methodological breakthroughs (Bornmann et al., 2022; Yan, 2014).

Content- and Semantics-Based Methods: Tracking Lexical and Topical Shifts

Co-word analysis (term co-occurrence)

Co-word analysis remains one of the most established methods for mapping the conceptual structure of a field (Ding et al., 2001; Khasseh et al., 2017; Leydesdorff, 2011). By constructing networks based on the co-occurrence of keywords or terms in titles, abstracts, and author keywords, co-word analysis identifies thematic clusters and reveals how terms co-locate and reconfigure over time (Cobo et al., 2011; Su et al., 2021). Applications to iMetrics and related fields have demonstrated that co-word structures can be tracked across time slices to monitor conceptual consolidation, diversification, or decline (Khasseh et al., 2017; Ding et al., 2001).

Burst and trend detection

Time-sliced keyword trajectories combined with burst detection provide a way to identify periods of rapid conceptual uptake and short-lived spikes in attention (Feng et al., 2015; Su et al., 2021). Many bibliometric mapping studies in Elsevier journals report "bursty" terms as markers of

emerging or hot topics and characterize research fronts by the onset and decay of such bursts (Cobo et al., 2011; Bornmann, 2014). This approach is particularly valuable for detecting early phases in the life cycle of scientometric concepts, before they become fully embedded in citation networks (Ortega, 2018; Yan, 2014).

Topic modeling and dynamic topic evolution

Latent topic models, such as Latent Dirichlet Allocation (LDA), have been widely used to extract thematic structures from large corpora and to chart the evolution of topics over time (Chen et al., 2017; Hu et al., 2020). Dynamic or time-aware topic models allow researchers to track topic birth, growth, split–merge events, and decline, yielding detailed timelines of domain evolution (Chen et al., 2017; Sun et al., 2016). Applications in *Journal of Informetrics* and *Information Processing & Management* demonstrate how topic models can be used to monitor shifts in the focus of scientometric research, such as the rise of altmetrics or the expansion of collaboration studies (Hu et al., 2020; Bornmann et al., 2022).

Embedding-based semantics and semantic shift

Embedding-based methods (e.g., word2vec, BERT-based language models) are increasingly used to generate dense semantic representations of words and documents, which can be exploited for keyword clustering, topic extraction, and cross-lingual mapping (Li et al., 2020; Xie et al., 2020). Comparative studies show under which conditions traditional TF–IDF, classic word embeddings, and contextual embeddings perform better for representing topical structures (Li et al., 2020; Hu et al., 2020). Time-aware semantic analyses assign "status roles" to terms based on measures such as entropy or shifts in their embedding neighborhoods, thereby operationalizing conceptual maturation and transformation (Zhang et al., 2023). In scientometrics, such embeddings have been integrated into network-based frameworks to refine concept detection and support more nuanced analyses of conceptual drift (Mei et al., 2022; Xie et al., 2020).

Community Detection and Cluster Tracking in Evolving Graphs

Graph-based community-detection algorithms, such as Louvain and Leiden, are now standard tools for partitioning citation, co-citation, and co-word networks into cohesive clusters that correspond to topics, specialties, or conceptual communities (Ding, 2011; Gómez-Núñez et al., 2014; Yun et al., 2020). Once communities are detected in each time slice, cross-time matching techniques can be used to track continuity, growth, splits, merges, and disappearance of communities (Sun et al., 2016; Tian et al., 2023). Studies explicitly comparing topological versus topical communities demonstrate that structural communities often align with thematic ones but can also reveal cross-topic bridges and structurally important clusters (Ding, 2011; Leydesdorff, 2011). Recent work also explores community-evolution prediction, using graph- and content-based features to forecast whether a community will grow, shrink, or split (Tian et al., 2023; Bornmann et al., 2022).

Hybrid and Heterogeneous Approaches

A prominent trend in recent scientometric research is the move toward hybrid approaches that combine citation structure with textual semantics in heterogeneous networks (Calero-Medina & Noyons, 2008; Mei et al., 2022). In these frameworks, multiple entity types (for example, documents, authors, venues, keywords) are linked and embedded jointly using graph-based or

neural techniques (Mei et al., 2022; Xie et al., 2020). Hybrid methods have been used to rank documents and concepts by combining structural centrality, semantic similarity, and temporal information, leading to more robust identification of influential concepts and their evolutionary trajectories (Chen et al., 2022; Li et al., 2020). When coupled with MPA, heterogeneous networks enable multiple, concept-specific main paths to be identified and compared, offering richer narratives of conceptual development in scientometrics (Chen et al., 2022; Yu et al., 2023).

Temporal Dynamics Beyond Citations: Early Attention and Lifecycles

Temporal analyses of citation counts and altmetrics complement structural and semantic approaches by characterizing how quickly and for how long scientometric concepts receive attention. Studies of citation aging examine parameters such as citation half-life and early versus delayed recognition (Finardi, 2014; Bornmann et al., 2022). Elsevier and Web of Science–based research show that these temporal profiles can identify "sleeping beauties" and rapidly rising topics (Finardi, 2014; Yan, 2014). Altmetric indicators—mentions in social media, policy documents, and news—have been evaluated as early-signal proxies that may forecast longer-term impact, though results are mixed (Bornmann, 2014; Ortega, 2018). Nevertheless, they provide detailed attention lifecycles and highlight communication practices (such as open peer review and preprints) that influence how quickly concepts are disseminated and discussed (Bornmann, 2014; Ortega, 2018; Web of Science, 2021–2025).

Indicators, Normalization, and Classification: Methodological Considerations

Field-normalized citation impact indicators remain essential when comparing concept-related outputs across domains with different citation cultures (Ruiz-Castillo & Waltman, 2015; Perianes-Rodríguez et al., 2015). Scientometric studies have emphasized the need for normalization not only at the paper and journal level, but also when aggregating indicators for conceptual clusters or communities (Bornmann et al., 2022; Cobo et al., 2011). At the same time, research on the accuracy of journal classification systems in Web of Science and Scopus warns against uncritical reliance on pre-existing subject categories, especially when they are used as basemaps for concept-evolution studies (Wang et al., 2016). These findings underline the importance of validating classifications and of using algorithmically constructed field delineations when tracking scientometric concepts across interdisciplinary boundaries (Gómez-Núñez et al., 2014; Wang et al., 2016).

Tools and Visual Analytics Supporting Evolutionary Inference

Visual analytics tools have been central to the development of scientometrics as a field and remain crucial for interpreting computational results on concept evolution (Börner, 2009; Garfield, 2009). Algorithmic historiography, overlay maps, and interactive network visualizations help to translate citation networks, topic models, and hybrid embeddings into intelligible narratives about how concepts evolve (Garfield, 2009; Cobo et al., 2011; Su et al., 2021). Elsevier journals have published conceptual and methodological contributions that highlight design principles and best practices for science visualizations (Börner, 2009; Feng et al., 2015), while Web of Science provides integrated tools for co-citation, co-authorship, and research-front mapping (Web of Science, 2021–2025). For the evolution of scientometric concepts specifically, visualizations make

it easier to identify path-breaking contributions, cross-disciplinary linkages, and the temporal ordering of conceptual shifts (Börner, 2009; Yan, 2014).

Synthesis: A Multi-Method Workflow for Concept Evolution in Scientometrics

Taken together, the reviewed literature points toward a pragmatic, multi-method workflow for analyzing the evolution of scientometric concepts using Elsevier and Web of Science data:

1. *Data retrieval and time slicing***.** Conceptual proxies (terms, venues, topical queries) are defined and corresponding records are harvested from Web of Science Core Collection and Elsevier databases (Web of Science, 2021–2025; Cobo et al., 2011). Time slicing (for example, yearly) allows longitudinal analyses of concept dynamics (Bornmann et al., 2022; Sun et al., 2016).
2. *Backbone mapping via citation networks.* A direct-citation network is constructed to provide a structural backbone, while co-citation and BC networks provide complementary views of established and emerging relatedness, respectively (Jarneving, 2007; Shen et al., 2019; Yun et al., 2020). This ensemble of citation-based representations forms the basis for subsequent clustering and path analyses (Calero-Medina & Noyons, 2008; Chen et al., 2024).
3. *Community detection and longitudinal tracking.* Community detection algorithms (e.g., Louvain/Leiden) are applied in each time slice to identify topic or concept clusters (Ding, 2011; Gómez-Núñez et al., 2014). Cross-time cluster matching and evolution-prediction models are then used to track clusters and anticipate their growth, decline, or fragmentation (Sun et al., 2016; Tian et al., 2023; Yan, 2014).
4. *Narrative lineages through main-path analysis.* Main-path analysis and its variants are performed on the direct-citation network, often enriched with semantic or prestige information, to extract one or more developmental trajectories that represent the intellectual history of the focal scientometric concept (Xiao et al., 2014; Jiang & Liu, 2019; Chen et al., 2022; Yu et al., 2021, 2023).
5. *Semantic labeling and conceptual shift.* Co-word networks, burst detection, topic modeling, and embedding-based methods are used to label clusters, detect emerging concepts, and measure semantic shift (Ding et al., 2001; Khasseh et al., 2017; Feng et al., 2015; Chen et al., 2017; Li et al., 2020; Zhang et al., 2023). These semantic perspectives refine the interpretation of structural clusters and main paths.
6. *Change metrics and attention lifecycles.* Novelty and disruption indices, together with temporal patterns of citations and altmetrics, are used to identify key conceptual turning points and to characterize the attention lifecycles of scientometric concepts (Ponomarev et al., 2014; Bornmann, 2014; Leydesdorff & Bornmann, 2021; Ortega, 2018; Luo et al., 2022).
7. *Normalization, validation, and visualization.* Field-normalized indicators are applied to ensure comparability across domains and time, while classification choices and cluster solutions are validated against alternative baselines (Ruiz-Castillo & Waltman, 2015; Wang et al., 2016; Perianes-Rodríguez et al., 2015). Finally, visual analytics tools are used to communicate the results and to support qualitative interpretation (Börner, 2009; Garfield, 2009; Cobo et al., 2011; Su et al., 2021).

Across Elsevier and Web of Science sources, the strongest empirical results tend to come from hybrid pipelines that (a) use direct-citation clustering as a structural backbone, (b) apply advanced main-path analysis to extract narrative lineages, and (c) enrich these with semantic models (from

co-word analysis to topic modeling and embeddings) to interpret and validate conceptual change (Calero-Medina & Noyons, 2008; Chen et al., 2022; Mei et al., 2022; Yun et al., 2020). Co-citation and BC provide complementary perspectives, especially for research-front detection and early-phase concept identification, while altmetrics and temporal profiles refine the timing and intensity of conceptual uptake (Bornmann, 2014; Ortega, 2018; Yan, 2014).

Discussion

Gaps and Future Directions for Scientometric Methods in the Age of AI and LLMs

The thematic review shows that scientometric research has developed a sophisticated toolbox for tracing the evolution of concepts, combining citation-based approaches (co-citation, bibliographic coupling, direct-citation clustering, main-path analysis) with co-word analysis, topic modeling, and more recent embedding-based methods (Cobo et al., 2011; Ding, 2011; Li et al., 2020; Sun et al., 2016; Xie et al., 2020; Yun et al., 2020; Zhang et al., 2023). At the same time, several gaps become visible when these methods are compared with the possibilities opened by contemporary artificial intelligence and large language models (LLMs).

First, most existing studies still operate at the level of documents and crude text units rather than fine-grained conceptual statements. Even when full text is available, analyses frequently rely on titles, abstracts, and author keywords, which can obscure how scientometric concepts are defined, operationalized, and contested within the body of papers (Ding et al., 2001; Khasseh et al., 2017; Leydesdorff, 2011). Topic models and word embeddings capture semantic neighborhoods but not the argumentative roles of concepts, for example whether a paper introduces, critiques, refines, or merely cites a given scientometric notion (Li et al., 2020; Xie et al., 2020). As a result, current historiographic reconstructions mostly follow where concepts appear (in which clusters, topics, or paths) rather than how they are used and transformed in scholarly discourse.

Second, there is a methodological separation between network-based and AI-assisted approaches. Citation-network methods have matured within scientometrics, while AI and LLMs are only beginning to be used as measurement tools in this domain. Recent work has evaluated LLMs as predictors of citation counts and readership (de Winter, 2024), as instruments for identifying potentially disruptive papers (Bornmann, 2024), and as quasi-reviewers of originality or methodological quality (Huang et al., 2025; Thelwall et al., 2025a, 2025b). However, these studies mainly treat LLMs as black-box quality scorers or evaluators, rather than deeply integrating them into the historiographic pipelines that map conceptual evolution. There is still very little work where LLMs are used to construct or refine concept taxonomies, to annotate citation functions, or to generate interpretable narratives of how scientometric concepts change over time.

Third, the evaluation of AI-based scientometric indicators remains limited and often focused on pairwise comparisons between LLM outputs and traditional metrics. Studies have shown that ChatGPT and related models can approximate or sometimes rival citation-based approaches for certain prediction tasks (de Winter, 2024; Thelwall, 2025), and that they display non-trivial biases with respect to age, field, and document type (Thelwall, 2025; Huang et al., 2025). Yet, systematic benchmark datasets that combine manual expert assessments, citation trajectories, and multiple LLM outputs are largely missing. Without such benchmarks, it is difficult to make robust claims

about when LLM-based measures complement, replace, or distort classical scientometric indicators.

Fourth, both traditional scientometric methods and emerging AI-based approaches share important coverage and bias issues. The bulk of empirical work is concentrated on English-language, high-impact journals, often from a limited set of disciplines (Bornmann, 2014; Wang et al., 2016). LLMs are trained on similarly skewed corpora and can reproduce or amplify these biases in their judgments and generated text (Thelwall, 2025; Alsudais, 2025). This raises methodological and ethical questions about the fairness and generalizability of AI-assisted indicators when applied to scientometric concepts that are themselves sensitive to disciplinary and linguistic diversity, such as "excellence," "impact," or "novelty."

Finally, the review highlights a gap in reflexive studies that examine how the adoption of AI tools in scientific writing, reviewing, and evaluation feeds back into scientometric indicators and the evolution of concepts. Early evidence suggests that the widespread availability of LLMs has already influenced textual properties such as readability and stylistic homogeneity (Alsudais, 2025), and recent debates in research evaluation point to changing norms around peer review and publication practices (Huang et al., 2025; Thelwall, 2025). Yet, there is very little longitudinal work connecting these behavioral changes to shifts in the meaning and measurement of scientometric concepts.

Looking ahead, several promising directions emerge for future research on scientometric methods, especially with LLMs as both objects and instruments of study. One direction is to develop LLM-assisted concept extraction and tracking from full text. Rather than focusing on keywords or topics, LLMs could be used to identify explicit definitions, conceptual distinctions, and methodological claims related to scientometric concepts across large corpora, and to align these statements across time. This would allow researchers to reconstruct not only the diffusion of labels but also the evolution of underlying meanings and operationalizations.

A second direction is to integrate LLMs into citation-context and citation-function analysis at scale. Existing main-path and network approaches treat citations as homogeneous links (Liu et al., 2012; Xiao et al., 2014; Yu et al., 2021, 2023), while qualitative studies emphasize the diversity of citation roles. LLMs trained or fine-tuned on annotated corpora could classify whether citations express support, critique, extension, or mere background, and these classifications could then be embedded into main-path analysis and community detection. This would enable richer historiographies where concept evolution is traced through sequences of supportive, critical, and consolidating contributions, rather than through raw citation counts alone.

A third avenue concerns hybrid predictive models that jointly exploit network structure, textual semantics, and LLM-derived signals. The review already identified hybrid embedding and heterogeneous-network approaches as a fruitful trend (Mei et al., 2022; Chen et al., 2022). Extending these models to incorporate LLM-based evaluations of originality, clarity, or methodological rigor could improve predictions of which scientometric ideas will become influential, disruptive, or short-lived (Bornmann, 2014; Luo et al., 2022; Ponomarev et al., 2014; Savov et al., 2020). At the same time, such models must be carefully validated to avoid circularity,

for example when LLMs have been trained on corpora that already include citation information or review texts influenced by impact considerations.

A fourth research direction is the design of open benchmarks and shared evaluation protocols for AI-assisted scientometrics. Building on the tradition of responsible metrics and normalization (Ruiz-Castillo & Waltman, 2015; Wang et al., 2016), future work could create multi-field, multi-language datasets that combine expert assessments, citation trajectories, altmetrics, and multiple LLM outputs. These benchmarks would support systematic comparisons of different LLM architectures, prompting strategies, and aggregation methods for scientometric tasks such as quality assessment, novelty detection, or identification of emerging fronts (Bornmann, 2014; Thelwall, 2025; de Winter, 2024).

Finally, the review points to the need for reflexive and ethical analyses of how AI and LLMs reshape the scientometric landscape itself. As LLMs are increasingly used to assist with literature reviews, manuscript drafting, and peer review, the quantity, style, and structure of scientific output are likely to change, which may in turn affect citation behavior and indicator distributions (Alsudais, 2025; Huang et al., 2025). Future studies could combine longitudinal scientometric analyses with surveys or experimental designs to examine how researchers use AI tools, how editorial and evaluation practices adapt, and how these shifts feed back into the conceptualization of core scientometric constructs. In this sense, LLMs are not only new instruments for scientometric measurement but also new actors in the science system whose effects must be monitored and theorized within the science of science.

Overall, the thematic review suggests that existing scientometric methods provide a strong foundation, but that the full potential of AI and LLMs for studying the evolution of scientometric concepts has not yet been realized. Bridging structural network approaches, semantic modeling, and LLM-based annotation offers a rich agenda for future research, provided that issues of bias, transparency, and responsible use remain central.

Conclusion

This article has examined “Computational Methods for Studying the Evolution of Scientometric Concepts” through a thematic literature review focused on Elsevier-indexed journals and Web of Science data. Building on previous chapters that introduced the theoretical background, reviewed the historiography of scientometrics, and outlined a thematic-review methodology, Chapter 4 mapped the concrete methodological repertoire currently used to trace how scientometric concepts emerge, stabilize, and transform over time. The review shows that scientometrics has evolved a rich, but partly fragmented, toolbox for conceptual historiography that combines citation-based, text-based, and hybrid approaches.

Across the literature, several major *families of methods* recur. Citation-network approaches—co-citation, bibliographic coupling, direct-citation clustering, and main-path analysis—provide structural backbones for reconstructing intellectual trajectories and identifying research fronts. Content- and semantics-based methods—co-word analysis, burst detection, topic modeling, and embedding-based representations—offer complementary views on lexical and topical shifts, enabling the detection of emerging themes and semantic drift. Community detection in evolving

graphs supports longitudinal tracking of clusters, while indicators, normalization, and classification methods ensure that concept-related outputs remain comparable across fields and time. Visual-analytics tools, finally, translate these computational results into interpretable historiographic narratives.

The article's core contribution is to synthesize these strands into a multi-method workflow tailored to the evolution of scientometric concepts. This workflow proceeds from data retrieval and time slicing (using Web of Science and Elsevier), through backbone mapping with direct citations, community detection and cluster tracking, main-path analysis for narrative lineages, semantic labeling via co-word/topic/embeddings, and the application of change metrics (novelty, disruption, altmetrics), all underpinned by normalization, validation, and visualization. Taken together, these steps articulate a practical, reproducible pipeline for studying how key scientometric notions—such as impact, interdisciplinarity, novelty, or research fronts—change in meaning, usage, and influence over time.

At the same time, the discussion has highlighted important gaps. Current methods mostly operate at the level of documents, keywords, and coarse topics rather than fine-grained conceptual statements or citation functions. Network-based approaches and emerging AI/LLM-based approaches are still largely separate, with LLMs treated as black-box quality scorers rather than integrated components of historiographic pipelines. Systematic benchmarks that combine expert judgment, citation trajectories, and AI outputs remain scarce, and both traditional and AI-based indicators share coverage and bias issues, particularly regarding language, discipline, and publication venue. Moreover, there is limited reflexive work on how the very use of AI tools in writing, reviewing, and evaluation feeds back into scientometric indicators and the evolution of scientometric concepts themselves.

These gaps point toward a future research agenda in which AI and large language models become deeply embedded in scientometric methodology rather than merely adjunct tools. Promising directions include: (i) LLM-assisted extraction and tracking of explicit conceptual definitions and methodological claims from full text; (ii) large-scale LLM-based classification of citation contexts and citation functions, integrated into main-path and community-evolution analysis; (iii) hybrid predictive models that combine network structure, semantic embeddings, and LLM-derived signals for identifying breakthroughs and conceptual turning points; (iv) open benchmark datasets and shared evaluation protocols for AI-assisted scientometric tasks; and (v) reflexive, ethical studies of how LLMs reshape scientific communication and, in turn, the indicators used to measure it.

In summary, the article argues that scientometrics now stands at a methodological crossroads. The established repertoire of citation and textual methods offers a strong foundation for studying the evolution of scientometric concepts, but the rapid advancement of AI and LLMs opens new possibilities for more nuanced, concept-sensitive, and reflexive analyses. Realizing this potential will require careful integration of structural, semantic, and AI-based approaches, accompanied by robust validation and a sustained commitment to responsible metrics. If these conditions are met, future scientometric research will be better equipped not only to map the changing landscape of science but also to understand how its own conceptual vocabulary evolves in response to new technologies, institutions, and practices.

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The competence development effects of gamification programs

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Abstract: We encounter numerous challenges in our everyday lives, for which it is difficult to find quick and effective solutions. The aim of my research is to present gamification, an approach that can be used to respond to these challenges. After a brief overview of gamification, I examine the competence development effects of gamification programs based on the results of a questionnaire survey conducted among domestic for-profit medium and large companies. The results provide an opportunity for those planning to implement gamification, as well as those who have not yet applied it, to gain inspiration, while those who have already implemented it can receive confirmation of their results.

Keywords: gamification, competence, competence development
JEL code: O30, A20, M20, M53

Introduction and justification for the choice of topic

Humans love to play by nature. Through play, we can relax, gain experiences and develop our social skills and competencies, for example when we play in a community. Our present age is being colored by the emergence of new generations who expect new methods from us, learn and work differently, as they start from different foundations. The development of information technologies and digitalization are reaching more and more people. The numerous changes also permeate the world of work, as more and more workplaces are transforming, and the emergence of new jobs increasingly requires flexibility, innovation and the possession of new competencies in order to maintain competitiveness. Workplaces also expect continuous renewal from employees. In recent years, competency expectations have also changed: we have to use more and more digital tools, knowledge of foreign languages and flexibility have become more valuable. The demand for productivity and independence has increased further. Difficult situations have strengthened the expectations for problem solving, innovation skills, continuous learning and creativity. The growing amount of data has contributed to increased efficiency, in addition to data analysis and critical thinking.

In my work, I aim to present the potential of gamification for competence development. Following a review of the literature, the research methodology is based on the questionnaire survey used in my doctoral research and involves data analysis.

About gamification

The definition of gamification is characterized by diversity, there is no unified position and commonly used definition. Many researchers characterize the method with their own definitions. Werbach and Hunter (2012:26) succintly defined gamification as *"the use of game elements and game design methods in a non-game environment".* Z. Karvalics (2018) put it this way: *"In this approach, gamification is nothing more than the extension of elements of the game ecosystem to*

areas of life where they were not previously present (primarily in science, corporate-organizational culture, healthcare, and political public life).” The definition that best fits the announcement is provided by Barna (2020:6), who states that *“Gamification is a process in which game-like thinking and game-like design elements (game dynamics, mechanisms, elements) are used in a non-game context in order to encourage user engagement, help solve a given problem, or reveal or develop a skill/ability.”*. The definition summarizes the conceptual framework of gamification well, as it presents the application of game elements as a process with a predetermined goal in addition to the non-game context.

Werbach and Hunter (2012) discussed the form of gamification related to individual/organizational benefits and the individual or community approach in their work. This is shown in Figure 2. External gamification encompasses programs aimed at consumers and customers. This is the most common occurrence of gamification, which is most often implemented in the field of marketing. The goal of internal (enterprise or organizational) gamification is to “…*improve productivity within the organisation in order to foster innovation, enhance camaraderie, or otherwise derive positive business results through their own employees.*” (Werbach and Hunter, 2012:21). It should be noted that, in this aspect, the people involved in gamification are already participants in the company. I have not found any significant studies on this topic, Singh and Gupta (2020) and Vesa (2021) have examined internal gamification, while Grönvall and Holmner Härgestam (2019) have examined the connection between internal gamification and internal marketing activities. I believe that research into internal gamification programs can remedy this gap.

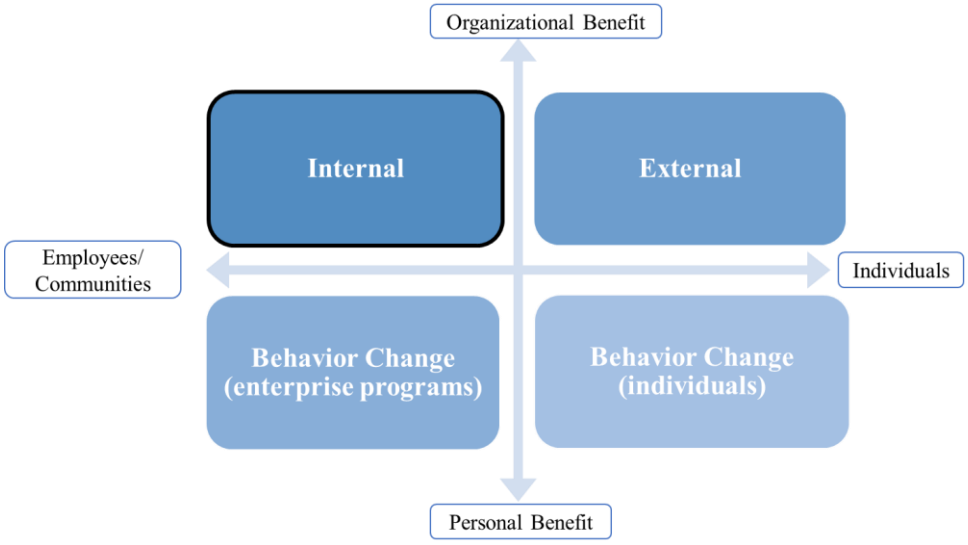

Figure 1. Presentation of gamification categories
Source: Werbach and Hunter (2012:21)

In my paper, I present a part of the questionnaire used for primary research in my doctoral thesis that deals with competencies, namely, the competency development effects of internal gamification programs used by domestic companies. One of the central elements of corporate goals and gamification programs is the development of knowledge and competencies, so the key

question of the research is: How do domestic for-profit medium-sized and large companies evaluate the development of competencies in gamification programs?

Research framework, sampling, and methodology

The planned base population for the study consists of for-profit companies in Hungary with more than 50 employees. I wanted to send the questionnaire to employees who have an overview of internal gamification processes, so I specified the target population as those responsible for internal employee gamification programs at medium-sized and large for-profit companies operating in Hungary. I obtained the sampling frame using a list of addresses compiled on the basis of the CrefoPort database and the partnerships of the University of Miskolc. I set the screening criteria as having 50 or more employees and active for-profit status in 2022. The resulting list consisted of 4,166 companies, 107 micro and small enterprises and 47 duplicate email addresses were filtered out. The questionnaire was sent electronically to 4,012 companies via the EvaSys (version: V9.1) software system between June 17 and July 24, 2024.

The trial run and preliminary validation prior to the survey involved seven people. The final target population consisted of 3,477 companies (as there were 429 delivery errors, three companies had ceased operations, 68 companies had a summer shutdown, and 35 companies did not wish to participate). 218 companies completed the questionnaire, with a response rate of 6.27%, after excluding two micro-enterprises, the final sample (N) consisted of 216 companies. The sample is not representative, so the findings apply to the sample. The characteristics of the sample are presented in Table 1.

Table 1. Presentation of sample characteristics

N = 216		Occurrence (number)
Nature of activity, by main activity	producer	87
	trader	27
	service provider	57
	other	45
By customer type	municipal	13
	county	12
	regional	7
	national	84
	within the EU	50
	global	50
By ownership	foreign	53
	Hungarian	155
	mixed	8
Number of employees	20-49 people	15
	50-100 people	67
	101-249 people	63
	250-1000 people	48
	1001-9999 people	20
	Over 10,000 people	3

Forrás: saját szerkesztés

Due to the larger number of items, I did not exclude small companies (20-49 employees) participating in the survey, as they fit my primary target group based on the primary data check. The sample consists of medium-sized companies with a nationwide customer base and Hungarian owners. Responses were received from every region of Hungary. Furthermore, it can be said that the respondents typically have a good understanding of the companies' activities, so their answers clearly help to understand the spread of gamification in Hungary.

Data cleaning and analysis were performed using Microsoft 365 Excel (version number: 2405) and JASP (version: 0.19.0) computer programs (JASP Team, 2024). I analyzed the sample using descriptive statistics (mean: *M*, standard deviation: *SD*), and I also used frequency, distribution, and cross-tabulation analysis. I analyzed the relationships between variables using Spearman's correlation (denoted by ρ). I examined the related samples using the Kruskal-Wallis test and Dunn's post-hoc test. Before applying the statistical analyses used in the tests, I checked the necessary conditions in each case. In the primary research, I set the significance level at $\alpha = .05$.

Presentation of the competencies examined

Mitchell et al. (2020) examined gamification and competencies and identified future research directions. In their work, Oxarart and Houghton (2021) developed and presented a conceptual model of the relationships between gamification, self-management, and valuable workplace outcomes. In their research, Prasad et al. (2019) also addressed the relationship between competencies and gamification, albeit implicitly, which provides an opportunity to identify the added value of gamification. Useful guidance and inspiration can be obtained from the study by Patricio et al. (2022), which examines the relationship between gamification and the results of innovation teams based on a case study of an innovation project in a business environment involving 23 participants. The paper also conducted a study on the development of employee competencies.

I find Csiszár's (2019) study thought-provoking, as it points out that consumers and entrepreneurs have incomplete knowledge of digitalization (specifically consumer protection law and law enforcement in the online world), which justifies the creation of gamification-based competency development programs in this area.

One of the advantages of gamification is that it develops skills and competencies, as creativity can increase during the gamified process, but individual and social skills, communication skills, and often digital skills also develop. Strategic and critical thinking and problem-solving skills will also improve, and cooperation between parties will be fostered (Mirzaie Feiz Abadi et al., 2022, Kiss, 2023). Knowledge expansion and competence development occupy a prominent place in corporate goal systems and gamification programs. The use of game elements can add variety to monotonous tasks, so that boring and sometimes simple, and often complex activities can develop participants even more. I was curious to find out how Hungarian companies evaluate competence development. The competencies included in the study are listed in Figure 2.

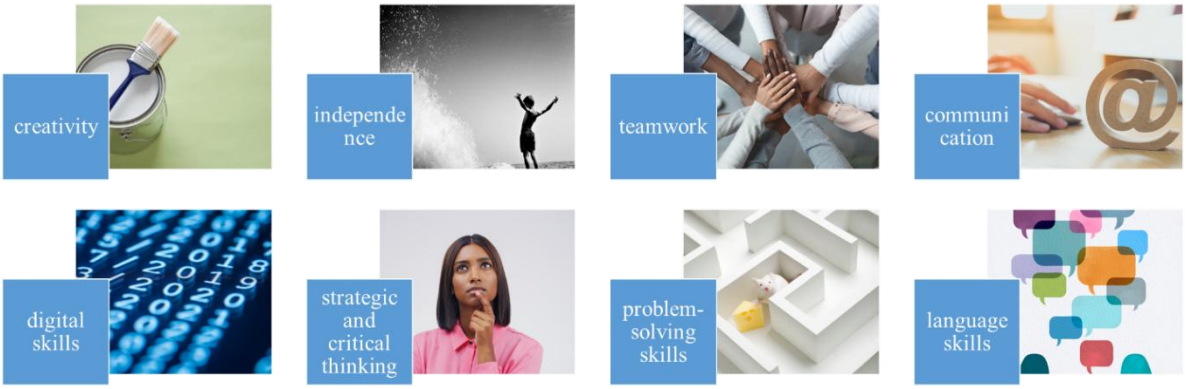

Figure 2. Competencies involved in the investigation
Source: own editing

Results

I examined three subsamples, comparing the responses of companies that use gamification (n = 44), plan to use it (n = 45), and do not plan to use it at all (n = 127) to determine to what extent skills and abilities can be developed through gamification programs based on their opinions. The evaluators responded the variables representing the skills and abilities using a paired Likert scale ranking them between 1 to 6, with the highest value indicating that the respondent fully agreed with the development of each variable during the gamification program. The lowest value meant that they completely disagreed with the statement. The aggregate values of the responses and the comparison are shown in Table 2, which shows that all three groups indicated a positive change and development in all of the competencies listed ($M > 3.00$). I used a green-white color scale for the color coding, with lower values appearing lighter and higher values appearing darker. Among the results, significant values are marked in yellow, while differences in trends are marked in blue.

Table 2. The relationship between gamification and abilities and skills

In your opinion, to what extent can the following abilities and skills be developed during the gamification program?	Users [U] (n = 44)		Planning to use [P] (n=45)		Not planning to use at all [N] (n=127)		Kruskal-Wallis Test		Dunn's Post Hoc Test		
	M	SD	M	SD	M	SD	p	η²	U-P	P-N	U-N
creativity	4,80	1,15	4,82	1,13	4,31	1,34	,016	,029	,92	,056	,056
independence	4,64	1,12	4,51	1,01	4,04	1,29	,008	,035	,586	,073	,019
teamwork	5,02	,98	5,02	,87	4,47	1,38	,022	,026	,921	,075	,075
communication	5,00	,86	5,11	,98	4,31	1,33	< ,001	,078	,462	< ,001	,007
digital skills	4,71	1,17	4,84	1,04	4,00	1,37	< ,001	,074	,615	< ,001	,006
strategic and critical thinking	4,27	1,04	4,47	1,14	4,10	1,35	,281	,003	,847	,341	,847
problem-solving skills	4,73	,97	4,89	1,15	4,43	1,34	,114	,011	,685	,121	,685
language skills	3,80	1,56	4,22	1,33	3,40	1,51	,005	,041	,289	,004	,289

Source: own editing

Data from gamification users indicate that teamwork improved the most, while language skills improved the least, which was also rated lowest by the other two groups. Companies planning to use gamification expected the greatest improvement in communication skills. Interestingly, those not planning to use gamification agreed with those already using it that gamification programs would most improve participants' cooperation and teamwork skills. Looking at the standard deviation data, the largest swing is in the language skills element, and especially among those who do not use gamification programs, this variable may even mean a decline in knowledge. I used the statistical methods previously applied to identify differences between the three groups and observed that the most significant differences typically exist between those who plan to use the method and those who do not, but there are also differences between users and those, who do not plan to use, albeit more of a trend. These can be linked to the mindset of gamification programs, i.e., those who are still planning to introduce them envision better and more results. It may be important information for them that there will indeed be positive changes, but smaller than they would like. I see two paths: either they set lower targets for the results to be achieved, or they need to invest more work, organization, and thought into gamification programs.

It is important to highlight that companies that used gamification rated these factors positively, meaning that gamification can be a tool for competence development. Based on the results, teamwork and communication among employees improved, but knowledge expansion also played a more significant role. It can be concluded that the method develops employee competencies better than previously expected, while it has less impact on processes and conditions within the company. It is becoming increasingly apparent that companies decide to introduce gamification programs in order to make the workplace better and more efficient, but confirmed data shows that this is not what ultimately happens; instead, it is the employees who are developed.

During my research, I found it interesting to further analyze the group of gamification users (n = 44), so I examined what experiences they had gained in terms of developing participants' competencies when using gamification programs. I found numerous correlations, but I will only present those with a significance level of $p < .01$. Technical skills and abilities (strategic and critical thinking; problem-solving skills) were significantly correlated with independence and digital knowledge. Personal competencies (soft skills such as creativity and communication) are related to independence and teamwork. The relationships and correlations between these competencies are shown in Table 3. Based on the data, it can be said that, for example, those who rated creativity higher also performed better in the adjacent elements, so if the emphasis is placed on increasing creativity when designing a program, the development of problem-solving skills will also appear as an additional benefit.

Table 3. Correlations between competencies

Factor1	Factor2	ρ	p
creativity	independence	,66	< ,001
creativity	digital skills	,56	< ,001
creativity	strategic and critical thinking	,43	,003
independence	digital skills	,47	,001
independence	strategic and critical thinking	,56	< ,001
independence	problem-solving skills	,46	,002
teamwork	communication	,71	< ,001
teamwork	problem-solving skills	,47	,001
digital skills	strategic and critical thinking	,57	< ,001
digital skills	problem-solving skills	,49	< ,001
digital skills	language skills	,39	,009
strategic and critical thinking	problem-solving skills	,71	< ,001

Source: own editing

To discover the relationships between competencies, I compared other responses, such as where gamified programs are used within the company, and in most cases (creativity, teamwork, and digital skills), I found a significant relationship during the company's main processes. Based on the correlations, even companies that use gamification in a general way develop teamwork. In the case of middle and senior managers, the competencies of teamwork (ρ = .33, p = .028) and communication (ρ = .34, p = .025) showed a significant correlation. The goal of providing feedback to individuals has a weak significant correlation with independence (ρ = .30, p = .048), but it was interesting to note that this goal has a weak negative correlation with teamwork (ρ = -0.32, p = 0.033), which stems from the fact that feedback is not given to individuals when evaluating teamwork, but rather the activity performed by the community. I did not find any other correlations, so the position and the implementation of gamification do not have a significant influence on what competencies are developed with gamification programs. I used the Kruskal-Wallis test to analyze the company demographic data: the study showed that there is a trend-level difference in the creativity variable between companies with different areas of activity. This difference consists in the fact that creativity can be developed in production companies with a trend-like relationship (χ^2 (3 n = 44) = *6.56* p = *.087*), as in the case of product, service planning, or even design. A significant correlation can be seen in digital skills, companies in the production sector also developing this competence (χ^2 (3 n = 44) = 8.20 p = .042). I found no connection with the company's ownership structure. These identified connections are significant because the aforementioned competency developments have already proven themselves in this area, at management levels, and in sector-specific contexts. Future programs can be planned with a focus on these, and ultimately, the synergistic competencies can yield even further benefits.

Conclusion

In summary, it can be seen that the effects achieved by gamification programs are positive, which can be stated based on the variables indicating various results and competencies.It is important to

note that companies that used gamification rated the factors examined positively, meaning that gamification can be a tool for competency development. Based on the results, teamwork and communication among employees improved, but knowledge expansion also played a more significant role. It can be concluded that the method develops employee competencies better than previously expected, while it has less impact on processes and conditions within the company.

The companies that use gamification tend to give more restrained evaluations than the other two groups. In terms of the differences between actual and perceived effects, companies that intend to introduce gamification programs have higher expectations of results than those that do not plan to use them or those that actually use them, but this difference is not particularly significant. However, if this difference were to become very large, the gamification program could lead to disappointment, as it would present an unrealistic picture of gamification. Finally, it is becoming increasingly apparent that companies decide to introduce gamification programs in order to make the workplace better and more efficient, but confirmed data shows that this is not the main outcome; rather, it is the development of employees that is achieved.

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International and Hungarian overview of the growing role, spread and trends of gamification

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Abstract: Gamification is a method that is easy to use. The reason is very simple: we do not consider it as a burden, but as an experience. In my paper, I examine how gamification is spreading. In my work, I explore its general spread via the internet, as well as the processes taking place in the scientific world (at international and domestic levels). I discuss changes in the gamification market and outline possible directions for research. The results will also be useful in practice: they can inspire international and domestic researchers to plan new researches, and they can also be valuable and instructive for companies and the education sector.

Keywords: gamification, trends
JEL code: O30, M20, M15, O32

Introduction and justification for the choice of topic

The world's population is growing overall, with more and more young and older people living on Earth who can enjoy the benefits of digitalization and technological advances. However, in everyday life, we are faced with more and more new challenges, such as armed conflicts, raw material shortages, rising inflation, environmental and sustainability efforts. The world of workplaces is changing in parallel: new tasks and jobs are being created, age differences among employees are changing, and new areas of competence requirements are emerging. Science is seeking new solutions to these challenges, placing social and technological innovations and better utilization of the opportunities offered by digitalization at the forefront. Continuous adaptation to these trends is necessary. Recently, gamification has also become increasingly popular, as games can provide enjoyable experiences even during a tiring workday. Gamification programs help employees of different ages to cooperate, break the monotony, enhance knowledge expansion, and increase innovation potential.

Companies have begun to use gamification to address emerging challenges drawing on recommendations and findings from the scientific community. Increasing competition and social responsibility, ensuring sustainability, and finally, significant changes in the labor market are also areas where gamification can provide solutions. The aim of this publication and its research question are limited to examining the extent to which the concept of gamification has spread and what impact it has had on the international and domestic scientific communities.

Definition of gamification

The concept of gamification was defined by Nick Pelling in 2002 (Pelling, 2011), but there were gamified initiatives even before that (Fuchs, 2014:133-134, Zichermann and Linder, 2013:23). The method aims to achieve results through the participant's experience by applying game elements and techniques in a non-gaming environment. This idea is reinforced by Seaborn and Fels's

(2015:17) definition: *„The deliberate use of game elements to experience the game experience in non-game tasks and contexts,"* as well as Fromann's (2016:156) definition: *„Gamification refers to the application of game elements, game mechanisms, and game dynamics necessary for the game experience in areas of life outside of games with the aim of making the given processes more interesting and effective."*. In another approach, where consumers and buyers are the focus, Pacsi and Szabó (2017:63) define gamification as *„...the presentation of information to be conveyed in a playful form to consumers in areas of life outside of games. Play is an instinctive behavior that aids in the processing of information and its long-term storage through lived experience."* I believe that the definitions presented above clearly illustrate what is becoming increasingly apparent about gamification: its conscious application helps the user to achieve better performance from the participants, and this is, what is making the method increasingly popular.

The popularity of gamification in everyday life

With the advancement of digitalization and the spread of the internet, gamification is reaching more and more users. I studied the popularity of this method based on information from one of the largest search engines. During my research, I ran the term „gamification" through the Google Trends (2025) database, which showed how many users were interested in and searched for gamification using the search engine. Data is available from the launch of Google Trends in 2004, but my data analysis focused on the period between 2010 and 2024 among Internet users worldwide. The data is shown in Figure 1.

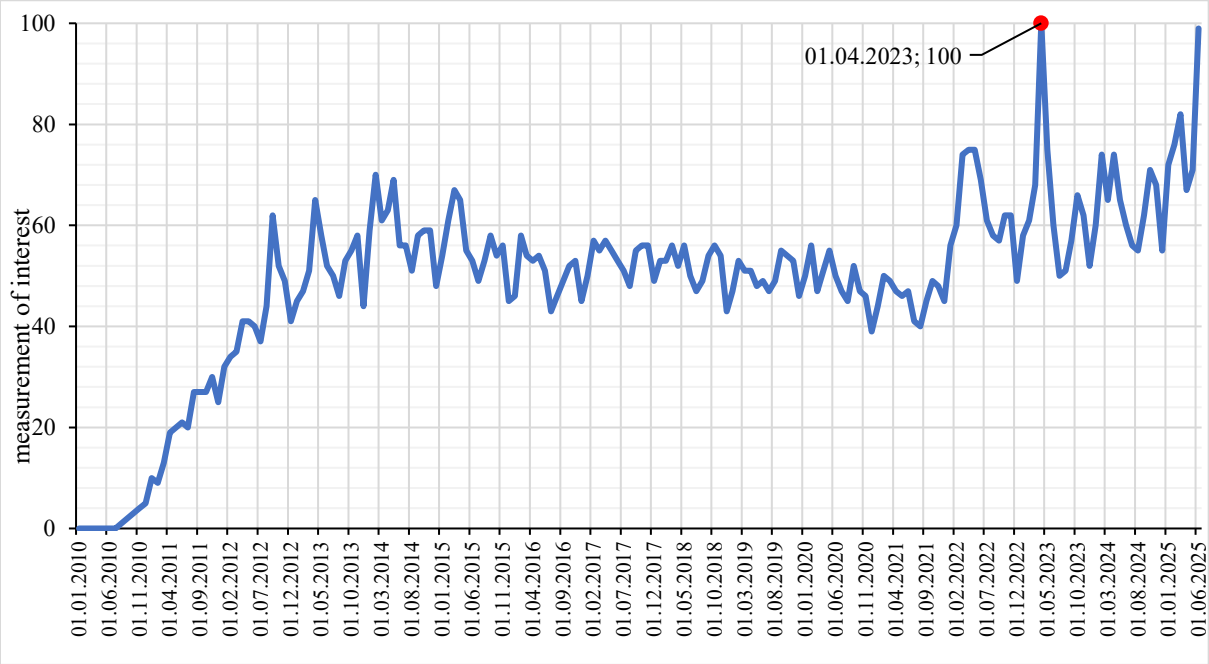


Figure 1. Internet searches for the term „gamification" worldwide between January 1, 2010 and June 30, 2025
Source: own editing based on data from Google Trends (2025)

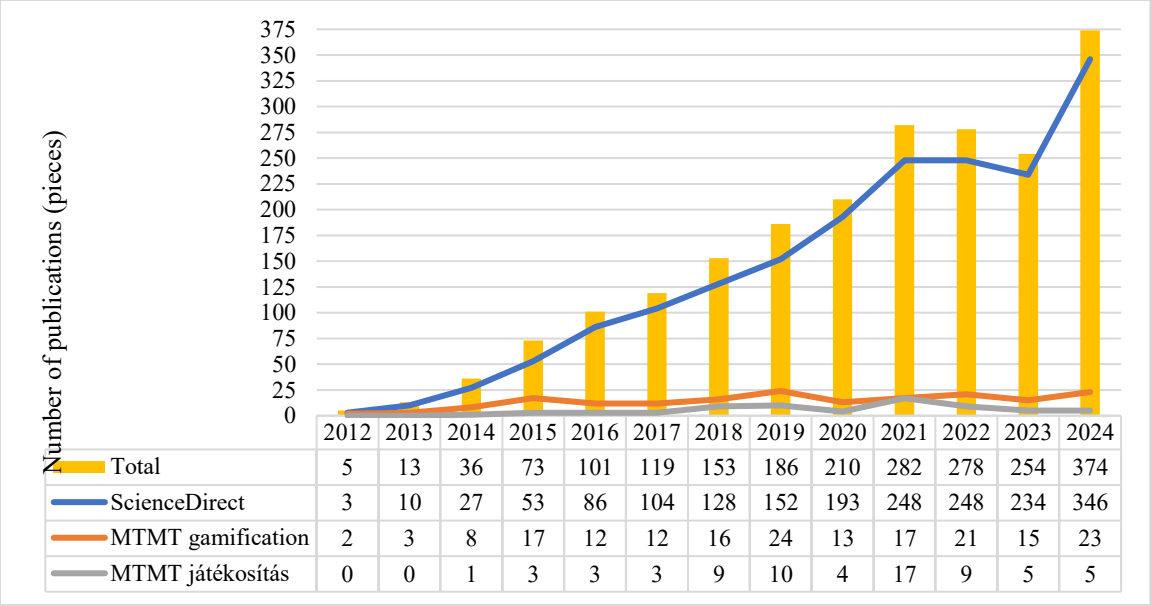
The values in Figure 1. indicate search interest, compared to the highest interest value (100), which was recorded in April 2023. This value means that interest in gamification peaked at that time, and although the values changed over time, the trend remained the same. It can be seen that interest in the topic has been growing steadily since 2011, and although there have been minor declines compared to the peak, its popularity has remained high ever since. I believe that these values also justify and support the idea that gamification deserves increasing attention.

The potential of gamification is well illustrated by the fact that the global gamification market was worth $9.1 billion in 2020. According to forecasts, this market will grow at an impressive annual rate of 27.4% and could reach $30.7 billion by 2025 (MarketsandMarkets, 2020). Precedence Research (2025) estimated the size of the global gamification market at $16.29 billion in 2024 and predicted that it would grow to $190.87 billion by 2034. According to the analysis, gamification is strongest in Europe (28%) after North America (41%), mainly in the United Kingdom, Germany, and France. The explanation given was that market players have moved towards modern solutions that simultaneously promote employee engagement, sales work, and a better customer experience, thereby increasing demand for gamified software. In other regions, the market shares of gamification are as follows: Asia and the Pacific 21%, Latin America 7%, and the Middle East and Africa 3% (Precedence Research, 2025).

The spread of gamification in the scientific world

Gamification is becoming an increasingly important and researched topic in the scientific world (Grünewald et al., 2019). I conducted a search for the term „gamification” in the international Sciencedirect (2025) search engine based on title, abstract, or keywords specified by author, which yielded 1,832 results. In the top five scientific fields, most publications (531) belong to the social sciences, while 445 are related to computer science, 441 to medical sciences, 281 to business, management, and accounting, and 235 to psychological sciences. Most publications were published in English, in the form of research articles.

Based on a keyword search conducted in the database search engine of the Hungarian Scientific Works Repository (MTMT), which is mandatory for Hungarian researchers to use, gamification appeared 183 times, while játékosítás (gamification in Hungarian) appeared 65 times (MTMT, 2025a, b). Figure 2 shows a summary of the data and the growing number of scientific publications related to gamification.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Total	5	13	36	73	101	119	153	186	210	282	278	254	374
ScienceDirect	3	10	27	53	86	104	128	152	193	248	248	234	346
MTMT gamification	2	3	8	17	12	12	16	24	13	17	21	15	23
MTMT játékosítás	0	0	1	3	3	3	9	10	4	17	9	5	5

Figure 2: The development of gamification literature at international and Hungarian level

Source: own editing based on ScienceDirect (2025) and MTMT (2025a, b) search engines

There are many international researchers who could be mentioned, but due to space constraints, I will list only a few who have been particularly influential for me. In addition to Nick Pelling, Sebastian Deterding, who has been involved in computer games and gamification research since the 2000s (Coding Conduct, n.d.), is also noteworthy. Juho Hamari is the author of numerous studies and the leader of the Gamification Group (GG) in Finland. This research group conducts multidisciplinary studies that assess the playfulness of technology, society, culture, and the economy (Gamification Group, n.d.).

Yu-Kai Chou's work is also worth mentioning, as in his Octalysis model, he views gamification as a design approach that focuses on human motivation and human-centered design rather than functionality, with the aim of changing participant behavior. His model is based on behavioral science and incorporates experiences from game design (Chou, 2016). The work of Andrzej Marczewski is particularly accessible, as his blog posts and book on gamification simply introduce gamification to users, thereby contributing to the development of gamification (Marczewski, 2021).

These data also confirm my assumption: researchers are keen to engage in gamification. Gamification is able to maintain the interest of the scientific world because we love to play by nature and are open to more innovative, often digitized solutions that we can use in the workplace. It is also evident that gamification is appearing in more and more places and research as a tool for increasing efficiency.

The spread of gamification in Hungary

From what we have seen so far, it is clear that proportionally significantly more people in the international scientific community are involved in the topic of gamification than Hungarian researchers. Unfortunately, this can be an obstacle for those interested who do not know foreign languages or are less proficient in them, and there are still gray, less mapped areas and good practices in relation to the exploration of Hungarian gamification knowledge. For this reason, in order to examine the topic in greater depth, I analyzed the doktori.hu (2025) database operated by the National Doctoral Council, and based on my personal knowledge, I also explored which areas are being studied, who is studying them, and what topics they are studying. The results are summarized in Table 1, which confirms that the topic is becoming increasingly popular in both the technical and social sciences, and that a number of educational research projects related to the sciences of education are also underway in Hungary (e.g., Máté Fridrich, Norbert Üst).

Among Hungarian gamification researchers, Árpád Szörény was probably the first to analyze the impact of digital culture through the example of gamification in his doctoral thesis in 2013. While Richárd Fromann's work focused on gamification, the motivational power of digital games, and their potential uses, he also founded the JátékosLét Research Center. Their research focuses on games and gamification, and since 2011, they have also been researching Hungarian gamer communities. On their website, they describe their primary goals as follows: „*By researching the advantages and practical uses of games (and gamification), we aim to provide various gamification solutions and developments with the goal of improving individual and organizational motivation and increasing efficiency."* (JátékosLét, n.d.).

Another pillar of gamification in Hungary is Kollektíva. Ádám Pusztai and his colleagues are helping to spread gamification through numerous blog posts and practical examples. In 2018, Pusztai published his book and accompanying tactical design templates, which, after laying the theoretical groundwork, help users with practical examples and game design practices to make the gamified customer experience easier, more effective, and more attention-grabbing (Kollektíva, n.d., Pusztai, 2018).

Among Hungarian researchers, it is worth mentioning the work of Mária Jaskóné Gácsi, who examines the method from a pedagogical perspective in the field of education (Jaskóné Gácsi, 2022, Jaskóné Gácsi, 2023). In her latest research, she deals with social and group dynamics (Jaskóné Gácsi, 2024). The practice of gamification in higher education was analyzed by Andrea Bencsik and Andriana Mezeiová, they focused on the topic of gamified knowledge transfer (Mezeiová and Bencsik, 2019), and presented the gamification of a university management course with a case study. A total of 260 students were involved in this study with the aim of identifying learning motivation factors and preferred types of classroom tasks (Bencsik et al., 2021). Further scientific endeavors and studies are appearing in the analysis of HR and marketing areas.

The research topics are also characterized by diversity, as gamification is applied in many different ways in many different areas. Table 1 shows that several researchers focus on users, mainly in the field of education. In relation to business sciences, there is also some research on gamification in

companies and organizations, but this is limited in number. This also prompted me to conduct research on internal gamification in my dissertation. In this type of gamification, gamification is directed towards employees. There was also a gap in the measurement and evaluation of gamified programs. To remedy this, I conducted a questionnaire survey involving 216 domestic for-profit companies. Based on the results, an overview of gamification in Hungarian companies has also emerged. I found that several respondents had heard of the method but did not use it, while those who did use it were not aware of gamification. I also discussed how the companies in the sample use the method. I consider the combination of digitalization, artificial intelligence, and data-driven operations with gamified programs to be a possible new direction for research. This is still an incomplete and unexplored area (Csiszár, 2019). It is important to pay attention to the data of those participating in gamification, as this is sensitive data and business secrets must also be protected.

Based on the results of my doctoral research, I have also identified a very important new research direction that links public service companies and internal gamification. The situation of the public service companies that make up the target group is not simple, as the issues of workforce and digitization are even more pressing for these companies, given their limited resources, including financial and human resource shortages. My planned methodology is to conduct empirical research: I intend to carry out a questionnaire survey and/or in-depth interviews among public service companies in Hungary.

By combining the two studies, the examination of forporfit and public service companies can reveal even more about the current state of gamification in Hungary, and it also allows me to test my own evaluation criteria. A useful result of the research is that it supports domestic innovation and the value-creating work that Hungarian companies are doing to promote sustainable growth and competitiveness. The results of the research provide a good opportunity to further explore the topic and can be useful elements in the development of higher education and science, for example through the preparation of case studies, and can ultimately enrich the good practices of companies.

Table 1. Doctoral research related to gamification

Discipline	Name (institution)	Year of award of PhD degree	Title of PhD thesis/topic
computer sciences	Balázs Barna (BCE)	2020	Examination of the effect of gamification in corporate and educational field
	László Toka (BME)	2010	Game Theoretic Analysis of Distributed Systems: Design and Incentives
	Kinga Emese Kovácsné Pusztai (ELTE)	2022	Computational Thinking in Higher Education
military engineering	Edit Szilvia Rubóczki (ÓE)	2019	The importance of user security awareness when introducing public cloud services in large companies
media and communctions	Richárd Péter-Szabó (BCE)	2023	„Why so serious?" Serious Games in the Field of Education
sociology	Árpád Szörény Rab (BCE)	2015	The impact of digital culture on human behiavor through the example of gamification

	Richárd Fromann (ELTE)	2016	On the threshold of Homo Ludens society
business and management	Mgr. Adriana Mezeiová (SJE)	2020	Gamification in higher education practice (Rola gamifikácie vo vysoskolskej praxi)
	Tamás Kovács (DE)	2021	The perception of gamification's technological acceptance in education
	László Szendrői (SZE)	2021	Describing and measuring the impacts of gamification considering personality types
	Tibor Czeily (DE)	in progress	Possibilities for introducing gamification in human resource management
	Hamza Ibrahim (BME)	2024	Empirical analysis of gamification influence on organisational behaviour: Exploring game elements exposure influence on employees' work engagement, job satisfaction, and performance
	Gergely Kiss (ME)	2026	The practice of applying gamification among medium-sized and large companies in Hungary
	Diána Pacsi (MATE)	2025	Application of gamification strategies in the field of tourism marketing - Examining travelers' travel decisions depending on their personality
	Péter Ádám Szentesi (BCE)	2025	Exploring the potential and impact of gamification in business higher education

Source: own editing based on data from doktori.hu (2025)

Summary

To summarize the analysis, it can be said that the diverse use and spread of gamification is significant from the perspective of both corporate and business life and researchers. The increasing number of publications shows the continuous and unbroken expansion of the topic. Extensive research has been conducted on the analysis of gamification elements and systems, with many authors focusing on the consumer side, but as I have already mentioned, very few publications discuss internal gamification programs aimed at employees and the analysis of their results. I believe that gamification still offers many interesting and instructive research opportunities, both internationally and domestically. In my opinion, the results of these studies will be useful for companies in practice, but they can also be instructive in education.

Acknowledgements

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Appendix

List of institutions
BCE – Corvinus University of Budapest, Hungary
BME – Budapest University of Technology and Economics, Hungary
ELTE – Eötvös Loránd University, Hungary
ÓE – Óbuda University, Hungary
SJE – J. Selye University, Slovakia
DE – University of Debrecen, Hungary
SZE – Széchenyi István University, Hungary
ME – University of Miskolc, Hungary
MATE – Hungarian University of Agriculture and Life Sciences, Hungary

Integrating the Theory of Constraints into Modern Management Control Systems

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Abstract: The Theory of Constraints (TOC) has evolved from a production-oriented scheduling philosophy into a comprehensive managerial decision-making framework that emphasises system constraints, flow optimisation and throughput maximisation. While the managerial accounting and controlling literature traditionally focuses on cost efficiency, planning, budgeting and performance measurement, TOC offers a contrasting paradigm built on throughput, constraint management and system-level optimisation. Recent research highlights that TOC can significantly influence the structure, logic and functioning of management control systems (MCS), particularly in environments characterised by high variability, capacity imbalance or multiple competing constraints. This study provides a structured academic analysis of the relationship between TOC and MCS and develops an integrative conceptual model that explains how TOC principles reshape financial, operational and strategic control subsystems. The findings support that TOC-oriented MCS can enhance strategic alignment, operational stability and financial performance.

Key words: Theory of Constraints (TOC), Management Control Systems (MCS), Throughput Accounting, Constraint Management, Multi-Constraint Decision-Making
JEL codes: M10, M11, M40, L23,

Introduction

Due to increasing competitive pressures and formidable technological advancements, industrial production is undergoing considerable change. Considering such challenges, emerging concerns among companies relate to the means of enhancing production, reducing costs, improving profitability as well as maintaining market share. Hussein Al-Beshtawi (2014) explains that modern cost management systems together with non-traditional management approaches provide answers to such challenges. Consequently, companies are more concerned than ever with improving production operations and reducing production costs.

The management control system (MCS) is one of the central mechanisms through which organisations translate strategic intentions into coordinated actions, measurable performance outcomes and continuous improvement. Classical authors such as Anthony and Govindarajan (2007) and Merchant and Van der Stede (2017) conceptualise MCS as a framework that encompasses planning, budgeting, performance measurement, incentive structures and feedback loops. In parallel, the Theory of Constraints (TOC), introduced by Goldratt (1990), offers a system-centric philosophy built on identifying and managing bottlenecks that limit organisational throughput. Although TOC is frequently associated with production scheduling, its later extensions — including throughput accounting (Corbett, 1998; Noreen, Smith & Mackey, 1995), constraint-based planning, and the TOC Thinking Processes — represent a broader paradigm for business decision-making. Despite the fundamentally different premises of TOC and traditional MCS, the two frameworks intersect increasingly in contemporary organisations. As variability, supply chain disruptions and resource fragmentation rise, the relevance of constraint-based thinking in management control grows (da Silva et al., 2024; Skoogh et al., 2023). TOC challenges the

conventional cost-based logic by emphasising system-level optimisation, global throughput and the strategic role of constraints. This leads to a shift from cost-centred measurement toward flow-centric control practices. At the same time, MCS provides the structural and informational backbone through which TOC principles can be embedded within formal organisational processes. A particularly complex area where TOC and MCS interact is the management of multi-constraint environments. While classical TOC assumes a single binding constraint, real-world systems often display multiple near-binding capacities competing for priority (Linhares, 2009). To address this, several heuristic and algorithmic solutions have been developed within the TOC literature, including throughput-per-constraint-time rules (Schragenheim & Dettmer, 2000), product-mix optimisation heuristics (Aryanezhad & Komijan, 2004), and multi-constraint selection algorithms (Tanhaei & Nahavandi, 2013). Within this family of heuristics appears the practice sometimes referred to — informally and mostly in practitioner contexts — as the "Pakuri model". Although the term is not used in peer-reviewed literature as a formal model name, its underlying logic aligns with established TOC heuristics: identifying the dominant constraint by comparing potential bottlenecks based on their contribution to throughput per unit of constraint time.

Given the above, the academic relevance of this study is twofold. First, it synthesises the growing literature on how TOC shapes and reconfigures management control systems at operational, tactical and strategic levels. Second, it positions the "Pakuri model" within the recognised TOC heuristic landscape and clarifies its role in multi-constraint decision-making, thereby eliminating the terminological ambiguity present in non-academic sources.

The purpose of this study is to answer the following research questions:
RQ1: How does TOC influence the structure and functioning of management control systems?
RQ2: How do throughput accounting, constraint-based planning and TOC performance indicators reshape financial and operational control subsystems?
RQ3: How do organisations manage multi-constraint environments, and what is the theoretical position of the "Pakuri model" within this context?
RQ4: What integrative framework can explain the combined impact of TOC principles on modern management control systems?

To address these questions, the paper employs a structured literature overview, focusing both on classical contributions (Goldratt, 1990; Corbett, 1998; Noreen et al., 1995) and recent empirical insights from 2020 onwards (Mehmandoost, 2024; Cox, 2021; Datt et al., 2024). Special emphasis is placed on throughput-based decision heuristics and their implications for MCS design.

The structure of the paper is as follows. Section 2 provides a comprehensive literature review on TOC, MCS, throughput accounting and multi-constraint heuristics. Section 3 develops an integrative conceptual framework for understanding TOC-driven control transformation. Section 4 presents the main conclusions and outlines future research opportunities.

Literature Review

Theoretical foundations of the Theory of Constraints

The Theory of Constraints (TOC) was originally articulated by Eliyahu Goldratt in The Goal (Goldratt & Cox, 1992) and later formalised in What is This Thing Called Theory of Constraints? (Goldratt, 1990). TOC is built on the premise that every system contains at least one limiting factor — the constraint — that determines overall system throughput. Goldratt (1990) defines throughput as the rate at which the system generates money through sales, positioning it as the primary managerial objective. TOC proposes five focusing steps: identify the constraint, exploit it, subordinate all other processes to it, elevate the constraint, and return to step one once the constraint has shifted. Over the decades, TOC has expanded beyond production scheduling into logistics, project management (Critical Chain), marketing, strategy and healthcare operations (Cox, 2021; Datt et al., 2024). Rahman's (1998) comprehensive review concluded that TOC had evolved into a general management philosophy characterised by system thinking, continuous improvement and decision-focused methodology. Chamrada and Kollmann (2023) further demonstrate that TOC has undergone an evolutionary shift from operational control toward strategic integration, emphasising variability management, flow optimisation and cross-functional alignment. A key extension of TOC is the Thinking Processes, a set of logic-based tools (e.g., Current Reality Tree, Evaporating Cloud, Future Reality Tree) designed to identify core conflicts and guide organisational change (Dettmer, 1997). These tools highlight TOC's role beyond operational scheduling, positioning it as a structured decision-making and organisational problem-solving framework. Recent empirical evidence reinforces this strategic dimension; Knop (2024) demonstrates that TOC-based thinking process tools improve root-cause analysis and decision quality in complex organisational settings.

Throughput accounting and its implications

Traditional management accounting relies on cost allocation, overhead absorption and unit cost calculation. TOC challenges these foundations with the financial logic of throughput accounting (TA), which focuses on three key metrics: Throughput (T), Operating Expense (OE) and Investment (I). Noreen, Smith and Mackey (1995) showed that TA provides superior decision support, particularly for product mix optimisation, capacity allocation and short-term profitability analysis. Corbett (1998) further established TA as a coherent financial subsystem that aligns decision-making with system constraints and throughput maximisation. To clarify these differences, Table 1 summarises the essential distinctions between cost accounting and throughput accounting. A core insight from TOC is that cost allocation can distort decision-making, especially when overhead absorption encourages excess inventory production — a result empirically reinforced by da Silva et al. (2024), who found that traditional costing can inflate profit by up to 70% under volatile demand. Kee and Schmidt's (2000) comparative analysis demonstrates that TA-generated product mix decisions differ substantially from those based on activity-based costing (ABC), particularly when the constraint is stable and non-expandable. Recent contributions strengthen TOC's relevance for contemporary business environments. Mehmandoost (2024) argues that throughput accounting enhances strategic decision making by shifting managerial attention from cost minimisation to throughput growth, especially under uncertainty. Empirical

studies in healthcare (Cox, 2021; Datt et al., 2024) confirm that throughput-based performance indicators significantly improve capacity utilisation and patient flow.

Table 1. Cost Accounting vs. Throughput Accounting

Topic	*Cost Accounting*	*Throughput Accounting*
Primary objective	Cost minimisation	Throughput maximisation
Inventory view	Asset; increases profit via absorption costing*	Liability; ties up Investment
Decision logic	Unit cost, marginal cost	Constraint time, throughput per unit
Effect on production	Encourages full utilisation	Encourages bottleneck protection
Profit calculation	Absorption costing-based*	Throuhput – Op.Expenses

*Absorption costing: All manufacturing costs — including indirect/overhead costs — are assigned ("absorbed") into the cost of each unit produced.

Source: Adapted from Noreen, Smith & Mackey (1995); Corbett (1998); Kee & Schmidt (2000); Goldratt (1990).

Management Control Systems (MCS): classical and modern perspectives

Management control systems have long been conceptualised as mechanisms for ensuring the alignment between organisational strategy and behaviour (Anthony & Govindarajan, 2007; Merchant & Van der Stede, 2017). Classical MCS frameworks emphasise planning, budgeting, performance measurement, target setting, and responsibility centre structures (cost, revenue, profit and investment centres). With the expansion of digitalisation, turbulence and uncertainty, modern MCS increasingly integrates real-time information, rolling forecasts, adaptive planning and cross-functional coordination. Kaplan and Norton's (1996) Balanced Scorecard extended the scope of MCS beyond financial measures to customer, process and learning dimensions. Bogsnes (2016) and the Beyond Budgeting movement advocate for more decentralised and adaptive control architectures, aligning well with TOC's emphasis on flow and decision decentralisation.

In the Hungarian context, Horváth (2010) and Bagdács (2025) highlight the growing importance of integrated planning, working capital control and liquidity-focused monitoring. Kovács and Bács (2024) demonstrate that management control is increasingly viewed as a strategic support tool even in public sector organisations, reinforcing the need for cross-functional coordination and dynamic performance indicators.
MCS can therefore be understood as a multi-layered system comprising:

- financial control (budgeting, cost control, profitability analysis),
- operational control (capacity, flow, inventory, scheduling),
- strategic control (S&OP, investment decisions, long-term performance measures).

This multi-layer structure provides fertile ground for integrating TOC principles into MCS design and operation.

TOC–MCS integration: points of convergence

The wider and the deeper methodologies of MCS manifestly implied by this all-embracing TOC underpinning hold undeniable modern managerial importance (Berry A. J. et al, 2009). The enriched integration of TOC–MCS leads to modelling or shaping the more elaborate planning methodology of the concurrent accounting planning systems.
The literature identifies several areas where TOC directly influences management control systems:

Performance measurement
TOC emphasises global performance indicators aligned with throughput, which often contrasts with traditional unit-cost, efficiency or utilisation metrics. This shift is summarised in Table 2. Mabin and Balderstone's (2003) meta-analysis showed that TOC implementations often lead to substantial improvements in lead times, inventory and profitability — effects that must be captured in MCS metrics. TA indicators (T, OE, I) provide a natural extension of financial performance systems.

Table 2. TOC Metrics and Their Roles in MCS

TOC Metric	***Definition***	***Role in MCS***
Throughput (T)	Revenue minus totally variable costs	Redefines contribution and short-term profitability
Operating Expense (OE)	Cost of running the system	Aligns cost control with system-wide flow
Investment (I)	Inventory + fixed assets	Basis for ROI, cash-flow and capital decisions
Constraint OEE	Efficiency of the bottleneck resource	Primary system-level operational KPI
Buffer Health	Buffer status as % of target	Indicator of flow stability under DBR
Lead Time	Time from order to delivery	Strategic customer-service metric

Source: Adapted from Noreen, Smith & Mackey (1995); Corbett (1998); Schragenheim & Dettmer (2000); Cox (2021); Datt et al. (2024).

Planning and budgeting
Constraint-based planning modifies traditional budgeting by beginning with the capacity of the constraint rather than financial targets. Rota and de Souza (2021) demonstrate that integrating TOC into Sales and Operations Planning (S&OP) creates alignment between demand planning, capacity management and financial objectives.

Decision-making and resource allocation
TOC-driven decision-making transforms responsibility centre logic. Instead of maximising local utilisation, MCS emphasises the system's constraint and its protection. This leads to structural

changes, such as establishing "constraint responsibility centres" or modifying incentives to prevent local suboptimization.

Organisational learning
TOC Thinking Processes contribute to organisational learning, enabling structured problem diagnosis and conflict resolution (Dettmer, 1997; Knop, 2024). MCS draws on these insights to improve decision coherence and strategy execution.

Multi-constraint environments and throughput heuristics

Classical TOC assumes a single binding constraint. However, real systems often exhibit multiple near-binding constraints, making constraint identification ambiguous. Linhares (2009) shows that TOC's classic heuristic — throughput per constraint time — is not always globally optimal but provides a workable decision rule in complex environments. This insight triggered the development of multiple heuristic and algorithmic extensions.

Throughput-per-constraint-unit (T/cu) rule
Schragenheim and Dettmer (2000) formalised a throughput-based heuristic that prioritises operations based on the ratio of throughput generated to the time consumed on each potential constraint. This rule provides a practical approach to selecting the "dominant constraint".

Product-mix optimisation models
Aryanezhad and Komijan (2004) and Tanhaei and Nahavandi (2013) developed algorithms for multi-constraint product-mix optimisation that reconcile TOC logic with resource-balancing requirements. Although not explicitly labelled as TOC, their models operationalise TOC principles.

The so-called "Pakuri model"
In some practitioner literature, the selection of a single system constraint among several candidates based on throughput-per-constraint-time is informally called the "Pakuri model". However:

- the term does not appear in peer-reviewed academic literature,
- its logic corresponds exactly to established heuristics (e.g., T/cu rule),
- it can be theoretically grounded in the work of Schragenheim & Dettmer (2000), Linhares (2009), Aryanezhad & Komijan (2004).

To ensure academic rigor, the present paper adopts the terminology of "throughput-per-constraint-time heuristic", while acknowledging the informal use of "Pakuri model" in some industry discussions. This family of models is summarised in Table 3.

Table 3. Multi-Constraint Models and Their Characteristics

Model / Heuristic	*Source*	*Description*	*Relation to "Pakuri" Logic*
T/cu Rule	Schragenheim & Dettmer (2000)	Ranks constraints by throughput per constraint	Fully equivalent heuristic
Combinatorial TOC Analysis	Linhares (2009)	Evaluates T/cu performance under NP-	Theoretical justification
Constraint Ranking Algorithm	Aryanezhad & Komijan (2004)	Ranks near-binding constraints	Equivalent throughput-based
Two-Constraint Model	Tanhaei & Nahavandi (2013)	Formal dual-constraint optimisation	Alternative formalisation
"Pakuri model" (informal)	Practitioner usage	Uses T/cu to select dominant constraint	Identical mechanism; non-academic term

Source: Based on Schragenheim & Dettmer (2000), Linhares (2009), Aryanezhad & Komijan (2004), Tanhaei & Nahavandi (2013). "Pakuri model" included only as practitioner terminology.

Empirical findings on TOC impact

Recent empirical studies demonstrate TOC's significant impact on organisational performance:

- Healthcare: Cox (2021) shows that TOC restructuring of scheduling and resource allocation improved flow, revenue and staff utilisation in a primary care setting.
- Healthcare – systematic review: Datt et al. (2024) confirm TOC's ability to reduce waiting times, increase throughput and reduce system-level variability across multiple clinical environments.
- Supply chain: da Silva et al. (2024) demonstrate that TOC improves supply chain synchronisation and reduces local optima.
- Product-mix decisions: Linhares (2009) shows how TOC heuristics interact with combinatorial complexity, and why throughput models outperform cost-based decision rules.

These findings support the argument that integrating TOC into MCS strengthens strategic alignment, improves operational stability and enhances performance.

Conclusion

This study examined how the Theory of Constraints (TOC) interacts with and reshapes modern Management Control Systems (MCS), integrating classical TOC principles with contemporary challenges such as high variability, multi-constraint operational environments and strategic alignment. The findings reveal that TOC provides a powerful conceptual and operational foundation for reorienting MCS from cost-focused to flow-focused paradigms. The shift is significant as traditional control mechanisms emphasise local efficiencies, resource utilisation and cost variances, whereas TOC promotes systemic optimisation, throughput maximisation and the protection of critical constraints.

The conceptual framework developed in this study highlights four central interfaces through which TOC transforms MCS: (1) performance measurement, (2) planning and budgeting, (3) organisational structure and responsibility systems, and (4) multi-constraint decision-making.

Flow-based performance metrics, throughput accounting (TA) and constraint-focused prioritisation provide a more coherent and strategically aligned information basis for managerial decisions than classical costing systems. The integration of TOC into Sales and Operations Planning (S&OP) and budgeting processes introduces a constraint-focused logic that enhances coherence between operational capacity and financial planning.

One of the significant contributions of this study is the theoretical clarification of the so-called "Pakuri model", an informal term used in practitioner contexts to describe the selection of a dominant constraint based on a throughput-per-constraint-time (T/cu) logic. While the term lacks recognition in peer-reviewed academic literature, its underlying mechanism aligns closely with established TOC heuristics described by Schragenheim & Dettmer (2000) and the combinatorial analyses of Linhares (2009). Multi-constraint algorithms by Aryanezhad & Komijan (2004) and Tanhaei & Nahavandi (2013) further reinforce the theoretical legitimacy of such heuristics.

Overall, TOC's integration into MCS provides several benefits, enhanced responsiveness to variability, improved alignment between operational and financial objectives, and reduced local suboptimization. However, limitations remain, particularly regarding the practical challenges of implementing throughput accounting in capital-intensive sectors and the complexity of managing environments with multiple interacting constraints. These limitations indicate promising avenues for future research, including hybrid control systems that combine TOC with lean, agile and data-driven digital control architectures.

In conclusion, TOC is not merely an operational methodology but a comprehensive managerial philosophy that, when systematically embedded into MCS, can significantly enhance organisational performance, strategic coherence and decision quality. This study provides a theoretically robust and practically relevant foundation for understanding and applying TOC principles within modern management control contexts.

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Digitalization and innovation for survival: the Hungarian hospitality sector's responses to the pandemic

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Abstract: The COVID-19 pandemic posed significant challenges for the hospitality industry in Hungary. Lockdown measures, curfews, and the decline in tourism severely affected the sector's revenues and operating conditions. Many restaurants, cafés, and accommodations were forced to close temporarily or permanently. Businesses had to adapt quickly to the new circumstances by introducing delivery and online ordering services. A large number of jobs were lost, leading to serious social and economic consequences. Government support and tax relief measures partly mitigated the damage but could not fully compensate for the losses. The pandemic highlighted the sector's vulnerability and the importance of innovation and digitalization. The transformation of the hospitality industry remains evident in the long term, particularly in consumer behavior and business strategies. The aim of this research is to explore the impacts of the pandemic and analyze possible recovery pathways after the crisis. The findings may contribute to the development of future crisis management strategies and sustainable growth directions.

Key words: COVID-19, Hospitaity, Economic impact, Crisis management
JEL codes: O31, L83, M20

Introduction

The COVID-19 pandemic, identified in China at the end of 2019 and declared a global pandemic at the beginning of 2020, has caused an economic and social crisis more severe than ever before. Following the World Health Organization (WHO) announcement in March 2020, governments around the world have introduced measures aimed at minimizing human contact and slowing the spread of the virus. One of the biggest losers from these restrictions has been the tourism and hospitality industry, which relies heavily on human mobility, personal interactions and experiential services (UNWTO, 2021). The hospitality industry in Hungary is a key subsector of the service sector, which showed dynamic growth in the years preceding the pandemic. According to the Central Statistical Office (KSH, 2024), the sector accounted for 6.5% of the gross domestic product (GDP) in 2019 and directly employed around 180,000 people. However, the closures ordered in the spring of 2020 practically wiped out demand in a few weeks, with 90% of catering establishments forced to temporarily close, and a significant part of the employed remaining unemployed (OECD, 2021). The COVID–19 crisis not only caused short-term liquidity problems, but also generated longer-term structural changes. Consumer habits changed, domestic tourism appreciated, and the importance of digitalization and online sales channels increased dramatically. According to the data for 2024–2025, the catering industry has gradually, but not yet, returned to the 2019 level: according to the estimates of the Central Statistical Office (KSH, 2025), the total sales revenue of the sector in 2024 reached about 92% of the pre-epidemic value, but the proportion of foreign guests is still lower than in previous years.

The pandemic has also revealed systemic lessons in the domestic hospitality industry. On the one hand, it has shown how vulnerable the sector is to external shocks, and on the other hand, it has highlighted that the ability to adapt – such as digital solutions, online sales forms and a culture of

innovation – plays a key role in survival (Glazer & Illes, 2025). According to a study by the European Commission (2024), those small and medium-sized enterprises that were able to react quickly and develop new business models (e.g. home delivery, online ordering, dynamic pricing) were much more likely to survive the crisis (Palazzo et al. 2022).

Based on all this, the COVID–19 crisis was not only an economic crisis for the domestic hospitality industry, but also a turning point that could determine the future competitiveness and sustainability of the sector in the long term (Strielkowski (2020).

Problem statement

The fundamental characteristic of the hospitality industry is that it is labor-intensive and capital-intensive, so the vast majority of businesses operate as small and medium-sized enterprises (SMEs). This structure allows for flexible and dynamic operations under normal economic conditions, but it carries serious risks in a crisis situation – especially in the event of a sudden drop in demand. During the COVID-19 pandemic, this vulnerability was fully demonstrated: domestic hospitality establishments suffered an average 30–60% drop in revenue during 2020–2021 (KSH, 2021), and nearly a fifth of businesses were forced to close permanently (MTÜ, 2022).

The complexity of the problem lies in the fact that the crisis has had multidimensional effects: on economic, social and psychological levels. In addition to the loss of demand, there were also confidence factors (consumer fear, decreased sense of security), labor market uncertainties (emigration, career abandonment), and regulatory challenges (changing epidemiological restrictions, support systems). The European Court of Auditors (ECA, 2021) pointed out that support systems often arrived late or were not targeted, so they were not always able to prevent mass bankruptcies of businesses.

In the domestic context, an additional problem was that a large proportion of employees in the hospitality industry (nearly 40%) worked in atypical forms of employment (part-time, seasonal or agency contracts), which reduced the effectiveness of social security and employee protections (KSH, 2022). As a result, many employees were not eligible for state wage subsidies during the epidemic, so the loss of income occurred directly at the household level.
The problem is therefore not exclusively economic in nature: the crisis in the hospitality industry also carries social and structural dimensions, which are relevant for the labor market, regional development and the entrepreneurial ecosystem.

Research Objectives

The primary objective of the research is to provide a comprehensive picture of the impacts of the COVID–19 pandemic on the Hungarian hospitality industry, with particular regard to economic performance, employment and the adaptation strategies of enterprises. The study focuses on the period 2020–2024, as this period includes the outbreak of the crisis, the period of restrictions and then the phase of gradual recovery.

The specific objectives are as follows:

1. Quantitative analysis of the economic impacts of the COVID–19 crisis in the hospitality industry, based on KSH and Eurostat data. In this context, we examine the development of turnover, employment, company survival and regional differences.
2. Exploring the adaptation mechanisms of enterprises. The aim is to systematize and analyze corporate responses to the crisis (business model change, innovation, digitalization, cost reduction).
3. Assessing the effectiveness of government and EU support measures. Within this, we examine the targeting, timing and economic effectiveness of support programs, with particular attention to small and medium-sized enterprises (SMEs).
4. Assessing the resilience and future sustainability of the sector. The aim of the research is to formulate structural and policy recommendations that can increase the crisis-resilience of the domestic hospitality industry in the future.

The aim of the study is therefore not only to describe the effects of the epidemic, but also to understand and model the mechanisms of recovery from the crisis. According to the basic hypothesis of the research, those hospitality businesses that (a) had prior financial reserves, (b) were able to digitize quickly, and (c) were able to develop new value propositions in the changed consumer environment were best able to minimize the negative effects.

Research methodology

The aim of the study is to comprehensively explore the effects of the COVID–19 epidemic on the domestic hospitality industry, during which the research uses both quantitative and qualitative approaches. The research design aims to provide a detailed analysis of the economic, structural and social impacts of the pandemic and to explore the adaptation strategies of businesses. To this end, the study uses a mixed-method approach, combining statistical analyses and qualitative interpretation. The quantitative component of the research examines the development of the economic performance, employment and revenues of the hospitality industry between 2019 and 2024, including the period before the outbreak of the pandemic, the crisis and the gradual recovery. The qualitative component aims to explore the crisis management strategies, management decisions and innovation processes of businesses. Such a combined approach allows for a multidimensional analysis of complex problems, ensuring the depth and validity of the research (Creswell & Plano Clark, 2017).

Data sources

Both primary and secondary data sources were used in the research.
Secondary data include annual and quarterly data from the Central Statistical Office (KSH) for the period 2019–2025, economic indicators from Eurostat and OECD, and reports and market research reports from the Hungarian Tourism Agency (MTÜ). These data form the basis of the quantitative analysis, with particular attention to income, employment and regional differences.

Primary data served to explore the direct effects of the crisis.

- We conducted semi-structured interviews with 25 domestic hospitality businesses, including small and medium-sized enterprises, restaurants, cafés and hotel catering services.

- In addition, 120 hospitality businesses participated in a questionnaire survey, which examined the effects of the crisis, adaptation strategies and changes in business operations.
- On the consumer side, 1,000 people filled out an online questionnaire, partly from the clientele of the 120 businesses mentioned above and partly from a representative sample of domestic consumers.

The aim of the survey was to explore the effects of the epidemic, changes in consumer behavior and the development of needs.

Sampling

For the quantitative analysis, we used stratified random sampling, taking into account the size, geographical location and profile of the businesses, to obtain a representative picture of the domestic hospitality industry. The qualitative interviews were conducted using purposive sampling, selecting businesses that had applied different adaptation strategies during the pandemic. This sampling approach ensures relevant and informative data collection.

Data collection methods

The study involved semi-structured interviews with 25 domestic hospitality businesses, consisting of small and medium-sized enterprises, restaurants, cafes and hotel catering services. The aim of the interviews was to explore the effects of the COVID-19 pandemic, identify the adaptation strategies and innovation mechanisms of businesses. During the qualitative analysis, we used thematic coding, which identified four main dimensions: crisis management, digitalization, introduction of new services and changing consumer demands. Crisis management and management strategies. Interviewees unanimously indicated that fast and flexible decision-making was key to survival. In the first phase of the crisis, the majority of businesses introduced immediate cost-cutting measures, including temporary layoffs, workforce reallocation and optimization of energy and material costs. The analysis revealed that businesses that had pre-developed crisis management protocols responded faster and more effectively to market uncertainties.

The role of digitalization proved to be prominent in the adaptation during the crisis. 64% of businesses introduced online ordering and payment systems, contactless service, and digital marketing in order to maintain their customer base. Based on the interviews, those businesses that already had digital platforms before the epidemic gained a significant competitive advantage and were able to respond quickly to the decline in demand and the transformation of domestic consumer needs (Wieczorek-Kosmala (2021).

According to the interviews, the adaptation of businesses was not limited to digitalization. Several businesses introduced home delivery, packaged food and beverage packages, and short-term rental options. The key to the success of innovation was rapid implementation and continuous monitoring of consumer needs. The thematic analysis revealed that service diversification and creative sales solutions contributed to mitigating revenue losses and enabling businesses to survive. Interviewees unanimously indicated that consumer behavior has changed permanently as a result of the pandemic. Hygiene and safety have become a priority, while demand for domestic tourism and online ordering have increased significantly. Businesses have continuously monitored this change and have adapted new services and digital channels to consumer expectations. Qualitative data

shows that taking into account consumer needs and ensuring safety and comfort was a critical factor in maintaining market position during the crisis.

Based on the analysis of the interviews, it is clear that the survival of the domestic hospitality industry during the crisis largely depended on flexibility, innovation capacity and the rapid application of digitalization. Crisis management strategies, the introduction of new services and rapid adaptation to consumer needs required an integrated approach. Qualitative data corroborate the results of quantitative analyses, highlighting that successful adaptation is a multidimensional process that combines management decision-making ability, technological adaptation and continuous monitoring of market needs .

Questionnaire survey analysis

During the research, we included 120 domestic hospitality enterprises, representing cafes, restaurants, hotel catering services and smaller catering units, using online and face-to-face questionnaires. The aim of the questionnaire was to explore the economic, organizational and consumer effects of the COVID–19 epidemic, as well as to quantitatively examine the adaptation strategies of enterprises. During the analysis, we used SPSS software, where we prepared descriptive statistics, cross-tabulation analyses and regression models between the variables in the sample.

Demographic characteristics

65% of the enterprises participating in the sample were small enterprises, 25% were medium-sized enterprises and 10% were larger units. The geographical distribution of the enterprises was concentrated in the capital and tourist centers (Budapest 40%, Balaton region 25%), while the remaining 35% were located in smaller rural towns. According to annual revenue categories, the majority of small enterprises in the sample had revenue between HUF 50–200 million, while medium-sized enterprises had revenue between HUF 200–500 million, and larger enterprises had revenue above HUF 500 million in 2019.

Revenue and employment impacts

Based on the results of the questionnaire, 82% of enterprises reported a decrease in revenue of over 20% in 2020 due to the pandemic. In the regional breakdown, enterprises in the capital and the Balaton area experienced an average decrease in revenue of 35–36%, while rural areas reported a decline of 15–20%. Employment data showed that the number of full-time employees decreased by an average of 17%, while the proportion of part-time and temporary workers increased (OECD, 2023).

Adaptation strategies

According to the questionnaire data, the most frequently used adaptation strategies of enterprises were:

- Digitalization and online services: 64%
- Introduction of new services (e.g. home delivery, packaged products): 58%

– Cost optimization and workforce reallocation: 72%
– Flexible workforce management (part-time, temporary employment): 50%

Based on the cross-tabulation analysis, the revenue decline of enterprises that applied digitalization was on average 10% lower than that of those that did not introduce online systems. This shows a significant correlation between digitalization and the reduction of revenue loss caused by the crisis ($p < 0.05$).

Consumer behavior and market demands

According to the questionnaires, changes in consumer behavior were felt by 78% of enterprises. The most important changes were the increase in hygiene expectations, the demand for contactless payment and the rise of domestic tourism. Regression analysis showed that digitalization and rapid adaptation to consumer needs are directly related to the reduction of revenue loss ($R^2 = 0.42$).

Use of state and EU subsidies

Based on the questionnaire survey, 78% of enterprises used some form of support. The most frequently used forms of support were wage subsidies (68%), liquidity loans (52%) and tax deferrals (45%). EU investment subsidies were used by 33%. The statistical analysis showed that the subsidies were primarily effective in providing liquidity in the short term, but did not show a significant effect on long-term structural transformation and innovation.
The results of the questionnaire survey confirm the conclusions of the qualitative interviews and the analysis of macroeconomic data. The COVID-19 pandemic fundamentally affected the revenues, employment and operating strategies of the domestic hospitality industry. The survival of businesses depended largely on digitalisation, innovation capacity, service diversification and rapid adaptation. State and EU support provided mainly short-term liquidity, while long-term competitiveness was determined by businesses' own adaptation strategies (OECD, 2023; European Commission, 2024).

Data processing and analysis

Quantitative analysis

We examined the development of revenue, employment and company survival in the pre- and post-pandemic period using descriptive statistics, time series analysis and regression models based on data of KSH, 2024; OECD, 2023 (Tables 1,2,3.).

Table 1. Revenue change during COVID–19 (%) by region

Region	2019 revenue (HUF million)	2020 revenue (HUF million)	Revenue decrease (%)
Budapest	1200	780	35
Balaton region	950	610	36
Great Plain rural cities	450	380	15
Northern regions	500	410	18
Total	3100	2180	29,7

Source: KSH, 2025 own calculation

Table 2. Changes in employment in the hospitality sector in 2019–2020

Munkavállalói kategória	2019 (heads)	2020 (heads)	Change (%)
Full-time employees	18 500	15 400	-16,8
Part-time employees	3 200	3 600	+12,5
Seasonal workers	1 800	2 100	+16,7
Total	23 500	21 100	-10,2

Source: KSH, 2025 own calculation

Table 3. Adapting strategies of enterprises in the selected sample

Strategy type	% of enterprises in the sample
Digitalization and online services	64
Introduction of new services	58
Cost reduction / allocation	72
Introduction of flexible working opportunities	50

Source: KSH, 2025 own calculation

Qualitative analysis

Thematic coding and content analysis were used to process the interviews. This allowed for the systematization and analysis of crisis management strategies, innovation processes and adaptation mechanisms. The content validity of the research is ensured by the triangulation of multiple data sources, which allows for the comparison and confirmation of quantitative and qualitative results. Reliability is ensured by standardized questionnaires, interview protocols and repeated checks, reducing subjective bias. All participants participated in the research anonymously, and data protection regulations were adhered to, ensuring that ethical aspects were met.

The combined research methodology allows for a comprehensive exploration of the effects of the COVID–19 pandemic on the domestic hospitality industry. Quantitative data display the economic and employment effects, while qualitative analysis reveals the adaptation strategies and innovation processes of enterprises.

Results and analyses

A detailed analysis of the impacts of the COVID–19 pandemic on the Hungarian hospitality industry, both quantitatively and qualitatively. The quantitative data show economic performance, revenues and employment, while the qualitative data reveal the crisis management strategies and adaptation mechanisms of enterprises. The analysis is carried out along the research questions and hypotheses, allowing for the systematization and comparison of complex impacts.

Economic impacts

Based on the quantitative analysis, the Hungarian hospitality industry suffered an average 28.3% revenue decrease in 2020 due to the COVID–19 pandemic, resulting in a significant decline in its contribution to GDP (KSH, 2025). The extent of the loss of income varied by region: in the tourist centers of the capital and around Lake Balaton, the decrease exceeded 35%, while in small rural

towns, which were based on domestic tourism, the decline ranged between 15–20% (Alreahi & Bujdosó, 2024).

Employment data also show an unfavorable picture: in the hospitality sector, the number of full-time employees decreased by an average of 17% in the first year of the epidemic, while the proportion of part-time and temporary workers increased (OECD, 2023). This change indicates the flexibility of the labor market, but also the vulnerability of the sector.

Regional differences

The differences between regions basically stemmed from the nature of tourism. Budapest and the Balaton region suffered the greatest losses due to the decline in international tourism, while the countryside, which relied on domestic tourism, recovered more quickly (Kupi & Szemerédi, 2021). During the analysis, we verified with regression models that the share of foreign tourists in the economic performance of the regions and the capacity of accommodation facilities were significant predictors of the extent of revenue loss.

Corporate strategies and adaptation

According to the analysis of qualitative interviews, the adaptation strategies of enterprises can be classified into three main groups: digitalization, the introduction of new services, and cost optimization and human resource management.

- Digitalization: Those enterprises that quickly introduced online ordering and payment systems, contactless services, and digital marketing enjoyed a significant advantage when demand fell.
- New services: Several enterprises introduced home delivery, packaged food and beverage packages, and new, short-term rental options, which reduced the impact of revenue loss.
- Cost optimization: Redeployment of labor, temporary layoffs, and reductions in energy and material costs all contributed to the survival of businesses.

Based on thematic coding, factors highlighted in the interviews included flexibility, openness to innovation, and management's ability to make quick decisions. The effectiveness of the strategies was strongly correlated with the size of the business and its digitalization readiness.

Impact of state and EU subsidies

Large proportion of enterprises used some form of state or EU support (OECD, 2023). Based on the analysis, the subsidies were primarily effective in alleviating short-term liquidity problems, but their impact on structural transformation and innovation was limited. In the interviews, several people highlighted that the administrative burdens and strict conditions of the subsidies slowed down the rapid response.

Consumer behavior and long-term effects

Based on the questionnaire survey, significant changes occurred among consumers: the priority of safety and hygiene became the most important aspect, while environmental awareness, although

still present, took a secondary role (Kupi & Szemerédi, 2021). The rise of domestic tourism and the demand for online services induced long-term changes in the sector, accelerating digitalization and diversification of services. Based on the results, the COVID–19 pandemic posed an unprecedented challenge for the domestic hospitality industry, which was reflected in a significant decrease in revenues, employment and regional performance. Digitalization, innovation and rapid adaptation played a key role in the survival of businesses. State subsidies mainly solved short-term liquidity problems, but were less effective in improving long-term competitiveness. The lasting change in consumer behavior and the digitalization of services induced long-term structural changes in the sector, which determine the direction of future development.

Evaluation of state and EU subsidies

As a result of the COVID–19 pandemic, the domestic hospitality industry suffered significant revenue losses and operational difficulties, to which the state and the European Union responded with various support programs. The aim of Chapter 5 is to evaluate the effectiveness, targeted nature and long-term effects of these subsidies, with particular attention to ensuring liquidity, retaining the workforce and facilitating structural adjustment.

State support in Hungary
In Hungary, the government has introduced various forms of support since the beginning of the pandemic. These include:

- Wage subsidies: employers covered part of the wages of employees, thus reducing the need for layoffs (OECD, 2023).
- Liquidity loans and guarantees: short-term, preferential loans that helped businesses maintain their operations.
- Tax benefits and deferrals: deferrals of VAT and corporate tax payments reduced financial burdens.Mo

Based on the survey of support, 78% of businesses received some form of state assistance. However, in the interviews, several highlighted the administrative complexity of the support programs and the limited ability to respond quickly. Wage subsidies were primarily effective in retaining the workforce, while liquidity loans ensured short-term financial stability.

EU support and programmes
The European Union provided various resources to domestic hospitality businesses, the main aim of which was to mitigate the direct economic effects of the crisis and promote sustainable recovery. EU programmes include:

- REACT-EU: funds created for COVID-19 crisis management, complementary to the cohesion funds, aimed at supporting small and medium-sized enterprises (European Commission, 2024).
- Local development funds: targeted investment support for the development of tourism and hospitality.
- Vocational training and labour market programmes: supported the retraining and reintegration of workers in the sector affected by the crisis.

Based on the qualitative analysis, the advantage of EU support was that it also supported long-term structural change, for example in the field of digitalisation and sustainability developments. However, it proved to be less effective in short-term crisis situations requiring a quick response.

Effectiveness and limitations of subsidies
The effectiveness of state and EU subsidies can be assessed along two main dimensions:
Providing short-term stability: The subsidies have significantly contributed to maintaining the liquidity of businesses and retaining the workforce, mitigating the direct economic damage of the epidemic (OECD, 2023).

Long-term adaptation: The subsidies have been less stimulating for structural transformation and innovation. According to interviews, the rigidity of the application conditions and the administrative burdens have slowed down the rapid response and the spread of digitalization.
Based on the statistical analysis, the subsidies have mainly helped the survival of larger businesses operating in the capital and tourist centers, while access was more difficult for smaller, rural businesses, which has resulted in regional inequalities.

Strategic lessons
The analysis of state and EU support offers several important strategic lessons for future crisis management:

Rapid and flexible support mechanisms can increase the effectiveness of crisis response. Long-term development goals (digitalization, sustainability) should be integrated into crisis management programs. Specially targeted programs are needed for smaller and rural businesses to reduce regional inequalities.

State and EU support fundamentally contributed to the short-term survival of the domestic hospitality industry during the COVID-19 crisis. Wage subsidies, liquidity loans and tax breaks mitigated workforce losses and ensured operational continuity. At the same time, they provided less incentive for long-term competitiveness and structural adjustment, especially for smaller businesses. In future crisis management strategies, it is important that support supports both short-term stability and long-term innovation and digital transformation (European Commission, 2024; OECD, 2023).

Conclusions and recommendations

The COVID-19 pandemic has presented the domestic hospitality industry with serious challenges, which have had a significant impact on the sector's operations in both the short and long term. According to the studies, the pandemic has been most evident in the decline in revenues and employment, as well as in the increase in performance differences between regions, highlighting the vulnerability of regions based on metropolitan and international tourism. In contrast, rural regions based on domestic tourism have regenerated faster, suggesting that the nature of tourism and the consumer base play a fundamental role in mitigating the effects of the crisis (KSH, 2025; Alreahi & Bujdosó, 2024).

The survival of businesses was largely facilitated by factors that enabled flexibility, innovation and rapid adaptation. Digitalisation, the introduction of new services and cost-efficiency measures all contributed to the operational continuity of businesses, while the ability of management to make quick decisions and adapt was a critical advantage during the crisis.

State and EU support provided significant short-term assistance in maintaining the liquidity of businesses and retaining the workforce. Wage subsidies and liquidity loans mitigated the need for layoffs, but provided less incentive for long-term structural adjustment and innovation. Access was particularly limited for smaller, rural businesses, leading to increased regional disparities (OECD, 2023; European Commission, 2024).

Consumer behavior has undergone a lasting change as a result of the pandemic: safety and hygiene have become the most important considerations, while the demand for digital services and domestic tourism has come to the fore. This will shape the operation of the sector in the long term, accelerating digitalization and diversification of services.
Changes in the labor market – the decrease in the mobility of workers in the sector, the emigration of young people and women, and the shortage of skilled labor – pose additional challenges for the sector's adaptability (Fekete et al. 2025). Based on these lessons, one of the most important elements of future strategies is to promote the retention and retraining of the workforce, as well as the development of flexible, crisis-resistant management structures.

The study highlights that the COVID–19 pandemic has brought about structural changes in the functioning of the domestic hospitality industry. The competitiveness and survival of businesses depend on the coordinated application of digitalization, innovation, flexibility, and targeted state and EU support. According to practical recommendations, future crisis management strategies should simultaneously ensure short-term financial stability and long-term competitiveness, integrating digital developments, sustainability goals, and regional equalization. The results of the study can thus serve as a basis for decision-makers in the domestic hospitality industry to develop future adaptation and development strategies (OECD, 2023; European Commission, 2024).

Summary and future research directions

The impact of the COVID–19 pandemic on the domestic hospitality industry has proven to be significant in all examined dimensions, from an economic, social, and organizational perspective. The analyses showed that the epidemic caused significant short-term revenue losses, workforce losses and operational difficulties, especially in metropolitan and international tourism-dependent regions. In contrast, rural, domestic tourism-dependent areas showed a relatively faster recovery, highlighting the role of the nature of tourism and the consumer base in crisis management. The quantitative data and qualitative interviews examined in the study confirmed that the key to the survival and adaptation of businesses was flexibility, rapid decision-making and innovation, especially in the areas of digitalization and service diversification. State and EU subsidies mitigated financial difficulties and supported workforce retention in the short term, but they did less to stimulate structural adjustment and innovation in the long term. Access to subsidies was limited for smaller, rural businesses, resulting in regional inequalities. Changes in consumer behavior, hygiene and safety expectations, and the demand for digital services have triggered long-term structural changes in the sector, which will determine future operating strategies.

The decrease in the mobility of workers in the sector on the labor market, the emigration of young people and women, and the shortage of skilled labor have created additional challenges. Training programs, measures to support workforce retention, and the development of flexible management structures are key to future adaptation. Businesses should develop integrated crisis management models that combine short-term financial stability with the promotion of long-term competitiveness and innovation, with a particular focus on digitalization and sustainability goals. The main contribution of the study is that it has explored in detail the structural effects of the epidemic, the adaptation strategies of businesses, and the short- and long-term role of subsidies. These results provide a basis for future research, which could focus on the following issues: the long-term economic impacts of digitalization, sustainable management of changes in consumer behavior, strategies for reducing labor market challenges and regional inequalities, and the development of crisis-resistant and innovative business models.

The COVID-19 pandemic has highlighted the vulnerability of the domestic hospitality industry and the need for rapid adaptation. Future research and strategies should focus on flexibility, innovation, digitalization, and targeted support to ensure that the sector remains sustainable and competitive in the global market in the long term. The relationships and analyses revealed by the study inform policy decisions and strategic plans of businesses, contributing to the future development of the domestic hospitality industry.

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The Eating Habits of Children in Restaurant Catering: The Impact of Parental Decisions, the Offer of Children's Menus, and Opportunities for Innovation

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Abstract: Children's eating habits have received increasing attention in recent years from both nutrition science and hospitality research. Dining in restaurants plays a growing role in children's daily energy and nutrient intake; therefore, the composition of children's menus has a significant impact on the development of long-term eating habits. The aim of this study is to review the relevant national and international literature, with particular focus on the decisive role of parental choices, the nutritional quality of children's menus, and various intervention approaches. Findings highlight that the responsibility of hospitality providers is essential in supporting healthy nutrition among children.

Keywords: Children's nutrition, foodservice in restaurants, children's menu, parental choice, nutritional intervention
JEL codes: D12, I12, M31

Introduction

Ensuring healthy nutrition among children is of paramount importance from a public health perspective. Childhood obesity has become a growing problem worldwide, including in Hungary, and it may lead to chronic diseases in the long term (WHO, 2020). Dining out has become increasingly common among families, creating new challenges in ensuring adequate nutrient intake for children. The aim of this paper is to explore how restaurant children's menus and parental decisions influence children's eating habits, and what kinds of interventions are available to promote healthier choices. Children's menus play a particularly important role in shaping dietary patterns, as their variety and composition can significantly affect daily energy and nutrient intake. The foods consumed in restaurants are not merely the result of single consumption decisions; rather, they also influence children's taste preferences and dietary habits in the long term. The design of children's menus is, therefore, not only a gastronomic matter but also an issue of nutritional education. The nutritional value, portion size, and preparation methods of the dishes offered determine the extent to which children receive the nutrients necessary for their growth and development. Menus dominated by high-fat and high-sugar items may contribute to the formation of unhealthy eating patterns at an early age. In contrast, balanced and health-conscious children's menus can reinforce proper dietary habits and positively influence children's overall health. Parental decisions play a crucial role in determining what type of food children consume, as their choices are shaped by a mixture of factors — such as children's preferences, financial considerations, health awareness, and time constraints. The complexity of parental decision-making is further compounded by the fact that perceptions of healthy eating are subjective and influenced by cultural and social factors. Some parents equate healthy eating with natural, home-style food, while others prioritise calorie-controlled, nutrient-regulated options.

From the restaurant's perspective, a children's menu is not merely a product category but a strategic element influencing consumer loyalty. A well-designed, healthy children's menu can enhance the restaurant's image and encourage repeat visits by families. In practice, however, most restaurants still offer traditional, high-calorie, easy-to-prepare meals for children, such as fried meat, chips, or pasta dishes. This tendency is partly due to efforts to align with children's preferences and partly a matter of economic rationality aimed at minimising kitchen risks and food waste.

Nevertheless, parents increasingly demand children's menus that are both nutritious and appealing. Health-conscious consumers tend to favour restaurants offering fresh ingredients, natural components, and meals accompanied by an adequate amount of vegetables and fruits. Such establishments often employ innovative presentation techniques, playful designs, and child-friendly communication strategies to make healthy food more attractive. Visual and experiential elements play a key role in helping children develop positive associations with healthy eating. Parental decisions, however, are also heavily influenced by price sensitivity and family budget constraints. For many households, economic factors override health considerations, limiting the selection of healthy options. At this point, the hospitality industry plays an especially important role: healthy menu options should not only appear in premium categories but also be accessible to a wider audience. Improving value-for-money ratios and employing conscious communication can help increase consumer trust.

Educating and informing parents is essential to improving the acceptance of healthy children's menus. A lack of nutritional knowledge often leads parents to underestimate the calorie and fat content of restaurant meals. Educational programmes, campaigns, and partnerships designed to promote healthy eating patterns can serve as effective tools in bridging the attitudinal gap between parents and restaurants. Social media and digital communication platforms can also play a significant role in promoting healthy eating, particularly among younger generations of parents. Developing children's menus requires close collaboration among dietitians, food technologists, and marketing professionals. Creating healthy yet enjoyable meals is a creative challenge that requires both nutritional expertise and consumer insight. In the future, the success of restaurants will increasingly depend on their ability to balance economic interests with social responsibility. A healthy children's menu not only serves children's wellbeing but can also enhance parental satisfaction and strengthen a restaurant's reputation.

Overall, the composition of children's menus and the dynamics of parental decision-making form a complex system where economic, psychological, and cultural factors are closely intertwined. Sustainable solutions will depend on strengthening the dialogue between restaurants and families, while viewing children's nutrition not only as a market opportunity but also as a matter of social responsibility. The long-term goal is to ensure that healthy choices become natural decisions for both children and parents.

This raises a key research question: *How can healthier choices be encouraged within the restaurant environment?*

Theoretical Background

International examples

Children's eating habits are closely linked to the family's dietary culture, parental decisions, and the availability of food choices. Numerous international studies have demonstrated that restaurant children's menus are often high in energy yet low in fibre, vitamins, and minerals (Krølner et al., 2011, Sacco et al. 2014). Parents tend to make choices based on price, convenience, and their children's preferences (Patrick & Nicklas, 2005). Among the various intervention programmes, menu labelling, child-focused educational campaigns, and structural modifications to restaurant offerings have proven effective (Forwood et al., 2015).

Restaurant dining plays a significant role in shaping children's eating behaviours, as these occasions typically differ from home meals in terms of both composition and caloric content. A review of peer-reviewed studies published after 2000 reveals that the restaurant environment and menu design can influence children's energy and nutrient intake as well as parental decision-making.

Schneider et al. (2022) conducted a real-world restaurant experiment to investigate how "nudging" elements in children's menus — such as playful names, visual depictions, and calorie information — affect the proportion of healthier choices. The findings suggested that such interventions alone exert only a moderate influence on children's food selection, implying that alongside environmental adjustments, parental involvement and education remain critical factors. Implementing children's choices into menus is a key factor of a sustainable and successful restaurant strategy (Lehota et al. 2015).

Similarly, the cluster-randomised trial by Ayala et al. (2016) examined the effectiveness of restaurant-based healthy menu interventions, including the promotion of healthy options, staff training, and marketing tools, in increasing the proportion of healthy food choices for children. Results showed that combined interventions significantly increased the frequency of healthier selections, whereas menu-only modifications were less effective. The role of parental decisions in the selection of children's menus is determining: mothers' choices were strongly associated with their nutritional goals and the information available on menus. The research emphasised that both the restaurant environment and the provision of nutritional information jointly shape children's dietary habits.

The *Best Food FITS Intervention* (Crixell et al., 2014) and the Dutch study by van Kleef et al. (2023) explored community and operational factors as well. These interventions demonstrated that reducing sugary drinks, limiting high-calorie main dishes, and increasing the availability of fruit and vegetable options were effective strategies in promoting healthier food choices. Furthermore, the research highlighted that involving restaurant owners and chefs is essential for sustainable change, as both business considerations and consumer demands influence menu development.

Overall, the reviewed literature suggests that restaurant dining has a dual effect on children's nutrition: it presents an opportunity to promote healthier choices but also carries the risk of reinforcing consumption of high-calorie, nutrient-poor foods. The success of effective

interventions depends on the simultaneous consideration of environmental factors (such as menu design, visual and informational support) and parental roles, as well as on the adoption of practical, context-sensitive measures aligned with local restaurant operations and community settings.

Family- and Child-Friendly Restaurants in Hungary: Attendance and Menu Offerings

Although no comprehensive statistical data are available regarding the attendance of family-friendly restaurants in Hungary, general trends indicate that families are increasingly visiting such establishments. Family-oriented services – such as play corners, high chairs and children's menus – contribute significantly to the popularity and visitation rates of these restaurants. Family-friendly establishments play an important role in Hungarian family dining culture. A dining experience designed with children's needs in mind is not only convenient for families but also contributes to the enjoyment of shared meals and the strengthening of family relationships. Family- and child-friendly restaurants have become particularly popular in large cities such as Budapest. Their goal is to provide a comfortable and entertaining dining experience for families, taking into account the specific needs of children.

In Budapest, several examples of family-friendly restaurants can be found:

- *VakVarjú restaurant chain:* This chain places special emphasis on families. All locations provide play corners and high chairs, and they often organise weekend entertainment activities with animators. The children's menu features creatively named dishes such as *"Chicken Race"* or *"Pinocchio's Favourite"*.
- *Városliget Café:* This venue offers a pleasant dining experience for both adults and children. It provides a comfortable environment for families and is conveniently located near City Park, offering additional recreational opportunities for children.
- *Kockás Abrosz Family-Friendly Bistro:* Situated in Budapest's 2nd district, this bistro features a play area, children's menu, and outdoor playground. Alongside traditional Hungarian flavours, the restaurant provides an enjoyable experience for young guests.

The meal options available for children in Hungarian family-friendly restaurants are diverse and designed to meet the specific needs of young diners. Children's menus generally feature easily consumable, nutritious and flavourful dishes tailored to children's tastes and eating habits. Restaurants pay attention to allergen-free preparation and increasingly provide special dietary options such as gluten-free or lactose-free alternatives. These establishments not only offer dining opportunities but also create environments in which families can spend pleasant time together while children enjoy themselves.

The growing popularity of child-friendly restaurants in Hungary is supported by several factors. Families increasingly seek places where they can dine comfortably while ensuring that their children are entertained. Restaurants are expanding their services – offering play areas, children's menus, and animation programmes – making them more appealing to guests with children.

Selection Criteria for Family- and Child-Friendly Restaurants

Families choose family- and child-friendly restaurants for a variety of reasons, all of which serve the comfort and enjoyment of children. The main considerations include:

1. *Child-Friendly Environment*
   Restaurants equipped with play areas or indoor/outdoor playgrounds allow children to stay occupied while parents dine peacefully. Many establishments provide high chairs, changing facilities, and baby-friendly equipment, making dining with young children more convenient.

2. *Children's Menu and Nutritious Food*
   Children's menus typically offer easily consumable, nutritious and tasty meals such as breaded chicken with mashed potatoes, spaghetti Bolognese, or fresh fruit for dessert. Many restaurants pay close attention to allergens and offer gluten-free or lactose-free options.
   Creative menu names and visually appealing presentations enhance children's appetite and make the dining experience more enjoyable.

3. *Entertaining Experience*
   Numerous restaurants organise activities such as animation, arts and crafts workshops, puppet shows or themed events for children.
   For families, dining out is not merely about eating but about shared experiences that strengthen family bonds.

4. *Comfortable and Safe Setting*
   The interior design of these restaurants prioritises family comfort, featuring spacious tables, child-friendly furniture, and safe surroundings.
   Convenient parking, accessible entrances, and easy reachability are also important components of family-friendly services.

5. *Positive Reputation and Word-of-Mouth*
   Parents often choose based on recommendations and online reviews, wishing to ensure that their children will enjoy themselves and that the food is of high quality.
   Family-friendly services increase restaurant visibility and popularity, as positive experiences generate returning customers.

These establishments typically provide child-friendly environments with play areas, high chairs, and changing stations, along with children's menus that feature nutritious, flavourful meals adapted to young tastes. Many also host entertainment programmes and themed events, transforming meals into safe, comfortable, and enjoyable experiences. From the parents' perspective, the presence of suitable infrastructure and a positive, welcoming atmosphere are key, while children benefit from healthy and varied dishes. Menus are designed with attention to nutritional needs and taste preferences, ensuring diversity and balanced meals.
Numerous restaurants offer allergen-free, gluten- or lactose-free options, allowing children with special diets to dine without concern. Creative presentation and playful dish names enhance the dining experience and encourage children to choose healthy options. Entertainment activities such as craft sessions or puppet theatre make eating out a special occasion.

For parents, convenient layouts, spacious tables and accessible locations provide major advantages. The positive atmosphere and friendly staff contribute to a pleasant family experience.

Increasing attendance is driven by the diversity of services and the attention paid to children's needs. In summary, these venues combine safety, enjoyment and healthy eating, making them ideal choices for families.

Methodology

The aim of the research was to explore children's eating habits, parental decision-making mechanisms, and perceptions of children's menus, as well as to identify innovation opportunities within restaurant catering. A mixed-methods approach was applied, combining quantitative and qualitative techniques to ensure a comprehensive understanding of the phenomenon.

Quantitative Phase

The quantitative data collection took place between July and August 2025, using a combination of online questionnaires and in-person surveys. The target group consisted of parents of children aged 3–12 years who had dined in a restaurant with their family at least once during the previous two months. A total of 116 responses were received, of which 102 questionnaires (94%) were deemed valid. Although the sample was non-representative, efforts were made to achieve quota-based diversity. Of the respondents, 62% were women and 38% men; 47% lived in urban areas, 35% in small towns, and 18% in rural locations.

The age distribution of the children was as follows:

- 41% preschool age (3–6 years)
- 59% school age (7–12 years)

The questionnaire was structured into four main sections:

1. Children's dietary preferences
2. Parental decision-making factors
3. Experiences with children's menus
4. Openness to innovation (e.g., healthier menu options, interactive or gamified menus)

Qualitative Phase

In the qualitative stage, eight semi-structured interviews were conducted: five with parents and three with restaurant managers. The interviews lasted between 25 and 45 minutes.
The parent interviews explored decision-making drivers, children's preferences, and dining experiences, while restaurant managers were asked about menu development principles, consumer trends, and innovation potential.
During the content analysis, three overarching thematic categories emerged:

1. The need for safe choices
2. Perceptions of healthy offerings
3. Opportunities for innovation

Results

Parents' Perspectives

The concept of a *"safe choice"* was central to nearly all parent interviews. Respondents repeatedly emphasised that their primary expectation was to find at least one meal on the menu that their child would certainly eat. In practice, this meant that parents often opted for familiar, classic dishes such as breaded meat, pasta, or pizza. Variety and experimentation were secondary, as parents wished to avoid the risk of a child refusing food altogether. Most parents evaluated the selection of children's menus as limited and insufficiently healthy. Several respondents complained that menus typically included only fried meat and chips, while vegetables or healthier alternatives appeared rarely. This suggests a growing parental demand for more health-conscious offerings, which current restaurant practices only partially reflect. A further recurring theme was the importance of experience-based dining. Parents reported positive experiences when the meal was accompanied by playful or motivating elements for the child. Small surprises, creative presentation, and themed dishes were mentioned as ways to make children more willing to try new foods. These findings align with international trends highlighting the influence of visual and playful elements on children's eating behaviour.

Restaurant Managers' Perspectives

Interviews with restaurant managers yielded similarly instructive insights. The most prominent theme was price sensitivity. Managers consistently reported that parents were typically unwilling to spend more than 2,000–3,000 HUF (approximately £4–6) for a child's portion, significantly limiting menu development options. This price sensitivity acts as a constraining factor, discouraging experimentation with new or healthier dishes. Implementing a healthy offering was also described as challenging. Several managers noted that most children were reluctant to eat vegetables or more health-conscious meals, rendering such menu innovations economically risky. Fear of financial loss and a perceived lack of demand both contribute to the continued dominance of traditional, less healthy dishes on children's menus.

Comparative Evaluation

Perceptions of healthy menu offerings varied considerably across stakeholder groups. Parents frequently expressed criticism concerning the quality, flavour, and value-for-money of healthy alternatives, whereas restaurant managers primarily viewed such changes as economic risks. This divergence between consumer expectations and provider realities generates structural tension within the hospitality sector. Parents often feel that healthy options are not sufficiently appealing to their children, while restaurants fear that low demand for such dishes would jeopardise profitability. Regarding innovation, restaurant managers expressed cautious optimism. While acknowledging cost and demand constraints, several indicated interest in thematic and experience-based menus — for example, festive offerings, dishes inspired by fairy-tale characters, or creative solutions that simultaneously attract children and strengthen the restaurant's family-friendly image.

Synthesis

Both parental and managerial perspectives share notable overlaps. Both groups recognise the significance of price sensitivity and the conservative nature of children's tastes, while also acknowledging a growing demand for variety and playful experiences. The main divergence lies in their evaluation of healthy options: parents tend to criticise current offerings, whereas restaurants interpret such modifications as financial risks. The findings suggest that children's catering in restaurants presents multiple challenges. Parents seek safe, familiar meals but also increasingly desire healthier and more enjoyable alternatives. Restaurants, constrained by economic rationality and uncertain demand, are hesitant to innovate, yet some openness to change is already evident. Thus, the development of children's menus and the expansion of more health-conscious offerings can succeed only if both parental needs and economic realities are simultaneously addressed. Restaurant decision-making is largely driven by economic rationality, which often marginalises nutritional considerations. From a profit-maximisation standpoint, priority is given to dishes with stable demand, regardless of their nutritional quality. However, an increasing segment of parents demand healthier meals prepared from natural, low-fat ingredients — a form of market pressure that may influence service providers over time.

Communication gaps also exacerbate this divide, as parents' perceptions of what constitutes "healthy" food often differ from how restaurants interpret the concept in their marketing. In the public discourse, healthy eating often carries a moral dimension, whereas for restaurants it primarily represents a business decision. This mismatch of motivations may hinder the implementation of innovation. The caution displayed by service providers is further reinforced by the unpredictability of consumer behaviour, especially among children, whose preferences can shift rapidly. Parental criticisms frequently target the availability, portion size, and flavour of healthy meals, revealing the fragile balance between supply and demand. The perception of financial risk is closely linked to the restaurants' operational strategies and target markets.

Establishments that successfully integrate healthy offerings in the long term tend to enjoy advantages in terms of social responsibility and brand reputation. To strengthen consumer trust, however, credible communication and parental education are essential. Influencing parental attitudes positively could reduce the perceived financial risks for restaurants in the long run.

Collaborative models — such as restaurant campaigns connected with schools or community initiatives — could help promote the social acceptance of healthy eating. Overall, the differing perceptions surrounding healthy menu options are deeply rooted in the interaction between consumer expectations, economic interests, and cultural values. Sustainable change requires improved dialogue between restaurants and parents, and a shift towards viewing healthy eating not merely as a moral imperative but as an economically viable alternative.

Motivations and Innovation Opportunities in Offering a More Varied Diet

Based on both the literature and practical experience, it can be concluded that young children are often cautious towards unfamiliar foods, whereas curiosity and willingness to try new tastes tend to increase with age, particularly during the school years. Parental role-modelling and positive reinforcement significantly enhance children's openness to novelty, while coercion can have the

opposite effect. In family- and child-friendly restaurants, the opportunities for innovation include playful presentation, sample-sized tasting portions, and visually appealing, colourful dishes, all of which motivate children to try new foods. A further creative approach involves combining new flavours with familiar dishes – for example, serving vegetable purée or exotic fruits alongside pasta or meat – which reduces children's fear of the unfamiliar. Digital innovations such as interactive menus or QR-code-based games providing playful information about the dishes can also stimulate curiosity. Additionally, the introduction of seasonal or locally sourced thematic menus enables children to encounter a wider variety of tastes, while allowing restaurants to integrate sustainability principles into their operations.

Innovative communication strategies – such as story-based or character-linked menu items that present new dishes within a playful narrative – can transform dining into a positive, memorable experience. The ultimate goal of these approaches is to make children's dining both nutritious and enjoyable, while creating a comfortable and engaging environment for families.

Integration of Food Innovation and Educational Contexts

The integration of food innovation into educational and public catering systems can play a crucial role in shaping children's taste preferences and eating habits. Enhancing multi-sensory dining experiences, along with creative presentation and aesthetically appealing meals, has been shown to increase children's willingness to try new, healthier ingredients. The effectiveness of innovations can be further strengthened through digital technologies, such as interactive educational applications and gamified learning tools, which encourage children's engagement with healthy eating and nutrition education. Combining behavioural science with food innovation can facilitate long-term dietary changes, while incorporating child psychology principles into product development can enhance both acceptance and consumption frequency of healthy foods. Early exposure to new tastes is particularly important, as it lays the foundation for later dietary preferences. In this context, introducing plant-based foods in innovative forms may serve as an effective means of increasing vegetable consumption among children.

The Role of Social Learning and Community Contexts

Social learning, imitation, and community models play key roles in shaping eating behaviours, particularly when paired with innovative community-based programmes. Nutritional interventions implemented within school settings can foster long-term health-conscious behaviour, which can be further reinforced by transforming the dining environment — for example, through interactive menu boards, sensory demonstrations, or educational campaigns. Promoting healthy eating habits requires the integration of pedagogical and dietetic innovation, as well as the implementation of structured taste-development programmes, which can strengthen children's natural preferences for wholesome foods. Within food industry developments, it is essential that health communication is scientifically grounded and credible. Next-generation dietary strategies should not only encourage the consumption of healthy foods but also promote positive food experiences and experiential learning about nutrition.

Understanding Motivation and Ensuring Sustainability

Understanding children's motivational structures and actively involving parents and educators are fundamental conditions for the successful introduction and sustainability of innovations. Initiatives promoting healthy eating are most effective when they align with cultural and social contexts and take into account the developmental characteristics of different age groups. In conclusion, the multidisciplinary application of innovations holds significant potential for supporting the early formation and reinforcement of healthy eating habits. Appropriately designed innovations can help children become more open to new flavours, thereby increasing the likelihood of adopting and maintaining healthy dietary patterns over time.

Conclusions

Childhood obesity and inadequate nutrition represent growing global challenges, and Hungary is no exception. Increasing attention has therefore been devoted to optimising children's diets. The frequency of family restaurant dining continues to rise, creating both new opportunities and challenges in ensuring children's adequate nutrient intake. According to the literature, the restaurant environment significantly influences the nutritional composition of meals chosen by children. Properly designed child-friendly restaurants can have a positive impact on the development of healthy eating habits. Children's dietary patterns are age-dependent: younger children tend to be cautious about trying unfamiliar foods, while curiosity and willingness to experiment increase with age. Parental role-modelling is crucial in fostering openness towards new foods. Positive feedback encourages children's interest in novelty, whereas coercion tends to produce the opposite effect. The design of children's menus should therefore prioritise the inclusion of diverse and nutritious dishes. Visual experiences — such as colourful presentation and creatively named meals — stimulate curiosity and willingness to taste. Small tasting portions allow children to explore new flavours without pressure, and combining novel ingredients with familiar favourites can reduce fear of the unknown.

Playful programmes and interactive activities, such as digital menus or animation, enhance the experiential dimension of dining. Providing allergen-free options ensures safe dining experiences for children with special dietary needs, while the use of local and seasonal ingredients supports both variety and sustainability. Families often prefer restaurants offering comfortable layouts and spacious seating arrangements, as these contribute to a pleasant dining atmosphere. A safe and welcoming environment, supported by friendly service, strengthens overall satisfaction. Creative presentation encourages children to experiment, and educational components — such as brief explanations about ingredients or their origins — can increase nutritional awareness. The inclusion of themed events, playful menus, and storytelling elements maintains engagement and enthusiasm.

Family-friendly services have become key drivers of restaurant popularity. Innovative approaches support the development of sustainable dietary habits over time. Story-based menus and character-linked meals increase children's motivation and emotional connection to food. Collaboration with parents further ensures the success of healthy eating initiatives. Ultimately, the dining experience for children should be both nourishing and enjoyable.

Conscious menu planning promotes a balanced diet, while interactive and playful elements foster active participation. Positive food experiences encourage openness to new tastes, and the formation of healthy habits contributes to long-term quality of life. The role of family-friendly restaurants extends beyond nourishment: they also provide valuable social and communal experiences. Integrating sustainability principles into family dining is important for cultivating environmental awareness from an early age. Restaurants should strive to meet children's nutritional needs while maintaining creativity and innovation in menu design. Regular review of menu offerings, combined with parental involvement, can further enhance the dining experience. Playful and interactive solutions increase curiosity and acceptance, while the combination of educational and entertaining elements creates an optimal environment for healthy eating. In sum, family- and child-friendly restaurants play a strategic role in shaping children's healthy eating habits and promoting acceptance of new flavours.

Emerging trends suggest that the popularity of child-friendly restaurants in Hungary will continue to grow. To meet the evolving needs of families, restaurants must continuously improve their services and adapt to changing expectations. It is likely that an increasing number of establishments will specifically tailor their offerings and services to family guests.
The steady rise in the popularity of family-friendly restaurants indicates that families' needs are gaining importance in the hospitality sector. To remain competitive, restaurants should integrate these expectations into their operational strategies. In addition to play areas, appropriate seating, cutlery, and equipment are essential for enhancing the dining experience.

Guests are often willing to pay more for comfort and safety, and positive experiences lead to repeat visits. Parents typically choose restaurants where their children feel comfortable, so marketing strategies should emphasise child-friendly features. Online reviews and recommendations play an influential role in selection decisions, meaning that child-friendly services significantly enhance competitiveness.

More restaurants are now offering interactive programmes and special events, such as birthday celebrations or themed family days, which attract families and foster loyalty. Establishing a child-friendly atmosphere can generate long-term returning customers; however, restaurants must also prioritise safety and hygiene standards, which are particularly important for family clientele. Incorporating child-friendly design elements — such as warm colours, toys, and comfortable seating — contributes to a pleasant atmosphere. The continuous development of family-oriented services is essential, as the future of the hospitality industry is closely intertwined with the quality of family and child-friendly offerings.

Overall, the growing popularity of family-friendly restaurants clearly demonstrates that the needs of families with children occupy an increasingly central position in the hospitality market. Restaurants that successfully adapt their menus and services to these expectations will be better positioned to attract and retain this important customer segment.

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Integrating Animal Welfare into Corporate Social Responsibility: A Critical Review of Global Frameworks and Practices

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Abstract: Animal welfare has become an emerging, yet often neglected, dimension of Corporate Social Responsibility (CSR). This paper provides a critical review of global frameworks and corporate practices to assess how animal welfare is integrated into sustainability strategies. Drawing on interdisciplinary literature from business ethics, sustainability studies, and animal protection research, it examines the inclusion of animal stakeholders within CSR discourse. Key CSR frameworks are analyzed to determine their treatment of animal-related issues. The paper concludes with a conceptual model proposing deeper integration of animal welfare into CSR policies through transparency, stakeholder engagement, and ethical accountability.

Keywords: Animal Welfare, CSR, Sustainability, Business Ethics
JEL code: M14, Q01, Q57

Introduction

Corporate Social Responsibility (CSR) has conventionally emphasized human welfare, community development, and environmental protection, while largely neglecting the interests of animal stakeholders. In this context, animal welfare - understood as the well-being of animals living under human control or impacted by business activities - is increasingly acknowledged as an essential but still insufficiently addressed dimension of CSR. Rising public concern about animals and intensifying ethical debates in business have pushed animal welfare onto the CSR agenda, as consumers and investors increasingly expect companies to ensure humane treatment of animals throughout their operations and supply chains, regarding this as a key element of responsible and sustainable business conduct. Yet, effectively integrating animal welfare into corporate strategy remains difficult, and many companies continue to frame it as a marginal add-on rather than as a central CSR responsibility. (Tallberg et al., 2021)

This review investigates how animal welfare can be more firmly embedded in CSR frameworks and corporate practice. It examines the theoretical foundations for recognizing animals as business stakeholders, evaluates global CSR and sustainability frameworks in terms of how they address animal-related concerns, and assesses corporate approaches to animal welfare in different domains, including farm animals, companion animals, and wildlife. Drawing on interdisciplinary scholarship and empirical case studies, the paper highlights both gaps and emerging opportunities for strengthening the animal welfare dimension of CSR. On this basis, it puts forward a conceptual model for integrating animal welfare into corporate sustainability strategies via enhanced transparency, meaningful stakeholder engagement, and robust ethical accountability, so that business activities are aligned with the interests of all stakeholders, human and animal alike.

Theoretical background and literature review

Animals as Stakeholders: The Ethical Case for Inclusion

Modern stakeholder theory posits that corporations have responsibilities to all groups significantly affected by the company's activities. Traditionally, this encompasses shareholders, employees, customers, communities, and the environment. An emerging perspective extends this principle to animal stakeholders - notably animals - who can be profoundly affected by business operations. From an ethical standpoint, animals possess moral status as sentient beings capable of experiencing pain and pleasure; thus, their interests merit consideration alongside human stakeholders. If companies are moral actors in society, they carry an obligation to account for the welfare of animals impacted by their decisions and supply chains. (Janssens, 2018)

Including animals in stakeholder discourse shifts CSR from an anthropocentric model to a more inclusive ethics framework. Scholars argue that corporate responsibilities toward animals can be supported by stakeholder theory's emphasis on ethical duties beyond profit. (Janssens, 2021) For example, a business that uses animals (for food production, product testing, entertainment, or as companions) affects those animals' lives and thus should consider their well-being as part of its corporate responsibility. Likewise, industries that indirectly impact wildlife through habitat alteration or resource use affect animal populations and ecosystems, implying a duty of care under the principle of "do no harm." In essence, if "stakeholder" is defined as anyone (or anything) significantly affected by the firm's pursuits, then farm animals, laboratory animals, wildlife, and even companion animals connected to a business can be viewed as stakeholders whose welfare is within the scope of CSR.

It is important to clarify that "animal welfare" in this context refers to ensuring good living conditions and humane treatment for animals, rather than the broader concept of animal rights which calls for ending all use of animals. Businesses today predominantly frame their efforts in terms of animal welfare (incremental improvements in treatment) rather than animal rights (which might challenge the legitimacy of using animals at all). Companies tend to adopt welfare measures - providing better care and minimizing suffering - without necessarily questioning whether animals should be used in their operations in the first place. (Matyášová and Tranová, 2022) This pragmatic approach aligns with societal expectations and legal standards, focusing on reducing cruelty and meeting animals' basic needs. A commonly cited benchmark is the Five Freedoms framework, which defines fundamental welfare standards: freedom from hunger and thirst, freedom from discomfort, freedom from pain/injury/disease, freedom from fear and distress, and freedom to express normal behavior. (Farm Animal Welfare Committee, 2013) Ensuring these conditions for animals under a company's influence is increasingly seen as part of a firm's ethical mandate. In summary, the ethical case for including animals as stakeholders in CSR is grounded in recognizing animals' capacity to suffer or thrive based on corporate actions, and the moral imperative for businesses to prevent harm and promote welfare where they have influence.

Global CSR Frameworks and Animal Welfare

Global sustainability and CSR frameworks have begun to reflect the importance of animal welfare, though progress is uneven. Historically, major international CSR guidelines largely omitted

explicit mention of animals. For instance, the United Nations Global Compact - a widely adopted set of ten principles for responsible business - addresses human rights, labor, environment, and anti-corruption, but it does not explicitly reference animal treatment. (UN Global Compact, n.d.) Similarly, the classic Triple Bottom Line concept (people, planet, profit) and early sustainability reporting standards treated animal welfare only indirectly, typically subsuming it under environmental or product safety concerns. (Alsaleh et al., 2022) This lack of recognition meant that companies could claim to be socially responsible while entirely overlooking animal impacts. (Keeling, 2025)

In the past decade, however, several developments have pushed animal welfare closer to the mainstream of CSR. A notable milestone is ISO 26000 (Guidance on Social Responsibility), published in 2010, which explicitly recognizes animal welfare as a relevant consideration for organizations. (ISO, 2010) Contemporary reporting about the ISO 26000 development process also highlights that the working group deliberately included animal welfare within the broader concept of social responsibility. Subsequent scholarly analyses of ISO 26000 discuss its role in "standardizing" CSR expectations across organizations and sectors, contributing to a more explicit, governance-oriented understanding of what responsible practice entails (Hahn, 2013; Johnston, 2012). By embedding animal welfare into a globally recognized CSR guidance framework, ISO 26000 helped legitimize the idea that impacts on animals belong within the scope of responsible business conduct (ISO, 2010).

Another global framework relevant to animals is the United Nations Sustainable Development Goals (SDGs), adopted as part of the 2030 Agenda for Sustainable Development. While the SDGs are not designed as an animal-welfare instrument per se, several goals and targets directly concern biodiversity, wildlife, and ecosystems. SDG 15 (Life on Land) focuses on protecting and restoring terrestrial ecosystems and halting biodiversity loss Its Target 15.7 explicitly calls for urgent action to end poaching and trafficking of protected species of flora and fauna and to address illegal wildlife trade. SDG 14 (Life Below Water) similarly emphasizes conserving and sustainably using oceans and marine resources. (United Nations, n.d.) Beyond conservation, a growing research and policy literature argues that animal welfare is interlinked with progress toward multiple SDGs (e.g., via health, environment, food systems, and governance), even if it is not explicitly named in the goals (Keeling et al., 2019; Otineo, 2020; Verkuijl, Sebo & Green, 2022). In practice, companies that align their sustainability strategies with the SDGs are increasingly expected to address biodiversity loss, wildlife trade risks, and ecosystem pressures across supply chains - especially in sectors such as agriculture, forestry, fisheries, tourism, and fashion. (United Nations, n.d.)

Corporate sustainability reporting standards have also evolved to cover animal welfare more explicitly in certain sectors. The Global Reporting Initiative introduced GRI 13: Agriculture, Aquaculture and Fishing Sectors (2022), a sector standard intended to support more consistent disclosure of sustainability impacts in upstream production systems involving crops, animals, and seafood (GRI, n.d.). Alongside broader ESG evaluation mechanisms, specialized benchmarks such as the Business Benchmark on Farm Animal Welfare (BBFAW) have emerged as external accountability tools focused specifically on how companies manage farm animal welfare in their supply chains (FOUR PAWS, 2022; BBFAW, 2023). More general sustainability indices, such as S&P Dow Jones Indices' "best-in-class" sustainability index family, provide additional investor-

facing signals by selecting leading companies on economic, environmental, and social criteria using defined methodologies. (S&P Global, 2025)

In summary, global CSR and sustainability frameworks are gradually catching up with the ethical and governance imperative to take animal impacts seriously. ISO 26000 helped normalize the inclusion of animal welfare within the scope of social responsibility guidance (ISO, 2010). The SDGs embed wildlife and biodiversity protection as core components of sustainable development, and a growing body of scholarship and policy commentary argues that animal welfare is structurally connected to SDG progress (United Nations, n.d.; Keeling et al., 2019; Verkuijl, Sebo & Green, 2022). At the same time, mainstream CSR architectures still often treat animals as secondary or implicit concerns, suggesting a need for deeper integration of animal welfare into "general" CSR frameworks - beyond sector-specific reporting and specialized benchmarks. (Matyášová & Tranová, 2022)

Methodology

This study employs a qualitative critical review methodology to examine how animal welfare is integrated into corporate social responsibility frameworks and practices. Rather than a formal systematic review, we conducted an integrative literature analysis across multiple disciplines - including business ethics, sustainability management, and animal protection - to capture a broad picture of current thinking and practice.

Literature selection and review process

To enhance transparency, the literature was selected using a purposive, criterion-based approach consistent with qualitative critical reviews. The corpus combined (i) peer-reviewed scholarship and (ii) authoritative "normative" and practice-oriented documents relevant to corporate responsibility and animal welfare (e.g., ISO guidance, UN/SDG materials, sustainability reporting standards, benchmark methodologies, and NGO/industry reports). Searches were conducted across multidisciplinary databases. Search strings combined CSR and sustainability terms with animal welfare terms (e.g., "corporate social responsibility" or CSR or ESG or "sustainability reporting" and "animal welfare" or "farm animal welfare" or sentience or "wildlife impacts" or "supply chain").

Practical corporate examples were selected as illustrative cases where publicly available disclosures demonstrate one or more of the identified CSR-animal welfare integration mechanisms (e.g., dedicated animal welfare reporting, external advisory structures, governance accountability). The synthesis is therefore integrative and critical: it maps how frameworks enable or constrain animal welfare inclusion, and it identifies gaps and leverage points for a more systematic model of Animal-Welfare CSR (AwCSR).

Results

Farm Animal Welfare in Corporate Responsibility

Farm animals - those raised for food, fiber, or other agricultural purposes - represent the area where corporate policies on animal welfare have seen the most development. Industrial agriculture involves billions of animals globally, and their well-being can be directly affected by corporate farming practices, sourcing decisions, and food supply chains. In the past, intensive farming methods prioritized production efficiency often at the expense of animal welfare (e.g. extreme confinement, routine mutilations, transport practices associated with elevated welfare risks or slaughter). Today, due to consumer awareness and NGO campaigns, farm animal welfare has emerged as a significant CSR issue for food producers, grocery retailers, restaurants, and apparel companies using animal products.

Many companies have started to adopt farm animal welfare commitments as part of their sustainability strategies. For example, major food retailers and restaurant chains have pledged to eliminate cruel practices like battery cages for egg-laying hens and gestation crates for pigs in their supply chains. Companies increasingly recognize that the use of Concentrated Animal Feeding Operations (CAFOs) - where animals are densely confined - poses not only ethical problems but also reputational and operational risks. As a result, some firms now *"discard suppliers that use CAFOs to prevent abuses through intensive confinement"* and instead require more humane housing systems. One common corporate goal has been to source 100% cage-free eggs by a target year, reflecting concern that traditional caged systems create severe welfare issues for hens. Indeed, welfare problems associated with keeping poultry in cages (versus free-range or enriched environments) have been documented and have driven these cage-free campaigns. (Fernández-Mateo & Franco-Barrera, 2020) By setting such standards for suppliers, businesses use their purchasing power to improve farm conditions, effectively spreading better welfare practices across the industry.

Investors are also paying attention to farm animal welfare, viewing it as part of good risk management and corporate governance. There is a growing understanding that poor animal welfare in a supply chain can translate into brand damage, supply disruptions (e.g. disease outbreaks), or even legal liabilities. Conversely, companies that proactively manage animal welfare may gain trust and preference from ethically minded consumers and investors. Surveys indicate that investors *"seek guarantees that the companies in which they invest have fully considered the risks and opportunities associated with farm animal welfare and have effective policies and processes to address the challenges."* In response, leading firms have integrated farm animal welfare into their ESG (Environmental, Social, Governance) oversight structures. They conduct animal welfare audits of farms, train suppliers and staff on welfare standards, and publish annual reports on their progress (e.g. percentage of animals sourced from higher-welfare systems, or compliance rates with humane slaughter standards). Such integration treats animal welfare similarly to other CSR concerns – as an issue to be managed through goals, monitoring, and disclosure. (Fernández-Mateo & Franco-Barrera, 2020)

External benchmarks and indices drive further improvements. The Business Benchmark on Farm Animal Welfare (BBFAW), launched in 2012, ranks food companies on their farm animal welfare

policies, management, and performance. It has become *"the leading global measure of company performance in farm animal welfare,"* pressuring companies to improve or risk a poor ranking. (Fernández-Mateo & Franco-Barrera, 2020) Similarly, certification schemes and labels (like Certified Humane, RSPCA Approved, or organic standards) provide frameworks for companies to verify and communicate higher animal welfare in their products. (Matyášová and Tranová, 2022) Winning awards from credible animal welfare organizations or being listed in sustainability indices for good animal welfare practices can enhance a company's reputation. (Fernández-Mateo & Franco-Barrera, 2020) Investigative disclosures have been associated with negative public reactions and heightened reputational risk for firms linked to the reported practices. These incidents create pressure on companies to distance themselves from the worst practices and adopt zero-tolerance policies for cruelty. In some cases, industry responses have included supporting so-called "Ag-gag" laws to prevent covert filming on farms, an approach which has drawn criticism for reducing transparency. (Broad, 2014) The push-and-pull between transparency and secrecy highlights that *hiding* animal mistreatment can backfire, undermining public trust. (Robbins et al., 2016) Empirical findings indicate that limited transparency can erode trust; accordingly, proactive disclosure and measurable welfare commitments may support accountability and legitimacy. From a strategic viewpoint, farm animal welfare is no longer seen purely as a cost or compliance issue; it is increasingly framed as an opportunity for leadership and value creation. Companies that set high welfare standards often find it aligns with evolving consumer preferences - many shoppers are willing to pay a premium for "humanely raised" or cage-free products, according to market research. (Napolitano, Girolami & Braghieri, 2010) This suggests that animal-friendly practices can be economically sustainable when communicated effectively to consumers who demand them. Indeed, some forward-thinking food businesses speak of adding an "A" for Animal welfare to the traditional ESG factors, yielding an "ESGAW" model of corporate sustainability that explicitly includes animals. In this view, corporate sustainability entails not just social (S), environmental (E), and governance (G) dimensions, but also actively managing animal welfare (AW) in operations and stakeholder relations. (Fernández-Mateo & Franco-Barrera, 2020)

In conclusion, farm animal welfare has become a mainstream CSR consideration in agriculture and food industries. Companies are establishing policies to improve living conditions (such as enriched environments or pasture access), phasing out the cruelest practices, and increasing transparency through reporting and certification. These efforts are driven by ethical imperatives, stakeholder pressure, and a business case that ties animal welfare to long-term corporate reputation and resilience. (Napolitano, Girolami & Braghieri, 2010) Challenges remain - especially in ensuring compliance down complex supply chains and balancing cost concerns - but the trend is clear: responsible companies are expected to treat farm animals not as mere commodities, but as sensitive beings whose welfare the literature suggests to be safeguarded as part of corporate responsibility.

Companion Animals and Corporate Social Responsibility

Companion animals (pets and domestic animals kept for companionship) enter the CSR arena in more indirect but meaningful ways. While most companies do not have companion animals in their operations per se, many engage with pet welfare and related social issues through philanthropy, community programs, and employee initiatives. The well-being of companion animals is closely tied to human social welfare – for example, pets are part of family units and

community life – so businesses often include pet-related causes under their community CSR or philanthropy efforts.

One prominent avenue is corporate support for animal shelters, rescue organizations, and pet adoption campaigns. Many companies donate funds, supplies, or services to local humane societies and animal rescue groups as part of their community engagement. For instance, pet food and pet care companies naturally take on pet welfare as a core CSR theme: they might run initiatives to improve shelter conditions, sponsor free or low-cost veterinary clinics, or support spay/neuter programs to reduce pet overpopulation. Even companies outside the pet industry sometimes contribute to companion animal causes, recognizing the public's strong emotional connection to pets. This can be seen in retail or tech companies sponsoring annual adoption drives or matching employee donations to pet charities. Such philanthropic efforts align with the philanthropic component of CSR (as described in Carroll's CSR pyramid), where voluntary giving and community support are expected of good corporate citizens. (Matyášová and Tranová, 2022) Including companion animal welfare in these efforts shows a broadening definition of community welfare to include the animals that share human lives.

Another aspect of CSR involving companion animals is the creation of pet-friendly policies and workplaces. Companies increasingly allow or even encourage employees to bring their dogs to work or provide pet daycare facilities, recognizing that this can improve employee well-being and job satisfaction. While this is more of an internal CSR (focused on employee quality of life) than an outward societal impact, it reflects a shift in how animals are valued within the corporate context. Progressive companies see accommodating employees' pets or supporting pet ownership (through pet insurance benefits, for example) as part of being a humane employer. These policies indirectly promote the welfare of companion animals by acknowledging their importance in people's lives and making it easier for owners to care for them. Furthermore, they send a cultural message that animals are welcome and respected in daily life, even in professional spaces.

Some corporations also leverage their platforms to raise awareness about responsible pet ownership and animal welfare education. For example, a large retail chain might partner with veterinarians or NGOs to educate communities on topics like animal cruelty prevention, proper pet care, or the link between domestic violence and pet abuse (recognizing that helping pets can mean helping people too). These programs enhance the company's social impact by tackling issues at the human-animal welfare nexus. In disaster relief situations, companies have also stepped up to assist companion animals – donating pet food and funding emergency shelter for pets displaced by hurricanes or other crises, acknowledging that caring for animals is part of holistic community recovery.

Overall, while companion animals are not typically "stakeholders" in the sense of being directly affected by most businesses' production processes, they feature in CSR via community engagement and ethical culture. Companies that are pet-industry leaders (e.g. pet food manufacturers, veterinary chains, pet-friendly hotels) bear a more direct responsibility to ensure their products and services enhance pet welfare and do no harm. This might include strict quality control to prevent pet food contamination, not selling pet products that are unsafe, and advocating against high-welfare-risk practices (such as inhumane breeding of pets). In the broader corporate world, championing companion animal welfare is a way for companies to demonstrate empathy

and alignment with the values of their employees and customers, many of whom view their pets as family. By supporting the well-being of these animals, businesses strengthen their social license to operate and showcase a well-rounded approach to CSR that covers *all* forms of well-being in the community – human and animal alike.

Wildlife Conservation and CSR

Wild animals and biodiversity constitute another critical frontier of CSR, typically addressed under environmental sustainability and conservation initiatives. Companies impact wild animals both directly and indirectly: directly, through activities like logging, mining, or construction that can destroy habitats or harm wildlife, and indirectly through contributing to climate change or pollution that affect ecosystems. In recent years, businesses have been called upon to mitigate their impacts on biodiversity and even to proactively contribute to wildlife conservation as part of their corporate responsibility. As global awareness of the biodiversity crisis rises – with scientists warning of mass species extinctions driven by human activity – the role of the private sector in protecting wildlife has become a significant CSR theme.

Many CSR strategies now include commitments related to wildlife and ecosystems. A common element is habitat protection: companies pledge to avoid or minimize damage to critical habitats and endangered species in their operations. For instance, palm oil, timber, and paper companies might commit to "zero deforestation" policies to protect tropical rainforests (and the countless wild species living there, such as orangutans or tigers). Similarly, mining or infrastructure firms may implement biodiversity management plans, setting aside conservation areas or creating wildlife corridors around project sites. These steps align with global norms like SDG 15, which, as noted, urges halting deforestation and protecting natural habitats. (United Nations, n.d.) By integrating such targets, corporations contribute to international conservation goals and reduce their ecological footprint on wildlife.

Another area of corporate action is combating the illegal wildlife trade. Trafficking of protected animals and animal products (like ivory, rhino horn, exotic pets, etc.) is a major driver of species decline. While this black market operates largely outside formal business, legitimate companies can influence it. Travel and e-commerce platforms, for example, have joined coalitions to ban the sale or promotion of illegal wildlife goods online. Shipping and logistics companies are training staff to detect and prevent illicit wildlife shipments. Through CSR collaborations with NGOs and law enforcement, firms are helping to *"end poaching and trafficking of protected species"* as called for by SDG target 15.7. (United Nations, n.d.) There are also corporate philanthropy efforts funding anti-poaching patrols, sanctuary programs, or technology (drones, tracking systems) to protect endangered animals. Such contributions not only aid conservation but also build goodwill by potentially strengthening perceived corporate legitimacy and stakeholder goodwill through support for conservation outcomes.

Wildlife conservation is further supported by companies in the tourism and entertainment sectors that interact with wild animals. Ethical guidelines are emerging for wildlife tourism – for example, travel agencies and hotels adopting animal welfare policies that discourage practices like elephant rides, dolphin shows, or tiger petting, which can involve cruelty. Instead, responsible tourism CSR might involve partnering with certified sanctuaries or promoting wildlife watching that contributes

to conservation funding. Zoos and aquariums, while primarily about animals in captivity, also increasingly frame their mission around conservation and education, often funded in part by corporate sponsorships or CSR grants. Companies sponsor exhibits or conservation programs as a way to give back and raise awareness of wildlife issues.

In sum, wild animals enter the CSR agenda mostly through the environmental pillar of sustainability, focusing on biodiversity preservation and ethical use of natural resources. Companies are expected not only to reduce harm (avoiding pollution, deforestation, overfishing, etc. that threaten wildlife) but also to make positive contributions, like restoring habitats or supporting conservation initiatives. This represents a broadening of corporate responsibility – from merely mitigating negative impacts to actively stewarding the natural world. The impetus comes from both moral responsibility and pragmatic concern: the loss of biodiversity can undermine ecosystem services that businesses and society rely on (such as pollination, climate regulation, and water purification). Therefore, engaging in wildlife and habitat protection is part of a long-term risk management strategy for companies as well. By integrating wildlife conservation into CSR, businesses help ensure the sustainability of the planet's ecosystems, aligning their operations with global efforts to safeguard life on land and below water.

Corporate Case Studies Integrating Animal Welfare in CSR

In the food and agriculture sector, several major companies have adopted animal welfare commitments as part of their CSR strategies. A prominent example is McDonald's, which in 2015 pledged to source 100% cage-free eggs across its U.S. and Canadian operations within ten years. Given McDonald's enormous supply chain, this cage-free commitment was a landmark shift that pressured egg suppliers industry-wide to eliminate battery cages – the cramped wire enclosures that severely restrict hen welfare. (ASPCA, 2015) Fast-food chains and grocery retailers have similarly set timelines to phase out intensive confinement systems (such as gestation crates for pigs and battery cages for hens) in response to consumer and NGO pressure. These corporate pledges signal that humane farming practices are becoming mainstream expectations. For instance, many food companies now require that their meat and poultry suppliers abandon *Concentrated Animal Feeding Operations* (CAFOs) in favor of more humane housing, both to address ethical concerns and to mitigate risks like disease outbreaks. This trend is bolstered by industry benchmarks: the Business Benchmark on Farm Animal Welfare (BBFAW) ranks food companies on their farm animal welfare policies and performance, encouraging transparency and competition on welfare criteria. As a result, leading firms in the food industry have started publishing metrics on animal care - for example, the percentage of animals sourced from higher-welfare farms or compliance rates with humane slaughter standards. Such reporting not only builds public trust but also enables companies to track improvements year over year. Overall, these case studies in food production show that animal welfare, once treated as a niche concern, is now recognized as a key component of sustainable supply chain management.

The cosmetics and personal care industry offers a clear case of integrating animal welfare through the adoption of *cruelty-free* practices. In the European Union, a complete ban on animal-tested cosmetics was introduced in 2013, prohibiting the sale of any cosmetics (or ingredients) that were tested on animals anywhere in the world. (European Commission, 2013) This regulatory shift was heavily influenced by decades of campaigning from ethical businesses and NGOs. The Body Shop,

for example, was the first global beauty brand to campaign against animal testing in cosmetics - its "Against Animal Testing" initiative launched in 1991 - and it played a pivotal role in advocating for the UK's 1998 ban and subsequent EU-wide bans. (The Body Shop, n.d.) Such corporate activism demonstrated the cosmetics industry's ability to lead on welfare issues. Today, virtually all major cosmetics brands publicly commit to ending animal testing, often seeking third-party certification (such as the Leaping Bunny program) to assure consumers of their cruelty-free status. Leading multinationals have invested in alternative testing methods: for instance, Unilever has been developing non-animal safety tests since the 1980s and in 2018 endorsed a worldwide ban on cosmetic animal testing, with its flagship brand Dove earning "PETA-Approved" cruelty-free status. (Unilever, 2023) Companies like L'Oréal have funded research into reconstructed human skin models to replace animal use, further embedding humane innovation into R&D. (L'Oréal, n.d.) The cosmetics case illustrates how public opinion and corporate ethics converged to make animal welfare a core consideration: surveys consistently show that an overwhelming majority of consumers expect cosmetics to be cruelty-free, and companies have responded by institutionalizing this principle in their corporate policies. (Wuisan & Februadi, 2022) Notably, some firms have gone beyond compliance to activism; in 2021, Unilever's Dove and The Body Shop joined with animal protection groups to launch a European Citizens' Initiative urging regulators to strengthen the ban on cosmetics testing, gathering over 1.2 million signatures in support. (Unilever, 2023) This exemplifies a CSR approach in which companies not only meet ethical standards but also actively champion them in the public policy arena.

The fashion and apparel sector has traditionally been associated with products (fur, leather, wool, down) that raise animal welfare concerns, but here too companies are integrating welfare into CSR. In luxury fashion, Kering - the group behind brands like Gucci and Balenciaga - introduced comprehensive *Animal Welfare Standards* in 2019, covering all species in its supply chain. Kering's standards, made publicly available to encourage industry-wide uptake, provide detailed guidelines for the treatment of animals on farms (e.g. cattle, sheep, goats) and at slaughter, with Bronze-Silver-Gold tiers to drive continuous improvement. (Kering, 2021) This reflects a proactive corporate governance approach: animal welfare is treated as a governance issue of traceability and standard-setting across global supply chains. In parallel, many fashion houses are adopting fur-free policies in response to ethical outcry. Notably, several high-end brands (Gucci, Burberry, Prada, Versace, and others) announced fur bans in the late 2010s, citing both ethical grounds and changing consumer preferences. Stella McCartney's eponymous brand has long been a pioneer in ethical fashion, operating as a vegetarian company that eschews leather and fur entirely; it sources sustainable wool only from farms with high welfare practices (strictly avoiding suppliers that engage in painful procedures like mulesing). (Stella McCartney, n.d.) These commitments are reinforced by new industry standards and certifications. For example, the Responsible Wool Standard (RWS) and Responsible Down Standard (RDS) certify that materials like wool and down come from farms with humane practices (no mulesing, no live-plucking, etc.). (Textile Exchange, n.d.-a; Textile Exchange, n.d.-b.) Likewise, major retailers have started to demand certified animal-friendly materials from their suppliers as part of their CSR sourcing criteria. The impact of consumer opinion is especially evident in fashion: a global 2024 survey found that 70% of Americans believe fashion companies should reduce their use of animal-derived materials and invest in alternatives, and over a third of consumers worldwide say they would choose brands that prioritize animal welfare. In response, companies are not only improving farm conditions for wool, down, leather, and other materials, but also innovating with vegan

alternatives (plant-based leathers, synthetic furs) and disclosing their progress. For instance, FOUR PAWS' 2024 "Wear It Kind" report noted that more than half of surveyed fashion brands have committed to sourcing 100% mulesing-free wool by 2030, indicating a concrete industry shift toward animal-friendly production. (FOUR PAWS, 2024)

In summary, across food, cosmetics, and fashion, real-world cases demonstrate that integrating animal welfare into CSR is both feasible and increasingly expected. Companies have been updating their policies, supplier requirements, and product lines to reflect humane treatment of animals - a trend driven by ethical leadership and reinforced by consumer and investor expectations.

Discussion

The Conceptual Model of Animal-Welfare CSR (AwCSR)

The analysis above reveals that while animal welfare is gaining ground in CSR, it is not yet uniformly embedded across corporate strategies. To truly integrate animal welfare into sustainability policies, companies should embrace a comprehensive approach. Based on the literature and the analysis of practical examples, we propose the introduction of a new integrated model: Animal-Welfare CSR (AwCSR). The aim of the model is to provide a structured framework for companies to manage animal welfare strategically.

The three pillars of the model

1. Transparency: Openness and disclosure are critical for integrating animal welfare into corporate accountability. Transparency means companies consistently measure and report their impacts on animals, just as they do for carbon emissions or labor practices. By publishing clear metrics (e.g. percentage of humane-certified products, number of animals used in R&D, wildlife impacts of operations, etc.), firms make animal welfare a visible part of their sustainability profile. Frameworks like the GRI standards and BBFAW rankings facilitate this by providing reporting guidelines and benchmarks. (GRI, n.d.; Fernández-Mateo & Franco-Barrera, 2020) Transparency serves several purposes: it informs consumers and investors about the company's performance, it builds trust, and it creates internal incentives to improve (since what gets measured gets managed). As one study notes, hiding information on animal welfare (for instance, through ag-gag laws or lack of disclosure) can *undermine trust* and damage credibility. (Robbins et al., 2016) Conversely, embracing transparency - even about challenges and shortcomings - signals that a company takes the issue seriously and invites stakeholders to hold it accountable. For example, if a food company annually reports how many of its supplier farms have passed animal welfare audits, stakeholders can track progress and push for continued improvements. In the long run, industry-wide transparency can raise standards, as companies do not want to be seen lagging peers in animal welfare performance. A growing number of corporations now publish *Animal Welfare Reports* or include detailed animal welfare sections in their annual sustainability reports. For example, JBS - one of the world's largest meat processors - releases an annual Animal Welfare Report outlining key welfare indicators and initiatives in its beef and poultry supply chains, demonstrating the company's accountability for humane treatment in production. (JBS, 2023) Similarly, restaurant chains like Wendy's provide regular progress updates on animal welfare;

Wendy's has publicly reported statistics such as the percentage of cage-free eggs or crate-free pork in its supply, as part of its commitment to transparency. (Wendy's, 2024)

2. Stakeholder Engagement: Genuine integration of animal welfare also requires engaging a broad set of stakeholders in dialogue and decision-making. This includes traditional stakeholders – consumers, investors, communities – who increasingly care about how animals are treated, as well as non-traditional voices such as animal welfare organizations, veterinarians, and ethicists. By consulting experts and advocacy groups, companies can better understand animal needs and societal expectations. For instance, forming advisory panels with animal welfare scientists or partnering with NGOs to develop species-specific welfare policies allows businesses to benefit from external knowledge and credibility. Engaging stakeholders could mean holding forums with community members about coexisting with wildlife around a facility or working with small farmers in a supply chain to implement higher welfare practices. Importantly, since animals cannot speak for themselves, stakeholder engagement often involves *surrogate representation* – advocates act on behalf of animal interests. Some companies have even created the role of an "animal welfare officer" or designated teams to liaise with humane groups and oversee animal-related issues in the business. Moreover, treating animals as stakeholders conceptually encourages empathy and consideration within the corporate culture: employees at all levels become more attuned to how their decisions impact living creatures. Proactive engagement can preempt conflicts and public scandals by addressing concerns early and collaboratively. It transforms animal welfare from a niche issue into a shared goal among the company's stakeholder networks.

Many corporations have established formal mechanisms for this. One illustrative case is Wendy's Animal Welfare Council, created in 2001, which brings together outside experts (veterinarians, animal scientists, welfare auditors) alongside company officials to continually refine Wendy's animal care standards. (Wendy's, n.d.) This council meets regularly and provides advice on emerging issues (from humane slaughter techniques to housing improvements), ensuring that the company's policies are informed by the latest science and ethical perspectives. Another example is the practice of forming advisory panels or partnerships with NGOs. Nestlé's collaboration with *World Animal Protection* - the first of its kind among major food companies - is a landmark instance: through a formal partnership started in 2014, Nestlé invited the NGO to audit its global supply chains and advise on upgrading welfare standards, effectively opening itself to stakeholder input and oversight. (World Animal Protection, 2014) Such partnerships not only lend credibility (showing stakeholders that the company is serious and transparent) but also leverage specialized knowledge that companies may lack internally.

3. Ethical Accountability: Finally, deeper integration hinges on making animal welfare an internalized ethical commitment, not just an external expectation. Ethical accountability means that a company's leadership and governance structures take responsibility for animal welfare outcomes. This could be implemented by embedding animal welfare into corporate codes of conduct, just as anti-corruption or human rights commitments are encoded. Companies might expand their ethical charters to state a duty of care for animals affected by business activities. The inclusion of animal welfare in ISO 26000 is a step in this direction, framing it as part of ethical behaviour and organizational governance. Ethical accountability also involves setting up oversight mechanisms – for example, board committees or senior executives tasked with animal welfare compliance and strategy. Research suggests that when boards and top managers recognize

the *"business implications of animal welfare"* and are prepared to respond, it greatly improves policy implementation and crisis response. (Fernández-Mateo & Franco-Barrera, 2020) In essence, the company must take ownership of animal welfare as a core value. This may require going beyond legal requirements (since laws often set only minimal standards for animal treatment). Companies demonstrating ethical accountability commit to doing what is right for animals even when not compelled by law, reflecting the idea that true CSR is about voluntary ethical responsibilities in addition to economic and legal duties. (Matyášová and Tranová, 2022) When a corporation's identity includes being a protector of animal welfare, it will allocate resources, innovate, and continuously improve to uphold that principle. Such a values-driven approach helps prevent ethical lapses (like ignoring cruelty in the supply chain) and ensures long-term consistency, as decisions will be filtered through an ethical lens that includes animal interests.

In practice, this can take several forms. One is explicit corporate policies – for example, amending the company's Code of Ethics or supplier Code of Conduct to include commitments to animal welfare. Some companies have revised their codes to state that cruelty to animals is unacceptable and that the firm commits to standards of care for any animals in its supply chain. This elevates animal welfare to the same level as other fundamental principles like human rights or anti-corruption. Another manifestation is assigning clear oversight responsibility. Progressively minded firms have created high-level roles such as a Chief Animal Welfare Officer (CAWO) or established board sub-committees that review animal welfare performance. For instance, agribusiness companies like Elanco have a Chief Animal Welfare Officer among their senior management team, signaling that animal welfare is managed with the same rigor as safety or quality. (Elanco, n.d.) In the food retail sector, some boards now receive regular animal welfare briefings, and executive compensation in a few cases is tied partly to achieving welfare targets – strong indicators that accountability has taken hold. Ethical accountability also involves a willingness to go *beyond compliance*. Companies demonstrating this pillar often adopt standards stricter than local laws, especially since animal welfare legislation in many jurisdictions sets only a minimum baseline (e.g. legal cage sizes or transport times that still may not ensure good welfare). For example, Kering's Animal Welfare Standards discussed earlier not only meet legal requirements but impose additional best-practice criteria on suppliers (such as requiring environmental enrichment for farm animals and meticulous humane slaughter protocols). (Kering, 2021) By holding suppliers contractually to higher standards and auditing against them, Kering enforces ethical accountability throughout its supply chain. Another illustrative case is industry leadership in advocacy: companies that treat animal welfare as a core value will sometimes support stricter government regulations, even lobbying for reforms that level the playing field. An example is the Global Coalition for Animal Welfare (GCAW) - co-founded by Nestlé, Unilever, and others - which, while voluntary, represented a collective push to improve welfare globally and implicitly urged the wider industry toward higher norms. (Nestlé, 2018)

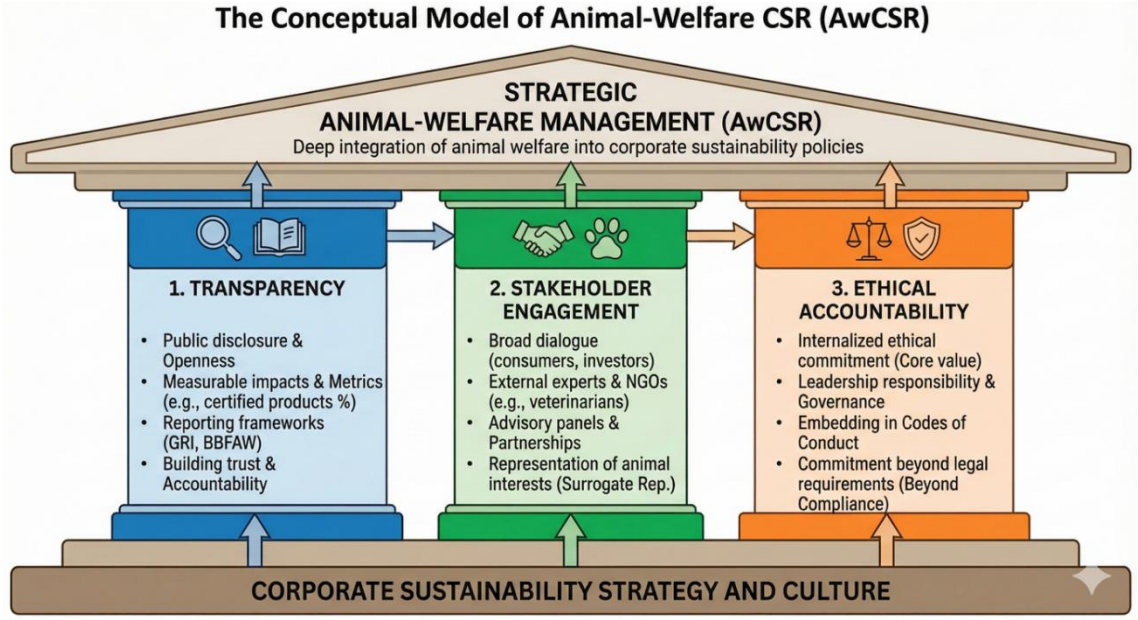

Figure 1. The Conceptual Model of Animal-Welfare CSR (AwCSR)
Source: self-made with Gemini AI

Conceptual Model Summary

These three pillars - transparency, stakeholder engagement, and ethical accountability - work in synergy. (Figure 1.) Transparency provides the data and visibility needed for accountability; stakeholder engagement brings diverse perspectives and legitimizes the company's efforts; ethical accountability ensures that concern for animals is entrenched in corporate governance and culture, not just in PR messaging. Together, they form a model where animal welfare is not an afterthought but an integrated dimension of corporate strategy and identity. A company following this model would, for example, publish an animal welfare report annually (transparency), collaborate with animal welfare NGOs and perhaps even include them in planning sustainable initiatives (engagement), and have explicit board-level oversight and ethical guidelines regarding animal treatment (accountability).

By adopting such an integrated approach, businesses can move from a reactive stance – addressing animal issues only when scandal arises or when forced by regulation – to a proactive and leadership-oriented stance. The ultimate vision is that considering animals becomes second nature in corporate responsibility, much like considering carbon footprints or community impacts is today. This not only improves the lives of animals (farm, companion, and wild) affected by business, however, also fortifies the company's sustainability profile and social legitimacy. Prior research and practitioner evidence suggest that stronger animal-welfare governance may contribute to reputational outcomes and reduced stakeholder conflict; however, effects are likely context-dependent and vary by sector. Integrating animal welfare can be framed both as a normative CSR expectation and as a component of risk management and value creation, depending on sector and stakeholder context.

Conclusion

Animal welfare is rising from a neglected afterthought to an integral component of Corporate Social Responsibility. This paper has reviewed how global frameworks are beginning to acknowledge animal interests - from ISO 26000's groundbreaking inclusion of animal welfare to sustainability goals addressing biodiversity - and how companies are gradually incorporating practices to safeguard animals in various domains. We have examined the spectrum of corporate impact on animals: farm animals in food and agriculture, companion animals in communities, and wild animals in ecosystems. Across all these areas, the trend is towards greater recognition that businesses have ethical duties toward animal stakeholders and that fulfilling these duties is part of being truly sustainable and socially responsible.

Yet, significant gaps remain. Many CSR strategies still largely focus on human-centric issues, and where animal welfare is addressed, it is often voluntary and uneven. The proposed model of transparency, stakeholder engagement, and ethical accountability offers a pathway to embed animal welfare more deeply into corporate DNA. By openly reporting animal impacts, collaborating with experts and advocates, and holding themselves to high ethical standards, companies can ensure that animal welfare is not just a PR line but a practiced principle. This development can be interpreted as an expansion of CSR's stakeholder scope toward animal stakeholders, consistent with stakeholder theory and care-ethics perspectives.

In conclusion, integrating animal welfare into CSR is both a moral imperative and a reflection of changing societal values. As consumers, investors, and international norms continue to push for compassion in business, companies that lead on animal welfare will not only mitigate risks but also differentiate themselves as ethical leaders. The "triple bottom line" of the future may well expand to a quadruple bottom line, explicitly adding animals to people, planet, and profit. By doing so, corporate social responsibility can truly live up to its promise of ensuring that business contributes positively to society - understood in the broadest sense to include all stakeholders, human and animal. Achieving wider adoption likely requires organizational change, governance commitment, and investment in monitoring, supplier engagement, and reporting mechanisms. Such an integrated approach will pave the way for more humane and sustainable business practices in the years to come, fulfilling the ethical accountability that our global community increasingly expects from corporate citizens.

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The impact of ESG integration on insurer performance: A bibliometric analysis of research trends

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Abstract: This study employs bibliometric analysis to explore the evolving landscape of Environmental, Social, and Governance (ESG) integration within the insurance industry. Utilizing a comprehensive dataset of 303 relevant publications retrieved from both Web of Science (WoS) Core Collection and Scopus databases, and advanced visualization tools like VOSviewer, the research maps key thematic clusters based on detailed keyword analysis. The findings reveal a growing scholarly focus on ESG principles as drivers of sustainable development and their increasing influence on insurer performance. Despite limited existing literature, the analysis underscores a trend toward greater adoption of ESG standards, driven by regulatory frameworks and stakeholder expectations. The study highlights the need for further research into causal mechanisms linking ESG factors to financial returns and risk profiles, as well as their long-term impacts.

Key words: insurance, ESG, sustainability, corporate social responsibility, bibliometric analysis
JEL code: G22, M14

Introduction

Environmental, Social, and Governance" (ESG) principles are founded upon the United Nations' "Transforming Our World: The 2030 Agenda for Sustainable Development" (Agenda 2030), a document unanimously adopted by 193 member states in 2015. This agenda aims to achieve balanced social development, sustainable economic growth, and environmental protection. (United Nations, 2015) ESG is gradually becoming more and more intertwined with the everyday lives of economic actors, facilitating the realization of sustainability. Financial service providers, including insurance companies, are directly affected, and indirectly as well, by the activities of the organizations they serve.

While ESG-related tasks have gradually been or are being incorporated into the everyday practice of insurers, partly on a voluntary basis and partly as a result of legal obligations, the academic literature on this topic is still quite limited. The aim of this study is to explore the evolving landscape of academic literature on ESG in insurance using bibliometric methods and to analyze its internal correlations and trends. We don't know of many such initiatives in the insurance field, but there have been at least one example of this. (Marti, Bastida-Vialcanet, & Marimon, 2024).

In contrast, there are excellent examples of research conducted in other fields using bibliometric methodology. For example, Abdi Khalife et al. conducted significant bibliometric research on the project management literature (Abdi Khalife, Dunay, & Illés, 2021), while Saadi et al. explored the literature of special project management-related topics for SMEs and in refugee projects' crisis management issues. (Saadi, Dunay, & Abdi Khalife, 2020), (Saadi, Gokce , & Dunay, 2023) Other highlightable researches focused on artificial intelligence in agriculture (Bhagat, Naz, & Magda, 2022) and on blue economy (Kabil, Priatmoko, Magda, & Dávid, 2021). These examples

confirmed the authors that bibliometric analysis is a complex and supportive tool for fixing the research gap for the selected topic.

In general, good methodological guidance is provided by the “How to conduct a bibliometric analysis: An overview and guidelines” article, created by a really international team. (Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021) Bibliometric network analysis, which involves extracting social networks from publication data, serves as a practical tool for mapping and understanding the structure of science (Zou, Yue , & Vu, 2018) These informative networks can be constructed from various metadata fields, such as the authors, their affiliated institutions, geography, publishers, or keywords associated with the research. (Chen, Liu, Luo, Webber, & Chen, 2016). For the analytical and visual exploration of these networks, VOSviewer stands out as a particularly well-regarded software tool. (Corsi, Pagani, Kovaleski, & Luiz ., 2020) (Lawal, Klink, Ndungu, & Moodley, 2019) (Yıldız, 2019) Its primary strength lies in its capacity to perform sophisticated clustering, map network structures, and visualize bibliometric information in an accessible manner. (van Eck & Waltman , 2010). Within this framework, keywords are a crucial element for analysis because they directly illuminate the central topic and intellectual contribution of each article. (Zhang, et al., 2015)

While VOSviewer excels at visualization and high-level clustering, its output can serve as the basis for more rigorous computational analysis. To achieve this, researchers can employ custom written analysis tools like the VOS_analyser Python pipeline (Juhász, 2025), which processes VOSviewer’s network files using the networkx library (Hagberg, Swart, & Schult, 2008).

Although the academic literature on the ESG obligations of insurers is currently quite limited, a substantive and interesting dialogue on this issue has begun within the academic community, especially in Europe. Marti et al. examine ESG reporting in the insurance sector, focusing on the quantity, quality and usefulness of reported Key Performance Indicators (KPIs) in their recent article. (Marti, Bastida-Vialcanet, & Marimon, 2025) Vercher-Moll diagnoses that the Principles for Sustainable Insurance (PSI) represent a significant paradigm shift, establishing a cross-cutting framework that redefines the traditional insurance business model. (Vercher-Moll, 2025) Bataller-Grau concludes that transparency for insurance entities is no longer a voluntary choice but a legally mandated duty under frameworks like the Corporate Sustainability Reporting Directive (CSRD). (Bataller-Grau, 2025) According to Kawiński's analysis while Central and Eastern European (CEE) insurance markets are less developed than their Western European counterparts, the Solvency II (European Insurance and Occupational Pensions Authority) regulatory framework is workable. Regarding ESG integration, CEE markets are underdeveloped, with low local demand for ESG products. Experts predict that while the readiness to offer ESG products is currently low, it is expected to increase. (Kawiński, 2025) Llorca Galiana interestingly connects the topic of ESG with product governance. (Galiana, 2025) Marano and del Val Bolívar Oñoro find that a major challenge for the effectiveness of ESG ratings is the lack of a unified, prescriptive social taxonomy within the EU legal framework. (Marano & del Val Bolívar Oñoro, 2025) Martínez concludes that insurers marketing Insurance-Based Investment Products (IBIPs) are now operating under a complex and detailed legal framework of transparency obligations, primarily driven by the SFDR and Taxonomy Regulation. The main purpose of this new framework is to provide policyholders with mandatory and comprehensive sustainability information on how insurers integrate ESG criteria into their governance and how the social and environmental impacts of their products are

managed. (Martínez, 2025) Petelczyc examines the issue of pensions in the light of climate risks. (Petelczyc, 2025) Kosi and Relard examine whether the announcement and passing of the CSRD impacts the sustainability reporting of German firms. (Kosi & Relard, 2024)

The comprehensive analysis conducted for this study reveals a period of substantial and dynamic expansion in academic publishing. It is indicated by a notable intensification of scholarly activity and communication. The trend is not geographically constrained, as it is observable on a worldwide scale; however, the analysis underscores its pronounced manifestation within the European research ecosystem, which is experiencing a parallel and equally robust increase in scientific contributions.

1. Methodology

This study employs a systematic literature review combined with bibliometric network analysis to map the intellectual structure of research at the intersection of ESG principles and the insurance industry. The methodology is structured into three main phases: (1) data sourcing and search strategy, (2) data screening and preparation, and (3) analytical techniques for network mapping and quantitative analysis.

Data Sources and Search Strategy

Data Sources

To ensure comprehensive coverage of high-impact scholarly literature, two leading academic databases were utilized: Web of Science (WoS) Core Collection and Scopus. These databases are renowned for their extensive indexing of peer-reviewed journals, conference proceedings, and books, making them ideal sources for a robust bibliometric study.

Search Strategy

A sophisticated Boolean search query was developed to precisely identify relevant literature. The query was designed to capture three core conceptual pillars:

Core ESG Concepts and Practices - This component included the primary term "ESG" and its full form, linked with terms related to its application and measurement, such as Factor*, Practic*, Strateg*, Complian*, Report*, and Perform*.

Related Regulatory and Thematic Concepts - This component broadened the search to include key related themes and regulatory frameworks that are central to the sustainable finance discourse, such as "greenwashing", "sustainable finance", and specific EU regulations like SFDR, ESRS, CSRD, and the "EU Taxonomy".

Domain Focus - To constrain the results to the relevant industry, the query required the presence of terms related to the insurance and life assurance sector (insur* OR "life assurance"). This focus was chosen to address the unique challenges and strategic importance of ESG integration within the risk management and long-term investment functions of the insurance industry.

The final combined search string executed in both databases was:
(("ESG" OR "Environmental Social Governance") AND (Factor* OR Practic* OR Strateg* OR Complian* OR Initiativ* OR Implement* OR Report* OR Perform* OR Rating* OR law OR legal)) OR ("greenwashing" OR "sustainable finance" OR SFDR OR ESRS OR CSRD OR "Corporate Sustainability Reporting" OR "EU Taxonomy" OR "Non-Financial Reporting") AND (insur* OR "life assurance")

The search was conducted on October 20, 2025, with no date restrictions applied to capture the entire historical evolution of the topic.

Data Screening and Preparation

The records retrieved from both databases were exported as .ris files and subsequently merged. The following data screening and cleaning protocol, inspired by the PRISMA framework, was applied:

Initial Compilation - The initial search yielded 265 records from Scopus and 185 from Web of Science, resulting in a raw dataset of 450 documents.
An automated deduplication process was performed based on document titles and DOIs, which identified and removed 134 duplicate records. This step resulted in a corpus of 316 unique documents.

Relevance Screening - The titles and abstracts of the 316 unique records were manually screened for relevance to the research questions. During this stage, 13 records were deemed irrelevant and excluded.

Final Corpus - The final dataset for analysis consisted of 303 unique and relevant records.
Following the screening, the bibliographic data, particularly keywords, underwent a normalization process to ensure analytical consistency. This involved merging plural and singular forms (e.g., "bank" and "banks" were consolidated) and standardizing common abbreviations with their full forms (e.g., CSR, SDG, ESG) to prevent fragmentation in the network analysis.

Analysis Techniques

The finalized dataset containing the 303 curated records was imported into VOSviewer (van Eck & Waltman , 2010) to conduct a bibliometric analysis. A keyword co-occurrence analysis was selected as the primary analytical method. This approach was chosen because preliminary assessments revealed that the author and institutional networks were highly fragmented with low document counts per entity, making them unsuitable for identifying meaningful collaborative structures. Keyword analysis, in contrast, is highly effective at revealing the thematic structure and intellectual core of a research field. To improve the resolution and interpretability of the network, a crucial filtering step was implemented. The foundational keywords used in the search query, specifically "ESG," "sustainability," and "insurance", were deliberately excluded from the co-occurrence analysis. This methodological choice prevents these ubiquitous terms from creating a

dense, centralized network structure, thereby allowing for a more granular visualization of the nuanced thematic clusters and sub-topics within the field.

To move beyond the visual capabilities of VOSviewer and gain deeper quantitative insights, the network data was exported as a node-edge list in CSV format. This file was then processed using the VOS_analyser Python pipeline (Juhász, 2025). This custom-built tool leverages the powerful networkx package (Hagberg, 2008) to perform a detailed computational analysis of the network's topology, allowing for the calculation of centrality metrics, community detection, and the identification of structurally important themes that are not apparent from visualization alone.

2. Results

Publication timeline

The following picture emerges when looking at the number of publications published annually within the research area. There is a dramatic increase in the volume of publications from 2020 onwards. Prior to this period, research in this area was sparse. In the early years, between 2004 and about 2020 the field was in its infancy, with very low and sporadic publication activity across all countries. The period starting in 2020 marks a clear inflection point. Nearly all countries represented show a steep rise in research output, signaling a global academic and industry-wide mobilization around the topics of ESG and sustainable insurance. The dynamic growth starting in 2020 indicates that the intersection of these fields has rapidly evolved from a niche topic to a major area of academic inquiry. This growth phase aligns with global patterns in sustainability reporting, ESG regulation, and the increasing attention of both policymakers and academic publishers.

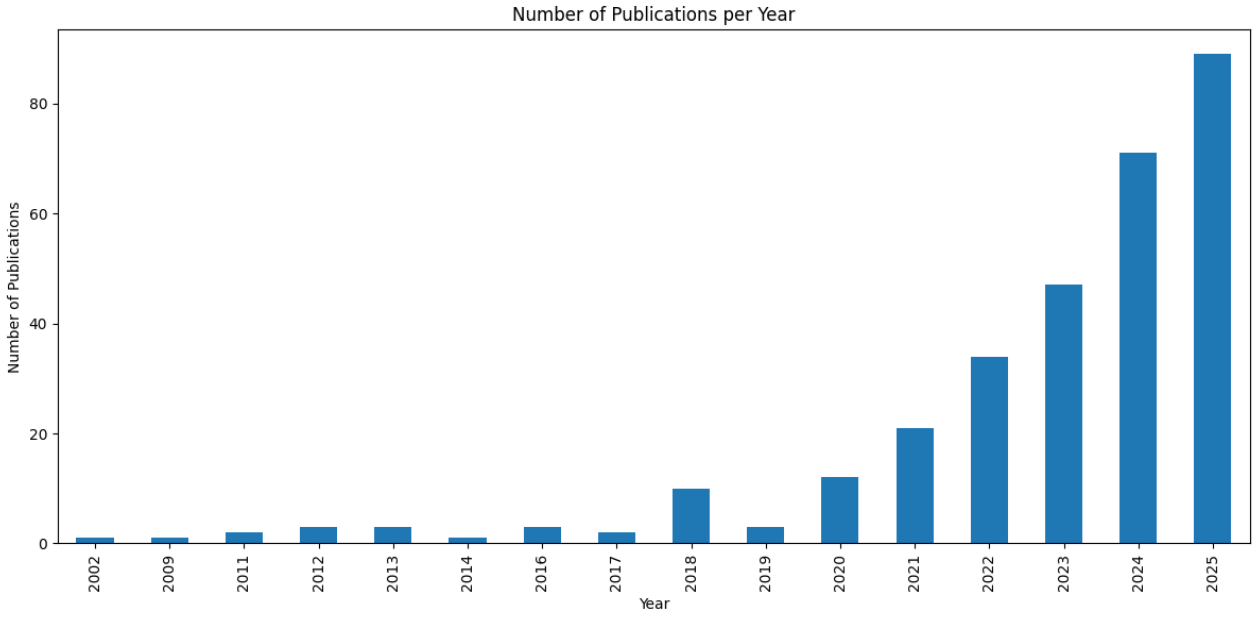

Figure 1. Number of publications per year
Source: own compilation

Distribution of publications by country

The research topic has come to the fore in America, Asia, and Europe, but we see significant differences in the publication performance of individual countries. The Figure 2 below illustrates the number of academic publications by country over time, revealing a significant and recent surge in research focused on ESG, insurance, and sustainability. (Countries are defined by affiliation of the first author.)

Leading Countries are China, the United States, European Nations and India. After a period of minimal output, China's research contributions have grown exponentially, positioning it as the clear leader in publication volume. The U.S. has been a consistent contributor over the years and also shows a significant increase in recent activity. Several European countries are key contributors, like Italy, Germany, the United Kingdom, Spain, the Netherlands, and Poland. India's research output has also grown notably in recent years.

The observed trends in publication data reflect fundamental shifts in the global economy, regulatory landscapes, and the insurance industry's role in addressing sustainability challenges. The sharp increase in research since 2020 is known to have three main, interrelated drivers. It mirrors a growing global consensus on the financial materiality of ESG factors. This surge is likely driven by:

- *Climate-Related Risks:* The increasing frequency and severity of natural disasters have forced the insurance industry – whose core business is risk management – to intensify its focus on climate change. Research is essential for modeling future risks, adapting underwriting practices, and developing new insurance solutions.
- *Regulatory and Policy Drivers:* Governments and international bodies are implementing stricter regulations. Initiatives like the European Union's Sustainable Finance Disclosure Regulation (SFDR) (European Commission) and national commitments to carbon neutrality including China's 2060 goal (Euractive) create an urgent need for research to guide compliance and strategy.
- *Investor Pressure:* As major institutional investors, insurance companies are under increasing pressure from stakeholders to integrate ESG criteria into their vast investment portfolios. This has spurred research into sustainable investment strategies and the long-term performance of ESG-focused assets.

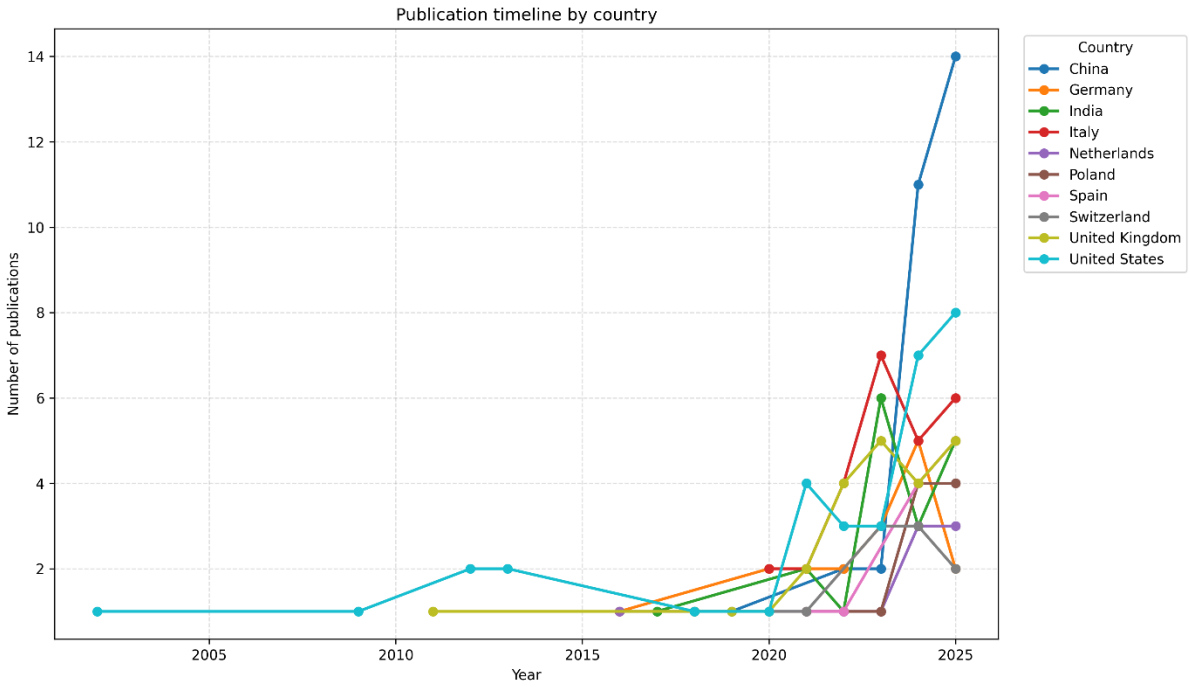

Figure 2. Publication timeline by country
Source: own compilation

Leading authors, institutions, journals

The analysis of authorship indicates that in the in the sample of 303 publications examined we find twelve scholars who list two or more works as first authors as detailed in the Table 1.

Table 1. Top first authors by publication

Top first authors	Documents
Bressan, S.	3
Chen, S.	3
Gatzert, N.	3
Marti, A.	2
Curcio, D.	2
Zhang, Y.	2
Lament, M.	2
Sibindi, A.B.	2
Sood, K.	2
Decker, D.K.	2
Lament, M.	2
Cheng, LTW,2	2

Source: own compilation

Based on the affiliation of the first author, there are 15 universities or other academic institutions that have 2 or more publications. The list of such institutions is detailed in Table 2.

Table 2. Top first affiliations by publication

Rank	Institution	Frequency
1	University of South Africa, Department of Finance, Pretoria, South Africa	5
2	Free University of Bozen-Bolzano, Faculty of Economics and Management, Bolzano, Italy	3
3	University of St. Gallen, St Gallen, Switzerland	3
4	University College London, London, United Kingdom	3
5	Chitkara University, Punjab, Rajpura, India	3
6	Universitat Internacional de Catalunya, Barcelona, Spain	2
7	Southwestern University of Finance and Economics, School of Economics, Chengdu, China	2
8	Dipartimento di Management, Venice, Italy	2
9	Saint Petersburg University of Management Technologies and Economics, Saint Petersburg, Russian Federation	2
10	Henry L Stimson Center, Washington, D.C., United States	2
11	Christ University, Bengaluru, India	2
12	Universita degli Studi di Milano-Bicocca, Department of Business and Law, Milan, Italy	2
13	Friedrich-Alexander-Universität Erlangen-Nürnberg, School of Business, Erlangen, Germany	2
14	Universita degli Studi di Napoli Federico II, Naples, Italy	2
15	Clyde & Co, London, United Kingdom	2

Source: own compilation

Regarding the publication type more than two-thirds of the publications are journal articles (210 out of 303). The list of the top 20 journals by publication frequency is shown in the figure below.

Figure 3. Leading journals by publication frequency

Source: own compilation

Results of the keyword analysis

The overall research resulted in the top 20 keywords shown in the Figure 4 below.

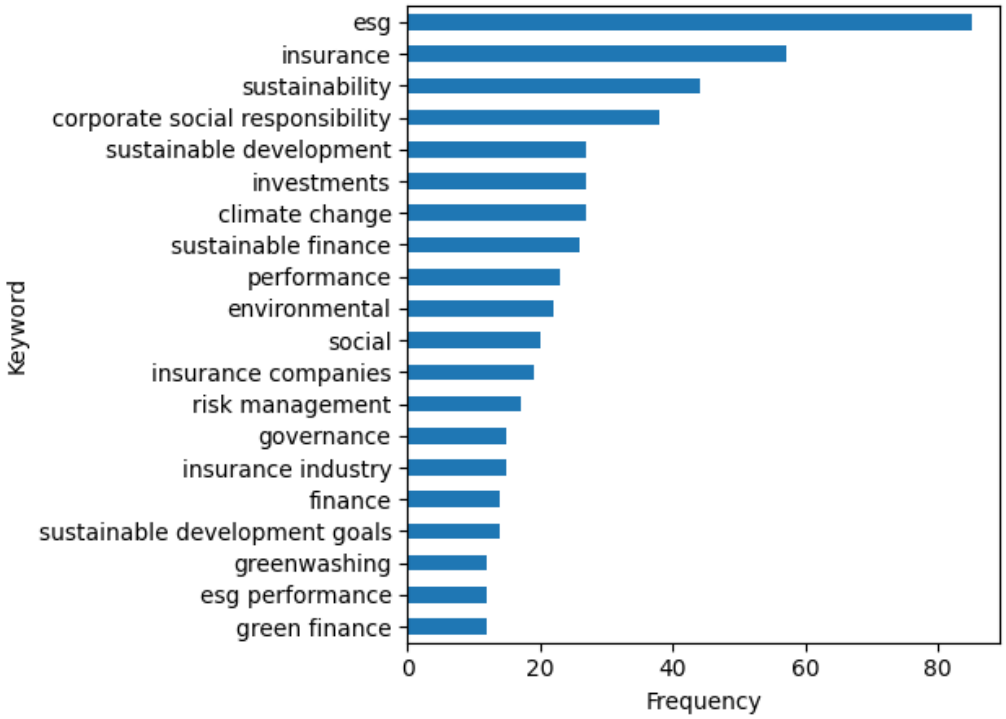

Figure 4. Top 20 keywords of the research
Source: own compilation

Given the relatively small number of items, in order to ensure that the header keywords do not distort the evaluation results, we removed the following keywords from further analysis: “esg”, “insurance” and “sustainability”. However, when evaluating the results and drawing conclusions, the context of insurance, esg and sustainability must be kept in mind.

Keyword Co-occurrence and centrality analysis

A keyword co-occurrence network was generated from the 1.489 keywords present in the dataset, with a minimum occurrence threshold of 6, resulting in a network of 5 key concept clusters. The full network is visualized in Figure 5.

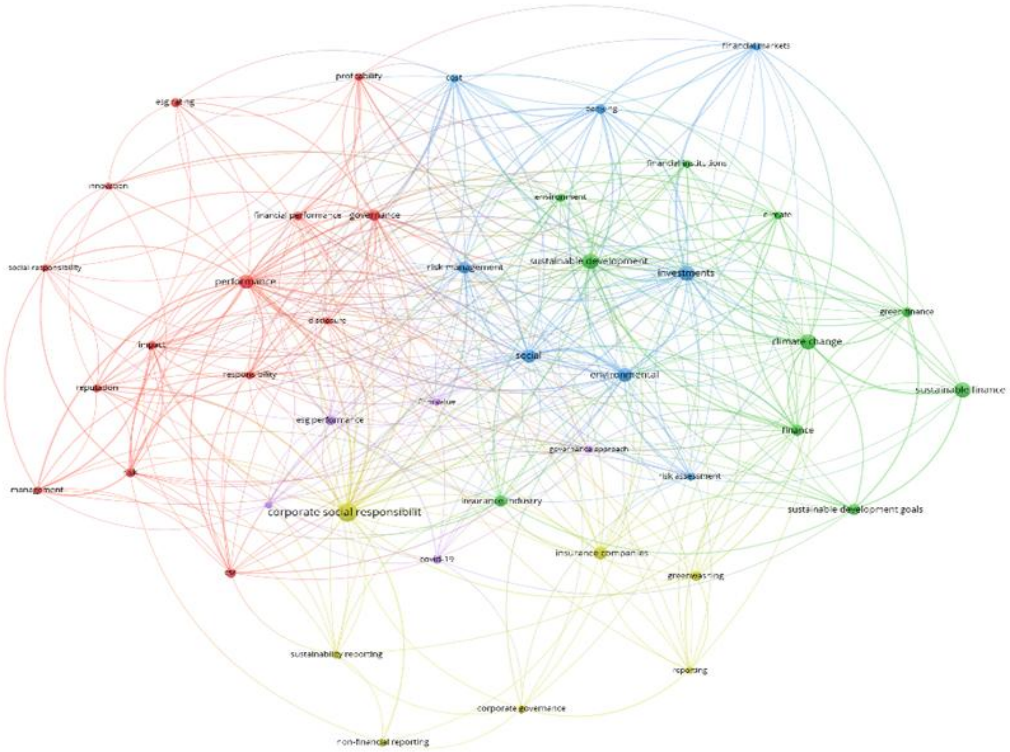

Figure 5. Keyword co-occurrence network
Source: own results prepared by VOSviewer

To perform an objective assessment of the importance of each keyword, we first examined their frequency and network connectivity, and then performed a detailed centrality analysis as follows. The Table 3 below contains the most frequently occurring keywords in the research results. The data show that „corporate social responsibility" (38 occurrences), „climate change" (27), „investments" (27) and „sustainable development" (27) are the most common terms.

Table 3. Top 10 keywords by occurrence count

Rank	Keyword	Occurrences
1	corporate social responsibility	38
2	climate change	27
3	investments	27
4	sustainable development	27
5	sustainable finance	26
6	performance	23
7	environmental	22
8	social	20
9	insurance companies	19
10	risk management	17

Source: own results

A more structurally accurate picture is provided by the Total Link Strength (TLS) metric, which shows the combined strength of a keyword's occurrence with all other keywords. As detailed in the below table, "performance" (TLS: 94), "investments" (TLS: 81), "corporate social

responsibility" (TLS: 78), "social" and "environmental" emerge in such a way that the first one stands out far away, while the other four appear almost head-to-head.

Table 4. Top 10 keywords by link strength

Rank	Keyword	Total Link Strength
1	performance	94
2	investments	81
3	corporate social responsibility	78
4	social	77
5	environmental	75
6	sustainable development	66
7	climate change	58
8	risk management	50
9	banking	49
10	governance	48

Source: own results

Network Centrality Analysis

In order to gain a more precise and multidimensional understanding of the structural importance of each keyword, we calculated four separate centrality metrics. The aggregated results for the eight most important keywords are presented in the table below, allowing for a comparison of the structural role of each term.

Table 5. Consolidated centrality metrics for top keywords

Rank	Keyword	Degree c.	Betweenness	Closeness	Eigenvector
1	CSR	0.8140	0.0747	0.8431	0.2510
2	performance	0.7674	0.0403	0.8113	0.3351
3	investments	0.7209	0.0481	0.7818	0.2940
4	social	0.7209	0.0328	0.7818	0.3241
5	environmental	0.6977	0.0295	0.7679	0.3275
6	risk management	0.6744	0.0328	0.7544	0.1842
7	sustainable development	0.6512	0.0329	0.7414	0.2428
8	climate change	0.5814	0.0269	0.7049	0.1841

Source: own results

The high *degree centrality* of keywords like "corporate social responsibility," "performance," and "investments" indicates a research field strongly centered on the intersection of business practices and societal impact. This network structure suggests a focus on how environmental and social factors ("environmental," "social," "climate change") influence business operations and financial outcomes ("cost," "risk management," "sustainable development"). Furthermore, the inclusion of "governance" highlights the importance of institutional frameworks in shaping these relationships, implying a field actively exploring the integration of sustainability and ethical considerations into core business strategies and investment decisions.

The high *betweenness centrality* of keywords like "corporate social responsibility," "investments," and "risk management" suggests a research field deeply concerned with the financial implications

of sustainability. These keywords highlight how researchers are investigating the relationships between business activities, environmental and social impacts, and financial performance. The inclusion of terms like "climate change" and "governance" further emphasizes a focus on the broader societal implications of corporate actions and the frameworks used to manage and mitigate associated risks. This structure indicates a field striving to bridge the gap between financial success, environmental stewardship, and social responsibility.

The high *closeness centrality* of keywords like "corporate social responsibility," "performance," and "investments" indicates a tightly integrated research field where these concepts are central hubs, facilitating rapid information flow. The inclusion of "social," "environmental," "risk management," and "sustainable development" suggests a strong emphasis on the interconnectedness of these aspects within the field. This structure highlights a focus on how CSR initiatives impact financial performance of insurers, are influenced by environmental and social considerations, and are managed to mitigate risk, all while contributing to sustainable development and mitigating climate change.

The high *eigenvector centrality* of these keywords indicates a tightly interconnected and influential research field. This network structure suggests a strong focus on the intersection of business and sustainability, with a clear emphasis on how performance, investments, and risk management are intertwined with environmental and social considerations within the insurance industry. The presence of "corporate social responsibility," "sustainable development," and "climate change" further reinforces this focus, pointing to a field grappling with the challenges and opportunities of integrating sustainability into core insurance business practices. This signifies a well-established research field where environmental and social aspects are seen as critical factors impacting business strategy and financial outcomes.

Thematic Cluster Analysis

The keyword co-occurrence network was further analyzed to identify distinct thematic clusters of primary research directions. The analysis, based on the VOSviewer clustering algorithm, grouped the 1489 keywords into five clusters. A summary of five clusters, including their coherence scores and top constituent keywords, is provided in table 6 below. A higher coherence score indicates a more closely related and internally consistent set of keywords within a cluster.

Table 6. Summary of Thematic Keyword Clusters

Cluster ID	Coherence	Top Keywords
1	3.1786	financial markets, risk assessment, risk management, environmental, investments
2	2.4000	sustainable development goals, sustainable development, financial institutions, sustainable finance, insurance industry
3	1.9123	financial performance, social-responsibility, responsibility, profitability, performance
4	1.4286	corporate social responsibility, sustainability reporting, non-financial reporting, corporate governance, insurance companies
5	1.2857	governance approach, stakeholder theory, esg performance, firm value, covid-19

Source: own edition

Cluster 1: intersection of financial markets and risk, with a strong emphasis on environmental considerations and investments.

The high coherence score of 3.1786 suggests a strong thematic link between the key concepts. The dominant keywords, including "financial markets," "risk assessment," "risk management," "environmental," and "investments," indicate a focus on how financial activities are impacted by and influence environmental factors. This likely explores areas such as Environmental, Social, and Governance (ESG) investing, climate-related financial risk, and the valuation of companies based on their environmental performance. The presence of "financial markets" alongside "social" and "environmental" in the recent keywords, coupled with the timeframe, suggests a focus on the evolving landscape of sustainable finance. This suggests research focused on how insurers and investors are incorporating ESG factors into their decision-making processes, the development of green financial instruments, and the management of environmental risks within financial institutions. The chronological data (2023-2024) shows it's a rapidly evolving area of research, focused on the immediate implications of environmental and social trends on the financial services sector, like insurance.

Cluster 2: intersection of sustainable development goals (SDGs) and the role of the financial industry in achieving them.

The analysis highlights a strong focus on sustainable finance and the contributions of financial institutions, including the insurance industry, towards sustainability efforts. The cluster indicates a strong coherence, signified by a Coherence Score of 2.4000, suggesting a well-defined and interconnected set of concepts. The presence of keywords like "climate" further emphasizes the link between sustainability goals and addressing environmental challenges. The recent keywords, including "sustainable development goals (2024)" and "climate (2023)," suggest a current and ongoing interest in this area. Specifically, the cluster's focus on the "insurance industry (2023)" alongside sustainable development reflects a growing awareness of the insurance sector's potential to both mitigate risks associated with climate change and support sustainable practices through investment and underwriting. This indicates a dynamic research landscape that is likely exploring innovative financial instruments and strategies aimed at facilitating the transition towards a more sustainable and resilient future, guided by the framework provided by the SDGs.

Cluster 3: intersection of financial performance and social responsibility.

This cluster demonstrates a strong coherence with a score of 1.9123. The core keywords highlight a central concern with how firms manage their financial outcomes while incorporating and reporting on their social obligations. The prominence of "financial performance," "profitability," and "performance" alongside terms like "social-responsibility" and "responsibility" suggests an investigation into the potential synergies or trade-offs between these aspects. This cluster likely explores the impact of social and environmental initiatives, or Environmental, Social, and Governance (ESG) factors, on a company's bottom line. The recent keyword activity reinforces this interpretation, with the inclusion of "ESG rating" and "disclosure" indicating a timely focus on the evaluation and reporting of a company's non-financial performance. The presence of "financial performance" and "profitability" in 2023 and 2024 demonstrates a sustained interest in the financial aspects of these relationships.

Cluster 4: intersection of corporate social responsibility (CSR), sustainability reporting, and corporate governance, specifically within the context of insurance companies.

The high coherence score (1.4286) suggests a strong and unified connection between these concepts. The keywords indicate a focus on how insurance companies are increasingly being held accountable for their environmental and social impacts. This involves the disclosure of non-financial information, particularly through sustainability reporting, to stakeholders. Keywords such as “greenwashing” are also integral here, indicating a critical awareness of the potential problems associated with misleading claims about sustainability efforts.

The recent keyword activity, including "sustainability reporting" (2023), further reinforces the ongoing relevance and growth of this theme. Keywords such as "corporate governance" (2022) and "insurance companies" (2022) highlight the governance structures and organizational contexts within which CSR and sustainability reporting initiatives are implemented. Overall, this cluster points to an evolving landscape where insurance companies are under increasing pressure to demonstrate their commitment to environmental and social responsibility, and where the efficacy and transparency of their reporting practices are paramount for building trust and mitigating reputational risks.

Cluster 5: intersection of corporate governance, stakeholder engagement, and firm performance, particularly in the context of Environmental, Social, and Governance (ESG) considerations and the impact of the COVID-19 pandemic.
The core keywords – "governance approach," "stakeholder theory," "ESG performance," and "firm value" – explicitly link the methodologies companies employ to manage their affairs, their consideration of various stakeholders beyond just shareholders, and the subsequent effects on their financial and overall performance. The inclusion of "COVID-19" suggests a focus on how these relationships have been affected or accelerated by the pandemic, potentially exploring how governance structures, ESG initiatives, and stakeholder relationships aided or hindered companies during this period of significant disruption. The appearance of "stakeholder theory" in 2024 and "ESG performance" in 2023, coupled with the prominence of "COVID-19" and "governance approach" in 2023, and "firm value" in 2022 suggests a dynamic and evolving research landscape. With a Coherence Score of 1.2857, the cluster demonstrates a reasonable degree of interconnectedness among the concepts, indicating a consistent thread tying these keywords together.

Temporal Analysis

To explore the evolution of topics covered by publications over time, a temporal analysis was performed, assigning each keyword an average publication year based on the documents in which it appeared. The results are presented in the Figure 6 below as an overlay visualization, where older concepts are shown in blue and newer, “hot” topics are shown in yellow.

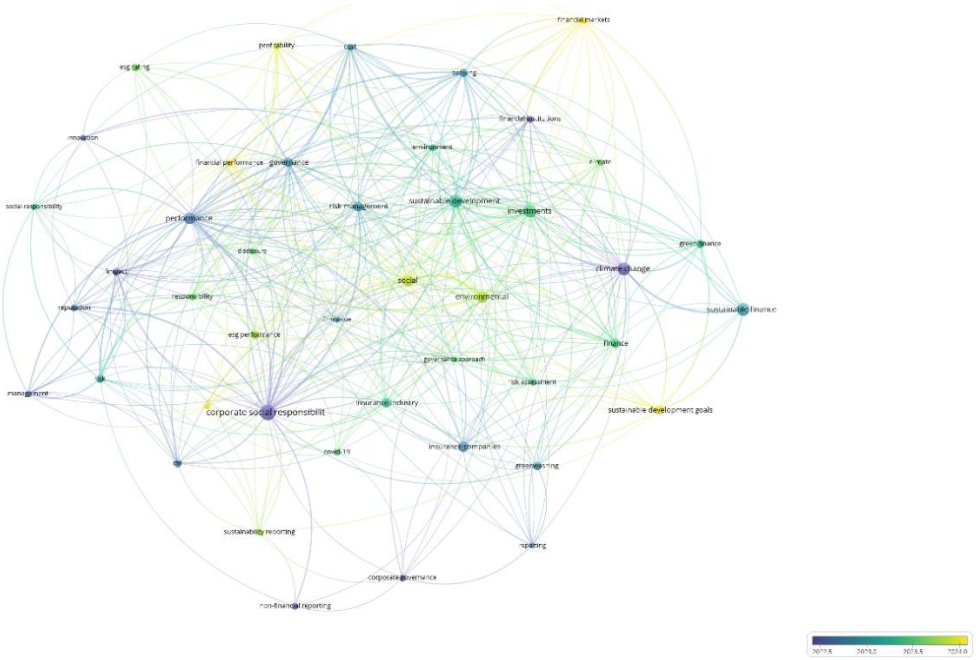

Figure 6. Temporal overlay of the keyword co-occurrence network
Source: own edition prepared by VOSviewer

The table below lists the ten most recent keywords in the network, ranked by their average publication year. The convergence of these keywords signals a burgeoning research front focused on the intricate interplay between financial markets and sustainability. The prevalence of "financial performance," "profitability," and "ESG rating" alongside "sustainable development goals (SDGs)," "social," "environmental," and "ESG performance" suggests a shift towards quantifying and integrating sustainability metrics into traditional financial analysis. "Stakeholder theory," "sustainability reporting," and "ESG rating" highlight the growing importance of transparent data, accountability, and the recognition of broader stakeholder interests beyond shareholders. This trend indicates a future trajectory characterized by a deeper understanding of how ESG factors influence financial outcomes, the development of more sophisticated ESG rating methodologies, the evolution of new financial instruments supporting sustainable development, and a push for greater corporate transparency and accountability in the pursuit of both financial and societal value creation.

Table 7. Most recent keywords across entire network

Rank	Keyword	Average Publication Year
1	financial markets	2024.3750
2	sustainable development goals	2024.1429
3	financial performance	2024.0000
4	stakeholder theory	2024.0000
5	profitability	2023.8571
6	social	2023.8500
7	environmental	2023.7727
8	ESG performance	2023.7500
9	sustainability reporting	2023.7500
10	ESG rating	2023.6000

Source: own edition

Keyword-level analysis

The research field appears fundamentally structured around the interconnectedness of corporate performance, environmental considerations, and social responsibility. 'Performance' acts as a central hub, directly linked to 'environmental impact' and, indirectly, through 'corporate social responsibility' and 'social' themes. 'Investments' and 'financial markets' form another crucial nexus, indicating a focus on funding and economic drivers of sustainability initiatives. The strong connection between 'corporate social responsibility', 'performance', and 'reputation' suggests a focus on the benefits of good social and environmental practices. Furthermore, 'social' links with 'environmental' and 'governance' underscores the importance of the interconnected issues and how they form the backbone of the field.

Table 8. Top 10 strongest connections for the 5 most influential keywords by connection strength

Keywords	**Influential**				
Connected	**performance**	**investments**	**CSR**	**social**	**environmental**
environmental, environment	7	3	3	15, 3**	
impact	7				
corporate social responsibility, CSR	6		3*	5	3
social	6		5		15
management	5				
cost	4	5	2	2	3
investments	4				3
reputation	4		6		
responsibility	4				
risk, risk management, risk assessment	4	3	6	3	3
sustainable development		9	3		
financial markets, finance		8		3	3
climate, climate change		7		3	3
banking		5		4	4
performance		4	6	6	7
profitability		4			
green finance		3			
disclosure			3		
non-financial reporting			3		
governance				6	5

* "csr"
** "environment"

Source: own research results

3. Discussion

The findings of this analysis converge on a central, unequivocal theme: the profound and accelerating integration of Environmental, Social, and Governance (ESG) factors into the fundamental architecture of financial decision-making and corporate strategy. This evolution signifies more than a marginal adjustment; it represents a paradigm shift toward a system of sustainable finance, where non-financial considerations are recognized as material drivers of investment strategies, comprehensive risk assessment, and long-term corporate performance. The intricate interconnectedness of the themes identified in our analysis indicates that this is not a siloed movement, but a holistic transformation reshaping the modern corporation.

At the heart of this transformation lies the indispensable role of corporate governance and authentic stakeholder engagement. Our research highlights that robust governance structures and a committed application of stakeholder theory are the primary mechanisms through which abstract ESG principles are translated into tangible firm value and enhanced resilience. This dynamic was thrown into sharp relief by disruptive global events, most notably the COVID-19 pandemic. The crisis acted as an unprecedented catalyst, not only accelerating awareness but compelling the practical implementation of ESG-aligned practices. It underscored the critical importance of stakeholder-centric strategies and adaptive governance models in navigating uncertainty, reinforcing the argument that companies with strong ESG credentials are better positioned to weather systemic shocks.

This heightened stakeholder focus inevitably places a spotlight on the credibility of sustainability reporting and transparency. The analysis reveals an evolving and increasingly scrutinized landscape of non-financial reporting, where the demand for accountability is paramount. This creates a dual challenge: while companies are pressured to disclose more, they simultaneously face the significant reputational and financial risks associated with "greenwashing." Consequently, the discussion within the literature forcefully argues for the urgent development and adoption of robust measurement, verification, and disclosure practices. Such frameworks are essential not only for building and maintaining stakeholder trust but also for providing the reliable data needed for accurate asset pricing and risk management.

Within this evolving ecosystem, our analysis positions the financial sector – particularly the banking and insurance industries – as pivotal agents of change. As the primary capital allocators and risk managers in the global economy, these institutions are central to advancing the entire sustainable finance agenda. There is a growing expectation, driven by regulators and investors alike, that banks and insurers will systematically incorporate ESG considerations into their most core operations. This includes everything from underwriting policies and credit risk assessments to the structuring of investment portfolios and the innovation of new financial products that support sustainability goals.

Despite this clear momentum, the path to full ESG integration is not without significant hurdles and unanswered questions, which in turn illuminate a rich agenda for future research. The study identifies several practical challenges, including persistent issues with data quality and transparency, the complexity of navigating fragmented and rapidly changing regulatory frameworks, and the ongoing struggle to effectively manage and penalize greenwashing. These

challenges point to clear gaps in the current body of knowledge. Future research must prioritize establishing clearer causal mechanisms that link specific ESG activities to tangible financial returns. Furthermore, there is a pressing need to develop more sophisticated methodologies for assessing and pricing climate-related physical and transition risks, improve and standardize global sustainability reporting frameworks, and explore how companies in emerging economies are adapting their business models in response to these global pressures.

Ultimately, the overarching conclusion drawn from this research is that the systemic embedding of ESG principles into financial and corporate frameworks transcends the goals of individual firms. It is a fundamental component in the construction of a more sustainable, equitable, and resilient global economic system that can deliver long-term benefits to society as a whole. These discussion points, taken collectively, frame the dynamic and critically important intersection of sustainability, finance, governance, and corporate responsibility. The implications are far-reaching, presenting a complex but essential agenda for policymakers, industry players, and academic researchers to collaboratively address in the years to come.

4. Conclusion

The publication trends indicate a profound evolution in the insurance industry's role. The focus is expanding from a traditional, reactive role of paying claims to a proactive one aimed at fostering a sustainable future. This is reflected in the following research on the topic:

- *Innovative Products:* Developing insurance for renewable energy projects, carbon capture technology, and policies that incentivize sustainable practices (e.g., discounts for green buildings).
- *Advanced Risk Management:* Moving beyond historical data to create predictive models for climate, social, and governance risks.
- *Insurers as Investors:* Analyzing the dual role of insurers as both risk carriers and influential investors who can drive capital towards sustainable outcomes.

In conclusion, the data clearly visualizes the mainstreaming of ESG within the insurance and sustainability discourse. The explosive growth in research since 2020, led by China and strongly supported by the U.S., Europe, and India, signals a global academic and industrial effort to understand and manage the complex risks and opportunities of a transition to a more sustainable economy.

The *keyword analysis* paints a clear picture: the intersection of financial markets, CSR, and sustainable development is becoming increasingly central. Performance, investments, and CSR act as key bridges, driving this integration. Research confirms growing interest in understanding how ESG factors affect financial performance, risk management, and overall firm value. The analysis highlights a dynamic environment where financial institutions, including insurers, corporations, and stakeholders are actively adapting to incorporate ESG principles and practices. This includes recognizing and addressing risks associated with environmental challenges and social responsibility. The emerging trends point toward enhanced monitoring, reporting, and investment strategies that are aligned with sustainable goals.

The results highlight that the integration of ESG considerations into financial markets including insurance industry, corporate governance, and decision-making processes is becoming increasingly central. The research underscores a clear trend toward more sophisticated assessment methodologies, greater transparency, and stakeholder engagement driven by investor, regulator, and societal pressures. The findings suggest that companies and financial institutions are actively adapting to incorporate sustainability metrics, which enhances risk management and long-term value creation. Furthermore, the study notes that emerging trends emphasize the importance of quantitative measurement of ESG impacts on firm performance and the development of innovative financial instruments supporting sustainable development. The conclusion is that this evolving landscape fosters a more sustainable, resilient financial system that benefits broader societal well-being and addresses pressing environmental and social challenges.

Identified Research Gaps & Future Directions

Future research should focus on several critical areas. Despite the clear focus on performance, studies need deeper explorations into the causal mechanisms linking ESG factors to financial returns and risk profiles. Longitudinal studies are needed to understand the long-term effects of ESG initiatives on insurance company performance and their contribution to broader societal goals. Further exploration of emerging trends, such as the use of ESG ratings and sustainable finance strategies, is crucial. Greater attention should be directed towards the integration of climate risk modeling into insurance pricing and risk assessment. Exploring the implications of stakeholder theory and the increasing importance of social and environmental factors in driving investment decisions is essential to build on the understanding of this evolving landscape.

Furthermore, continued investigation is required of the effectiveness of sustainability reporting standards and their influence on corporate behaviour. Future studies should focus on how companies are creating and managing new business models based on the emerging demands of ESG and stakeholder management, especially in emerging economies.

Limitations of the study

The scope of this analysis is defined by the Web of Science (WoS) Core Collection and Scopus database. While these are the most important sources of high-impact researches, these do not encompass all academic publications. In addition, a bibliometric mapping is necessarily a static representation of a dynamic process, even if the temporal analysis reveals the evolutionary trajectory of key concepts.

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In the Crosshair: Plastic Waste Trade

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Abstract: This paper explores the most recent developments in international plastic waste trade from a Southeast Asian perspective and the efforts of Thailand to keep the transboundary flow of plastic waste into its territory under control. The research also examines the international and regional legal background intended to enforce the sustainability requirements of environment quality as well as to regulate the international trade of plastic scraps as hazardous materials. Reference will be made to the ongoing consultations in international for a with a view to improving the available legal structures and mechanisms meant to address plastic waste challenges. The present study also briefly addresses the term of 'waste colonialism' as a theoretical approach of the flow of hazardous plastic leftovers between certain countries and regions. The paper concludes that the ban on plastic waste imports constitutes merely a temporary, though applauded, measure, it is essential to elaborate long-lasting methods to tackle the undesirable environmental and health repercussions these adverse trade flows may prompt.

Keywords: plastic pollution, global plastic waste trade, international trade, plastic waste management, Southeast Asia
JEL codes: F18, Q53, Q56

1. Introduction

As of January 2025 a new era kicked in in Thailand. The Southeast Asian kingdom enacted a total ban on the import of plastic waste, marking a significant shift in its waste management policies. This move reflects the country's growing commitment to environmental sustainability and reducing the adverse impacts of plastic pollution. The ban comes in response to increasing concerns about the global plastic waste crisis and Thailand's previous role as a prominent destination for foreign plastic waste trade. 'Thailand must not be a dump site for plastic waste', announced the Thai minister for environmental issues, *Varawut Silpa-archa* in September 2022 (Bangkok Post). The import ban has been implemented in stages, firstly by restricting imports of plastic waste from 2023, followed by a 50% reduction in import quotas from 2024, and a full ban from the beginning of this year.

2. 'Waste colonialism'?

Brooks' (Brooks et al. 2018) meticulous research explored that between 1988 and 2016, from a global perspective, the top ten plastic waste *exporting* countries, with the exception of Mexico, were all economically developed countries, practically, with the exception of Italy, the G7 group encompassed this category. (Although research figures show that Hong Kong was the largest plastic waste exporter in this group, this can be explained by the fact that in that period the city-state was considered the gateway port to mainland China.).

If the 28 EU Member States had been considered as a single entity, the bloc would have ranked the first among exporters with 31%. As for *imports*, in the same period under review, China (together with Hong Kong) was the primary destination for the global plastic waste trade, at that time China imported 72.4% of all plastic waste globally. On the import list, far behind China (together with Hong Kong), come the US (3rd), the Netherlands (4th) and Germany (5th). Here we

can also conclude that if the 28 EU Member States had been considered as a single entity, the bloc would have ranked the first among importers with 8%. (Brooks et al. 2018).
Following the Chinese ban on plastic waste imports in 2018 (the so-called Operation National Sword), the evolution of plastic waste trade underwent a drastic shift in terms of the recipients of these materials. The magnitude of plastic waste imports moved to the major ASEAN countries, with the region – mainly Malaysia, Vietnam, Indonesia and Thailand – accounting for 54% of all plastic waste exports from 2018 onwards (Brooks et al. 2018). (Fig. 1 below highlights the trade flow data of plastic waste to selected Southeast Asian countries before and after the Chinese import ban of 2018.)

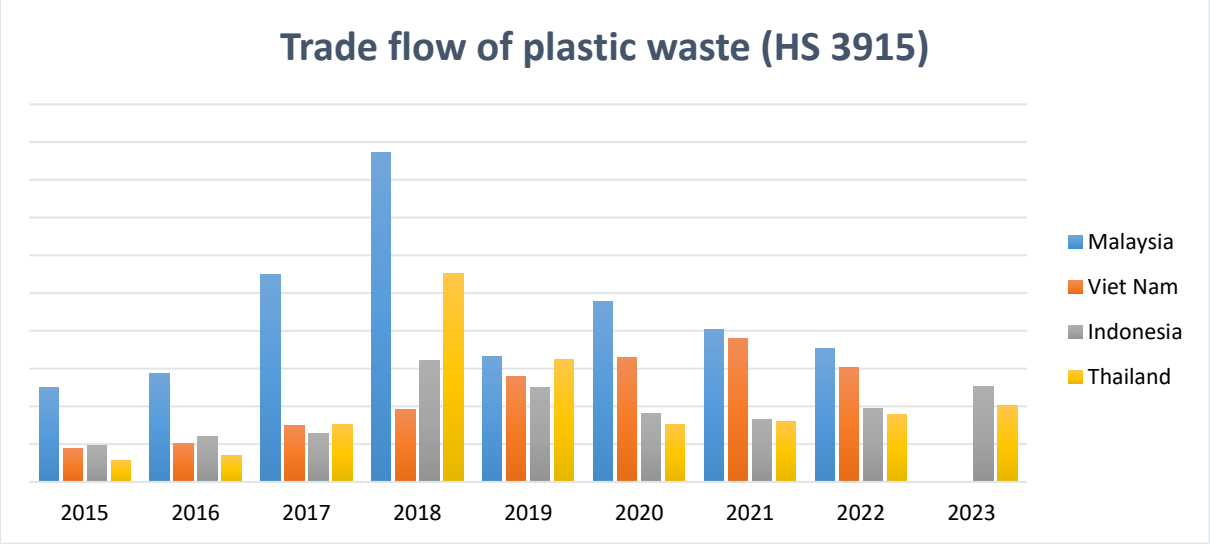

Figure 1. Trade flow of plastic waste to certain Southeast Asian countries (in net weight – kg/year)
Source: own edit by data from UN Comtrade
Note: HS 3915: the international harmonised tariff code of plastic waste

The redirection of plastic waste shipments, however, led to significant environmental challenges in Thailand. Local landfills and recycling facilities were overwhelmed, and improper disposal resulted in widespread pollution. There is also an inherent risk that recycling enterprises are planning for the relocation of plants to the Southeast Asian region, where they are very likely to have adverse impacts on the local environment, especially for countries lacking the latest treatment technologies (Liang et al. 2021). The country's decision to ban plastic waste imports is a direct response to these issues, aiming to protect its environment and reduce the harmful effects of plastic pollution (Thaitrakulpanich 2021). The Thai government's active determination was influenced not only by years of pressure from environmental NGOs, but also by the fact that the kingdom was exposed to international condemnation of the country's global ranking as the sixth worst marine plastic polluter and one of Asia's highest consumers of single-use plastic products (Marks et al. 2023).

The above phenomenon, whereby exporting plastic waste from higher-income countries to lower-income countries that are ill-equipped to handle the waste is well known in the academic discourse and is often called as 'waste colonialism' or, in more extreme terms, even 'environmental racism' or 'waste colonialism.' In these cases plastic waste is mostly traded under the guise of plastic

"recycling." (Sangaralingam, 2024). Waste colonialism is also approached as imbalanced power dynamics evident in the transboundary movement of waste (Peryman et al. 2024).

3. Thailand's response

It is a truism that rapid economic growth, and hence increased consumption, necessarily leads to increased waste generation, which in turn increases the burden on the environment. In this regard Thailand is not an exception either. Recognition of the obvious adverse environmental and health impacts of plastic waste is reflected in Thailand's integration of environmental and sustainability considerations into its national development programmes, on three levels. The fundamental framework is the 20-year *National Strategic Plan (2018-2037)*, the main focal points of which are the sustainability of the country's biodiversity, the preservation of environmental quality and the proper management of natural resources.

The *13th National Economic and Social Development Plan 13 (2023–2027)*, on the second level, addresses sustainable growth, which includes contributing to growth via the green economy (sustainable consumption and production), the blue economy (recovery of marine and coastal resources), as well as pollution management in line with international standards. The *Thailand Plastic Waste Roadmap* (2018–2031) constitutes the third level which aims at reducing plastic waste at the source and the use of single-use plastic bags as well as managing post-consumer plastic waste (Jirapornvaree et al. 2023).

The figures 2, 3, 4 and 5 of the *Basel Action Network (BAN)*, a global advocate for environmental justice, plainly highlight the source countries or jurisdictions that direct their plastic waste flows towards the Southeast Asian region in recent years.

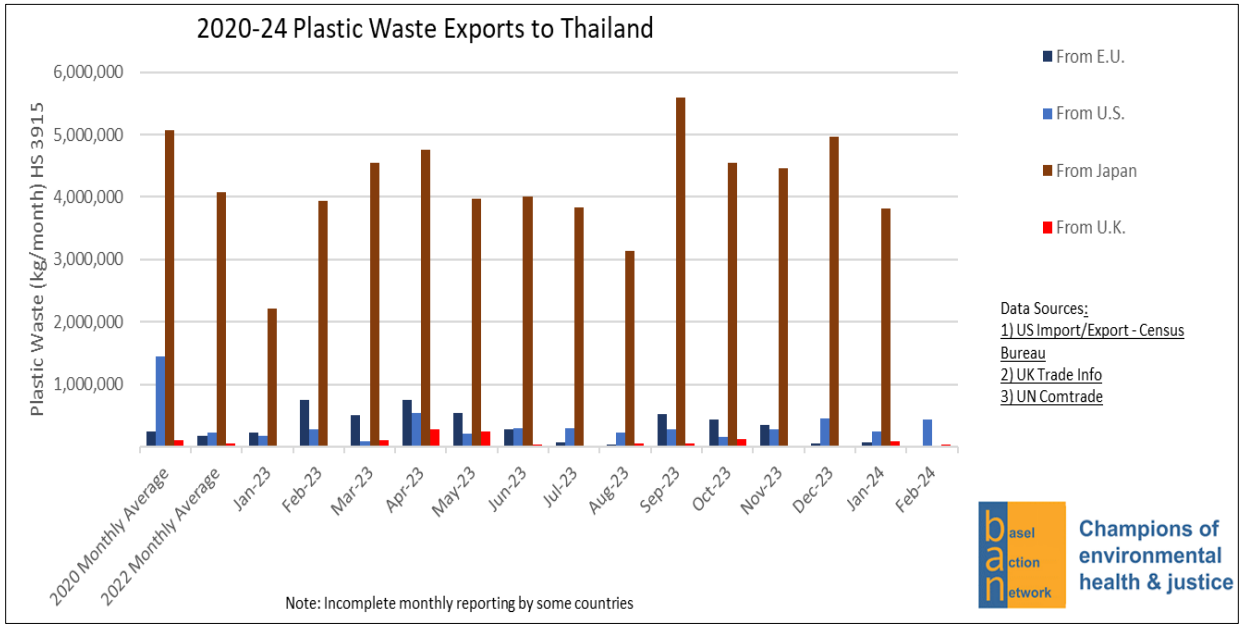

Figure 2. Major plastic waste exporting countries vis-à-vis Thailand
Source: Basel Action Network (https://www.ban.org/plastic-waste-project-hub/trade-data/thailand-import-data)

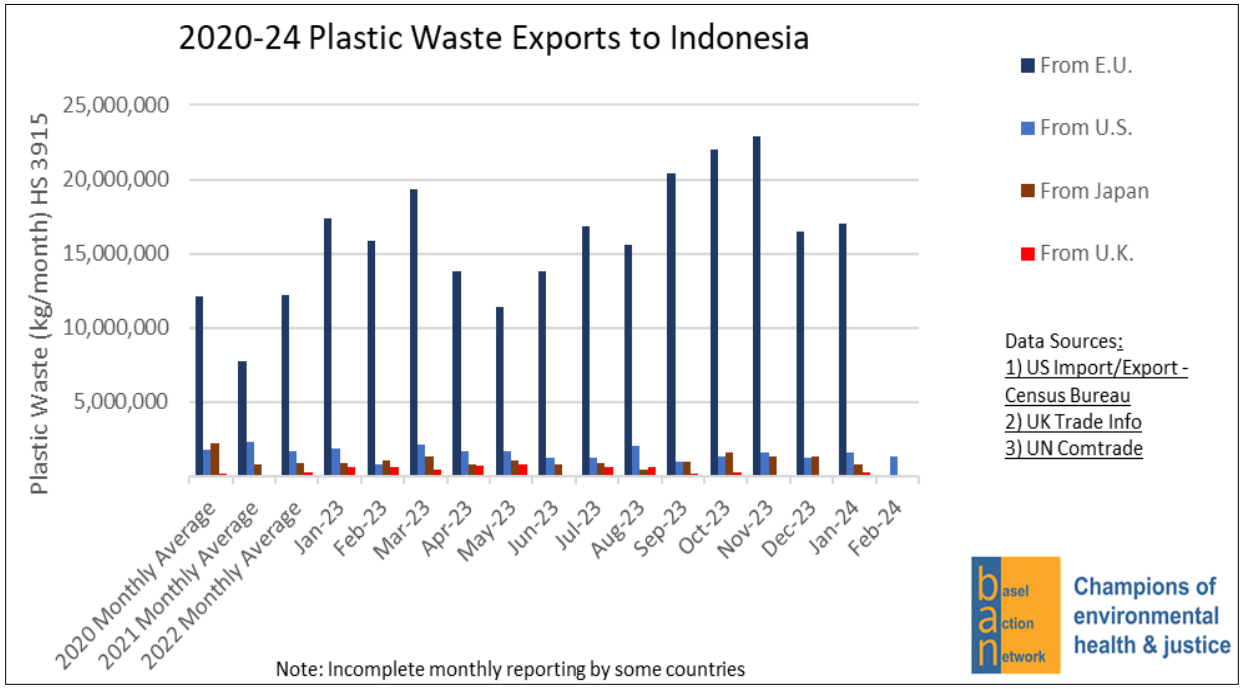

Figure 3. Major plastic waste exporting countries vis-à-vis Indonesia
Source: Basel Action Network (https://www.ban.org/plastic-waste-project-hub/trade-data/indonesia-import-data)

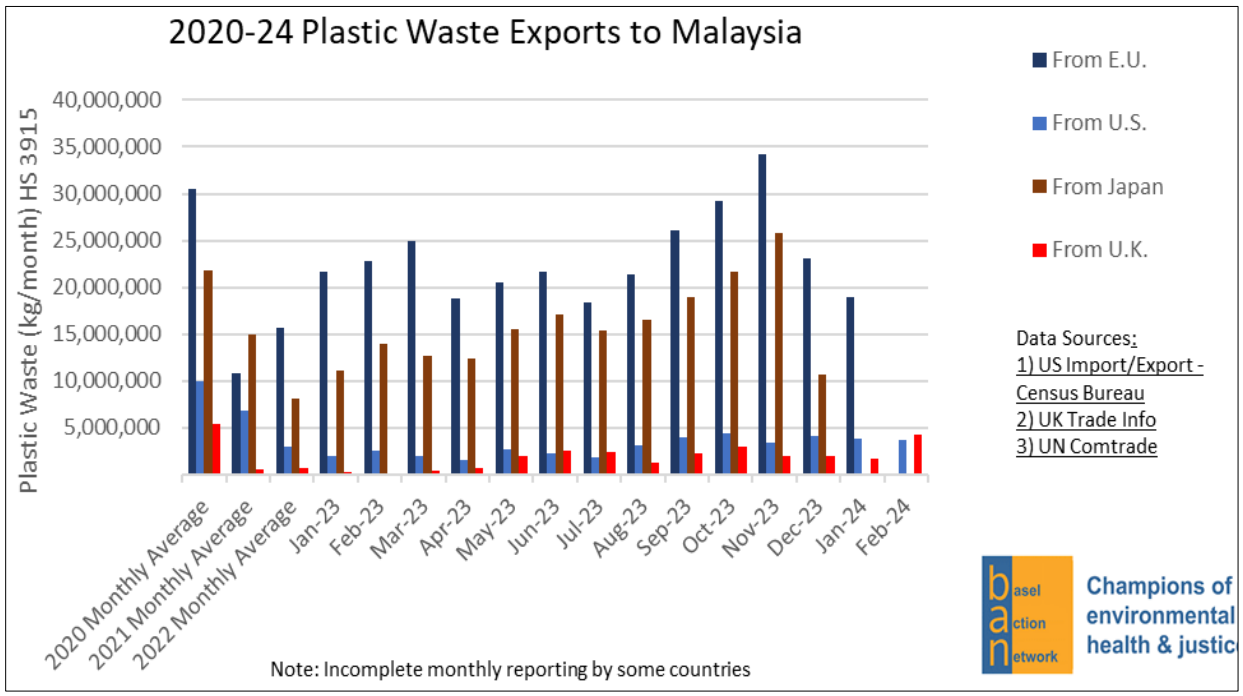

Figure 4. Major plastic waste exporting countries vis-à-vis Malaysia
Source: Basel Action Network (https://www.ban.org/plastic-waste-project-hub/trade-data/malaysia-import-data)

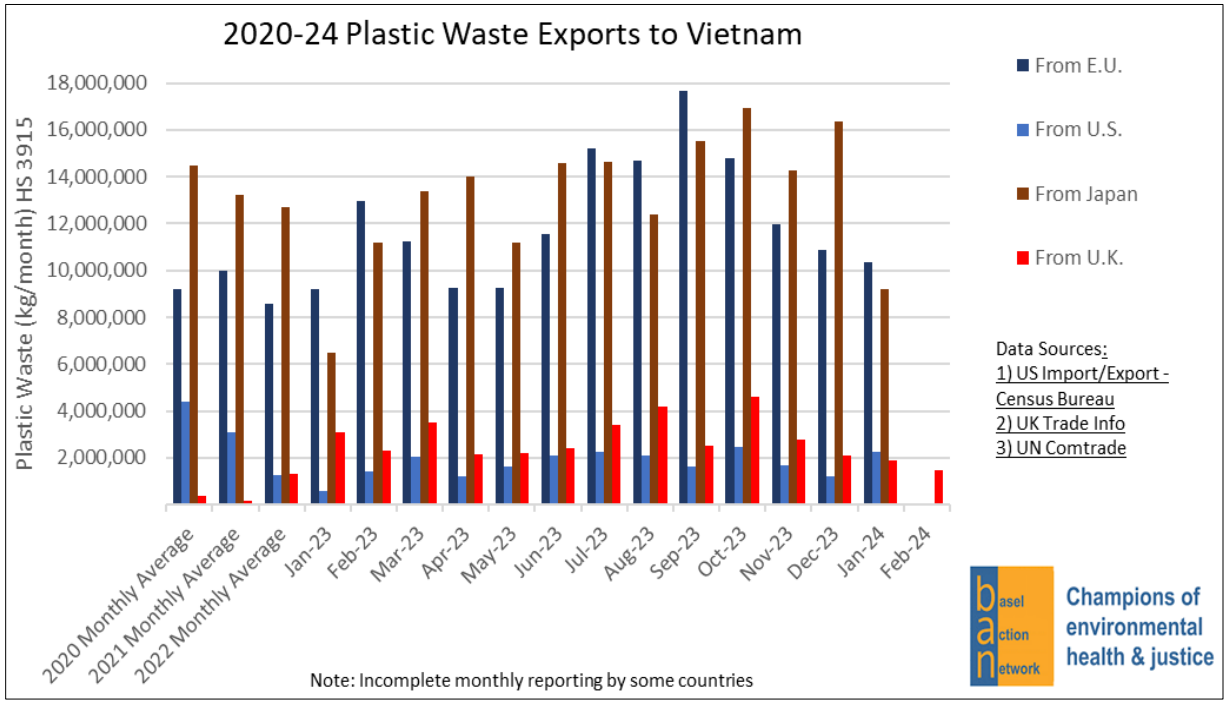

Figure 5. Major plastic waste exporting countries vis-à-vis Vietnam
Source: Basel Action Network (https://www.ban.org/plastic-waste-project-hub/trade-data/vietnam-import-data)

Beyond Thailand, other regional partner countries also touched upon the plastic waste issue and adopted strategies with a view of addressing this kind of pressing challenge. *Malaysia* published its *Plastics Sustainability Roadmap 2021-2030*[5] which has been supposed to be the guidance policy to all stakeholders in ensuring plastic and environmental sustainability. The *National Plastic Action Partnership (NPAP) of Indonesia*[6] aims for a 70% reduction in marine plastic leakage by 2025 and near-zero by 2040. The similarly called strategy of *Vietnam*[7] sets the goal of swiftly and strictly controlling the importation of plastic scraps and, in concert with the Indonesian strategy, foresees partnership to reduce plastic litter in oceans by 50% by 2025 and by 75% by 2030.

4. International legal background

4.1. The United Nations

In the 1970s and 1980s environmental awareness began to emerge in the societies of developed countries along with the tightening of environmental regulations. As a result, the management of hazardous waste has been put on the international environmental agenda and the issue was

[5] Malaysia Plastics Sustainability Roadmap 2021-2030 https://www.nres.gov.my/ms-my/pustakamedia/Penerbitan/MALAYSIA%20PLASTICS%20SUSTAINABILITY%20ROADMAP%202021-2030.pdf
[6] National Plastic Action Partnership (NPAP) of Indonesia
https://weforum.ent.box.com/s/3dx0h6h3iyab847msnx7iw62kjtv5myu
[7] National Plastic Action Partnership (NPAP) of Vietnam
https://weforum.ent.box.com/s/vl8em44kohefbdknk09p8ihdpogxlgk1

included into the priority areas in the United Nations Environment Programme's (UNEP). One of the major international legal instruments governing this topic is the Basel Convention (by its full name: the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal).

The objective of the Convention, which was adopted in 1989 and entered into force in 1992, is to protect human health and the environment against the adverse effects of hazardous wastes and other wastes requiring special consideration. Thailand is also party to this treaty, with regard to the country it entered into force in February 1998.

In the mid-nineties, recognising the environmental and health risks of cross-border tide of plastic waste, the Parties decided to amend the Convention. One of the most significant of these modifications was the so-called 'Ban Amendment', whereby Parties, inserting a new Article 4A into the text of the Convention, decided to prohibit immediately all transboundary movements of hazardous wastes which are destined for final disposal, recovery or recycling operations from OECD to non-OECD States. Almost two decades later, in May 2019, another revision ('Plastic Waste Amendment') was adopted, by amending Annexes II, VIII and IX to the Convention, with the objectives of enhancing the control of the transboundary movements of plastic waste and clarifying the scope of the Convention as it applies to such waste.

The Plastic Waste Amendment entered into force for Thailand in March 2020 whilst the Ban Amendment did so in June 2023. According to the Plastic Waste Amendment, certain types of plastics are rendered 'other wastes' under the Basel Convention. In effect, this allows Thailand, a Party to the Convention, to regulate imports of plastics specified in it. This is, therefore, a significantly important justification for Thailand to refurbish its plastic regulatory system to one that is robust and more environmentally friendly in tackling plastic pollution.

As the forerunner of the Thai import ban as of January 2025 on the international arena as well as against the backdrop of the need for more effective international regulation, in March 2022, a resolution was adopted by the United Nations Environment Assembly which requested the Executive Director of the United Nations Environment Programme (UNEP) to convene an intergovernmental negotiating committee, to begin its work during the second half of 2022, with the ambition of completing its work by the end of 2024. The INC is tasked with developing an international legally binding instrument (a.k.a. a Global Plastics Treaty) on plastic pollution, including in the marine environment, which could include both binding and voluntary approaches, based on a comprehensive approach that addresses the full life cycle of plastic. So far altogether 5 sessions of negotiations took place, the last conference held in November-December in Busan, Korea.

As a result of intense consultations the negotiating parties adjourned the 5th session with agreement on a preliminary text that would serve as the starting point for negotiations at a resumed session this year (UNEP 2024). This means that no breakthrough has been achieved at the 2024 round of discussions, no final agreement has been attained.

4.2. The Association of Southeast Asian Nations (ASEAN)

The trade and import of plastic scraps is unavoidably intertwined with marine plastic pollution as well. Recognising the complementarities between the former and the latter, ASEAN Member States actively cooperate in the implementation of the global agenda and goals of multilateral environmental agreements. The organisation continuously reiterates its commitments to contribute to these arrangements. An indication of their endeavour is reflected in the adoption of the Bangkok Declaration on Combating Marine Debris in the ASEAN Region on the occasion of the 34th ASEAN Summit June in 2019. Based on this commitment, in May 2021, they launched the Regional Action Plan for Combating Marine Debris (2021-2025).

This five-year plan draws on an integrated approach to tackle marine debris with opportunities for action at three key stages of the value chain: reducing inputs, enhance collection along with minimizing leakage and promoting reuse. One of the pillars of the ASEAN Blue Economy Framework, released at the 43rd ASEAN Summit in September 2023, is the Blue Conservation Management (Blue Strategy 1) which fosters promoting sustainable use of natural resources, ecological health, and combatting (plastic) pollution. (The concept of blue economy has been advocated for as a mechanism for social, economic, and environmental development through the sustainable exploitation of oceans and inland water resources.)

5. Implications and Future Outlook

The introduction and entry into force in January of a total ban on plastic waste imports in Thailand is a major step forward for the Kingdom, not only in terms of better environmental enforcement, but also in terms of implementing and extending the bio-circular-green (BCG) economic model in a broader perspective. The implementation of the ban signals an end to the long-standing fight by civil society to protect Thailand from becoming a dumping ground for plastic waste. But in order for an effective and wide-ranging improvement in environmental conditions to be achieved, an efficient monitoring and enforcement of the law are indispensable to prevent waste freights from illegally entering the country. For this reason not only the law enforcement authorities have to exercise their competences rigorously, but also civil society organisations need to be vigilant in monitoring and actively cooperating with authorities to make sure the ban was appropriately enforced.

The strict application of import regulations is necessary not only with regard to biodiversity and human and animal health, but it also heavily impacts the tourism and fishing industries, which are vital to Thailand's economy. Additionally, with a better organised waste management institutional background the disadvantageous environmental effects of economic development could be mitigated.

6. Conclusions

This study has directed attention towards transboundary plastic waste trade issues and its implications for Thailand and the Southeast Asian region. Though the decision of Bangkok on the total ban of plastic waste imports could be conducive to the combat with the large influx of plastic scraps into the country in the short or middle term, in the process of active collaboration of all

interested stakeholders in mitigating the acute waste management challenges and in hammering out a long-lasting solution for the plastic waste crisis is still a long way to go.

It has been shown that the regulation of the international trade in plastic waste is not satisfactory within the existing international legal framework (Basel Convention). Although the codification process carried out in the context of the Intergovernmental Negotiating Committee, under the auspices of the UNEP, requires extensive and time-consuming rounds of negotiations due to conflicts of interest between regions and groups of countries, the reform of the current regulatory context is inevitable if we want to elaborate substantial solutions for the sake of sustainability of our environment and the preservation and protection of human health.

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Natural and artificial intelligence in hotel industry: HotelMentor AI – a brand-new Hungarian innovation

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Abstract: Artificial intelligence is a hot topic these days. The study reviews the general significance, content and usefulness of artificial intelligence (AI), with a special emphasis on its emergence in the tourism and hotel industry, where it is bringing revolutionary changes in personalized experiences, efficiency gains and sustainability. It presents the tourism applications of AI – from chatbots to robots to predictive analytics – and the RAISA model of the smart hotel. AI does not replace, but supports human work, increasing competitiveness and guest satisfaction. The second part of the study presents a brand-new Hungarian development, HotelMentor.ai, a platform that combines decades of professional experience with the latest technology, opening a new era in the digitalization of domestic and international hospitality. The Hungarian hotel industry, like international trends, faces serious challenges: labour shortages, inefficiencies in task management, fragmented data management, and difficulties in guest communication all threaten profitability and service quality. In response to these problems, HotelMentor.ai was born, with a mission to increase efficiency, guest satisfaction, and profitability through the synergy of artificial and natural intelligence.

Key words: tourism, hotel industry, artificial intelligence, HotelMentor.ai
JEL codes: A1, L83, O33, Z31, Z32

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Introduction

Artificial intelligence cannot replace human natural abilities, but when used skilfully, it can be a useful aid in many areas. The significance of artificial intelligence (AI) lies in its ability to automate, optimize, and support human activities in various industries, thereby bringing about social and economic change. AI technology enables intelligent decision-making, complex problem-solving, and efficient data processing, which improves productivity, healthcare services, education, and other industrial processes. Artificial intelligence encompasses the ability of machines and programs to perceive their environment, process data, adapt, learn, and perform specific tasks independently. This includes machine learning, deep learning, natural language processing, and robotics, which enable AI systems to make decisions and solve problems similar to human behaviour.

The usefulness of artificial intelligence can be seen in several areas:

- Faster and more accurate decision-making in various business and other economic areas
- Automated repetitive tasks that free up human resources for more creative activities
- Solving complex problems, such as fraud detection, medical diagnostics, or weather forecasting
- Optimization of business processes, gaining competitive advantage,
- Assistance in risk management and crisis management.

This makes artificial intelligence a key technology for future social and economic development, and it is already an indispensable tool for increasing efficiency and innovation in many areas.

Artificial intelligence can be software-based (e.g., virtual assistants, image analysis software, search engines, speech and facial recognition systems) or physical (e.g., robots, self-driving cars, drones). There are three main types of artificial intelligence: (1) narrow AI or weak AI (designed to perform a specific task, for example, used in applications); (2) general or strong AI (a system capable of performing all intellectual tasks that a human being is capable of; does not yet exist, but research and development are ongoing); (3) super-intelligent AI (a fully self-aware system that surpasses human capabilities; currently only exists in science fiction, no known method). (sap.com, europarl.europa.eu). Either way, it has been present in our everyday lives for some time now.

The study presents the emergence of artificial intelligence in tourism, with a particular focus on the hotel industry. It reveals new opportunities and introduces a new system that is a huge help to hotel managers and employees in their daily work and in increasing their efficiency.

1. The emergence of artificial intelligence in tourism

AI emerged in the tourism industry during the mid-2010s, initially through basic applications like chatbots and recommendation engines, evolving rapidly into advanced tools for personalization and operations by the 2020s. AI technology is transforming modern travel in several ways. Figure 1 summarises the possibilities of integrating AI in tourism:

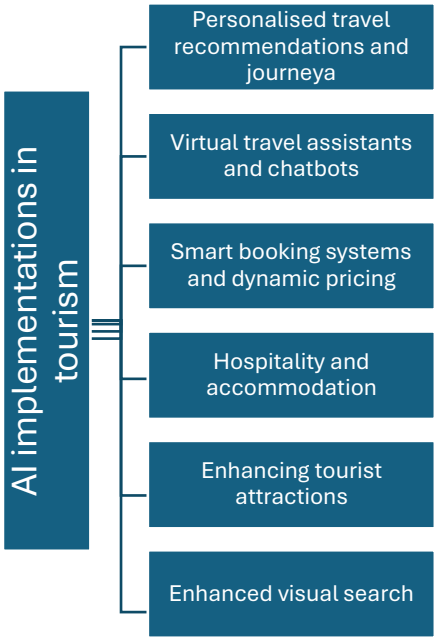

Figure 1. Possible use of AI in tourism
Source: own compilation based on Ibrahim 2024

Artificial intelligence was a key topic at the World Travel & Tourism Council (WTTC) summit in September 2025, too, where it was concluded that revolutionary changes can be expected in the personalization of travel experiences and operational efficiency (hotelnews.hu). Artificial intelligence (AI) began to spread in tourism in the late 2010s, initially with chatbots and recommendation systems such as Booking.com's AI-based search engine, then accelerated in the 2020s with post-pandemic digitalization. In 2023-2024, Hungarian developments such as Everguest AI software appeared (fmbusiness.hu), which automates guest relations, while in 2025, the virtual host Gizella was launched in Veszprém, supporting the city's tourism with personalized recommendations (veol.hu). Expedia and Airbnb are also working on their own AI solutions. As part of smart tourism, AI is now transforming bookings, tour guiding, and marketing globally. The essence is that a tourist destination is determined based on its technological capabilities. China is currently leading the way in smart tourism (travelikum.blog.hu). Smart technologies improve the tourist experience, contribute to the development of sustainable tourism, and strengthen the local economy. Blockchain technology promotes the transparency of tourism services, increases consumer confidence, uses decentralized systems, and helps reduce the number of intermediaries. Artificial intelligence can optimize the tourist experience, improve the efficiency of services in destination management, and support data-driven decision-making (Fejes et al. 2024). It helps respond to new trends such as personalized services, comparability, business + leisure, smart cities, and the development of cooperation between industry players (Danyi et al. 2020).

AI is key to increasing competitiveness in tourism, as it optimizes operations, reduces costs, and offers personalized experiences, thereby increasing bookings for service providers by 28% (nice.hu). From a sustainability perspective, it forecasts demand, prevents overtourism, optimizes energy use in hotels, and supports ecosystem restoration. It provides an economic competitive advantage, especially for small town destinations, where it assists in performance measurement and tourism monitoring, in line with efficiency-focused management. The content of AI in tourism includes machine learning for personalized recommendations (accommodation, programs, dining), predictive analytics for forecasting trends, and generative AI for creating unique vacation packages based on guest data. Through these, AI is transforming the guest experience while making the industry more sustainable.

Danyi and his co-authors (2020) conducted comprehensive secondary research (literature and blog articles) on the emergence of AI in tourism. They classified the approaches and methods into four main groups and illustrated them in a structure they called a "hype map." The four main areas identified where AI appears are: (1) solving institutional problems related to destinations (e.g., urban development, municipal, administrative, etc.) with AI tools, (2) solving problems of tourism service providers with AI tools, (3) supporting tourists with AI tools, and (4) technologies incorporating AI.

Table 1. Benefits and challenges of AI in tourism

Benefits of AI in tourism	Challenges of AI in tourism
➢ **Enhanced customer service and personalized experiences: AI provides 24/7 customer support through virtual assistants and chatbots, offering personalized recommendations and quickly resolving queries leading to higher customer satisfaction as travellers receive tailored services that meet their individual needs.** ➢ **Improved efficiency in travel logistics and planning: AI optimizes travel logistics by managing schedules, predicting potential disruptions, and optimizing routes. This ensures a smoother travel experience for customers and helps travel companies efficiently plan and manage resources.** ➢ **Cost savings for travellers and travel companies: AI-driven dynamic pricing and smart booking systems allow travellers to find the best deals in real time, while travel companies can maximize revenue by adjusting prices based on demand. Additionally, automation of routine tasks reduces operational costs for travel companies.**	➢ Privacy concerns and data security: The use of AI in tourism involves collecting and processing large amounts of personal data, raising concerns about privacy and data security. Ensuring the protection of this data is crucial to maintain user trust and to comply with regulations such as GDPR and CCPA. ➢ Dependence on technology and loss of personal touch: Over-reliance on AI technology can lead to a loss of the personal touch that many travellers value. Human interaction and personalized service are critical aspects of the travel experience that AI may not fully replicate. ➢ Challenges in handling complex, unstructured travel queries: While AI excels at managing straightforward tasks, it often struggles with complex, unstructured travel queries that require nuanced understanding and judgment. This limitation necessitates a balance between AI tools and human expertise to handle diverse customer needs effectively.

Source: Ibrahim 2024, ultralytics.com

A novel approach has also emerged, namely personalized digital tourism (PDT), which combines "cognitive info-communication, generational theories, digital reality, and AI-based (artificial intelligence) data management to offer personalized, innovative solutions for both individual travellers and tourism service providers. PDT uses the latest advances in technology and data analysis to provide personalized tourism experiences that meet the unique preferences and needs of travellers. ... By using AI-based data management, PDT provides a framework for enhancing tourism experiences, optimizing tourism management, and improving the quality of tourism services. The integration of PDT into the tourism sector can lead to a significant increase in customer satisfaction and loyalty, which can ultimately result in increased revenue and profitability for tourism service providers." (Grotte 2025:44).

Finally, we cannot ignore one of the most exciting areas of AI: robotization. Robots, which have already appeared in the hospitality and hotel industry, not only make certain tasks easier, but also attract guests. The ones we encounter most often are serving robots; transport and hotel service robots (e.g., carrying suitcases, escorting guests); and communication robots. In China and Japan, we can already find robot restaurants and fully robotized hotels (Pántya et al. 2023).

The summary of the stages of emerging AI in tourism can be found in Table 2:

Table 2. Stages of the roles of AI in tourism

Early Adoption (2010s)	Technological advancements laid groundwork with online travel agencies and mobile apps, paving the way for AI integration around 2015–2020. Examples include Hilton's "Connie" AI concierge robot in 2016, powered by IBM Watson for guest recommendations and information. These early tools focused on customer service enhancements and basic data analysis.
Acceleration (2020s)	Post-pandemic recovery accelerated AI use, with chatbots, dynamic pricing, and predictive analytics becoming standard by 2023–2024. Investments surged, projecting AI as a $15.7 trillion global industry by 2030, transforming tourism through efficient bookings and demand forecasting. VR/AR tours and predictive maintenance further boosted adoption.
Recent Developments (2024–2025)	Generative AI drives hyper-personalization, itinerary planning, and national initiatives like Singapore Tourism Board's OpenAI partnership for multilingual support and forecasting. Market consolidation around core applications continues, with AI agents acting as virtual concierges. By 2025, 83% of travel firms view AI as essential for innovation and satisfaction gains.

Source: own compilation, based on the summary made by perplexity.ai

2. Artificial intelligence in hotel industry

HITEC (Hospitality Industry Technology Exposition and Conference) is the world's largest hotel and hospitality technology event in the US (hitec.org). This year's trade show was dominated by the topic of artificial intelligence. However, hotels are still approaching this "technological wonder weapon" with caution. Here are some interesting quotes from the summary on hotelnews.hu:

"Artificial intelligence has become almost a magical term, but the industry is still looking for ways to use it to create real value" (Klaus Kohlmayr, Chief Strategy Officer at IDeaS).
"We can't conjure up a swimming pool if there isn't one" (Natalie Kimball, Shiji). Artificial intelligence can be creative, but it works from reality—if a service is missing, it can't replace it.
“It’s not the job of hoteliers to be AI experts—it’s our job to give them simple, working tools” (Scott Wilson, Sabre Hospitality). He believes that integrated, user-friendly solutions (such as SynXis Concierge.ai) may be the key to widespread adoption.

The current position in the hotel industry is that artificial intelligence has a place where it can deliver concrete, measurable results. HITEC's message is clear: AI is here, but it will only be as useful as we know how to use it (hotelnews.hu).

Now let's see what AI itself has to say about which specific AI applications improve the guest experience in hotels:

“*AI Chatbots and Virtual Assistants*
AI chatbots provide 24/7 support to guests, handling reservations, questions about services and local attractions, as well as check-in and room settings (e.g., temperature). Examples: Hilton's

Connie robot (based on IBM Watson) plans itineraries and recommends services, reducing the workload at the front desk; Hungarian AI-Boost and Crowdy.ai chatbots save on labour by providing fast service.

Personalized Recommendations
Machine learning analyses guest data (reservations, behaviour) to provide personalized recommendations for rooms, dining, spa treatments, or activities, increasing satisfaction and engagement. In hotels, this recommends premium rooms or exclusive services based on preferences, while guest apps send timely notifications with special offers.

In-room smart devices
AI-based IPTV systems and smart tablets (e.g., Hoteza HotPad) enable in-room control: service requests, local information, personalized entertainment, and promotion of additional services (e.g., room service) directly in the room. This enhances convenience and collects behavioral data for future fine-tuning.

Prediction and Analytics
AI analyses feedback, trends, and preferences to improve services, respond more quickly to demands, and optimize capacity (pricing, demand forecasting). This ensures continuous personalization throughout the entire guest journey." (perplexity.ai)

Artificial intelligence has enabled the emergence of the concept of the "smart hotel," which integrates new technological solutions into guest services. These services are referred to by the acronym RAISA, which stands for Robots, AI, Service Automation. They play a key role in enhancing the guest experience (Kökény 2024).

2.1. HotelMentor AI – the first Hungarian AI assistant serving the hotel industry

At the forefront of domestic innovation, HotelMentor.ai is the first complex assistant platform based on artificial intelligence that has been specifically tailored to the unique challenges of the Hungarian hotel industry. The development is backed by decades of expertise in tourism and the hotel industry, ensuring that the system is not just a technological novelty, but provides effective and measurable solutions to real, practical problems. The timeliness and relevance of the platform is demonstrated by the fact that the developers first presented it to a professional audience at a conference in Miskolc, where the theme was data-driven and sustainable operation.

The basic philosophy of HotelMentor.ai is that artificial intelligence is not intended to replace human labour, but rather to complement and support it. As highlighted in a 2024 analysis by EY, hotels that embrace AI "gain a clear competitive advantage" by using the technology to improve operational efficiency and guest experience (Riaz 2024). HotelMentor.ai aims to automate repetitive, administrative tasks and provide data-driven insights to managers, allowing staff to focus on what matters most: the guest experience and higher value-added work.

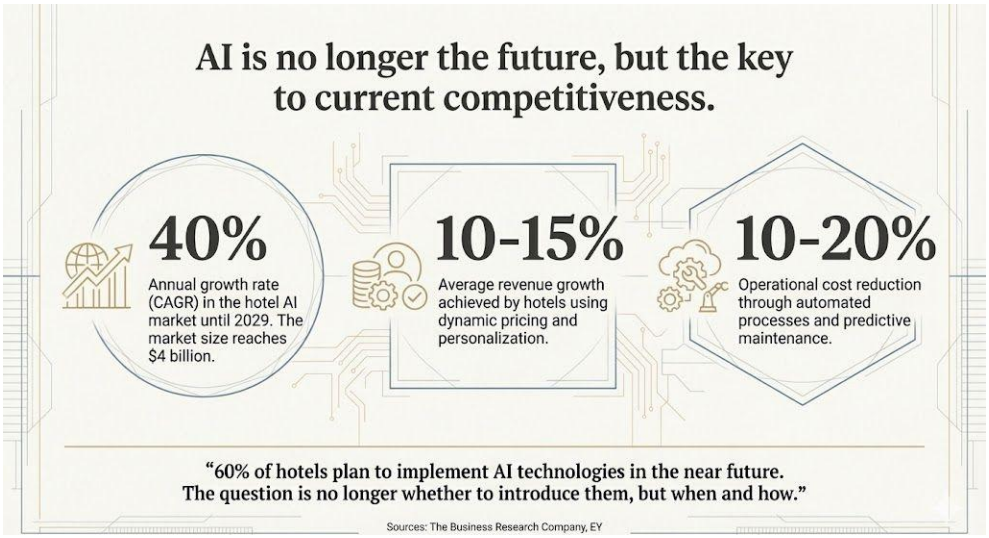

Figure 2. AI serving competitiveness in hotel industry
Source: Turcsán 2025

We now present the features and modules of HotelMentor.ai in a structure that corresponds to the main challenges facing the industry today, responding to individual international publications:

Simplification of daily tasks and 24/7 availability

Vashishth et al. (2024) examined the role of AI-powered chatbots in providing instant support and personalized recommendations to guests. (Chatbots, short for "chat robots," are computer programs designed for conversations with users, typically through text or voice-based interactions. They serve as virtual assistants capable of understanding and responding to user queries, requests, or commands in a conversational manner.) These intelligent virtual assistants offer real-time responses to inquiries, streamline guest communications, and enhance overall guest satisfaction. Figure 3 shows the hospitality services using chatbot:

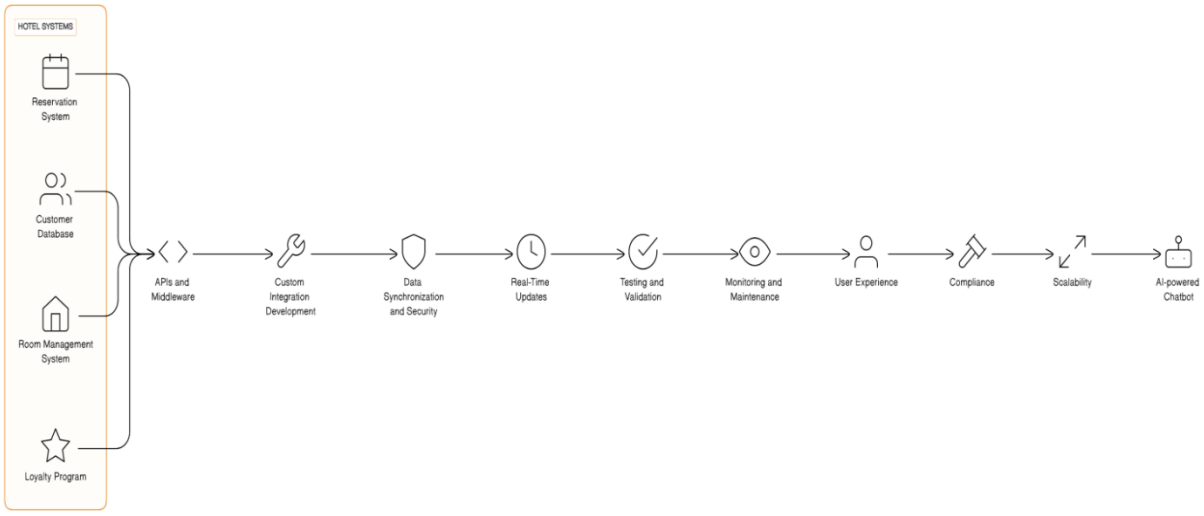

Figure 3. Hospitality services using chatbot
Source: Vashishth et al. 2024:16

In the hotel industry, labour shortages and increased guest expectations place double pressure on staff. One of the most important practical benefits of HotelMentor.ai is that it alleviates this burden. The central element of the platform is the AI Chatbot, which is based on the Knowledge Base, available 24 hours a day, seven days a week, and provides immediate, accurate answers to questions from both guests and hotel staff. This 24/7 availability revolutionizes communication:

- For guests: A guest remembers at night that they want to order a taxi for the next day, or they don't know the opening hours of the wellness area. Instead of calling the reception (which may be overloaded), they can simply ask the question to the chatbot integrated into the hotel's website or mobile app and get an answer within seconds. This not only serves the convenience of the guest, but according to international research, 24/7 instant support significantly increases guest satisfaction (Vashishth, T. K. et al. 2024).
- For employees: A new receptionist or an employee transferred from another department does not have to seek out more experienced colleagues or managers for specific procedures (e.g., "How do I handle the loyalty card?"). Instead, they can ask HotelMentor.ai a question in the internal system, which will immediately provide the exact protocol from the central knowledge base. This drastically reduces training time, minimizes the possibility of errors, and relieves the burden on senior staff.

Project management and effective delegation

Hotel operations involve a complex series of parallel projects, ranging from daily cleaning to wedding planning. The HotelMentor.ai Task Board module provides managers with a modern, project management-oriented tool. This Kanban-style interface allows tasks to be broken down precisely, assigned to responsible parties, and given deadlines. The delegation process becomes transparent and traceable:

A guest uses the chatbot to report that the air conditioning in their room is not working. HotelMentor.ai automatically creates an "Urgent" priority task on the Task Board titled "Air conditioning repair – Room 302" and assigns it to the maintenance department employee on duty. The system sends a notification to the maintenance technician's mobile phone, who indicates with a single click that they have started the work. When finished, they close the task, which is automatically reported to the reception manager and the system. At the end of the process, the chatbot can even send an automatic message to the guest: "We would like to inform you that the air conditioning repair in room 302 has been successfully completed. We wish you a pleasant stay!"

This type of automated yet controlled process organization eliminates communication gaps, reduces human error, and ensures that all tasks are completed on time and with the right quality. For managers, it provides a real-time view of work in progress, enabling more efficient resource planning and performance measurement.

The Personal Assistant and the modular vision

The most innovative feature of HotelMentor.ai is the personal assistant designed specifically for hotel managers, which acts as a proactive, strategic partner (Figure 4). It continuously analyses hotel data, compares it with market trends, and makes recommendations on topics such as dynamic pricing and inventory management optimization. The platform's modular structure ensures

scalability: a hotel can start operating with the basic operational modules and then gradually introduce additional specialized modules, such as the planned Restaurant Service Module or Sustainability Module, based on return on investment. This flexibility makes HotelMentor.ai a long-term strategic partner for modern hotels open to digital transformation.

Figure 4. HotelMentor AI as hotel managers' personal assistant
Source: Turcsán 2025

Data-driven analytics and a deeper understanding of the guest experience

HotelMentor.ai is not just a task management and communication tool, but also a data aggregator and analytics platform. The guest reviews module, for example, does more than just collect feedback from various online platforms (Booking.com, TripAdvisor, Google, etc.) in one place. With the help of artificial intelligence, it can perform sentiment analysis, i.e., determine whether a review is positive, negative, or neutral. In addition, it uses natural language processing (NLP) to identify key themes and patterns in the text.

This allows management to see not only whether guests are generally satisfied, but also exactly why. For example, the system can detect if there has been an increase in mentions of "slow check-in" or "cold breakfast" in negative reviews over the past month. This kind of in-depth, real-time insight allows for targeted intervention before a minor shortcoming becomes a systemic problem. Hotel management can then make decisions about improving service quality based on concrete data rather than hunches, which is essential in today's competitive environment.

The revolution in internal communication and knowledge sharing

Staff turnover is a common problem in hotels, posing a constant challenge for management in terms of knowledge transfer and training. The HotelMentor.ai knowledge base module offers an effective solution to this problem. This module functions as a central digital "brain" where all of the hotel's internal protocols, procedures, and even solutions to previous problems are stored. When a new employee is faced with an unfamiliar situation, whether it's a complicated billing

issue or handling a special guest request, they don't have to bother their supervisor or a more experienced colleague. Instead, they can ask their question in natural language to HotelMentor.ai in the internal system, which will provide relevant guidelines, checklists, or previous case studies within seconds. This process not only drastically reduces training time, but also standardizes service levels, as all employees work from the same authoritative source. The system relieves senior colleagues from answering repetitive questions, giving them more time for more complex, guest-focused tasks. This type of internal efficiency improvement contributes to increased employee satisfaction and reduced turnover, resulting in significant long-term cost savings for the hotel.

The future: Predictive analytics and a comprehensive ecosystem

HotelMentor.ai's vision goes beyond supporting current operational tasks. The platform is constantly evolving, and in the future, predictive analytics and even deeper integration will take centre stage. In the future, the personal assistant module will not only make suggestions but will also be able to run complex simulations. For example: "What would happen to occupancy and revenue if we offered a 10% discount on wellness packages next month and supported this with a targeted Facebook campaign?" The system will be able to predict the expected impact of different marketing and pricing strategies, minimizing the risk of bad decisions.

The modular structure allows HotelMentor.ai to become a comprehensive hotel ecosystem. The planned restaurant service module, for example, would link table reservations with inventory management and procurement. If the system sees that there are many reservations for salmon main courses on a given weekend, it automatically notifies the kitchen of the required amount of ingredients and can even prepare the purchase order with preferred suppliers.
The sustainability module, connected to IoT (Internet of Things) sensors, would monitor energy and water consumption and make recommendations for optimization, such as automatically regulating room temperature when guests are away. This not only reduces the environmental impact, but also lowers overhead costs, further increasing the hotel's profitability.

Customer acquisition, marketing, and smart upselling

In the modern hotel industry, the key to success is not only providing an excellent guest experience, but also effectively acquiring guests and retaining existing customers. The Marketing module and Automatic Communication System of HotelMentor.ai serve precisely these purposes, with the power of data-driven personalization.
“10 ways AI is transforming hotel upsell strategies:

1. *Machine learning predicts what hotel upsell a guest will actually want.*
2. *Predictive analytics finds the moment that matters most.*
3. *Natural language processing spots opportunities in conversation.*
4. *AI guidance helps reservation teams sell naturally*
5. *Automation keeps channels in sync.*
6. *Dynamic pricing adjusts offers in real time.*
7. *Real-time guidance turns every channel into a revenue stream.*
8. *Personalization at scale deepens loyalty.*
9. *Smarter reporting continuously improves the process.*

10. Ethical AI builds trust, not friction.
As such, guests should never feel manipulated by offers. Remember, your goal is to enhance their experience, not automate the human element of hospitality. So, make sure you use your guest data responsibly and design your systems in a way that keeps your guests' best interests top of mind." (Roelings & Stephens 2025)

The platform continuously collects and analyzes guest data – from previous bookings to preferences during their stay (e.g., spa use, restaurant consumption) to online feedback. This 360-degree guest profile enables the hotel to send targeted marketing messages and offers rather than generic ones. According to a 2025 article in HospitalityNet, machine learning can predict what type of offer a given guest will respond to most, whether it's a wellness package for a returning couple looking to relax or a family pass to a nearby theme park for a family with children (Roelings & Stephens 2025).

This is supported by a study from Cornell University, which found that hotels using AI-driven revenue management systems achieved an average revenue increase of 10% (Pandey & Agarwal 2025).

The HotelMentor.ai system identifies guests who have previously used wellness services. When these guests make a new reservation, the system automatically sends them a personalized email a few days before their arrival, recommending a new type of massage or a discounted spa package. This proactive, relevant offer is much more likely to convert than a generic newsletter.

"While increased repeat bookings represent the most visible benefit, AI personalization affects multiple, interconnected revenue streams. These capabilities translate into measurable financial outcomes that extend far beyond direct bookings:

- *Room rate optimization based on individual willingness-to-pay models.*
- *Targeted upsell opportunities for premium accommodations.*
- *Personalized ancillary service recommendations (spa, dining, activities).*
- *Dynamic package creation based on guest history.*
- *Customized loyalty incentives that maximize lifetime value.*

Properties using advanced AI systems report 15-20% higher average spending per stay alongside the 40% improvement in rebooking rates. Furthermore, the revenue impact extends to operational efficiencies: hotels using AI-driven staffing models report labour cost reductions of 8-12% while maintaining or improving service quality. These systems analyse historical occupancy patterns, booking trends, and even weather forecasts to optimize staff scheduling across departments." (Kenyon 2025)

However, intelligent upselling and cross-selling do not stop at email marketing. HotelMentor.ai is able to display the right offer at the right time and on the right channel. For example, during check-in, the AI Chatbot can use the context of the conversation (e.g., the guest mentions an anniversary) to offer a relevant offer, such as a bottle of champagne or a romantic dinner. According to a case study by HospitalityTech, hotels using AI-based, personalized offers can achieve up to 17-28% growth in ancillary revenue (Kenyon 2025). Directful's analysis (Figure 5) shows that marketing automation not only increases revenue but also optimizes guest loyalty, encouraging deeper engagement and repeat visits (directful.com).

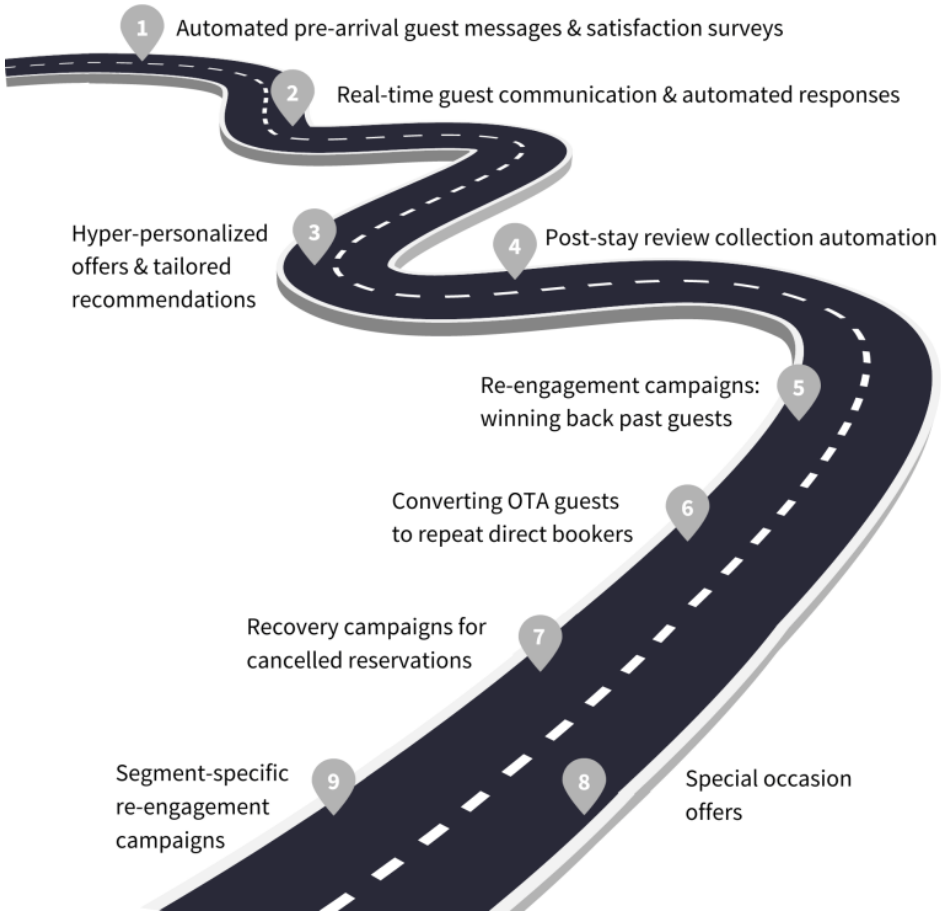

Figure 5. Hotel marketing automation strategies leading to guest loyalty and revenue growth

Source: https://directful.com/blog/hotel-marketing-automation-strategies/

Building guest loyalty and enchanting returning guests

"Keeping the hotel guests engaged and interested is a crucial part of their customer retention strategies." Regarding the hospitality guest lifecycle, there are five main touch points in their satisfaction and loyalty:

1. *"Acquisition or successful reservation of a room via hotel website or travel portals. At this point, the customer shares all the necessary information like date of check-in, type of room, additional services, etc.*
2. *Welcome/On-Boarding along with Pre-Arrival engagement during which the customer is kept occupied to build relationship and loyalty.*
3. *Check-in and During Stay when the customer is at the peak of engaging with the hotel services. If he/she is happy and satisfied with the stay, then he/she might be receptive to the upsell and/or cross-sell offers.*
4. *Check-out and Post-Departure engagement which, based on the customer's overall experience, he/she will share the feedback which will either highlight the USPs or the loopholes of the hotel.*

5. *Retention and Loyalty/Rewards in form of membership and loyalty program, special discounts on the next stay, upgraded services etc.*

If you want to keep your guests interested and involved with the brand at every stage mentioned above, you'll need to dedicate an engagement strategy for each touchpoint to improve your customer retention rate." (Pandey 2018).

The most valuable guest is a returning guest. HotelMentor.ai plays a key role not only in acquiring new customers, but also in retaining existing ones. The data collected by the platform is a gold mine for building loyalty. The system remembers guest preferences and allows the hotel to provide a truly personalized experience during their next stay.

Imagine that a guest stayed in a corner room during their previous visit and mentioned in their online review that they loved the view. The next time they book, the HotelMentor.ai system automatically alerts the front desk to this preference and recommends that they provide a corner room again, if possible. This kind of attention is what makes guests feel that they are truly cared for, and this feeling is the basis of brand loyalty. A 2025 study showed that hotel groups using AI-based personalization achieved up to a 40% increase in repeat guests.

This is consistent with research showing that personalized experiences and proactive communication are the most important factors in guest retention (Pandey 2018).

HotelMentor.ai is therefore a tool that helps hotels treat the guest experience not just as a one-off, pleasant event, but as an ongoing, personalized travel opportunity. With data-driven analytics and automated marketing tools provided by the system, hotels can proactively build guest relationships, increase revenue, and create memorable experiences that guarantee guest return.

3. Summary

Artificial intelligence has become part of our everyday lives. Tourism is a globally successful industry, accounting for practically one in ten jobs worldwide. Experience, enjoyment, and artificial intelligence are becoming inseparable. The hotel industry is experiencing such fierce competition worldwide that it is no longer possible to stand out solely based on quality services. Guest experience and satisfaction depend on the speed of service, the provision of information, and the happy feeling of being remembered. Artificial intelligence can be a very useful tool in supporting all of this.

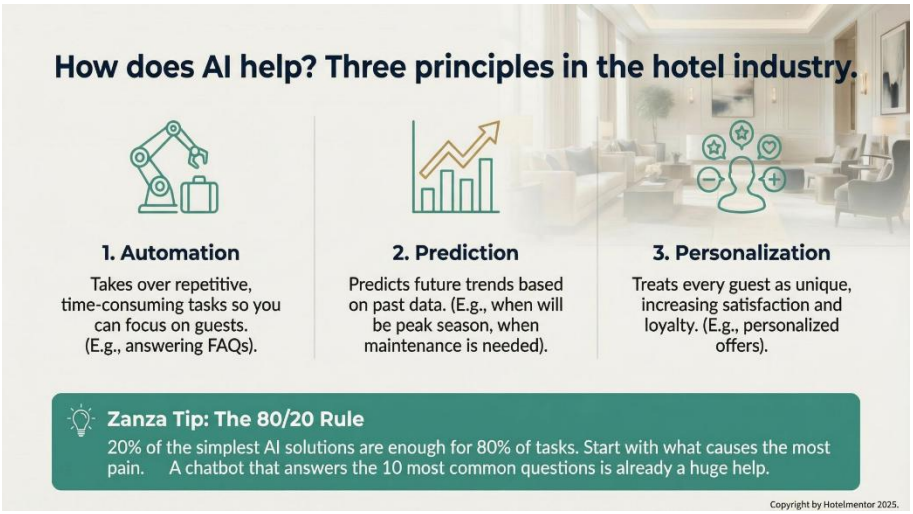

Figure 6. HotelMentor AI as an answer for the principles
Source: Turcsán 2025

The new Hungarian-developed HotelMentor.AI presented in the study is not just software, but a long-term strategic partner that guides hotels through the challenges of the 21st century through digitalization and data-driven operations (Figure 6). The goal of HotelMentor.AI is to provide hotel executives and managers with a tool that not only makes their work easier but also takes the quality of hotel services to a new level. With the help of AI modules, you can manage daily tasks more efficiently, improve the guest experience, and increase the hotel's competitiveness in the market. The system's mobile app makes hotel management accessible from anywhere, so managers and staff always have up-to-date information at their fingertips. HotelMentor.AI is not just a tool, but a reliable partner in optimizing hotel operations.

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CSR: Sustainable Business Approach – A systematic review

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Abstract: Focusing on Corporate Social Responsibility (CSR) supports companies' long-term interests. Beyond profit generation, businesses must consider their impact on society, the environment and stakeholders. A strategic CSR approach strengthens competitiveness by improving risk management, reducing costs, attracting capital, enhancing customer relations, supporting HR management and fostering innovation. Engaging internal and external stakeholders helps firms anticipate societal changes, develop new markets and identify growth opportunities. As CSR becomes a priority, companies enhance their reputation while opening new paths to profitability and resilience, driving meaningful change and generating value for both business and society.

Key words: corporate social responsibility, stakeholders, organizational culture
JEL Classification: D23, M15, O15

Introduction

The present research provides a literature and bibliometric overview of the topics of Corporate Social Responsibility (CSR), stakeholders, and organizational culture, as part of the doctoral dissertation research process. The aim of the study was to comprehensively explore the scientific discourse surrounding CSR, for which the methodology of bibliometric science mapping was applied within the framework of a systematic literature review. Data were collected from the 'Core Collection' database of Web of Science (WoS), as this source offers extensive coverage of high-quality, peer-reviewed publications in the field of management and related disciplines.

Theoretical background

Definitions of Corporate Social Responsibility (CSR) are consistently organized around the central idea that CSR extends beyond legal compliance and involves a proactive commitment to creating social and environmental value. Key elements of CSR definitions and interpretations include proactivity, shared value creation, risk management, and consideration of organizational context, such as the distinction between large corporations and small and medium-sized enterprises (SMEs). The following discussion summarizes these aspects and highlights representative contributions from the literature.

A common feature of dominant CSR definitions is the emphasis on a proactive approach, which suggests that responsible practices should be integrated into corporate strategy, rather than being treated as reactive or peripheral activities. Both the European Commission and Shuremo et al. (2020) emphasize this proactive approach, where CSR is embedded in corporate strategies, not merely responding to legal requirements (European Commission, 2011; Shuremo et al., 2020). This perspective is also reflected in Bowen's foundational work, which interprets CSR as a moral obligation rather than a legal or financial necessity (Bowen, 1953).

Additionally, bibliometric analysis identifies key authors such as Kantabutra and Ferrell, who have significantly contributed to the interpretation of CSR as a proactive strategy. Kantabutra and his co-author Ketprapakorn advocates for the strategic integration of CSR into organizational

management, highlighting its long-term sustainability benefits (Kantabutra & Ketprapakorn, 2022). Ferrell focuses on ethical leadership, which is essential for successful CSR implementation, encouraging companies to take responsibility beyond compliance, aligning it with the core values of the organization (Ferrell, 2018). Other influential authors, such as McWilliams & Siegel and Carroll, further support the proactive perspective, emphasizing that CSR should be an integral part of corporate strategy, fostering both ethical practices and business performance (McWilliams & Siegel, 2001; Carroll, 1999). In summary, a leadership-driven, strategically and culturally integrated proactive CSR approach can yield competitive advantages and stronger stakeholder relationships.

Another important development in CSR thinking is the concept of Creating Shared Value (CSV), which suggests that corporate policies and practices can simultaneously enhance corporate competitiveness and improve social well-being. Skowron-Grabowska et al. (2016) focus on shared value creation, where CSR benefits both the company and society. This strategic approach suggests that CSR is not only about mitigating negative impacts but can be a tool for improving business outcomes by aligning business operations with broader societal goals (Skowron-Grabowska et al., 2016). Porter and Kramer similarly introduce the concept of shared value creation, arguing that companies can achieve profits while addressing social challenges, thereby creating mutual benefits for both corporations and communities (Porter & Kramer, 2011). Morsing and Schultz also emphasize that CSR, when strategically aligned with a company's core operations, can contribute to competitive advantage by strengthening reputation and trust (Morsing & Schultz, 2006). Essentially, the shared value perspective suggests that CSR is not a cost or constraint, but a source of innovation, opportunity, and mutual benefit for both companies and communities.

With the growth of global supply chains, CSR has increasingly become linked with risk management and corporate governance. Modern CSR frameworks encourage companies to conduct due diligence on environmental, social, and governance (ESG) risks, particularly within their supply chains. Recent European Commission guidelines, such as proposals for mandatory human rights and environmental due diligence, stress that large companies must identify and mitigate the potential negative social and environmental impacts of their operations. Integrating CSR into risk management means proactively preventing harm, rather than merely complying with regulations. For example, companies are expected to ensure responsible labour practices, prevent human rights violations, and minimize environmental damage at all stages of production (European Commission, 2011). Similar views are held by authors like Eccles et al., who discuss how integrating CSR into risk management processes helps companies identify and mitigate risks associated with ESG factors (Eccles et al., 2014). Additionally, Steger emphasizes CSR's role in risk management within global supply chains, particularly in relation to human rights and environmental impacts, reinforcing the importance of due diligence in reducing harmful effects (Steger, 2009). In conclusion, the literature suggests that this research direction considers CSR as an integral part of corporate risk management and governance: socially responsible behaviour not only involves performing good deeds but also avoiding harmful consequences that could jeopardize the company’s viability.

The nature of CSR practice can vary significantly depending on the size and context of organizations. The literature review indicates that SMEs may approach CSR differently due to their size and structure, often relying on informal or intuitive approaches. This contrasts with the

formalized CSR practices preferred by larger companies (Dunay et al., 2021). Similar views are expressed by authors such as Spence, who suggests that SMEs often implement CSR practices informally and spontaneously, influenced more by personal values and the immediate business environment than by formal, strategic planning (Spence, 2007). Jamali et al. note that CSR in SMEs is often embedded in daily operations, stemming from the owner's personal commitment to social responsibility rather than external pressures (Jamali et al., 2009). Bos-Brouwers further reinforces this view, highlighting that many SMEs apply a more flexible approach to CSR, balancing economic, social, and environmental aspects in a less structured manner than large corporations (Bos-Brouwers, 2010). Moreover, authors like Vives emphasize that limited resources in SMEs often lead to informal CSR practices, which, despite being less formalized, can still produce positive social outcomes (Vives, 2006). Overall, the literature suggests that CSR is a scalable and adaptable concept: while larger corporations may formalize CSR through strategies, metrics, and reports, smaller companies often practice it based on informal norms and values. Both approaches have their merits, and there is an increasing demand for frameworks that assist SMEs in CSR without imposing excessive burdens. The key takeaway is that businesses, regardless of size, are expected to account for their social and environmental footprints.

In my view, the literature as a whole suggests that CSR has evolved from an initial voluntary, often informal practice into a more structured and strategic business element. CSR no longer merely involves doing good deeds; it is about creating long-term value for both the company and society. However, flexibility is needed in implementing CSR, particularly for SMEs that may not have the resources to formalize CSR processes. Therefore, CSR should be a scalable concept that adapts to the size, structure, and operational environment of the business, while always aiming at shared value creation and minimizing negative social impacts. The role of regulatory frameworks in encouraging CSR cannot be overstated, as they create the environment in which businesses are motivated to engage in voluntary responsibility. At the same time, the voluntary nature of CSR should not obscure the importance of ethical governance and risk management, particularly for large companies with significant societal impact.

Methodology

During the bibliometric analysis, the established methodological protocol developed by Zupic and Čater (2018) was followed to ensure objectivity. This included the clear definition of search criteria, the application of various bibliometric techniques, and the validation of results using well-known indicators such as citation counts and the H-index.

Data collection was carried out based on a multi-layered search strategy implemented in the WoS system, using 'Corporate Social Responsibility' and related terms, complemented by the keywords 'stakeholder' and 'organizational culture'. The search structure consisted of three layers:

- *The first layer (CSR keywords) included: 'Corporate Social Responsibility' OR 'CSR' OR 'Social Responsibility' OR 'Corporate Responsibility' OR 'Corporate Sustainability' OR 'Responsible Business Practices' OR 'Corporate Citizenship', along with their synonyms that focus on sustainability and ethics.*
- *The second layer (stakeholder keywords) consisted of: 'Stakeholder' OR 'Stakeholders' OR 'Stakeholder Engagement' OR 'Stakeholder Analysis' OR 'Industry' OR 'Industries', in order to capture industry-specific characteristics and the involvement of stakeholders.*

- *The third layer (organizational culture keywords) comprised: 'Organizational Culture' OR 'Leadership Styles' OR 'Employee Motivation' OR 'Team Dynamics' OR 'Change Management', which were intended to address the internal organizational, cultural, and leadership aspects of CSR.*

As a result of the three-layered search strategy, 440 relevant documents were identified, which formed the basis for further analysis. The data collection was finalized on 14 February 2025. The analysis covered the period between 1975 and 2025. The database included all document types and languages; however, the majority of the records were published in English. The bibliographic data of the 440 documents were analysed according to the following key criteria:

- annual publication output and citation count (see Figure 1: CSR Citations and Publications),
- document types
- most active authors and countries
- leading journals and CSR categories (see Figure 2: CSR Categories)
- keyword co-occurrence network analysis, density visualization and clustering (see Figure 3: CSR Keyword Co-occurrence Network and Figure 4: Density Visualization of CSR Keywords)

Bibliometric science mapping was conducted using the VOSviewer software. The software automatically generated network maps based on the specified keywords, which were then qualitatively interpreted to identify key terms, clusters, and emerging trends. Particular attention was paid to the most frequently occurring expressions, their temporal appearance patterns, and the density and overlay visualisations of conceptual clusters.

The following section presents the main findings derived from the bibliometric analysis of 440 CSR-related publications in a structured format. The analysis provides insights into the dynamics of the field's development, the contributions of different authors and countries, the disciplinary distribution of CSR research, and the temporal evolution of key topics.

CSR Frameworks and Standards

Over the past few decades, numerous international frameworks and standards have been developed to guide and evaluate CSR practices. These systems collectively reflect the growing importance of CSR in the globalized business environment. The OECD guidelines and the UN Global Compact (UNGC) formulate comprehensive global norms for responsible business conduct (OECD, 2023; United Nations, 2011), while the UN Guiding Principles on Business and Human Rights (UNGPs) and International Labour Organization (ILO) documents focus primarily on human rights and labour law standards (United Nations Global Compact, 2000; International Labour Organization, 2017).

The Global Reporting Initiative (GRI) standards and the World Economic Forum (WEF) metrics provide tools for measuring and reporting CSR activities (Global Reporting Initiatives, 2000; World Economic Forum, 2020). Additionally, the UN Sustainable Development Goals (SDGs) offer a unified international framework that companies can contribute to (Department of Economic and Social Affairs, Sustainable Development, 2015). The ISO 26000 standard and International

Finance Corporation (IFC) guidelines offer flexible frameworks for CSR implementation, enabling companies to tailor their activities to their specific context (ISO 26000, 2010; International Finance Corporation, 2002).

In my opinion, these frameworks complement one another, building on each other, and their combined application enables the strategic integration of CSR. Embedding CSR into business strategy not only fulfils an ethical obligation but also ensures long-term value creation for both the company and society. As CSR evolves, companies must move beyond mere compliance and adopt a holistic approach that encompasses environmental protection, human rights, employee well-being, and social impact, aligning with global sustainable development goals.

The practical combination of these frameworks is characteristic of large corporations that take CSR seriously; for example, a multinational corporation might apply the OECD guidelines and the UN Business and Human Rights Principles to shape its corporate policies, use ISO 26000 for practical implementation, and rely on GRI or WEF metrics to report the outcomes of CSR initiatives. These systems have contributed to CSR's shift from a charitable, voluntary practice to a strategically significant, measurable corporate obligation.

Research results

Annual publication output and citation count

From my point of view, CSR has become an integral part of global corporate governance. Companies are increasingly integrating multiple frameworks into their operations, aligning business objectives with societal goals for sustainable development. In the context of bibliometric analysis, these frameworks serve as keywords and references, while the examination focuses primarily on academic publications that analyze or further develop these standards.

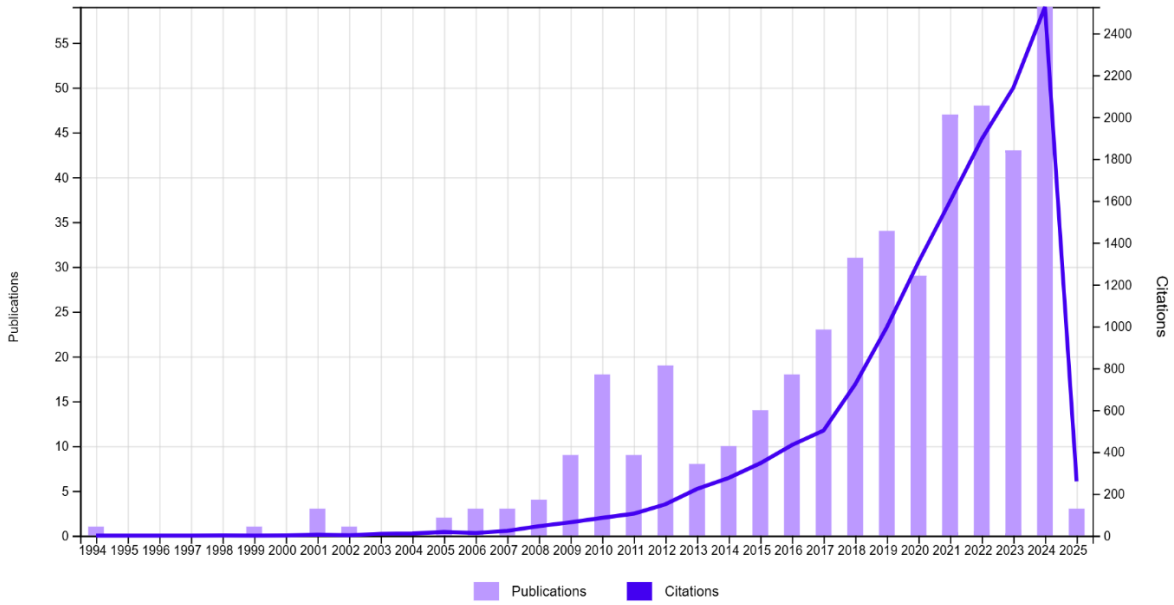

Figure 1. CSR Citations and Publications
Source: own results using VOSviewer

Illustrating with Figure 1 the following two main metrics: the number of publications, indicated by purple bars, and the citation count and its trend, represented by a blue line. Scientific interest in Corporate Social Responsibility remained moderate until the late 1990s, followed by a gradual increase throughout the 2000s, and from the 2010s onwards, a clearly steep rise has been observed.

The total sample comprised 440 publications, of which 59 studies were published in 2024, accounting for 13% of the total corpus and indicating a significant jump compared to previous years. Similarly high publication activity was observed in 2021, 2022, and 2023, with over 40 publications each year. In contrast, the annual publication numbers in earlier years typically remained below 30.

Citation data also showed dynamic growth: CSR-related publications were cited a total of 13,755 times, averaging 31.26 citations per study. An intensive increase in citation counts was particularly noticeable after 2017. The research set's H-index was 58, meaning that at least 58 publications received 58 or more citations, which is an important indicator of the maturity and impact of CSR research.

The most cited publication was the study by Surroca et al. (2010), published in the *Strategic Management Journal*, which received 1,320 citations, averaging 82.5 citations per year. The article examines the relationship between CSR and financial performance, with particular emphasis on the mediating role of intangible resources. The analysis highlights the significance of corporate reputation, brand value, and employee relations as mechanisms through which CSR initiatives can lead to positive financial outcomes. The study concludes that the effective utilization of these resources strengthens stakeholder trust, provides a sustainable competitive advantage, and improves the company's long-term financial performance (Surroca et al., 2010).

In my opinion, the increase in CSR publications has been significantly influenced by European Union regulations and policy frameworks, especially after the turn of the millennium. The second half of the 2010s witnessed several major policy and societal changes, such as the European Commission's CSR communication (2011), the United Nations Sustainable Development Goals (2015), the Paris Climate Agreement (2015), as well as the EU Non-Financial Reporting Directive (NFRD, 2014) and the Green Deal (2019). In addition, growing demands for consumer and corporate transparency, the rise of ESG investments, and technological and globalization effects have also stimulated the surge in CSR-related research. These factors collectively contributed to positioning CSR at the center of scientific discourse and corporate governance practice. In the future, CSR research is expected to continue expanding, with an increasing focus on data-driven, impact-based studies that can measurably contribute to the achievement of sustainability goals.

Distribution of document types

This research includes the distribution of document types. A total of 440 records were retrieved during the analysis. Of these, 377 were classified as research articles, 31 as proceedings papers, 31 as review articles, 15 as early access publications, 7 as book chapters, 1 as a book, 1 as editorial material, and 1 as a retracted publication. Consequently, the majority of the documents, representing 85% of the total sample, were published in the form of scholarly journal articles.

This distribution indicates that the article format is the most widespread and widely accepted form of academic research dissemination, allowing for the detailed presentation of original research findings. Articles are published more frequently than other document types, enabling the rapid communication of new results within a dynamically evolving research field such as Corporate Social Responsibility. The peer-review process ensures the scientific reliability and credibility of these publications.

The presence of review articles also suggests that the field has reached a level of maturity that justifies the systematisation and synthesis of existing literature, as well as the mapping of research trends and gaps. The present bibliometric analysis may likewise be categorised under this summarising and evaluative genre of academic literature.

Most active authors and countries

This research represents the countries/regions contributed the most to CSR-related academic publications. Of the analysed documents, 97% were written in English. China leads the ranking with 60 publications, representing 13.6% of the total 440 articles. This is followed by the United States with 55 publications (12.5%), and the United Kingdom with 39 (8.8%). The subsequent countries in descending order are: India (39 publications, 8.8%), Malaysia (28 publications, 6.3%), Australia (26 publications, 5.9%), Italy (26 publications, 5.9%), Spain (26 publications, 5.9%), Pakistan (20 publications, 4.5%), and Germany (18 publications, 4%), forming the top ten contributing countries.

The dominance of English in CSR research (97% of publications) highlights its key role in global business and academic discourse. English has become the standard language of international communication, especially in fields such as business and CSR, where cross-border collaboration, global supply chains, and multinational corporations are fundamental factors. Countries such as China, the United States, and the United Kingdom, which dominate CSR publication output, reflect the global role of English in academic and corporate environments, facilitating the cross-border exchange of ideas and research outcomes. The widespread use of English in scholarly communication enables CSR research to reach a global audience, contributing to the international development and application of CSR practices. This linguistic unity promotes collaboration and a shared understanding of CSR strategies, policies, and challenges, making English an essential tool for business success and innovation in the CSR domain.

China's leading role in terms of publication volume is notable and reflects the country's growing academic performance across various disciplines, as well as the rising importance of CSR within its corporate and policy environment. Chinese researchers are increasingly engaging with topics such as sustainability reporting, CSR practices in state-owned enterprises, and the influence of Confucian ethics on CSR, often publishing in international journals. The United States and the United Kingdom, by contrast, have long-standing traditions in CSR research, rooted in mid-20th century studies on business ethics and corporate citizenship, which explains their strong and sustained presence in the field.

However, it is important to distinguish between quantitative indicators of publication output and qualitative or impact-oriented metrics. While China slightly surpasses the United States in terms

of publication count, other bibliometric indicators, such as citation impact or centrality in collaboration networks suggest that the US may hold greater overall influence. For instance, a bibliometric study on the relationship between CSR and corporate value identified the US as the most influential country in terms of both citation frequency and collaborative network positioning (Suhartati et al., 2024). The presence of leading business schools and high-impact journals in the US and the UK often contributes to the greater visibility of their academic outputs. At the same time, China's growing contribution indicates that Asian perspectives are increasingly shaping CSR discourse, with rising academic attention to issues affecting emerging markets, such as poverty alleviation, community engagement, and governance challenges in global supply chains.

The top ten authors with the highest number of CSR-related publications (d). The leading contributor is Kantabutra, followed by Ferrell. Each of these authors represents distinct yet complementary perspectives on CSR. Kantabutra is based in Thailand, focuses on the integration of CSR into business strategies, particularly in developing markets, where CSR is viewed as a tool for long-term success and competitive advantage (Kantabutra & Ketprapakorn, 2022). In contrast, Ferrell, from the United States, explores CSR through the lens of marketing and business ethics, emphasizing the importance of ethical leadership and the connection between corporate governance and CSR (Ferrell, 2018). While Kantabutra's work addresses strategic CSR in emerging regions, Ferrell focuses on the ethical dimensions of CSR. Together, their research enriches the understanding of CSR from strategic, ethical, and sustainability-oriented perspectives.

The top ten authors also include scholars from various regions, offering diverse perspectives, for example, European researchers contributing to sustainability management, and North American scholars focusing on stakeholder theory and performance outcomes.

Beyond publication counts, citation networks and collaboration patterns offer deeper insights into the academic influence of these authors. According to a co-authorship analysis, while many authors work independently or in small groups, there are also collaboration networks centred around specific institutions or regions. For instance, in China, university researchers frequently co-author publications, forming national collaboration clusters, while also engaging in international partnerships, particularly with European counterparts, in the areas of CSR and sustainability.

Through co-citation analysis, certain authors and works emerge as intellectual hubs. Classic CSR theorists such as Archie B. Carroll, Edward Freeman (representing stakeholder theory), and Michael Porter are frequently cited, indicating the foundational role of their work in CSR research. Overall, the leading authors offer a multidimensional framework for understanding CSR, integrating strategic, ethical, cultural, and sustainability-based approaches.

CSR categories

Distribution of Corporate Social Responsibility publications across various disciplinary categories illustrated (Figure 2.). Based on the Web of Science database, the leading category is *Management*, with 143 articles, representing 32.5% of the total 440 publications. This is followed by *Business* with 135 articles (30.6%), *Environmental Sciences* with 103 articles (23.4%), *Environmental Studies* with 102 articles (23.1%), and *Green Sustainable Technology* with 101 articles (22.9%).

In my view, this distribution demonstrates that CSR is not an isolated concept but rather a multifaceted one that integrates management, business operations, environmental responsibility, and technological development. The categorization of CSR-related articles within the Web of Science reflects the broad, interdisciplinary nature of the field. The dominance of the *Management* category (32.5%) is justified, as CSR is often treated as a key element of corporate strategy, leadership, and organizational behaviour. Companies integrate CSR into their management practices to create long-term value, enhance reputation, and meet stakeholder expectations.

The high representation of the *Business* category (30.6%) is also expected, given CSR's close connection to business operations. Increasingly, firms acknowledge that CSR is essential for their competitiveness, profitability, and sustainability. Articles within this category are likely to explore the impact of CSR on business models, consumer behaviour, and market dynamics. This reflects research on CSR in fields such as corporate governance, marketing (e.g., consumer responses to CSR), accounting (e.g., CSR reporting), and finance (e.g., the effects of CSR on firm value or risk). In my interpretation, the combined weight of the *Business* and *Management* categories highlights CSR's central position in corporate research, where it is examined for its strategic, performance-related, and stakeholder implications.

The inclusion of *Environmental Sciences* (23.4%) and *Environmental Studies* (23.1%) is particularly significant, as CSR practices often overlap with environmental responsibility. Many contemporary CSR initiatives are focused on sustainability, reducing environmental impact, and addressing climate change. These categories play a vital role in shaping the environmental dimension of CSR, with studies assessing how corporate activities affect ecosystems, resource use, and global sustainability.

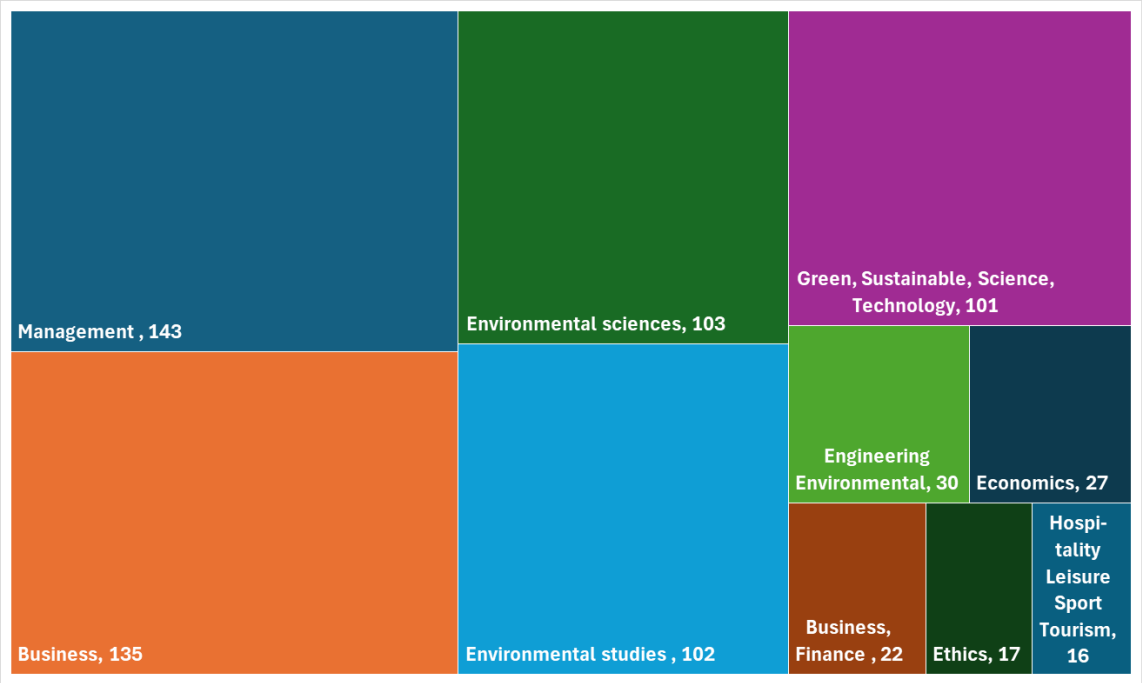

Figure 2. CSR Categories
Source: own results using VOSviewer

Finally, the *Green Sustainable Technology* category (22.9%) reflects the growing importance of technological innovation in CSR practices. Companies are increasingly adopting green technologies to address environmental challenges, reduce carbon footprints, and develop sustainable products and services. CSR initiatives focused on energy efficiency, waste reduction, and sustainable product innovation are naturally classified under this category.

In summary, approximately half of the CSR publications are business- and management-oriented, while the other half are environmentally and sustainability-focused—with substantial overlap between these domains. This interaction is a defining feature of CSR research today, as CSR simultaneously addresses social and environmental impacts, corporate strategy, and business outcomes.

Academic journals reviewed that have published articles on CSR related topics. The leading publication outlets for CSR research include *Sustainability*, *Journal of Cleaner Production*, and *Corporate Social Responsibility and Environmental Management*, all of which focus explicitly on sustainability, environmental management, and corporate responsibility. *Sustainability*, an open-access journal, tops the list with 51 publications. This is likely due to its broad coverage of global sustainability issues, making it a popular choice among CSR scholars. Its popularity is also attributed to its high publication frequency and inclusive editorial policy, which accommodates both theoretical and empirical contributions—facilitating a high volume of CSR-related outputs.

The *Journal of Cleaner Production* follows with 28 articles, focusing primarily on sustainable production and eco-friendly business practices—core elements of CSR strategies. *Corporate Social Responsibility and Environmental Management*, with 20 publications, is another prominent journal explicitly dedicated to CSR and environmental management. Its scope includes CSR strategies, stakeholder engagement, sustainability management, and related policy issues.

It is also important to highlight the presence of the *Journal of Business Ethics* and the *Social Responsibility Journal*, which have published 12 and 11 articles on CSR respectively. These journals underscore the growing academic attention toward the ethical dimensions of CSR. While less focused on environmental sustainability, they emphasize ethical business conduct and corporate societal responsibility. As such, they contribute to positioning CSR within the broader discourse on business ethics, governance, and the social role of organizations.

In summary, CSR research is predominantly published in journals dealing with sustainability, environmental management, and ethical business practices. The most frequent publication platforms prioritize global sustainability challenges, sustainable production techniques, and corporate environmental accountability. In addition, a significant portion of CSR studies addresses stakeholder relations, governance, and policy implications. The ethical dimension of CSR is also well represented, particularly in relation to corporate conduct, social accountability, and the broader societal responsibilities of businesses.

Keyword co-occurrence network analysis

Using the VOSviewer software, a keyword co-occurrence analysis was performed, during which the frequency and groups of keywords were visually identified as pairs, based on the minimum

occurrence count. By mapping how often keywords appear together in the titles and abstracts of articles, we can observe which concepts are closely related to each other, thus identifying those thematic clusters that represent subfields or common research directions of CSR. The analysis was narrowed down to the most frequent keywords to focus on significant patterns. In the present study, the occurrence of 10 keywords related to corporate social responsibility is presented. The goal is to identify the connections between concepts, where the frequency of co-occurrence clearly indicates stronger relationships between concepts. Based on the bibliographic data generated by the Web of Science database, the keyword network is shown (Figure 3.).

The top ten keywords, which are most frequently occurring keywords within the dataset: CSR (165), organizational culture (149), performance (99), management (99), sustainability (85), impact (71), social responsibility (57), sustainable development (57), innovation (46), and financial performance (41).

The high frequency of these keywords, the research suggests that CSR is not an isolated concept but is integrally connected to various dimensions of organizational culture, performance, management, and sustainability. The stronger the co-occurrence of these terms, the deeper the integration of CSR, aimed at simultaneously addressing internal organizational objectives and external societal issues. Visually, it is evident that the keywords CSR and organizational culture stand out prominently; however, they are closely followed by the clusters of performance, management, and sustainability, collectively indicating the strategic nature of CSR.

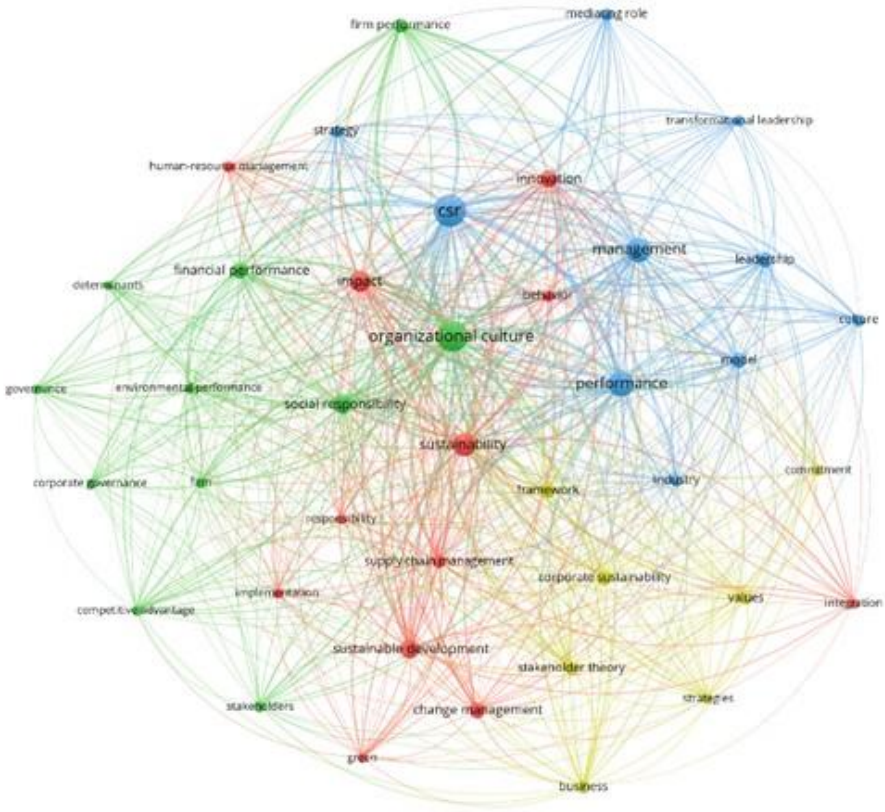

Figure 3. CSR Keyword Co-occurrence Network
Source: own results using VOSviewer

CSR Clusters

The keyword co-occurrence-based keyword network demonstrates how these keywords subsequently cluster together to show CSR clusters. Each cluster represents a set of keywords that frequently appear together within the same articles, thereby indicating conceptual connections. The present analysis identified four main clusters, distributing a total of 10 high-frequency keywords among them. These clusters are named and interpreted as follows.

Cluster 1 "Sustainable Operations and Change Management"
An average weight of 4.51 is observed among the keywords, which include human resource management, supply chain management, sustainable development, change management, and implementation. This cluster focuses on the operational and strategic aspects of CSR within organizations. It highlights how companies integrate sustainable practices into their human resources and supply chain processes. This cluster reflects the practical side of CSR, where enterprises embed sustainability into their operations, adapt their organizational structures to achieve long-term goals, and effectively manage change.

Cluster 2 "CSR Performance and Competitive Advantage"
Keywords in this cluster bear an average weight of 5.33, encompassing environmental performance, organizational culture, competitive advantage, financial performance, and social responsibility. This cluster emphasizes the balance between environmental and social responsibility and corporate performance indicators. It underscores how CSR practices relate to broader organizational goals such as competitive advantage and financial outcomes, highlighting the role of organizational culture in promoting a responsible and sustainable business environment. The impact of CSR on both internal corporate culture and external market performance is reflected here.

Cluster 3 "Leadership"
This cluster, with an average keyword weight of 8.11, includes transformational leadership, mediating role, performance, leadership, and management. It links leadership with CSR, focusing on how transformational leadership influences CSR initiatives and the role of leadership in driving CSR strategies. The term "mediating role" indicates that leadership functions as a key factor facilitating the integration of CSR practices, while performance and management emphasize the connection between leadership and organizational success.

Cluster 4 "Strategic CSR and Stakeholder Engagement"
With an average keyword weight of 4.05, this cluster aggregates corporate sustainability, stakeholder theory, engagement, corporate strategies, and framework. It centers on the strategic foundations of CSR. The cluster contains key concepts related to sustainable business practices, stakeholder involvement, and organizational strategic commitment. CSR appears as a framework aligning business strategies with societal expectations, particularly regarding ethical responsibility and sustainability, while stakeholder theory highlights the consideration of diverse group interests within CSR strategy.

In my opinion, the clustering of keywords represents various facets of CSR research, ranging from operational and leadership perspectives through organizational performance to strategic

frameworks. Each cluster emphasizes different approaches and focus areas within CSR, demonstrating that CSR is a complex, multidimensional field drawing on findings from multiple disciplines such as management, leadership, sustainability, and performance evaluation. Based on these clusters, it can be observed that CSR research spans from the micro-level (leadership, culture, HR) to the macro-level (strategy, stakeholders, external impact), covering both process (implementation) and outcome (performance) dimensions. The clustering confirms that the bibliometric approach captures a real structure that corresponds well with intuitively expected divisions in CSR literature. I hold that these thematic clusters effectively illustrate the multidimensional nature of CSR research.

Density visualization

Density visualization of CSR keywords (Figure 4), highlighting areas with high keyword density, thereby indicating the main thematic clusters within the network. Through this density visualization, research areas receiving the greatest emphasis can be identified, as these are the regions where the highest concentration of keywords occurs. This visualization method assists researchers and academic communities in quickly recognizing the most significant and active research directions and topics within the examined scientific database. In the current study, the keywords CSR, organizational culture, management, performance, sustainability, and impact stand out visually, represented by larger yellow signs.

According to expert opinions, the high density of these keywords suggests that these topics lie at the core of research interest, as they are integrally interconnected and fundamentally important to both the strategic and practical approaches to CSR. This visualization reflects the multidimensional nature of CSR, which simultaneously addresses corporate governance processes, organizational behaviour, social and environmental impacts, as well as sustainable development goals. Density visualization demonstrates the importance of these prominent areas and indicates that researchers are striving to make their most intensive scientific contributions within these key fields.

Overlap visualization illustrating the chronological evolution of keywords, where colours indicate the average publication year of documents containing the respective keywords. The research domains of corporate management and sustainability have undergone significant changes in recent years. In the early stages of CSR research, prior to 2010, emphasis was predominantly placed on establishing the conceptual foundations of CSR, normative issues, values, stakeholder theory, ethical commitment, general interpretations of CSR, and corporate responsibility. By 2018, attention shifted towards the integration of CSR into strategic frameworks, with increasing interest in business models, stakeholder engagement, corporate governance, and factors determining competitive advantage. In 2019, leadership and supply chain management became focal points, supported by the broader theme of corporate sustainability. From 2020 onwards, the scientific discourse has increasingly concentrated on the integration and implementation of sustainability strategies, with particular emphasis on environmental performance, innovation, industry frameworks, as well as the mediating role of human resource management and transformational leadership in enhancing corporate performance. This progression reflects a dynamic shift from the establishment of foundational concepts toward more complex, holistic, and strategic approaches within business practice.

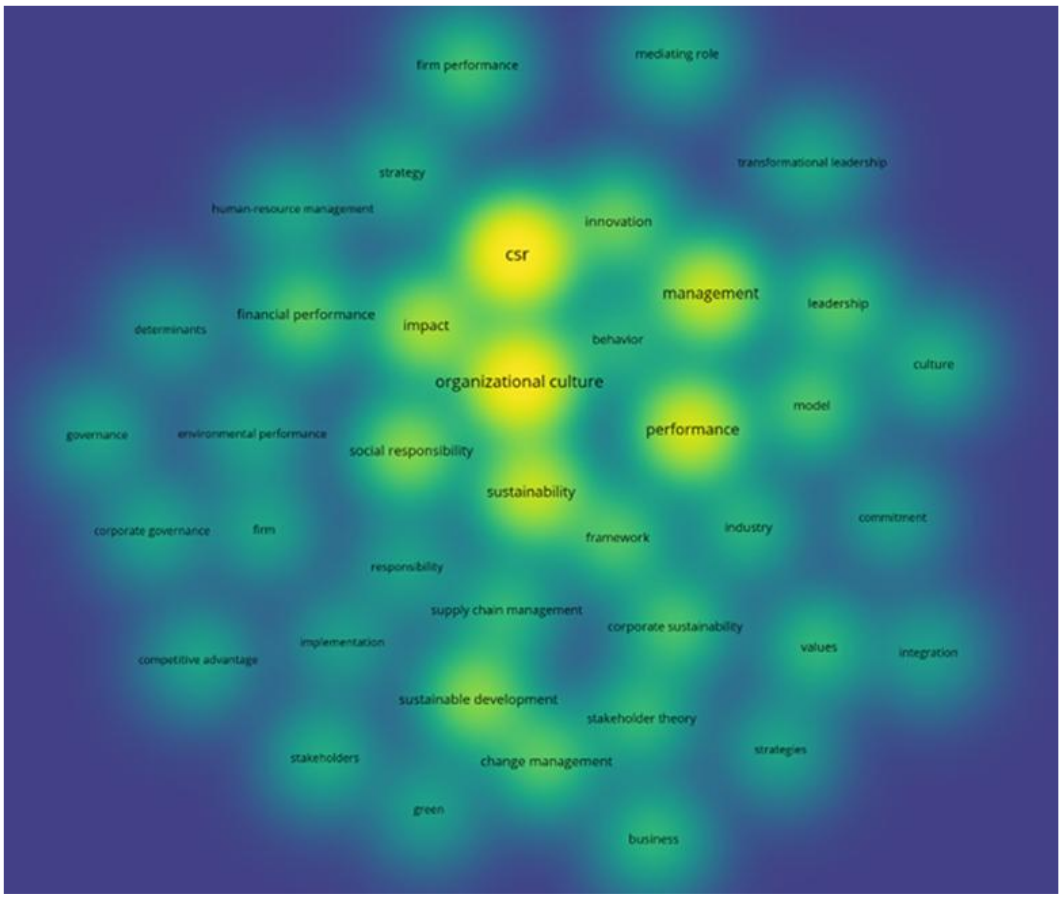

Figure 4. Density Visualization of CSR Keywords
Source: own results using VOSviewer

Conclusions

Summarizing the research findings, recent trends have been analyzed based on the Web of Science database, which includes a total of 440 CSR-related articles from a pool of 13,755 publications dating back to 1975. The number of publications has shown continuous growth since the early 2000s, with especially significant increases observed during the past decade. Citation counts have risen substantially since 2017, indicating the growing influence of CSR research. This growth has been facilitated by multiple factors, including European Union regulations, consumer demands for ethical corporate practices, globalization, and technological advancements. Approximately 85% of CSR studies are published in peer-reviewed journals, ensuring thorough analysis and scientific credibility. The research landscape is dominated by the USA, China, and the United Kingdom, with English serving as the primary language of communication (97%), thereby facilitating global knowledge exchange. Notable scholars such as Kantabutra and Ferrell have made significant contributions in the areas of strategic integration, sustainability, and ethical leadership. CSR research is predominantly associated with the fields of management (32.5%) and business sciences (30.6%), underscoring its integration into organizational strategies. Additionally, environmental sciences and green technologies hold substantial importance. Key journals, such as *Sustainability* and *Journal of Cleaner Production*, reflect the increasing ethical and sustainability focus within CSR research. The post-2020 period's shift toward sustainability, performance, and innovation

demonstrates the progressive incorporation of CSR into business strategies. Active stakeholder collaboration enables corporations to adapt to evolving social expectations, enhancing their reputation, profitability, resilience, and market expansion.

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The Digital Transformation Leadership Gap in the Age of AI: A Thematic Literature Review

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Abstract: Artificial intelligence (AI) is now central to digital transformation (DT), yet many organizations report a persistent leadership gap: a mismatch between AI ambition and leaders' capabilities, structures, and routines to deliver reliable, responsible, and value-creating AI at scale. Using a thematic literature review focused on Elsevier-published scholarship, this article synthesizes recent evidence on the nature, sources, and remedies of the gap. Six recurring themes emerge: (1) uneven AI readiness and strategy formation; (2) governance, risk, and trust deficits; (3) talent, literacy, and capability shortfalls; (4) culture and organizational design misalignments; (5) technical operations and data foundations (e.g., MLOps) that leaders underappreciate; and (6) value realization and measurement challenges. We integrate these themes into a practical lens for executives and propose leadership priorities to narrow the gap.

Key words: digital transformation; artificial intelligence; leadership; governance; AI readiness; organizational culture; skills gap; value realization
JEL codes: O33 – Technological Change; O32 – Management of Technological Innovation and R&D; M14 – Corporate Culture; Diversity; Social Responsibility

1. Introduction

Artificial intelligence (AI) has become a foundational driver of digital transformation (DT), reshaping organizational structures, work practices, business models, and competitive dynamics across industries. As organizations transition from experimental AI pilots to enterprise-wide integration, they increasingly confront a persistent leadership gap: the mismatch between technological ambition and leaders' strategic, organizational, and ethical capacities to deliver responsible and scalable AI systems (Willcocks, 2021; Shrestha et al., 2021). While technical capabilities have accelerated rapidly, the managerial systems and leadership competencies required to orchestrate AI-enabled transformation have evolved more slowly.

Recent studies conceptualize AI readiness as a multidimensional construct involving technological infrastructure, organizational routines, culture, governance, and cross-boundary coordination (Kraus et al., 2023; Shih et al., 2024). Yet empirical evidence suggests that many executive teams struggle to translate readiness into sustained value creation, often overestimating technical maturity while underestimating the organizational demands of AI lifecycle management, responsible AI governance, and data-driven decision-making (Morley et al., 2023). As a result, organizations face stalled pilots, inconsistent scaling outcomes, trust deficits, and fragmented governance architectures.

Parallel literature in responsible AI underscores rising regulatory, ethical, and societal expectations. Frameworks such as the EU AI Act highlight the growing responsibilities of leaders in establishing transparent, accountable, and risk-sensitive AI systems (Floridi et al., 2024). Studies on trust in AI further show that leadership practices influence not only compliance

outcomes but also employee and customer trust, thereby shaping adoption quality and organizational legitimacy (Longoni et al., 2024).
Moreover, the emerging "AI productivity paradox" suggests that performance gains materialize unevenly, depending on complementary managerial investments in culture, human-AI teaming, MLOps infrastructure, and learning-based performance measurement (Brynjolfsson et al., 2023). These findings highlight leadership as a bottleneck—or catalyst—in determining whether AI produces measurable value.

Given these converging insights, scholars increasingly argue that AI-enabled DT is not primarily a technological challenge but a leadership challenge. This article addresses this gap by synthesizing recent evidence from Elsevier-indexed scholarship through a thematic literature review. The goal is to identify recurrent themes explaining why leadership gaps persist and what leadership capabilities are required to close them. By integrating conceptual, empirical, and governance-oriented research, this article contributes a structured understanding of leadership priorities for the AI era.

2. Literature Review

2.1. Digital Transformation and the Expanding Role of AI

Digital transformation literature has evolved from a focus on information technologies to a broader understanding of business model reinvention, organizational agility, and data-driven innovation (Jonathan & Kuika Watat, 2023). AI now represents the most disruptive component of DT, influencing both strategic orientation and everyday organizational routines (Raimo et al., 2023). Scholars highlight that AI-driven DT requires leaders to develop new forms of sensemaking, orchestration, and cross-functional coordination (Sousa & Rocha, 2022).

However, research indicates a persistent disconnect between strategic AI ambitions and organizations' operational capacity to execute these strategies. Empirical studies show that many firms remain stuck in the "pilot trap," where AI initiatives proliferate but fail to scale due to weak leadership oversight, unclear prioritization, and insufficient investment in enabling infrastructure (Shrestha et al., 2021; Kraus et al., 2021).

2.2. Leadership, Governance, and Trust in AI

A rapidly growing body of scholarship emphasizes responsible AI governance as a core leadership responsibility. Reviews identify governance architectures—including policies, human oversight, documentation, model monitoring, and ethical guidelines—as necessary to mitigate risks and ensure trustworthy deployment (Morley et al., 2023; Floridi et al., 2024). Despite this, research shows that leaders often treat governance as a peripheral or compliance-only activity, resulting in inconsistent practices across departments (Wirtz et al., 2023).

Studies on trust in AI further highlight leadership's influence on adoption quality. Transparent decision-making, communication, and ethical alignment significantly shape user trust, particularly in high-stakes environments (Longoni et al., 2024). Poorly designed algorithmic management or

opaque AI systems can undermine autonomy and psychological safety, creating cultural resistance (Jarrahi & Sutherland, 2023).

2.3. Talent, Skills, and AI Literacy Gaps

Literature consistently reports shortages in AI-related skills across managerial, technical, and operational roles (Kumari et al., 2024). These gaps include both technical competencies (e.g., data literacy, model interpretation) and managerial capabilities (e.g., redesigning workflows, managing human-AI teams). AI literacy frameworks emphasize the need for structured, role-based upskilling to improve adoption and reduce risk (Renn et al., 2025).

However, few organizations institutionalize AI literacy at scale. Studies suggest that without foundational literacy, decision-makers misinterpret AI outputs, underinvest in infrastructure, and fail to embed responsible AI principles into daily workflow (Shah et al., 2024). As a result, talent and literacy shortcomings become major barriers to value realization.

2.4. Organizational Culture, Structure, and Ambidexterity

Effective AI scaling requires organizational ambidexterity—the ability to exploit existing processes while exploring new AI-enabled opportunities (Kammerlander et al., 2020). DT research emphasizes that culture, collaboration structures, incentives, and leadership behaviors determine whether ambidexterity can flourish (Jonathan & Kuika Watat, 2023; Marabelli et al., 2024).

Algorithmic management literature warns that poorly implemented AI systems can erode autonomy and trust, reducing willingness to experiment (Jarrahi & Sutherland, 2023). Studies on culture design in DT argue that leaders must intentionally create cross-functional teams, shared data practices, and feedback-rich environments to enable experimentation (Hanelt et al., 2021).

2.5. Technical Foundations, MLOps, and Lifecycle Management

Although AI research often foregrounds algorithms, MLOps and data lifecycle management represent the primary determinants of scalable AI success. Systematic reviews document recurring failure points—data unreliability, brittle pipelines, shadow AI systems, unclear model ownership—and highlight the need for robust MLOps frameworks (Polyzotis et al., 2024; Martínez-Plumed et al., 2024).

Studies consistently show that leaders underestimate the importance of operational AI infrastructure relative to model development. MLOps maturity models propose structured pathways for improving data quality, testing, observability, model monitoring, and governance integration (Lwakatare et al., 2022). Leadership commitment to these “invisible” layers is critical for safety, compliance, and value capture.

2.6. Value Creation, Performance, and the AI Productivity Paradox

A large body of empirical and review literature examines whether and how AI improves organizational performance. While many firm-level studies report positive effects, macro-level

indicators show uneven productivity growth, creating a modern AI productivity paradox (Brynjolfsson et al., 2023). The literature concludes that value depends on complementary assets such as data quality, leadership competence, culture, and measurement systems (Raimo et al., 2023).

Research also emphasizes the importance of defining realistic value metrics, learning cycles, and feedback loops. Without these managerial complements, AI remains isolated in pilots or produces inconsistent ROI (Hanelt et al., 2021; Sousa & Rocha, 2022).

3. Thematic Literature Review as a Methodological Approach

3.1. Understanding the Thematic Literature Review

A thematic literature review brings together existing scholarship by organising it around recurring ideas, conceptual patterns, and shared meanings rather than summarising individual studies or arranging material historically. The approach stems from the tradition of thematic analysis, where Braun and Clarke (2006) describe analysis as the systematic recognition and interpretation of patterned meaning within a dataset. When this analytic logic is applied to academic publications, it allows the reviewer to move beyond simple reporting and instead construct broader conceptual structures, relationships and interpretive categories, as illustrated in Thomas and Harden's (2008) foundational work.

Thematic reviewing occupies a methodological middle-ground between narrative reviews and fully structured systematic reviews. Snyder (2019) positions such reviews within a continuum of designs that balance interpretive depth with procedural rigour. In practice, thematic reviews often employ systematic search strategies and transparent study-selection procedures while preserving space for qualitative interpretation. This makes them particularly well suited for disciplines where conceptual precision, theoretical development and sense-making are central objectives.

The method is also rooted in advancements in qualitative evidence synthesis. Thomas and Harden (2008) demonstrated how coding and theme-building can translate diverse qualitative findings into integrated interpretations. Subsequent contributions highlight the need for reflexive awareness, clear documentation of coding practices, and openness regarding the researcher's interpretive stance (Ahmed, 2025; Purssell & McCrae, 2021, Saadi et al., 2023). These principles shape the epistemic foundations of thematic reviewing and guide its application across research fields.

3.2. Methodological Bases and Core Stages

Although thematic literature reviews vary in complexity, most follow a series of closely related phases. The process begins by defining the review's scope and research questions. This includes selecting relevant databases, designing search strategies, and setting inclusion criteria—practices aligned with Snyder's (2019) emphasis on methodological transparency. Studies in review methodology, such as Chong (2022) and Hamel et al. (2021), demonstrate how structured search protocols enhance reliability even in review formats that allow interpretive flexibility.

The next step is locating and selecting relevant studies through systematic or semi-systematic searches. Articles are screened at multiple stages to ensure consistency and minimise bias. Work on rapid reviews shows that even accelerated formats require explicit documentation of search processes to maintain credibility (Hamel et al., 2021).

Coding represents the third stage. Here, the reviewer treats each publication as qualitative data and examines its content line-by-line. Braun and Clarke's (2006) framework guides the movement from familiarisation to initial coding, while Thomas and Harden (2008) show how such coding supports the construction of descriptive and interpretive themes. Recent methodological writing stresses the importance of reflexive coding practices and clear analytical records (Ahmed, 2025; Purssell & McCrae, 2021).

Theme construction forms the fourth stage. Individual codes are aggregated into broader thematic groupings that capture significant patterns across studies. Research such as Sezgin et al. (2019) on frailty and Salm et al. (2021) on global health illustrates how themes help clarify conceptual inconsistencies and contested meanings. As themes evolve, they are checked against the underlying evidence and refined to reflect both descriptive detail and analytical insight, echoing the model set out by Thomas and Harden (2008).

In the final stage, themes serve as the organising framework of the written synthesis. Instead of structuring the review around individual studies, the analysis is organised around the themes themselves. Classic examples include Ward, House and Hamer's (2009) development of a knowledge-translation framework and Uttley et al.'s (2023) thematic mapping of methodological problems in systematic reviews, both of which demonstrate how thematic structures can generate new conceptual models or reveal structural weaknesses within a field.

3.3. Use Across Research Domains

Thematic literature reviews have become a common analytical tool across multiple academic disciplines. In health sciences, they are frequently employed to make sense of complex or ambiguous concepts and to synthesise qualitative findings. Ward et al. (2009) demonstrated how a thematic approach can unify diverse strands of knowledge translation research. Salm et al. (2021) used a related strategy to distil the principal conceptual components of global health, while Sezgin et al. (2019) highlighted definitional inconsistencies surrounding frailty.

Thematic synthesis also plays a central role in research on lived experience and practice. Newington et al. (2021) explored the experiences of clinical academics; Warr et al. (2021) analysed healthcare providers' attitudes towards obesity; Howard and Bartholomew (2024) synthesised research on structural and experiential barriers to physical activity among Black women; and McMahon et al. (2022) brought together studies on musical engagement in dementia care.

In community and public health research, thematic reviews help interpret socially embedded phenomena. Examples include Lee et al. (2020), who synthesised evidence on community exchange systems, and Metsis et al. (2025), who analysed young people's understandings of health.

In management and marketing research, thematic reviews enable scholars to distil conceptual trends from rapidly expanding literatures. Cioppi et al. (2023) mapped the thematic contours of digital transformation in marketing, while Li (2023) applied thematic synthesis to academic help-seeking, identifying influences at personal, relational and institutional levels.

The methodology itself has also become the subject of thematic inquiry. Chong (2022) analysed systematic reviews in higher education to reveal common methodological shortcomings. Hamel et al. (2021) used thematic methods to clarify the evolving role and limitations of rapid reviews. Uttley et al. (2023) applied thematic synthesis to evaluate recurrent weaknesses across systematic reviews as a research genre.

Thematic approaches further extend to technology and computing. Cooper et al. (2022) employed reflexive thematic analysis to examine community-centred strategies in computing, highlighting patterns related to participation, accountability and ethics.

3.4. Thematic Reviews as a Tool for Revealing Research Gaps

One of the core strengths of thematic literature reviews is their ability to make research gaps visible. Because the analysis centres on thematic patterns, it becomes clear which ideas or contexts dominate the literature and which are comparatively absent or insufficiently developed. Ward et al. (2009) showed how certain components of knowledge-translation research were conceptually rich but empirically under-examined. Salm et al. (2021) pinpointed areas of global health discourse that lacked theoretical or contextual nuance.

Thematic reviews also highlight population and context gaps. Howard and Bartholomew (2024) demonstrated that mainstream physical activity research rarely addressed the specific experiences of Black women, while Metsis et al. (2025) revealed a lack of youth-centred conceptualisations in public health.

Conceptual issues become equally visible. Sezgin et al. (2019) identified competing definitions of frailty, and Salm et al. (2021) exposed divergent interpretations of global health.

Methodological gaps are another common finding. Chong (2022) reported that many higher-education reviews relied heavily on narrative synthesis and lacked methodological rigour. Uttley et al. (2023) catalogued recurring problems such as publication bias, inconsistent quality appraisal and insufficient attention to heterogeneity.

Finally, thematic reviews often point directly toward future research strategies. Cioppi et al. (2023) used thematic clusters to propose new directions in digital-transformation research. Li (2023) translated thematic findings into testable propositions. Cooper et al. (2022) identified themes that underpin a research agenda for community-centred computing. Methodological analyses by Hamel et al. (2021) and Uttley et al. (2023) offered recommendations for improving the design and conduct of evidence syntheses.

Through these contributions, thematic literature reviews provide a robust methodological foundation for identifying where knowledge is well developed, where it is fragmented, and where new conceptual or empirical work is most needed.

4. Results: Thematic Classification of the AI Transformation Leadership Gap

Based on the thematic analysis of peer-reviewed articles indexed on Elsevier platforms and Web of Science between 2010 and 2025, six recurrent and historically evolving leadership gaps in AI-enabled digital transformation (DT) were identified. These themes synthesize findings from AI readiness frameworks, responsible AI governance research, AI literacy and skills studies, organizational culture and ambidexterity work, MLOps literature, and empirical studies on AI-driven productivity and performance.

4.1 Historical trajectory of AI transformation leadership research

Early DT literature (pre-2016) focused primarily on digital technologies (ERP, cloud, mobile) and emphasized transformational leadership, organizational agility, and digital strategy as key drivers of performance (e.g., AlNuaimi et al., 2022). AI appeared mainly as a generic "advanced analytics" capability within broader digitalization programs.

From around 2018–2021, AI became a distinct object of analysis. Studies began to conceptualize AI readiness as a multidimensional construct encompassing technological infrastructure, data assets, organizational routines, and strategic intent (Holmström, 2022). Leadership was increasingly framed as the "translator" between AI potential and organizational capabilities.

Between 2020 and 2024, three developments reshaped the research agenda:

1. Responsible AI governance became a central topic, with frameworks detailing structural, relational, and procedural practices for trustworthy AI deployment (Papagiannidis et al., 2025; Batool et al., 2025).
2. AI literacy and skill gaps were systematically reviewed, highlighting deficiencies in managerial and workforce capabilities (Almatrafi et al., 2024; Rikala et al., 2024; Mhaske et al., 2025).
3. MLOps and lifecycle management emerged as critical enablers of scalable AI, shifting attention from models to operational infrastructure (Zarour et al., 2025).

From 2023 onward, generative AI and human-AI teaming introduced new leadership concerns around adoption dynamics, collaboration, and cognitive demands on executives (Ali et al., 2025; Schmutz et al., 2024; Sidorkin, 2025).

Across this historical arc, we observe a consistent pattern: technical capabilities advance faster than leadership practices, generating a multi-dimensional "AI transformation leadership gap." The six themes below classify this gap.

4.2 Theme 1 – Strategy & Readiness Gap: From digital ambition to AI-specific execution

Historical evolution. Early DT studies emphasized the importance of transformational leadership and digital strategy for achieving agility and organizational change (AlNuaimi et al., 2022). With the advent of AI readiness frameworks, researchers began to articulate more specific dimensions (technologies, activities, boundaries, goals) required for AI-enabled transformation (Holmström, 2022).

Gap pattern. The thematic synthesis shows a persistent mismatch between:

- High-level AI narratives in boardrooms (e.g., "AI-first," "data-driven" strategy), and
- Operationalized roadmaps that align use-cases with data availability, process redesign, and capability building.

Studies report that many organizations adopt AI in an ad-hoc, project-based fashion, lacking clear prioritization criteria, sequencing logic, or integration with enterprise architecture and change management (Holmström, 2022; Yang, 2022).

Historically, the literature moves from generic calls for "digital leadership" to more granular AI-specific guidance (e.g., AI transformation frameworks, AI orientation constructs), yet empirical work still finds low maturity in strategic orchestration and portfolio governance. This constitutes a strategy and readiness gap: leaders articulate AI ambitions but do not consistently translate them into executable, resourced transformation programs.

4.3 Theme 2 – Governance, Risk & Trust Gap: Responsible AI as underdeveloped leadership practice

Historical evolution. Initial AI adoption studies treated governance mainly as data protection or IT compliance. Over time, responsible AI and AI governance became distinct research streams, defining governance as a set of structural, relational, and procedural practices (e.g., roles, policies, oversight mechanisms, documentation, monitoring) aimed at aligning AI with ethical, legal, and societal expectations (Papagiannidis et al., 2025; Gunasekara et al., 2025).

Gap pattern. The thematic analysis indicates that:

- Conceptual frameworks for responsible AI governance are rich and mature, but
- Evidence of systematic, organization-wide implementation remains limited.

Studies highlight fragmentation of responsibilities (e.g., data protection officers, CIOs, product owners) and the absence of integrated governance architectures spanning the full AI lifecycle (design, training, deployment, monitoring, decommissioning).

Research on trust in AI shows that opaque models, weak documentation, and insufficient human oversight erode employee and customer trust, limiting adoption, especially in high-risk contexts (Longoni et al., 2024; Batool et al., 2025).SpringerLink While regulatory initiatives such as the EU AI Act provide external pressure, studies report uneven preparedness among leaders in risk classification, impact assessment, and redress mechanisms.

This yields a governance, risk, and trust gap: leadership discourses increasingly reference responsible AI, but many organizations lack coherent governance structures and routines to make these principles operational.

4.4 Theme 3 – Talent, Literacy & Capability Gap: The human capital lag

Historical evolution. Earlier DT work considered "digital skills" in broad terms. More recent research differentiates between AI-specific technical skills (e.g., data science, MLOps), managerial skills (e.g., translating business problems into AI use-cases), and AI literacy across diverse populations (Almatrafi et al., 2024). Reviews of skill gaps in Industry 4.0 and digital workforces document systemic shortages in data, AI, and advanced analytical competences (Rikala et al., 2024; Mhaske et al., 2025).

Gap pattern. Across cases and sectors, the literature identifies:

- Executives and managers who lack sufficient AI understanding to critically evaluate proposals, ask the right questions, or design complementary changes in structure and incentives.
- Non-technical staff who are expected to work with AI-enabled systems but receive limited training or involvement in design, undermining adoption and trust.
- Specialist bottlenecks in data engineering, MLOps, and AI safety that slow scaling and create dependency on vendors.

Systematic reviews of AI literacy conceptualization and assessment stress that organizations rarely move beyond ad-hoc training; comprehensive, role-based literacy programs are the exception rather than the norm (Almatrafi et al., 2024).

The resulting talent, literacy, and capability gap is historically persistent: despite repeated warnings since the big-data era, leadership investment in human capital has not kept pace with the increasing complexity and ubiquity of AI systems.

4.5 Theme 4 – Culture, Structure & Ways-of-Working Gap: Ambidexterity under pressure

Historical evolution. Digital transformation research has long emphasized the need for organizational ambidexterity—the ability to exploit existing capabilities while exploring novel digital opportunities. Studies show that digital transformational leadership and organizational agility jointly drive DT outcomes (AlNuaimi et al., 2022).

Recent work deepens this view by examining how organizational culture and data-driven norms enable or constrain data-centric and AI-enabled transformation (Ghafoori et al., 2024; Ghafoori et al., 2024). Research on "strategic design of culture" for DT demonstrates that leaders who actively shape values, artefacts, and collaboration patterns foster more resilient and innovative transformations (Butt et al., 2024).

In parallel, algorithmic management literature documents risks when AI is used primarily for monitoring and control. Algorithms that rigidly define work tasks, performance metrics, and

feedback loops can reduce autonomy, increase stress, and erode trust (Parent-Rocheleau & Parker, 2021).

Gap pattern. Synthesizing these streams reveals:

- Many organizations retain siloed, hierarchical structures that hinder cross-functional AI teams and iterative experimentation.
- Cultural norms often prioritize short-term efficiency and risk avoidance over learning, experimentation, and data-sharing.
- AI-mediated control mechanisms, if implemented without careful design, can undermine the very engagement and collaboration needed for successful transformation.

This constitutes a culture, structure, and ways-of-working gap: leaders recognize the importance of culture and ambidexterity in theory, but empirical studies show limited progress in redesigning structures and norms to support AI-enabled exploration and responsible algorithmic work design.

4.6 Theme 5 – Technical Operations & Data Gap: Underestimated MLOps and "run" capabilities

Historical evolution. Early AI adoption work focused on algorithm choice and proof-of-concept accuracy. More recent studies highlight MLOps—the set of practices for integrating, deploying, monitoring, and maintaining models—as a critical determinant of scalable AI success (Zarour et al., 2025). Systematic mappings of MLOps literature catalogue common failure modes (brittle pipelines, lack of versioning, ad-hoc deployment, poor observability) and propose maturity models and best practice templates.

Gap pattern. The thematic synthesis shows that:

- Leadership discourse still often treats AI as a series of projects rather than long-lived socio-technical systems, with dedicated ownership, SLAs, and lifecycle budgets.
- MLOps and data engineering are frequently under-resourced compared to model development; investment in monitoring, drift detection, documentation, and rollback is delayed until incidents occur.
- Responsibility for operational AI is fragmented across IT, data science, and business units, leading to unclear accountability for failures or ethical breaches.

These patterns define a technical operations and data gap: leaders underestimate and under-govern the "plumbing" of AI—data quality, pipelines, deployment practices, and monitoring—even as the literature increasingly shows that these layers are essential for safety, compliance, and value capture (Zarour et al., 2025; Ghafoori et al., 2024).

4.7 Theme 6 – Value, Performance & Productivity Gap: From AI promise to measurable outcomes

Historical evolution. A substantial body of firm-level and macro-level research investigates the productivity and performance effects of AI. Studies find that AI can raise productivity and innovation but with highly uneven outcomes across firms, sectors, and countries (Czarnitzki et al.,

2023; Yang, 2022). This has given rise to a modern "AI productivity paradox": despite localized success stories, aggregate productivity gains often lag.

Recent work links these uneven outcomes to complementary managerial and organizational assets—data quality, human capital, dynamic capabilities, governance, and culture—rather than to AI technologies alone (Raimo et al., 2023; Ghafoori et al., 2024). Emerging generative AI studies similarly show that adoption outcomes depend on leadership decisions about workflows, incentives, guardrails, and evaluation metrics (Ali et al., 2025; Hughes et al., 2026).

Gap pattern. Across these strands, the literature identifies:

- Weak or absent baseline metrics for processes affected by AI, making it difficult to attribute gains or losses.
- Narrow focus on short-term efficiency metrics, with less attention to innovation, risk, and human-centric outcomes.
- Limited use of learning loops (A/B experiments, longitudinal dashboards, post-deployment reviews) to iteratively improve AI solutions and governance.

This yields a value, performance, and productivity gap: leaders often invest in AI without establishing robust value hypotheses, measurement frameworks, and feedback mechanisms, contributing to disappointment, misaligned expectations, and public skepticism about AI's true benefits.

5. Discussion

This thematic literature review shows that the "AI leadership gap" is not a single deficit but a system of misalignments in strategy, governance, talent, culture, technical operations, and value measurement. In other words, organizations are not only struggling to "do more AI," but to lead AI-enabled digital transformation in a coherent, responsible, and measurable way. In this section, we discuss how these gaps can be narrowed in practice and outline future research directions that follow from the historical evolution of the field on Elsevier and Web of Science.

5.1 Reframing AI-enabled digital transformation as a leadership problem

Across the historical record, AI is often framed as a technological or analytics upgrade, while leadership appears mainly as an enabling condition. The evidence reviewed here suggests the opposite: AI transformation is fundamentally a leadership and organizational challenge, with technology embedded in broader socio-technical systems.

Closing the gap requires a reframing: leaders need to treat AI not as a set of isolated projects, but as a long-term reconfiguration of strategy, governance, talent, culture, and operations. This implies that board members, C-suites, and top public-sector officials must develop specific AI-related competencies—strategic, ethical, and operational—rather than delegating "AI issues" to technical teams alone.

5.2 Closing the strategy and readiness gap

The first gap concerns strategy and readiness: many organizations articulate ambitious AI narratives without a concrete pathway to execution. AI readiness frameworks, DT canvases, and transformation journeys already provide structured tools to connect vision, capabilities, and portfolios. The literature suggests several levers to close this gap.

First, AI strategy should be explicitly integrated into corporate and public-sector strategies, with clear links to priority domains (e.g., customer service, operations, fraud detection, public service delivery) and to broader digital ambitions. Rather than "AI for everything," leaders should define a small number of value archetypes (efficiency, quality, new revenue, risk reduction, citizen experience) and map use-cases accordingly.

Second, organizations need dedicated structures for AI transformation orchestration—for example, an AI transformation office or cross-functional steering group that coordinates pipelines, architecture, change management, and capability building. This mitigates the "pilot trap" by aligning data readiness, MLOps requirements, and organizational change with strategic priorities.

Third, leaders should use maturity models and readiness assessments not as static checklists but as part of ongoing learning cycles: periodic assessments, portfolio reviews, and adjustments of ambition as capabilities evolve.

5.3 Embedding responsible AI governance and rebuilding trust

The governance, risk, and trust gap emerges because responsible AI is often treated as a regulatory obligation rather than a core leadership domain. Yet the literature on AI governance and trustworthy AI provides detailed guidance on structures (committees, roles), processes (impact assessments, audits), and principles (fairness, transparency, accountability).

To narrow this gap, leaders can take three steps.

- First, they should design a formal AI governance operating model, with clear allocation of responsibilities (e.g., board oversight, executive ownership, data/AI councils, ethics committees) and integration with risk management, legal, and compliance functions.
- Second, organizations should move from "paper principles" to embedded governance routines: mandatory risk classification for AI use-cases (especially under regimes such as the EU AI Act), standardized impact assessments, human-in-the-loop requirements for high-risk decisions, and continuous monitoring of models in production.
- Third, trust needs to be built not only externally but also internally. Transparent communication about AI capabilities and limits, participatory design with frontline workers, and meaningful explanations for AI-supported decisions can counteract fear and resistance.

Future research can support this agenda by empirically comparing different AI governance operating models, identifying which combinations of structures and routines are most effective in specific sectors and regulatory contexts.

5.4 Developing AI talent, literacy, and leadership capabilities

The talent and literacy gap is one of the most persistent findings across studies. Reviews show that organizations face shortages in both technical and managerial AI capabilities, as well as uneven AI literacy among employees.

The literature suggests that role-based, systemic AI literacy programs are more promising than ad-hoc courses. For example, executives need competencies in portfolio selection, risk oversight, and AI economics; middle managers in process redesign and human-AI teaming; frontline workers in understanding system boundaries and escalation paths; and technical staff in MLOps, safety, and ethics.

Leadership development programs can integrate AI modules into existing curricula on strategy, governance, and change management, rather than treating AI as a separate technical topic. Organizations may also benefit from hybrid roles (e.g., product owners with AI knowledge, AI translators, or "digital mentors") that bridge business and technical communities.

There is a clear research opportunity to evaluate which AI literacy and leadership interventions actually change behavior and outcomes. Longitudinal and quasi-experimental designs could examine how specific training programs affect adoption quality, risk incidents, or innovation rates.

5.5 Designing culture, structure, and ways of working for ambidextrous AI

The culture and structure gap reflects tensions between stability and experimentation. The literature on digital transformation leadership and organizational ambidexterity shows that leaders must simultaneously exploit existing capabilities and explore new ones.

The findings point to several design choices:

Leaders can create cross-functional, product-oriented teams that own AI solutions end-to-end (from idea to operation) and are empowered to experiment within clear guardrails. Stable team membership, shared accountability, and access to data and domain expertise are key.

Psychological safety and a learning-oriented culture matter as much as tools. Studies of algorithmic management warn that AI-mediated surveillance or hyper-standardization can undermine autonomy, trust, and creativity. Leaders need to explicitly design for "good work" with AI: involving employees in system design, ensuring meaningful human control, and aligning metrics with human well-being, not only throughput.

Future research should explore micro-level dynamics of human-AI collaboration and algorithmic work design: for example, how different leadership behaviors and cultural norms shape workers' acceptance of AI, creativity, and well-being in AI-mediated workplaces.

5.6 Elevating MLOps, data, and lifecycle management to the boardroom

The technical operations and data gap arises because MLOps, data engineering, and lifecycle governance are often perceived as purely technical issues. Yet the literature demonstrates that scalable, safe AI depends on robust pipelines, documentation, monitoring, and governance embedded in everyday operations.

To close this gap, leaders should treat MLOps and data infrastructure as strategic assets comparable to core production or financial systems. This implies:

- clear product and ownership models for AI systems (e.g., accountable product owners and system stewards),
- explicit service levels and risk thresholds for AI components,
- board-visible KPIs on data quality, model robustness, incidents, and technical debt, and
- investment in shared platforms (feature stores, monitoring tools, documentation standards) that reduce fragmentation.

Here, future research could investigate the relationship between MLOps maturity and outcomes such as incident frequency, regulatory compliance, and time-to-value, and explore how board oversight practices adapt to AI infrastructure.

5.7 Measuring value and addressing the AI productivity paradox

The value and productivity gap is driven by weak measurement and learning practices. Empirical work on AI and productivity shows that benefits depend heavily on complementary assets and that macro-level gains are uneven.

To move from promise to proof, leaders need to:

- articulate explicit value hypotheses for AI initiatives (e.g., “reduce processing time by 30%,” “increase cross-sell rate by 10%,” “cut false positives by half”),
- establish baselines before deployment,
- track a balanced set of indicators (efficiency, quality, innovation, risk, employee and citizen experience), and
- embed learning loops such as A/B testing, post-implementation reviews, and continuous improvement cycles.

Future research can support this agenda by developing standardized frameworks for AI value measurement, including human-centric and societal outcomes, and by studying how different measurement strategies influence portfolio allocation and legitimacy of AI in organizations.

5.8 Future research directions

The historical review suggests several promising avenues for future work:

First, there is a need for causal evidence on leadership interventions. Most studies describe correlations between leadership, culture, governance, and AI outcomes. Future research could use longitudinal, multi-firm, or experimental designs to test the impact of specific interventions such

as governance councils, AI literacy programs, or structural changes (e.g., product teams) on adoption quality, risk, and performance.

Second, future work could develop multi-level models that connect individual leader cognition (e.g., AI mental models, risk perceptions), team-level practices (e.g., cross-functional collaboration, psychological safety), and organizational structures (e.g., governance, MLOps maturity). This would help explain why similar tools and frameworks yield different outcomes in different contexts.

Third, comparative studies across sectors, countries, and institutional environments can deepen understanding of how regulation, professional norms, and societal expectations shape AI leadership practices. The EU AI Act, for example, provides a natural experiment to study how regulatory pressure interacts with internal governance and capability building.

Fourth, more micro-level research on human-AI teaming and algorithmic management is needed to capture worker perspectives, power dynamics, and long-term effects on skill development, identity, and well-being.

Finally, generative AI introduces new leadership questions around content provenance, prompt governance, cognitive load, and the redesign of knowledge work. Future studies should analyze how leaders experiment with generative AI in strategy, innovation, education, and public services, and what governance and cultural patterns support responsible use at scale.

Taken together, these directions can help move the field from descriptive accounts of the AI leadership gap toward evidence-based prescriptions on how leaders can design, govern, and sustain AI-enabled digital transformation.

6. Conclusion

This article set out to understand the "digital transformation leadership gap" in the age of AI by synthesizing recent scholarship from Elsevier and Web of Science. The thematic literature review shows that the gap is not simply a lack of technical knowledge, but a systemic misalignment between AI ambition and the leadership capabilities, governance structures, cultures, and operational infrastructures required to deliver responsible AI at scale. Historically, research has moved from generic digital transformation and analytics discussions toward more granular treatments of AI readiness, responsible governance, AI literacy, MLOps, and productivity, but empirical evidence still points to uneven and fragile outcomes across organizations and sectors.

The review identified six interrelated themes that classify this leadership gap: strategy and readiness, governance and trust, talent and literacy, culture and structure, technical operations and data, and value and productivity. Together, these themes depict AI-enabled transformation as a socio-technical endeavor in which leadership decisions and behaviors are central. Many organizations remain trapped in proof-of-concept cycles, with fragmented governance, underdeveloped human capital, cultures that dampen experimentation, under-resourced MLOps capabilities, and weak value measurement. These deficits compound one another: for instance,

limited AI literacy constrains strategic choices, while poor governance and measurement erode trust and support for further investment.

At the same time, the literature offers a growing repertoire of frameworks, tools, and practices that can help narrow the gap. AI readiness models, governance and maturity frameworks, AI literacy canvases, ambidexterity and culture design studies, and MLOps templates together provide a conceptual and practical foundation for more coherent AI leadership. The discussion section translated these insights into actionable priorities: reframing AI as a leadership problem, embedding responsible governance, institutionalizing role-based literacy, organizing for ambidexterity, elevating MLOps and data to the board agenda, and adopting learning-oriented value measurement. Implemented in combination, these interventions can move organizations away from sporadic experimentation toward sustained, trustworthy AI value creation.

Finally, the review highlights important directions for future research. There is a clear need for longitudinal and comparative studies that test which leadership interventions, governance models, cultural designs, and MLOps investments most effectively improve adoption quality, risk outcomes, and performance. Emerging developments—especially generative AI and evolving regulatory regimes—create new questions about human–AI teaming, algorithmic work design, and institutional adaptation. By shifting from descriptive accounts of AI leadership challenges to evidence-based prescriptions and causal analysis, future studies can support executives, policymakers, and practitioners in closing the AI transformation leadership gap and realizing AI's benefits in more equitable, responsible, and resilient ways.

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Trends in Medicinal Plant Cultivation in Hungary

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Abstract: In Hungary, medicinal plants are often cultivated by small businesses that can have significant impacts on local economies and communities. Over recent decades, domestic trends in medicinal plant cultivation have changed markedly: the total cultivated area has decreased, while mechanization, infrastructure and cultivation technologies have improved, often resulting in better quality and higher-yield medicinal plants. As a primary part of my PhD research, I conducted semi-structured, in-depth interviews with 32 medicinal plant growers and four municipal (village) leaders from different parts of the country. Interviewees in both respondent groups were selected from small settlements with populations below 5,000. Interviews took place by telephone between May and June 2025. The interview guides comprised 32 questions for growers and 18 for municipal leaders. On average, interviews lasted 30 minutes. Here we present a subset of the findings, examining how respondents perceive current trends in medicinal plant cultivation and whether they are aware of other medicinal plant growers in their locality, and we compare these perceptions with the literature.

Keywords: medicinal plants; medicinal plant cultivation; small and medium-sized enterprises (SMEs)
JEL Code: Q1

Introduction

In Hungary, medicinal plants are often grown by small businesses, which can have significant impacts on local economic and social processes and communities (Pászk-Szűcsné Markovics, 2023). Domestic cultivation trends have changed considerably in recent decades: cultivated area has decreased; however, mechanization has increased, and related infrastructure and technologies have improved, often leading to higher-yield and better-quality production (Bernáth-Czirbus, 2014).

The number of businesses engaged in medicinal plant cultivation has fallen in recent years due to ageing owners, limited new entrants and a lack of support accessible to smaller growers (Pászk-Szűcsné Markovics, 2024). At the same time, demand for cultivated medicinal plants is present in both domestic and export markets (Agrotrend, 2017). Household and sectoral use of medicinal herbs is rising (Bodeker, 2007). Research suggests that approximately 80% of the world's population still relies primarily on medicinal herbs for healthcare (Variskhanov et al., 2024). In 2020, the global market value of herbal medicines and dietary supplements was estimated at about USD 115 billion (Witkittiluck-Kortana, 2021). Countries with large herbal-products markets include Japan, Korea, China, France and Germany, among others; for example, more than 300 types of medicinal herbs are available in Thai markets (Variskhanov et al., 2024).

A Hungarian survey (2015–2016; n = 1,050; ≥14 years) found that one-third of respondents (34.6%; 363 people) purchase and use medicinal herbs. Women constitute the majority among regular users, likely reflecting higher health awareness. Purchases are most often made in specialist stores, mainly in dried form. Health awareness was the dominant purchase driver, rarely accompanied by medical recommendation. Consumers predominantly view medicinal herbs as complementary tools for prevention and healing (Polereczki et al, 2019).

Competitive dynamics vary across plants and regions. In some areas there is effectively no competition because smaller growers cannot access the capital required to enter and scale (Variskhanov et al., 2024). Conversely, for certain plants the domestic market is often dominated by one or two growers, and limited volumes make entry difficult for newcomers (Pászk, 2024).

Our research was motivated, among other things, by the desire to examine the impact that medicinal plant cultivation businesses can have on local communities. As Litpák and Musinszki point out in their 2019 work, local development plays an important role in peripheral regions, and a lack of development can lead to serious economic and social problems in local communities. (Lipták and Musinszki 2019) In our article, we present how the interviewees see the trends in herbal medicine production and whether they know of other herbal medicine growers in their town.

1. Research purpose and methodology

As a primary component of my PhD research, I conducted in-depth, semi-structured interviews with 32 medicinal plant growers and four municipal (village) leaders from different parts of Hungary. All interviewees—both growers and municipal leaders—were selected from small settlements (<5,000 inhabitants). Interviews were conducted by telephone between May and June 2025. The guides comprised 32 questions for growers and 18 for municipal leaders; the average interview lasted 30 minutes. In this paper, we present selected results, focusing on perceived cultivation trends and the awareness of other growers in the respondents' localities.

2. Results and analysis

2.1. Awareness of other growers in the same locality

Question. "Do you know of any other medicinal plant growing businesses in your town?" Responses were coded as 0 = No; 1 = Yes.

Findings. Most interviewees did not know of another medicinal plant growing business in their town (84.38%; 27 people); 15.63% (5 people) answered "Yes". Because "Yes" responses were fewer, the median and mode are 0 (No). The mean (0.16) reflects the low share of "Yes". The variance (0.13) and standard deviation (0.36) indicate relatively homogeneous responses; the standard error was 6.4%.

Table 1. Basic statistical indicators (n = 32) (source: own editing)

Response	Number of responses	Share (%)	Mean	Median	Mode	Variance	Standard deviation	Standard error
Yes	5	15.63	0.16	0	0	0.13	0.36	6.4%
No	27	84.38						

Source: own compilation

2.2. Perceived trends (three sub-questions)

Each sub-question used the same categories: 0 = Decreasing; 1 = Stagnant; 2 = Increasing; 3 = No information.

2.2.1. Trend in medicinal plant cultivation

Most interviewees perceive increase (81.25%; 26 people); 9.38% (3) perceive decrease; 6.25% (2) perceive stagnation; 3.12% (1) have no information. Mean = 1.78; median = 2; mode = 2; standard deviation = 0.66.

Table 2. Basic statistical indicators (n = 32) (source: own editing)

Category	Number of responses	Share (%)	Mean	Median	Standard deviation
0 Decreasing	3	9.38	1.78	2	0.66
1 Stagnant	2	6.25			
2 Increasing	26	81.25			
3 No information	1	3.12			

Source: own compilation

2.2.2. Demand trend

Most interviewees perceive increasing demand (81.25%; 26 people); 12.50% (4) perceive decrease; 0% stagnant; 6.25% (2) have no information. Mean = 1.81; median = 2; mode = 2; standard deviation = 0.74. Respondents clearly see rising demand, consistent with literature trends.

Table 3. Basic statistical indicators (n = 32) (source: own editing)

Category	Number of responses	Share (%)	Mean	Median	Standard deviation
0 Decreasing	4	12.50	1.81	2	0.74
1 Stagnant	0	0.00			
2 Increasing	26	81.25			
3 No information	2	6.25			

Source: own compilation

2.2.3. Competitive situation trend

Most interviewees reported no information about how competition is changing (84.38%; 27 people). Increasing: 9.38% (3); Decreasing: 3.12% (1); Stagnant: 3.12% (1). Mean = 2.75; median = 3; mode = 3; standard deviation = 0.67. The lack of information complicates assessment of sectoral competitiveness.

Table 4. Basic statistical indicators (n = 32) (source: own editing)

Category	Number of responses	Share (%)	Mean	Median	Standard deviation
0 Decreasing	1	3.12	2.75	3	0.67
1 Stagnant	1	3.12			
2 Increasing	3	9.38			
3 No information	27	84.38			

Source: own compilation

Correlations

A Pearson correlation matrix was prepared to compare the three sub-questions. The correlation between demand trend and cultivation trend was r = 0.656 (strong positive). The correlation between cultivation trend and competitive-situation trend was r = 0.455 (moderate positive). The correlation between competitive-situation trend and demand trend was r = 0.163 (weak). Where cultivation increases, a shift away from wild collection (foraging) is more likely; the rise in cultivation may also be related to how respondents perceive the competitive situation.

Table 5. Pearson correlation matrix (source: own editing)

	Trend in medicinal plant cultivation	Competitive situation trend	Demand trend
Trend in medicinal plant cultivation	1.000	0.455	0.656
Competitive situation trend	0.455	1.000	0.163
Demand trend	0.656	0.163	1.000

Source: own compilation

Cluster analysis

A cluster analysis identified six distinct groups (Clusters 0–5). Cluster 0 was the most common (23 people), indicating many respondents displayed a similar pattern across all three questions (growth in cultivation and demand; no information about the competitive situation). Clusters were well separated, indicating meaningful differences across response profiles.

Table 6. Cluster analysis (source: own editing)

Cluster	Cluster characteristics	n
0	Largest group; growth reported across all areas; no perceived information on competitive situation	23
1	Low cultivation tendency and dominance of wild collection; no information on competition	2
2	No cultivation reported, yet wild collection appears "replaced" — an internal inconsistency	1
3	Negative response profile across all three questions	1
4	Mixed answers across questions; mid-range values	4
5	Maximum values on all three questions	1

Source: own compilation

Conclusion

Following a brief literature review, we conducted primary research using semi-structured interviews with 32 medicinal plant growers and four municipal leaders from small settlements across Hungary. We analysed two questions in detail. First, 84.38% of respondents reported no awareness of other medicinal plant growing businesses in their locality—a high proportion that may reflect the small-settlement context and the challenges of market entry. Second, we examined perceived trends. The cultivation trend was predominantly increasing (81.25%), and respondents also perceived increasing demand (81.25%). By contrast, most had no information regarding the competitive situation (84.38%). Correlation analysis showed a strong positive association between demand and cultivation ($r = 0.656$). Cluster analysis revealed six distinct respondent profiles, suggesting targeted development or information-provision strategies could be tailored to each group. Overall, the sector is perceived to be developing dynamically, but limited awareness of competitiveness and market information may hinder strategic development.

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Cluster Analysis of Enterprises in Transcarpathia During the Years of War: A Focus on the Berehove Territorial Community

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Abstract: The aim of this study is to explore the revenue-, profitability-, and employment-based structure of profit-oriented legal-entity enterprises operating within the Berehove territorial community of Transcarpathia (Ukraine) during 2020–2024, in the context of wartime conditions and relocation processes. The empirical database, covering the local area with the highest proportion of ethnic Hungarians, was constructed using registration, financial, and employment data of 230 enterprises obtained from the Opendatabot platform. Due to the substantial heterogeneity of the firms, we applied univariate clustering based on net revenue for 2024, setting the upper threshold of within-cluster relative dispersion at 30%. As a result, we identified 14 clusters that distinguish between relocated "flagship" enterprises, upper-middle-revenue firms with high profit ratios, the mid-range of small local businesses, and marginal micro-enterprises that are often loss-making. The findings highlight that the economic structure of the territorial community is shaped by the dominance of micro and small enterprises, the impact of the relocation wave, and the fragmented nature of employment, which together justify targeted, cluster-sensitive development policy interventions.

Key words: Berehove Territorial Community; Cluster analysis; Enterprises; Relocation; Profitability analysis.
JEL code: R11, L26, C38

Introduction

The purpose of this study is to provide a comprehensive overview of the structure of profit-oriented legal-entity enterprises operating in the Berehove territorial community (Berehove micro-region) during the years of war, with particular emphasis on the dynamics of revenue, profitability, and employment. The analysis focuses on officially registered enterprises within the community, for which we collected and systematized financial and employment data for the period 2020–2024 using the Opendatabot database. A central element of the research is the univariate, revenue-based clustering approach, which enables the identification of groups of enterprises with similar scale and performance profiles, as well as the differentiation of relocated large-enterprise actors, stable local SMEs, and marginal micro-enterprises.

The structure of the study is organized accordingly into three main sections. The first section provides an overview of the relevant domestic and international literature and outlines the specific socio-economic context of the region. The second section presents the construction of the database, the indicators used, and the methodological justification of the clustering procedure—with particular attention to the 30% relative dispersion threshold. The third, empirical section summarizes the detailed cluster results, the development of the enterprise typology, and the key economic-policy implications relevant in the wartime environment.

1. Literature Review

Micro, small and medium-sized enterprises, as the most important pillars of national economy, shall continuously face challenges for survival, competitiveness, development. The crises periods

of the past decade (pandemic, political and economic crises) brought new challenges for development (Németh et al., 2023; Hossain et al., 2022).

The economic viability of a given micro-region is shaped by a wide range of factors. It is therefore essential to examine, from a broader perspective, the macro-level influences affecting the economic ecosystem of the target area. The UNDP study *"Assessment of the Impact of the War on Micro-, Small-, and Medium-sized Enterprises in Ukraine"* (2024) provides a solid starting point for analysing Ukrainian micro, small, and medium-sized enterprises during the years of war, and serves as a useful reference for assessing the position of Transcarpathia, and specifically the Berehove territorial community.

In Ukraine, the evolution of the absolute number of micro-, small-, and medium-sized enterprises follows a similar pattern to that observed in Central and Eastern Europe (Pataki and Balogh, 2024). These enterprises practically constitute the entire corporate sector: they account for 99.98% of all firms, provide 74% of total employment, and generate 64% of added value.
The Russo-Ukrainian war caused the Ukrainian GDP to contract by approximately 29% in 2022. Around 31.7% of enterprises fully or almost fully suspended their operations, while those that remained active saw their revenues decline by an average of 31.2% compared to 2021. According to surveys cited by UNDP, nearly 91% of enterprises resumed operations after the initial shock of the war. By October 2023, only 9.6% of firms were still suspended or on the verge of closure, compared with 33.8% in September 2022 and 46.8% in June 2022.

The study presents, in a separate table, the changes in the number of legal entities and sole proprietors by region between 1 October 2022 and 1 October 2023. In the first year of the war, nearly 1.5 million enterprises were operating nationwide, of which 25,674 were located in Transcarpathia. This figure increased by 3.4% by the same date in the following year. Based on this indicator, the region ranked among the best-performing areas during the examined period (the number of legal entities grew by 2.0% nationwide, while in Transcarpathia the increase reached 3.4%).

In the case of sole proprietors, their number stood at 35,388 in October 2022, and grew by 8.8% one year later. This falls slightly below the national average (10%). According to the study, the increase in the number of sole proprietorships is partly the result of forced entrepreneurial adaptation (job loss, simplified taxation schemes, transition to self-employment). However, in our view, there is also a significant "decline buffer" behind this figure: many male sole proprietors who left the country due to the war were unable to formally close their businesses from abroad. As a result, the statistics include enterprises that exist legally but are not functioning in practice, which distorts the overall regional performance.

Identified Relocation Trends

Research (Bacho, Loskorikh, Pataki and Perchi, 2025a, b) findings indicate that the successful relocation of enterprises depends on four fundamental factors: the accessibility and quality of production infrastructure, the efficiency of administrative and bureaucratic procedures, the availability of skilled labour, and the provision of financial support. Particular attention should be given to the regional dimension of relocation. Successful relocation to Transcarpathia can

significantly contribute not only to the development of individual enterprises but also to the economic growth of the entire region. The Transcarpathian region plays a special role in this process, as its advantageous geographical position, production capacities, and infrastructure enable rapid and efficient relocation.

According to the Ministry of Economy of Ukraine, within the framework of the implementation of the Program of the Ministry of Economy of Ukraine for the relocation of Ukrainian enterprises located in the zone of active hostilities, which was launched in March 2022, the Transcarpathian region ranks second after the Lviv region in terms of the number of relocated enterprises (Fig. 1).

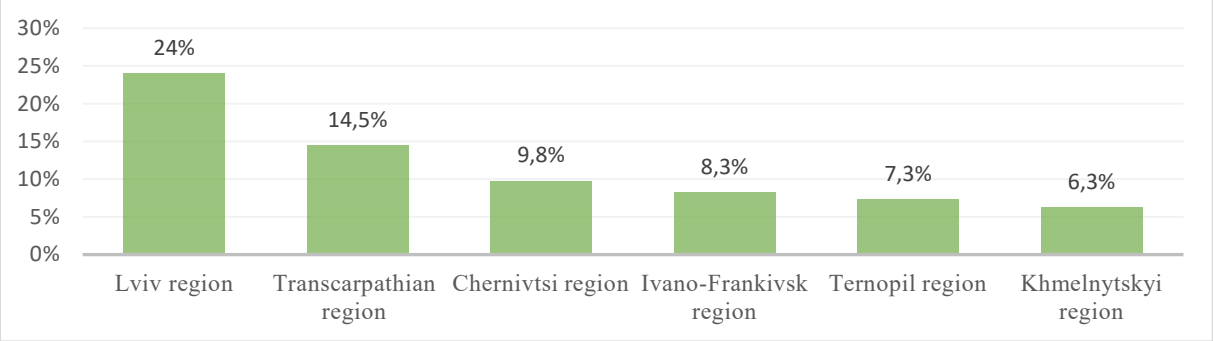

Figure 1. Leading regions by the number of relocated enterprises (according to the Ministry of Economy of Ukraine, 2023)
Source: based on Loskorikh, Pataki, Husar and Perchi (2025)

The Transcarpathian region is one of the main regions for the relocation of Ukrainian enterprises due to its logistical, geographical and economic advantages. The share of relocated enterprises located in the districts of the Transcarpathian region is (Bacho, Loskorikh, Pataki and Perchi, 2025a):

- 42.0% - in Berehove district;
- 29.0% - in Uzhgorod district;
- 16.9% - in Mukachevo district;
- 10.0% - in Khust district;
- 1.7% - in Tyachiv district;
- 0.4% - in Rakhiv district.

Since the beginning of the Russo-Ukrainian war, Transcarpathia has become one of the main regions to which business activities have been relocated from frontline and occupied territories. By the end of 2024, a total of 282 relocated enterprises were operating in the region, all of which had moved from areas directly affected by hostilities.

Among all enterprises relocated to the region, 27.1% (62 enterprises) belong to the manufacturing sector. Their main areas of activity are as follows:

- Manufacture of wearing apparel and footwear – 24.2% of all manufacturing enterprises;
- Manufacture of fabricated metal products, excluding machinery and equipment – 16.1%;
- Manufacture of machinery and equipment – 11.3%;
- Processing of wood and production of wood products, excluding furniture – 8.1%;

- Manufacture of other products – 6.5%;
- Manufacture of furniture – 4.8%;
- Manufacture of machinery and equipment – 4.8% (duplicate category in the original classification);
- Manufacture of chemicals and chemical products – 3.2%;
- Manufacture of food products – 3.2%;
- and others.

The relocation of enterprises serves not only to preserve intellectual and industrial potential but also to create a new economic configuration within the region. In Transcarpathia, the newly introduced economic activities include: metalworking; production of electric-welded pipes; manufacturing of lattice containers for transport networks; production of equipment for lifting trucks; manufacturing of filtration devices and vacuum systems; production of energy-efficient houses based on modular-frame technology; development of high-tech defence electronics systems; manufacturing of wind turbine components for wind power plants; construction of wind energy facilities; glass production and processing; development of the pharmaceutical sector; and manufacturing of cosmetic products, among others.

Several major enterprises relocated to Transcarpathia stand out as key industrial actors that contribute not only to the local economy but also to the broader economic development of Ukraine. The companies presented below have each brought significant technological and industrial advancement to the region:

- Shufani Corporation: The corporation comprises 11 companies with different industrial profiles, all united by their focus on metal processing and the manufacture of metalworking equipment. The company plays an important role in the development and modernization of local industrial infrastructure.
- Wind Parks of Ukraine: This enterprise manufactures multi-megawatt wind energy equipment for wind farms and provides installation and commissioning services. Through the production of sustainable energy solutions, the company contributes to the region's energy independence and the advancement of the green economy.
- AJAX SYSTEMS: A market leader in the development and production of wireless security systems. Its innovative security solutions create a safer environment for local communities and businesses.
- Centravis Ltd: A recognized company in the development and production of solid aluminum tubes, widely used across various industrial and energy sectors.
- SOTON: A manufacturer of polycarbonate sheets offering sustainable solutions for lightweight construction and industrial applications.
- LEGIO Ltd: The company provides full-cycle services in designing and sewing specialized clothing and equipment, particularly for military and industrial use.
- ZENTEX: A manufacturer of gel burn-protection dressings and bandages ("OpikUn") and skin disinfectants ("DezUn"), contributing to the development of local healthcare services.
- SheMax Ukraina: A producer of electrical equipment for beauty salons, supporting the modernization of the cosmetics sector and the improvement of service quality.
- APEX PLANT: A manufacturer of plastic products for industrial applications, supporting the growth of local industrial sectors and enhancing sustainability.

These enterprises each have a significant economic and social impact on the region, as they not only provide employment opportunities but also contribute to economic diversification and the strengthening of local competitiveness through the introduction of new technologies and industrial development.

There are several important reasons behind the relocation of production capacities to Transcarpathia, all of which have a direct influence on the region's economy and long-term development. The factors outlined below have played a key role in making the Transcarpathian region an attractive destination for enterprises:

- Security considerations: As a result of the Russo-Ukrainian war, enterprises located in areas affected by active hostilities were forced to flee from immediate military threats, including missile strikes, destruction, and the overall degradation of infrastructure. The Transcarpathian region, being a comparatively safer area, provided relocated companies with the opportunity to operate in a stable environment and continue their activities without disruption.
- Logistical advantages: Western Ukraine, including Transcarpathia, lies in close proximity to the borders of the European Union, offering favourable conditions for the rapid and efficient export of goods. The region's strong logistical connections enable fast production, transportation, and commercial activities toward EU and other international markets, thereby contributing to economic integration and global competitiveness.
- Government support: Relocation programs launched by the Ukrainian government aim to facilitate the transfer of businesses from war-affected areas. These programs include the establishment of industrial parks, infrastructure development, tax incentives, and various forms of financial assistance for enterprises, all of which support the development of the local economy. Government measures also benefit the workforce by creating new jobs, thus contributing to regional economic stability and growth.

The Transcarpathian Regional Military Administration (and local communities established "one-stop windows" for relocated enterprises, offered industrial zones and warehouse facilities, and provided assistance with the accommodation of employees. Local authorities actively supported businesses in adapting to the new environment and launching their operations rapidly. Last year, Ukraine's Ministry of Economy allocated a dedicated financial resource for enterprises in the region—amounting to at least 530 million UAH—within the framework of the "Made in Ukraine" programme aimed at supporting domestic producers (Fact-news, 2025).
Moreover, long-term measures aimed at promoting the economic development of the Transcarpathian region have also been initiated. These efforts support the creation of a sustainable entrepreneurial environment, as well as the diversification of the local economy and the strengthening of its competitiveness.

The relocation of the population and businesses has had a significant impact on the region's financial indicators. In 2021, Transcarpathia's budget was 64% subsidized, whereas by 2025 the share of transfers from the state budget had decreased to 34.7%. The total volume of investments associated with the implemented projects amounts to 1.5 billion USD.
The relocation of enterprises and people has stimulated the region's economy. The budgets of territorial communities, together with municipal budgets, have doubled compared to 2021. During this period, tax authorities began collecting six times more revenue than before (Uaonline, 2025).

Proskura, Markova and Bilak (2025) analyse enterprise relocation under wartime conditions in Transcarpathia from a municipal management perspective. They identify four key factor groups shaping relocation outcomes: local infrastructure capacities, bureaucratic and administrative barriers, human resource and social adaptation, and the design of financial support schemes. The article shows that constraints in utilities, transport and industrial premises, combined with slow registration and permitting procedures, significantly raise the time and cost of relocation. At the same time, the successful housing, training and socio-psychological integration of relocated staff is highlighted as a critical condition for long-term embeddedness.

What do these findings mean for the Berehove enterprise study?

Based on the above data, the entrepreneurial environment of Berehove (Transcarpathia) during the years of war can be described as a region in which the number of enterprises increased substantially. Transcarpathia outperformed the national average in terms of the growth of legal entities, positioning itself among the leading western regions of the country. The number of sole proprietors also rose significantly, although at a slightly slower pace compared to the national average.

The region increasingly became a relocation destination: approximately one-quarter of Ukrainian enterprises relocated in some form to western regions or opened branch offices there. Although the cited study does not provide a regional breakdown, Transcarpathia can be interpreted as one of the key target areas within these western territories.

At the same time, it should be noted that, compared to areas closer to the frontline, Transcarpathia suffered less direct physical damage from the war. However, the region faced considerable indirect pressure: accommodating relocated firms, supporting incoming refugees, and meeting the heightened local demand for goods and services required significant adaptive efforts from the local economy.

The western regions—including Transcarpathia—also have a more export-oriented economic structure, with a larger share of enterprises engaged in foreign trade, and they exhibit the most positive expectations regarding employment expansion and growth. As a result, during the war, Transcarpathia has emerged as one of the expanding hubs of entrepreneurial activity, driven in part by internal migration and the relocation of enterprises.

2. Research Materials and Methods

The foundation of the research was a proprietary enterprise database constructed through primary data collection, initiated at the end of 2024 and completed in August 2025. Access to data on enterprises and entrepreneurs registered in Ukraine depends significantly on their legal status. Financial statements of legal-entity for-profit and non-profit organizations are available on several platforms, which, primarily as paid services, provide various datasets for business, research, and transparency purposes.

In contrast, economic actors without legal personality—most notably sole proprietorships (in Ukrainian terminology: *natural person – entrepreneur*, ФОП/FOP)—cannot be directly identified through such platforms, as they are not subject to annual reporting requirements, and their tax number is not separate from that of the individual entrepreneur as a natural person. (It is important to note, however, that if the tax identification number of a sole proprietorship is known, general information about these actors can also be found in certain databases.)
For this reason, at this stage of the research, the focus was placed on profit-oriented organizations with legal personality.

We used the Opendatabot platform for data collection. Opendatabot is a Ukrainian open-data provider and analytical platform that aggregates and makes searchable data from various state registries (companies, sole proprietors, court cases, tax debts, etc.). Its primary purpose is to increase transparency regarding businesses and individuals, prevent "raider-type" corporate takeovers, and support risk assessment of business partners (visa.com.ua/). The service relies on more than 30 open data sources, including the state company register, court databases, the tax authority, and sanctions lists (tapas.org.ua). It is also closely connected to the official Ukrainian open data portal (data.gov.ua/), and its development was carried out in cooperation with the Ministry of Justice (for further details, see opedatabot.ua).

Our research was conducted at the Transcarpathian regional level, covering several micro-regions, mainly in areas inhabited by borderland Hungarian communities, and examining the main economic hubs of the region (Uzhhorod, Mukachevo, Vynohradiv, Khust, etc.). In this study, we highlight the center of our research activity and the focal point of the target group (the Hungarian population of Transcarpathia) by analyzing the enterprises of the Berehove territorial community.

Key data on the urban-type territorial community can be found on one of Opendatabot's subpages (https://opendatabot.ua/c/UA21020000000051405?type=employees).

The community includes Berehove, a city with county rights, as well as 17 rural-type settlements. Based on the most recent official Ukrainian census of 2001, the combined population of these 18 settlements was nearly 49,000, of whom, according to estimates, more than 70% were Hungarian-speaking (Statistical Publication, 2017).

The subpage for the territorial community provides the possibility to examine organizations according to their main activity (KVED), which corresponds to the current Ukrainian classification system (discussed in detail later). As of November 2025, the database lists 1,825 enterprises**,** which can be grouped by year of establishment, revenue size, and number of employees.

In the case of the Berehove territorial community, our research aimed to retrieve all for-profit organizations from the database. The system allows free extraction of up to five units, after which data can only be exported as a paid service (automated exporting was unfortunately not available). The relevant enterprises were examined in descending order according to the number of employees, meaning that the analysis began with the largest firms and proceeded toward the smallest organizations.

The database closed in August 2025 contains 230 sample units, covering 13% of the total population of organizations. Non-profit entities (educational institutions, civil organizations, charitable foundations, state institutions, etc.) were not included in the analysis.
The distribution of income-oriented organizations by legal form is presented in the table below (n = 230).

Table 1. Distribution of enterprises in the Berehove micro-region sample by legal form (n = 230).

Legal form	*Number of enterprises*
Joint-stock company (public, PJSC)	0
Joint-stock company (private, PrJSC)	0
Limited Liability Company (TOV / LLC)	146
Private Entrepreneur (PP / Sole proprietorship)	25
Farm Enterprise (FG)	59
Cooperative	0
Other (subsidiary, concern)	0
Total	***230***

Source: Authors' compilation.

It is evident that no joint-stock companies operate within the Berehove territorial community, which immediately indicates the absence of large enterprises in the region. The most commonly chosen legal form is the Limited Liability Company (63%), followed by farm enterprises (26%), and a specific Ukrainian legal form known as the "private enterprise" (ПП, PP), which corresponds to a quasi-individual but legally registered business entity (11%).

An analysis of the sample and the subsequent results is presented in the following chapter. Before that, however, it is important to evaluate the research methodology, which forms the foundation of both the findings and the analytical conclusions.

In addition to basic company information, the database contains the organizations' activity classification (KVED), data on establishment and possible closure, ownership-related information (qualitative data), and quantitative financial indicators (net revenue, net income, average value of assets and liabilities, number of employees).

Using basic statistical analysis, we examine the distribution of enterprises in the sample by activity type, as well as information related to establishment and closure, relying on distribution and dynamic ratios, measures of central tendency, and indicators of dispersion.

However, it is necessary to divide the data into subgroups, since—as will become evident—the 230 enterprises display substantial heterogeneity. That is, based on revenue, income, and number of employees, it is not possible to obtain accurate, aggregate results regarding the average performance of enterprises during the examined period (2020–2024). For this reason, clustering is required, allowing us to analyze financial performance within adequately homogeneous groups.

The clustering procedure was based on a single dimension: net revenue in 2024. Enterprises were ordered in ascending order of revenue, after which a *greedy segmentation* approach was applied (Chen et al., 2023): clusters were formed from consecutive observations until the within-cluster relative dispersion reached the 30% threshold. Relative dispersion was defined in the usual way, as the ratio of the standard deviation to the mean:

$$CV_k = \frac{\sigma_k}{\mu_k} \cdot 100\%,$$

where μ_k denotes the average revenue of cluster k, and σ_k represents the within-cluster sample standard deviation. If adding a new enterprise would have caused CV_k to exceed the 30% threshold, the cluster was closed at the previous observation and a new cluster was initiated. This procedure resulted in 14 clusters (K1–K14), each satisfying the criterion $CV_k \leq 30\%$.
To assess profitability, the clustering results were compared with the cluster-level average net income for 2024. The profitability of the clusters was evaluated using a profit-ratio approximation (Vidal-Tomás, 2022), defined as the ratio of average net income to average revenue:

$$PR_k = \frac{net\ income_k}{sales\ revenue_k} \cdot 100\%,$$

where we examined the average profit rates of the k-th enterprise, i.e. the given cluster. Let's take a look at the main results and conclusions of the research.

3. Presentation of Results

In the following section, we examine the key indicators and trends of enterprises operating within the Berehove territorial community, based on the sample of 230 legal-entity businesses.
General Statistical Analysis of Enterprises

First, we analyze the trend in the establishment of these enterprises over the period 1991–2024.

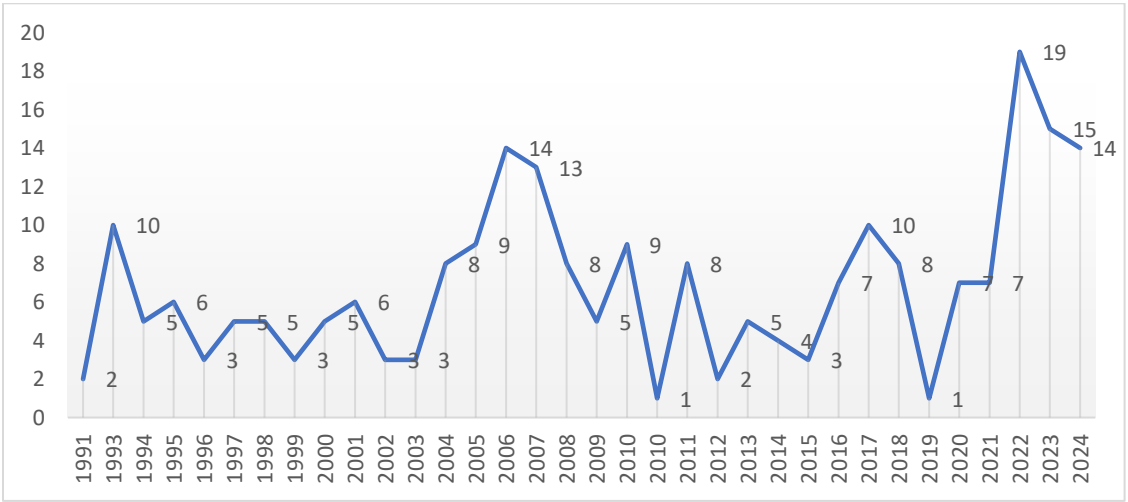

Figure 2. Opening trends of enterprises in the Berehove micro-region between 1991 and 2024 (n = 230).
Source: Authors' compilation.

The registration of enterprises can be traced back to the period of political transition, that is, to the establishment of an independent Ukrainian state. In the early years, the number of new firms was higher due to privatization processes; however, when adjusted for the 18 settlements and their nearly 50,000 inhabitants, the entrepreneurial inclination remained very low. Between 1991 and 2005—a 15-year interval—an average of only five enterprises were founded per year.
Subsequently, a period of positive economic momentum emerged nationwide, during which both the population and the economic sector experienced the most optimistic outlook in Ukraine's history. The number of new enterprises reached its peak in 2006 (14 new registrations).

At the end of the decade, the global financial and economic crisis emerged. While other countries in the region began to move toward recovery after 2012, Ukraine continued to face overlapping crises: the Maidan Revolution in 2014, the annexation of Crimea, ongoing armed conflict in Eastern Ukraine, followed by the pandemic, and ultimately the full-scale Russo-Ukrainian war in 2022. These shocks significantly affected the economy, including the entrepreneurial sector.

However, the shock effects did not manifest exclusively in negative outcomes. As shown at the end of the diagram, 2022 marked the highest annual number of newly established enterprises in the micro-region (19 firms). This sharp increase can be clearly attributed to the relocation process. Although relocated companies primarily targeted Uzhhorod and Mukachevo—cities with stronger economic pull—there was nevertheless an inflow into Berehove as well, given its status as a city with county rights.

With regard to the official closure of enterprises, the database contained limited information. Within the sample, an average of one enterprise per year ceased operations between 2016 and 2024, amounting to a total of 11 closures.

The following figure illustrates the activity status of the 230 enterprises examined. According to registry records, three quarters of the sample are classified as active, while an additional 20% are listed as passive, meaning that they have not been officially closed but currently exhibit no economic activity.

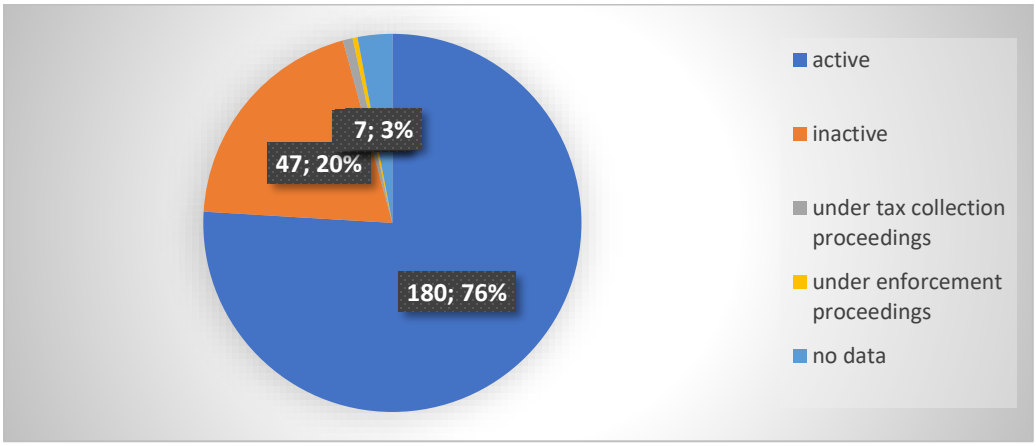

Figure 3. Distribution of enterprises in the Berehove micro-region by activity status (n = 230).
Source: Authors' compilation.

When analyzing enterprises, it is essential to examine their main fields of activity. In Ukraine, these are indicated by the so-called KVED codes. In the Opendatabot database, we reviewed the distribution of all currently listed organizations (1,825 entities, including for-profit, non-profit, and state institutions), and compared it with the distribution of the 230 profit-oriented enterprises in our sample. Since the two groups differ in nature, their proportions are not expected to align perfectly; however, the comparison still allows meaningful conclusions regarding both the general and enterprise-specific activity structure of the territorial community.

As shown in Figure X, within the sample of 230 enterprises, the category "Agriculture, forestry, and fishing" is the most prominent, accounting for 33%. Within this category, forestry-related activities are negligible; the majority of firms belong to various agricultural activities. In the full population, this category is also the second most common.

The second most frequent category in the sample is Manufacturing (17%), followed by Wholesale and retail trade; repair of motor vehicles and motorcycles.

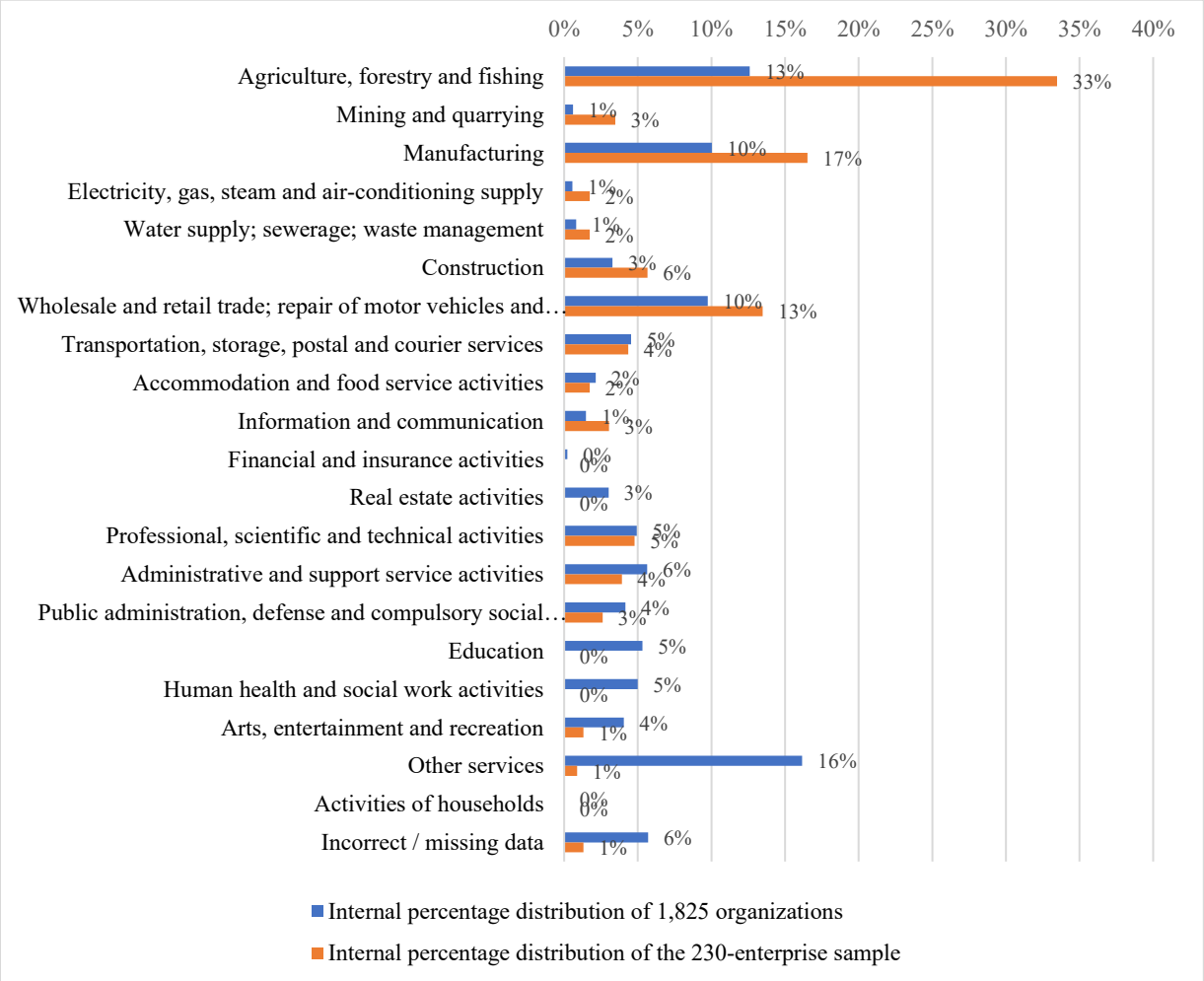

Figure 4. Distribution of enterprises in the Berehove micro-region by economic activity (KVED) in 2024–2025 (n = 230).
Source: Authors' compilation.

Cluster Analysis of the Financial Situation of Enterprises

In 2024, the 230 enterprises examined generated a total of 1.7 billion UAH in net revenue, with an average revenue of 23.1 million UAH. However, only 75 enterprises out of 230 reported any revenue. This indicates that a significant number of firms did not carry out productive activities, while a few displayed exceptionally high values. As a result, the dataset exhibited very high variability, with a relative dispersion of 371.5%. The same pattern of extreme variability is observable for other financial indicators, both in 2024 and in previous years. Thus, we are dealing with a highly heterogeneous population, for which the use of simple averages would be misleading. This led to the recognition and methodological decision to perform a cluster analysis. In defining the research methodology, we aimed for homogeneity and allowed a maximum relative dispersion of 30% within enterprise groups, forming clusters accordingly.

The 30% upper threshold for relative dispersion was not an arbitrary choice; rather, it aligns well with quality categories commonly applied in economic statistics. Several European statistical offices—such as the Statistical Office of the Republic of Slovenia (SURS, 2023) in its business tendency and foreign trade surveys—classify the reliability of estimates based on the coefficient of variation (CV). Indicators with a CV below 15% are considered sufficiently accurate; estimates falling within the 15–30% range are published with reduced accuracy or warning labels; while estimates with a CV above 30% are deemed too unreliable and are generally not published or are marked with cautionary notes.

A similar principle is applied in labor market and household surveys. For example, the methodological guidelines of the UK Labour Force Survey (ONS, 2007) set a recommended publication threshold at a relative dispersion of around 20–25%, whereas Canadian guidelines (Statistics Canada, 2015), along with those of other national statistical offices, consider CV values in the range of 15–35% to fall into a *use with caution* category, with values above 30–35% frequently classified as *too unreliable* and therefore suppressed or published only with explicit warnings (Marchetti, 2025). A regional industry report (Ifan, 2019) on the economic analysis of the legal sector even treats CV values of 5–10% as *reasonably precise*, which further suggests that the 30% threshold represents the upper bound of what can still be considered acceptable.

Lowering the relative dispersion threshold would have caused the dataset to fragment into micro-clusters of only a few units, thereby reducing the generalizability of the economic conclusions.

The average revenues of the clusters span an extremely wide range: in the case of the K1 cluster, which consists of a single enterprise with exceptionally high revenue, the value reaches 703.5 million UAH, while in the lowest clusters (K12–K14) the average turnover amounts to only a few thousand hryvnias. In addition, there is another category—namely the 155 enterprises out of 230 that reported no revenue in the examined year. Due to the absence of performance data, this group was not included in the cluster analysis.

The intermediate clusters are concentrated within the typical revenue ranges of micro and small enterprises in Transcarpathia: in clusters K3–K5, average revenues fall between 6 and 48 million UAH, while in K6–K9 and K11 average values range between 26,000 and 1.7 million UAH. The

clusters are presented in the table below: the left section shows the average revenues for 2020–2024, while the right section displays the number of enterprises included in each cluster.

It can be observed that the largest cluster size is 12 enterprises, while several clusters contain only one or a few firms. Since the clustering was performed using 2024 revenue data, earlier years display a certain degree of "emptying," meaning that enterprises with the revenue levels characteristic of a given cluster were either not present or were present in smaller numbers in previous years. This observation is particularly true for cluster K1, which in 2024 consisted of a single enterprise with a revenue of 703.5 million UAH. The second-largest enterprise in the same year recorded 136.5 million UAH, meaning that the leading firm constituted an extreme outlier relative to all other clusters.

Therefore, this enterprise had to be treated separately due to its exceptional value. In November 2025, we examined this company in more detail and found that it was a relocated enterprise which operated in Zaporizhzhia prior to 2023 and subsequently returned its headquarters to its original location by 2025. As a result, the enterprise will no longer appear in the statistics of the following period, and the corresponding cluster will also disappear—unless a new enterprise of similarly high revenue enters the dataset.

Table 2. Cluster analysis of enterprises based on net revenue between 2020 and 2024 (n = 230, n'=75).

Cluster	Average net revenue (thousand UAH)					Number of enterprises operating in the examined cluster (pcs)				
	2020	*2021*	*2022*	*2023*	*2024*	*2020*	*2021*	*2022*	*2023*	*2024*
K1	–	–	–	221 755,8	703 511,5	0	0	0	1	1
K2	–	–	18 529,3	72 322,7	136 465,8	0	0	2	4	4
K3	467 467,0	388 196,0	44 446,2	54 093,2	47 627,2	2	3	4	5	5
K4	6 105,3	9 335,4	12 408,1	27 471,2	21 920,7	4	2	6	6	7
K5	346,6	7 618,2	5 304,5	12 426,3	6 201,9	2	1	9	12	12
K6	-	26,0	312,1	1 013,2	1 667,5	0	2	5	5	8
K7	950,9	1 306,3	242,8	1 223,9	664,5	2	2	3	3	4
K8	1 120,5	268,8	434,2	684,2	296,1	1	1	3	4	8
K9	-	63,5	89,5	140,0	143,2	0	2	2	2	5
K10	-	-	30,0	78,0	60,0	0	0	1	1	1
K11	37,9	22,2	50,0	104,3	27,7	1	5	8	8	9
K12	–	10,3	12,6	140,0	12,4	0	2	3	4	5
K13	–	45,9	6,3	3,8	5,3	0	2	3	3	3
K14	–	15,0	11,0	0,5	0,5	0	1	1	1	1

Source: Authors' compilation.

In revenue-based cluster analysis, once the clusters have been formed, it is essential to evaluate the financial indicators of the enterprises operating within each homogeneous cluster. Table 3 presents the average revenue by cluster.

Table 3. Dynamics of clusters between 2020 and 2024 (n = 230, n'=75).

Cluster	Change in revenue compared to the previous year (in %)			
	2021	2022	2023	2024
K1	-	-	-	217%
K2	-	-	290%	89%
K3	-17%	-89%	22%	-12%
K4	53%	33%	121%	-20%
K5	2098%	-30%	134%	-50%
K6	-	1100%	225%	65%
K7	37%	-81%	404%	-46%
K8	-76%	62%	58%	-57%
K9	-	41%	56%	2%
K10	-	-	160%	-23%
K11	-41%	125%	109%	-73%
K12	-	23%	1012%	-91%
K13	-	-86%	-39%	39%
K14	-	-27%	-95%	0%

Source: Authors' compilation.

In the case of *cluster K1*, only two years can be compared, during which revenue more than doubled. For *cluster K2*, revenue in 2023 was also more than twice the previous year's level, although this dynamic weakened in 2024.

Cluster K3 shows greater variability: enterprises here tend to have been operating for a longer period, and growth occurred only between 2022 and 2023, while the other years exhibited declines of varying magnitude.

Enterprises in *cluster K4* generally performed well, with the only collective downturn occurring between 2023 and 2024.

Cluster K5 is the largest homogeneous group, yet displays highly diverse annual results: a twentyfold increase in 2021 compared to the previous year, a decline in 2022, slight growth in 2023, and another decline in 2024. It is important to examine the firms in this cluster individually, as significant shifts likely occurred among key actors due to relocation processes and other forms of corporate fluctuation.

In *cluster K6,* average revenue drops considerably compared to the previous cluster, and annual fluctuations are also substantial. However, a positive trend is visible: the cluster's average performance increased every year.

Clusters K7 and *K8* are similar in magnitude to the preceding cluster, yet annual performance varied strongly in both cases.

The *K9–K14* range comprises the poorest-performing clusters, showing negative tendencies both in absolute revenue levels and in annual dynamics.

In the next step of the analysis, we examined the net income of enterprises by cluster. To compare revenue and profitability, we also calculated profit ratios, that is, the net profit margin. The higher the percentage value for a given enterprise—and, by extension, for the cluster—the more efficiently the enterprise (or cluster) manages its costs, or, from another perspective, the more profit it is able to generate relative to its revenue.

The results are presented in Table 4, which displays cluster-level outcomes for the year 2024. Table 4 provides a summary of the number of enterprises within each cluster, the average, minimum, and maximum revenue values, the difference between the latter two, as well as the average net income and profit ratio for 2024.

The highest net income (16 million UAH) was achieved by the enterprise in the exceptionally outstanding K1 cluster. Although this value significantly exceeds the average net income of all other clusters, its net profit margin—that is, the profit ratio—amounts to only 2.3%. The best-performing cluster is K3, where a 16% revenue-based profit was recorded in 2024. This is followed, slightly behind, by cluster K4 with 14.5%, and cluster K5 with 9.1%.

A negative profit ratio indicates that the enterprise group performed at a loss in the given year. This applies strongly to cluster K6, and to a lesser extent to cluster K8. Cluster K12 also exhibits substantial losses; however, its indicator becomes extremely negative because the average revenue is minimal. Therefore, this case requires separate evaluation, as the profit ratio cannot be reliably interpreted.

Table 4. Cluster analysis of enterprises based on profitability and profit rate in 2024.

Cluster	Number of elements	Average revenue (UAH)	Minimum revenue (UAH)	Maximum revenue (UAH)	Difference	Average net income 2024 (thousand UAH)	Profit rate approximation (%)
K1	1	703 511 500	703 511 500	703 511 500	0	16 024,4	2,3
K2	4	136 465 750	114 748 800	161 787 000	47 038 200	5 439,95	4,0
K3	5	47 627 160	29 296 700	60 983 200	31 686 500	7 633,84	16,0
K4	7	21 920 714	14 151 000	28 168 600	14 017 600	3 174,26	14,5
K5	12	6 201 875	3 258 900	8 258 600	4 999 700	562,77	9,1
K6	8	1 667 500	938 400	2 478 700	1 540 300	-610,5	-36,6
K7	4	664 450	463 100	893 700	430 600	3,5	0,5
K8	8	296 063	175 500	408 500	233 000	-14,8	-5,0
K9	6	131 621	73 800	160 000	86 200	11,56	8,8
K10	1	60 000	60 000	60 000	0	–	–
K11	10	26 830	16 500	38 000	21 500	1,54	5,8
K12	5	12 420	8 000	16 400	8 400	-85,4	-687,3
K13	3	5 333	4 000	7 000	3 000	0	0,0
K14	1	500	500	500	0	–	–

Source: Authors' compilation.

Figure 5 illustrates the cluster map based on profitability. The vertical axis shows the net profit relative to revenue, while the horizontal axis displays the average revenue of each cluster.

The diagram does not include the extreme K12 case, as excluding it allows for a clearer evaluation of the remaining clusters with respect to revenue and profitability. Another special case is cluster K1, which, despite its high revenue, exhibits low profitability. Clusters K3 (16%) and K4 (14.5%) consist of medium-revenue but highly profitable enterprises. Clusters K5 (9.1%), K9 (8.8%), and K11 (5.8%) represent enterprise groups that achieved moderate profitability despite low revenue levels. In clusters K7 and K13, low average revenues are accompanied by nearly zero profit. Clusters K8 and K6 are loss-making; however, the extent differs: cluster K8 shows relatively small losses, whereas cluster K6 has a significantly higher loss ratio.

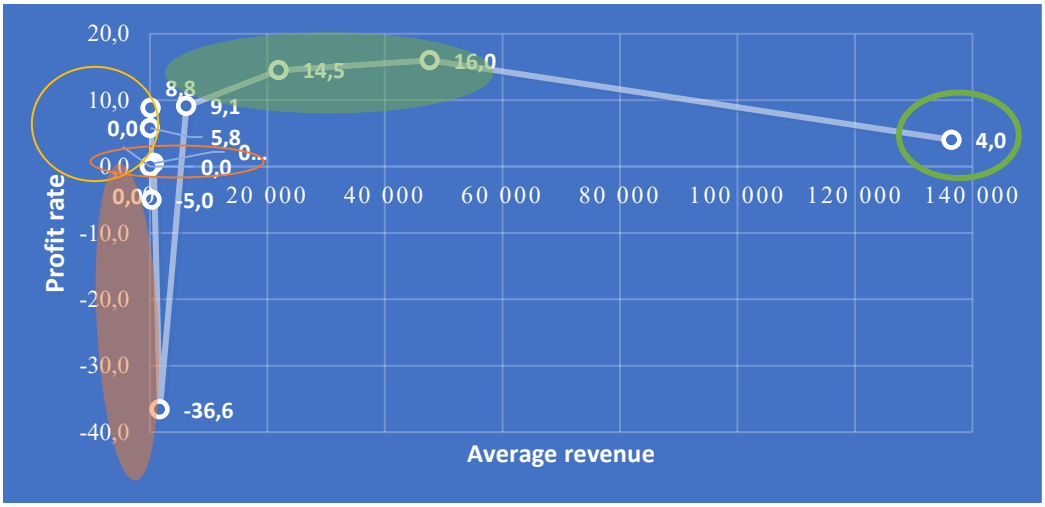

Figure 5. Profit rate map of the Berehove micro-region in 2024 (n = 230, n'=75).
Source: Authors' compilation.

Figure 6 illustrates the correlation between revenue and net income.

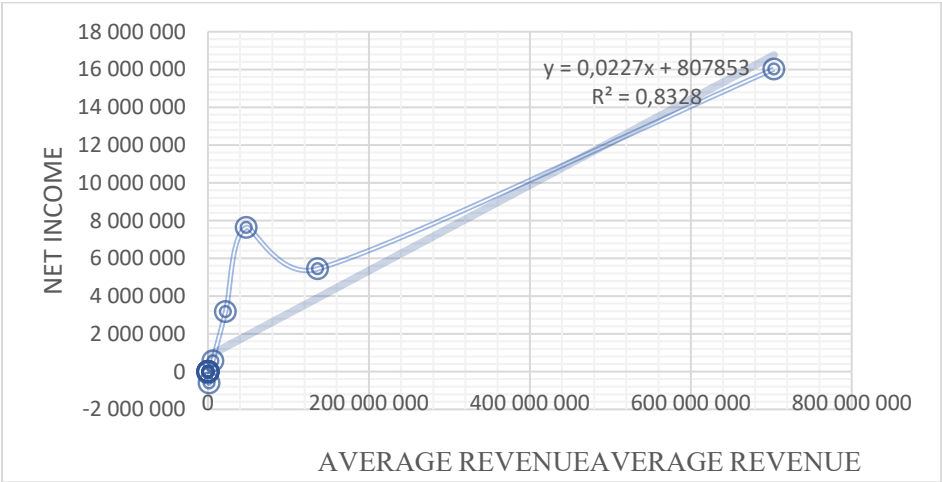

Figure 6. Correlation between average revenue and average net profit across enterprise clusters in the Berehove micro-region in 2024 (n = 230, n'=75, k = 14).
Source: Authors' compilation.

Placing the values of the 14 clusters on the function reveals a moderately strong linear trend between revenue and net income. This trend is disrupted by cluster K1, which, despite its extremely high revenue, exhibits a low profit margin.

Finally, the analysis is complemented by an examination of the number of employees (Table 5).

Table 5. Cluster analysis of enterprises based on profitability and profit rate in 2024 (n = 230, n'=75).

Cluster	Number of elements	Average number of employees in 2024	Minimum (persons)	Maximum (persons)
K1	1	32	32	32
K2	4	62	12	87
K3	5	52,4	2	128
K4	7	20,86	0	55
K5	12	10,42	0	32
K6	8	2	1	6
K7	4	2,75	0	7
K8	8	2,38	0	6
K9	5	0,8	0	2
K10	1	0	0	0
K11	10	0,2	0	1
K12	4	0,25	0	1
K13	3	0,33	0	1
K14	1	0	0	0

Source: Authors' compilation.

It can be observed that the highest average level of employment is found in cluster K3, yet overall it can be concluded that the Berehove territorial community has no large employers. In clusters K6–K14, employment levels decrease steadily and generally remain below 10 employees, indicating that these enterprises qualify as micro-level economic actors.

Summary

The analysis of enterprise clusters within the Berehove territorial community clearly demonstrates that profit-oriented legal-entity businesses in the region form a highly heterogeneous group in terms of revenue, profitability, and employment.

Based on 2024 revenue data and applying a 30% relative dispersion threshold, 14 clusters (K1–K14) were constructed, allowing the enterprise structure to be evaluated within internally homogeneous groups while mitigating the distorting effect of extreme values. The clusters typically contain 1–12 enterprises, resulting in small yet well-interpretable groups that satisfy the homogeneity criterion.

Table 6. Summary characteristics of enterprise clusters in the Berehove micro-region based on revenue, net profit, and employment data for the period 2020–2024.

Cluster	*Main finding*	Indicator characteristics		
		Revenue	Revenue	Employment
K1	High-turnover "flagship" enterprise	Extremely high revenue; the largest actor in the sample	Low profit rate (2–3%), narrow margin	Medium-to-large employer (several dozen employees)
K2	Large-revenue, moderately profitable employers	Classic large-enterprise revenue level, stable turnover	Moderate profit rate (~4%); positive but not outstanding profitability	Significant employers, on average more than ten employees per firm
K3	**Upper-medium-revenue, high-yield enterprises**	Upper-medium revenue, stable market position	High profit rate (~16%); strongly profitable operation	Major employers, including several firms with larger workforce
K4	Medium-sized, financially healthy enterprises	Medium revenue, diversified group	Good profit rate (~14–15%); stable profitability	Mix of small and medium employers (from a few to several dozen employees)
K5	Core of the small-enterprise segment	Lower-medium revenue, typical SME volume	Healthy profit rate (~9%); sustainable profitability	Smaller employers, typically 5–15 employees
K6	Loss-making micro-enterprises with medium turnover	Medium revenue in the lower half of the sample	Persistently negative profitability (−35% to −40%)	Micro-enterprises, typically 1–6 employees
K7	Low-turnover enterprises operating at the margin	Low revenue, limited market volume	Slightly positive (~0.5%) profit rate; close to breakeven	Small employers, mostly 1–7 employees
K8	Low-revenue, slightly loss-making micro-enterprises	Low revenue, often auxiliary business activity	Slightly negative profitability (~−5%)	Micro-enterprises with 0–6 employees; minimal activity
K9	Very small-scale but efficient micro-enterprises	Very low revenue, narrow market niche	Relatively good profit rate (~9%) given the small scale	Minimal employment (0–2 employees), often one-person firms
K10	Low-turnover enterprise with unknown profitability	Low revenue; single enterprise	Net income data incomplete; profit rate not assessable	Formally operating, but 0 employees
K11	Micro-enterprises with very low turnover	Extremely low revenue, marginal business activity	Small but positive net income (profit rate ~5–6%)	Virtually no employment (0–1 employee)
K12	Extremely loss-making micro-enterprises	Very small revenue; mostly formal presence	Strongly negative, extremely low profitability (large losses)	No or negligible employment (0–1 employee)
K13	Firms maintaining formal presence with near-zero balance	Minimal revenue; marginal business activity	Near-breakeven profitability (~0%)	Nominal employment (0–1 employee), no real labour demand
K14	Marginal-revenue, economically insignificant unit	Negligible revenue; statistically marginal actor	Net income not meaningfully measurable	0 employees; minimal economic relevance

Source: Authors' compilation.

From a revenue-profile perspective, a few dominant enterprises stand out sharply from the rest. Cluster K1 consists of a single "flagship" enterprise with several hundred million UAH in turnover, while the firms in cluster K2 represent classic medium-sized enterprise revenue levels. Clusters K3–K5 represent the upper-middle and lower-middle revenue ranges typical of small and medium-sized enterprises, characterized by stable, multi-million-hryvnia turnover.

In contrast, the lower cluster range (K6–K14) is dominated by revenues of only tens or hundreds of thousands of hryvnias, often corresponding to enterprises operating as side activities or maintaining merely formal presence.

The synthesized typology of the clusters outlines four main groups of enterprises:

1. High-turnover but limited-profitability "flagship" and large-enterprise-type actors (K1–K2);
2. Upper-middle-revenue, high-return, consistently profitable firms (K3–K4);
3. The core segment of small enterprises and efficient micro-enterprises operating with low volumes (K5, K9–K11);
4. Loss-making or formally present micro-enterprises (K6, K8, K12–K14).

This structure clearly illustrates that, despite wartime conditions and relocation dynamics, the region's endogenous base of micro and small enterprises remains decisive. With targeted economic development tools—such as financing, advisory services, and market-access support—this segment can become a key pillar of local resilience.

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External shocks and internal adaptation: Responses of the Hungarian construction industry to emerging challenges

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Abstract: This study examines the interplay between external macroeconomic shocks and internal adaptation mechanisms in the Hungarian construction industry during 2019–2023. The sector faced multiple challenges, including the COVID-19 pandemic, inflationary pressures, rising energy costs, and labor shortages, which significantly affected corporate performance and operational stability. The research analyzes the impacts of these shocks at both sectoral and firm levels, highlighting the strategies employed by Hungarian construction companies—such as cost optimization, innovation, and restructuring of supply chains—to respond to crises. The findings indicate that internal flexibility and adaptive management are crucial for the sector's long-term competitiveness.

Keywords: construction industry, economic shock, adaptation, competitiveness, financial performance, resilience, digitalization
JEL code: M21

1. Introduction

The construction industry is one of the most important sectors of the Hungarian economy, playing a significant role not only in GDP generation but also in employment. However, between 2019 and 2023, the sector faced several external macroeconomic shocks. The COVID-19 pandemic, fluctuations in global raw material prices, the surge in energy prices, and the inflationary environment collectively shaped the industry's operations (HCSO, 2023; MNB, 2023). These challenges affected not only production volumes but also the financial stability and strategic decision-making of firms.

The impact of economic crises has been well documented in other sectors as well: in manufacturing, both production and employment responded rapidly to declining demand, while in the service sector, digitalisation and online sales models significantly mitigated the negative effects of the crisis (OECD, 2020; Eurostat, 2022). The macroeconomic effects of the post-2020 period have been felt not only in the manufacturing sector, but also in public services (such as state-run hospitals). (Horváthné Csolák 2021; Horvátné Csolák 2022; Horváthné Csolák et al. 2023., Horváthné Csolák 2024) These findings highlight that sectoral resilience and innovation capacity are key determinants of crisis resistance.

The aim of this study is to examine the adaptation mechanisms through which Hungarian construction companies responded to these external shocks. The research combines sectoral (macroeconomic) and micro-level (corporate financial) analyses, drawing on databases from the Hungarian Central Statistical Office (HCSO) and the National Bank of Hungary (NBH), as well as firms' annual financial statements. The objective is to identify the factors that strengthened

financial stability and operational flexibility, and the strategies that supported crisis resilience and the maintenance of competitiveness (OECD, 2021; Eurostat, 2022).

2. Structural characteristics of the Hungarian construction industry (2010–2023)

The structure of the Hungarian construction industry has undergone significant transformation over the past thirteen years, shaped partly by the economic environment and partly by internal structural changes. Between 2010 and 2023, the sector's characteristics were closely linked to macroeconomic processes, investment volumes, firm size, and ownership structure (HCSO, 2023; Eurostat, 2022).

2.1 Firm size and market concentration

The construction industry has traditionally been dominated by small and medium-sized enterprises (SMEs), which continue to account for the majority of market participants. According to data from the Hungarian Central Statistical Office (HCSO), between 2010 and 2023 the share of micro- and small enterprises remained stable at around 65–70%, while the proportion of medium-sized and large firms gradually increased, particularly in the implementation of large-scale, state- and EU-funded projects (HCSO, 2023). This process led to greater market concentration, enabling larger firms to operate more efficiently and to invest more in technological development.

2.2 Ownership structure

The ownership structure has also changed in recent years. Alongside domestic private enterprises, the role of state and international investors has increased. EU funding and public procurement significantly improved capital availability and ensured long-term stability, especially for medium-sized and large companies (Eurostat, 2022). At the same time, smaller firms often responded to market changes through flexible adjustment strategies and short-term, project-based operations.

2.3 Workforce composition and employment

The labour market structure of the sector is another key factor influencing flexibility. Between 2010 and 2023, employment levels fluctuated in response to economic crises and investment cycles. Skills shortages became particularly pronounced between 2021 and 2023, encouraging firms to invest in workforce retraining, digitalisation, and automation (McKinsey, 2023; Deloitte, 2024). Labour market dynamics are closely linked to the cyclical nature of the sector and to investment activity. During the 2020–2023 period, many workers temporarily left the industry due to the pandemic, mainly because of the suspension of foreign projects and uncertain income prospects. According to HCSOdata, employment in the sector declined by 7% in 2021, followed by a partial recovery in 2022. Workforce retention was supported by training programmes and the introduction of flexible employment arrangements. Larger firms implemented incentive-based compensation systems and internal career paths, while smaller companies relied on project-based cooperation and the expansion of subcontracting networks to maintain operational continuity. Digitalisation (e.g. BIM, online project management, remote work) became an important tool for mitigating skills shortages, particularly in administrative and design-related functions.

2.4 Investment and production structure

The structure of construction output has varied depending on infrastructure development, residential construction, and industrial investment. EU funds and government support significantly increased the share of large-scale projects between 2015 and 2020, while after 2020, the pandemic and inflationary pressures shifted demand toward smaller, short-term projects (HCSO, 2023). These changes also influenced the flexibility of firms' adaptation strategies.

2.5 Technological development and digitalisation

Between 2010 and 2023, technological development became an increasingly important factor. Larger firms gradually adopted Building Information Modeling (BIM) systems, automated construction technologies, and online project management tools, while smaller companies typically relied on simpler digital solutions to support their operations (KPMG, 2023; McKinsey, 2023).

Overall, the structural characteristics of the Hungarian construction industry – including firm size, ownership structure, workforce composition, investment patterns, and technological development – jointly influence the sector's resilience and adaptive capacity.

3. Impact of external macroeconomic shocks on the Hungarian construction industry

The performance of the Hungarian construction industry between 2019 and 2023 was shaped by significant external factors. The COVID-19 pandemic, fluctuations in global raw material prices, the surge in energy prices, inflation, and rising interest rates jointly posed serious challenges to the sector (HCSO, 2023; NBH, 2023).

3.1 COVID-19 pandemic and decline in production

In 2020, the pandemic caused a 9.2% decline in construction output, followed by a partial recovery in 2021 (HCSO, 2022). Labour shortages, logistical disruptions, and reduced production capacity all contributed to the downturn. Similar trends were observed in other sectors, where rapid response and flexibility played a decisive role in mitigating the negative impacts (OECD, 2020).

3.2 Inflation and rising energy prices

In 2022, inflation rose to 14.5%, while the sharp increase in energy prices significantly raised operating costs (NBH, 2023). The financing of investments and the maintenance of short-term liquidity placed substantial pressure on firms, particularly on small and medium-sized enterprises (SMEs). Inflationary pressure in the construction industry was most strongly reflected through cost-side effects. In 2022, material prices increased by an average of 35–40%, especially for steel, cement, timber, and insulation materials. Companies responded to the cost surge in three main ways:

1. renegotiating project budgets and adjusting pricing strategies;
2. shortening supplier contracts and diversifying procurement sources;
3. investing in energy efficiency (e.g. on-site solar panels, modernisation of machinery).

Due to the combined effects of inflation and rising interest rates, the liquidity position of small firms became particularly vulnerable. According to NBH data, the share of short-term loans in the SME sector increased to 58% in 2023, indicating higher financing risks.

3.3 Labour shortages and skills availability

Labour market tightness intensified between 2021 and 2023. Skills shortages not only limited production volumes but also made the timely completion of projects more challenging. Large firms attempted to mitigate the problem through technological investments and digitalisation, while smaller companies focused on workforce retraining and diversifying supplier relationships (Eurofound, 2023; KPMG, 2023).

Labour shortages became a structural problem, exacerbated not only by rapid wage growth but also by an ageing workforce and a lack of new entrants. The number of graduates from vocational training has been declining for years, while working abroad remains an attractive alternative for skilled workers.

Companies increasingly employed foreign workers (mainly from Ukraine, Serbia, and Vietnam), who accounted for approximately 12–15% of total construction employment by 2023. The spread of digitalisation and prefabricated technologies partly reduced the need for manual labour but required new competencies (e.g. digital project management, machine operation skills), further increasing training demands.

3.4 Financial stability and investment constraints

Rising interest rates and increasing financing costs narrowed investment opportunities, particularly for short-term, project-based firms. State and EU subsidies eased financial pressure in some cases, but stable operations required internal adaptation and improved cost efficiency (NBH, 2023).

Between 2019 and 2023, corporate capital structures shifted: the share of external financing increased, while the proportion of equity declined. Among small enterprises, the average liquidity ratio fell from 1.15 to 0.92, while for large firms it remained stable above 1.3.
Tighter financing conditions led to a slowdown in investment activity. The construction loan portfolio of the NBH decreased by 6% in 2022, mainly due to high interest rates and uncertain market prospects. However, well-capitalised large firms and companies involved in state-funded projects were able particularly pronounced between 2021 and 2023, encouraging firms to invest in workforce retraining, digitalisation, and automation (McKinsey, 2023; Deloitte, 2024).

Labour market dynamics are closely linked to the cyclical nature of the sector and to investment activity. During the 2020–2023 period, many workers temporarily left the industry due to the pandemic, mainly because of the suspension of foreign projects and uncertain income prospects. According to HCSO data, employment in the sector declined by 7% in 2021, followed by a partial recovery in 2022.

Workforce retention was supported by training programmes and the introduction of flexible employment arrangements. Larger firms implemented incentive-based compensation systems and

internal career paths, while smaller companies relied on project-based cooperation and the expansion of subcontracting networks to maintain operational continuity. Digitalisation (e.g. BIM, online project management, remote work) became an important tool for mitigating skills shortages, particularly in administrative and design-related functions.

3.5 Summary

The impact of external shocks on companies operating in a given sector has been the subject of numerous studies. Kucséber (2022), for example, examined the financial performance of sustainable technology companies in light of the Covid-19 pandemic. The impact of external shocks between 2019 and 2023 clearly demonstrated that the resilience of the Hungarian construction industry is closely linked to firms' internal flexibility, technological development, and financial stability. The challenges faced by the sector highlight the importance of digitalisation, innovation, and human capital in crisis management, as well as the role of structural characteristics – such as firm size and ownership structure – in shaping the effectiveness of responses to shocks.

Table 1. External shocks and internal response mechanisms in the Hungarian construction industry (2019–2023)

Type of external shock	Impact on the sector	Corporate adaptation mechanisms	Outcome / effect
COVID-19 pandemic	Decline in production, logistical disruptions, labour shortages	Flexible project management, remote work, short-term contracts	Mitigation of production losses, partial recovery from 2021
Inflation and rising energy prices	Rising costs, financing difficulties	Cost optimisation, energy efficiency investments	Improved liquidity, higher cost efficiency
Labour shortages	Project delays, capacity constraints	Retraining programmes, automation, digitalisation	Increased efficiency, stronger workforce stability
Rising interest rates and financial constraints	Reduced investments	Alternative financing, use of EU and state funds	Partial stability, moderate investment activity
Technological challenges	Competitive pressure, international competition	Innovation, implementation of BIM systems	Productivity gains, increased resilience

Source: Authors' own compilation based on data from HCSO (2023), MNB (2023), McKinsey (2023), and Deloitte (2024).

4. Internal adaptation and corporate strategies

Corporate responses to external shocks differed significantly depending on firm size and ownership structure. The key elements of internal adaptation included cost optimisation, technological development, digitalisation, and the strengthening of human capital (McKinsey, 2023; Deloitte, 2024).

4.1 Differences by firm size

Small enterprises: Short-term cost reduction, the restraint of operating expenses, and project-based flexibility were typical. Smaller firms often responded to crises by reallocating resources, diversifying supplier relationships, and implementing retraining programmes (KPMG, 2023).
Medium-sized and large enterprises: These firms tended to focus more on long-term technological investments, digitalisation, and efficiency-enhancing measures. The use of Building Information

Modeling (BIM) systems, automated construction technologies, and online project management tools enabled faster responses to market fluctuations.

4.2 The role of innovation and digitalisation

Innovation and digitalisation played a key role in crisis management.
Digitalisation: Companies increased the use of IT and management systems, improving project traceability and the speed of decision-making.

Automatisation and BIM: Larger firms reduced their reliance on manual labour by implementing BIM systems and automated technologies, mitigating production risks and increasing efficiency.
Human resource development: Retraining and training programmes helped address skills shortages, especially among smaller firms, where flexibility and a multi-skilled workforce were critical.

Digitalisation emerged as a crucial factor in maintaining operational flexibility during crisis periods. By 2023, around 45% of medium-sized and large companies were using BIM systems or digital project management tools, compared to only about 20% in 2019.

Innovation was not limited to technological aspects but also appeared at the organisational level. Companies introduced new partnership models (e.g. consortia and joint procurement platforms) to share risks. Digitalisation also enabled more precise monitoring of costs and resources, which significantly improved decision-making response times during crisis periods.
According to various case studies, firms that integrated digitalisation at a strategic level achieved, on average, 8 to 10% higher profitability indicators during the crisis than their traditionally operating competitors.

4.3 Cost optimisation and financing

As part of internal adaptation, companies optimised operating costs, restructured their supply chains, and sought financing solutions to improve liquidity. For medium-sized and large firms, the reorganisation of investments, the digitalisation of project management, and long-term strategic planning contributed to maintaining financial stability.

Cost optimisation appeared in several dimensions: at the level of project planning (material use and logistics), energy efficiency (modernisation of machinery and vehicle fleets), and human resource management (outsourcing and subcontracting arrangements).

Based on quantitative results, operating costs accounted for 87% of revenues among small enterprises in 2022, compared to 72% for large firms. This difference reflects the effects of economies of scale and the efficiency gains from technological investments.

On the financing side, alternative sources such as factoring, leasing, EU funding, and, to a lesser extent, crowdfunding models became increasingly important. Firms with stable financial backgrounds were in a more advantageous position, as they could plan investments with a longer-term perspective rather than relying solely on short-term cash flow considerations.

4.4 Summary

The success of corporate adaptation clearly depended on a combination of managerial flexibility, innovative capacity, and strategic foresight. The analysis shows that companies that responded proactively during the crisis – for example, through liquidity management, digitalisation, or supplier diversification – stabilised their operations and profitability more quickly.

For small enterprises, the lack of financial reserves and limited access to preferential loan programmes increased vulnerability, while larger firms were able to adapt more effectively due to economies of scale and stronger technological capabilities.
Based on our research, the key factors of resilience are:

1. financial discipline and liquidity management;
2. strategic development of human resources;
3. long-term integration of digital investments;
4. strengthening partnerships and network-based cooperation.

Together, these factors contribute to enhancing the resilience of the Hungarian construction industry and maintaining its competitiveness.

5. Results and financial performance

The time-series analysis of financial indicators confirmed that external shocks (the pandemic, inflation, and rising interest rates) and internal adaptation mechanisms (cost management, digitalisation, and supplier diversification) directly affected the revenue, profitability, and liquidity of construction companies. Kucséber and Csoma (2025) examined the TOP 100 companies on the public sustainability list, analyzing 35 financial and non-financial indicators, including those we also examined to analyze the situation of construction companies. To analyze changes between 2020 and 2023, they used indicators such as ROE, ROA, and EBIT.

Based on the collected data, growth trends across the sector slowed after 2021, but by 2023 a partial recovery was observable, particularly among well-capitalised firms. The key to financial performance was rapid adaptation: companies that introduced integrated management systems, digital project control, and effective liquidity management experienced smaller declines during the crisis years.

5.1 Revenue trends

The revenues of small enterprises fluctuated more strongly between 2019 and 2023, especially in 2020 during the COVID-19 crisis, when an average decline of 12 to 15% was observed. Medium-sized and large firms showed more stable revenues, partly due to larger projects and more diversified client portfolios.

Within the analysed corporate sample, revenue growth rates differed by 8–10 percentage points depending on firm size between 2019 and 2023. Small enterprises experienced a sharp decline in 2020, as many minor projects and private investments were postponed during the pandemic. A

partial recovery occurred in 2021–2022; however, due to inflation, nominal growth did not correspond to real expansion.

Revenues of medium-sized and large companies remained more stable thanks to diversified project portfolios, state- and EU-funded contracts, and longer-term contractual structures. The 6.8% revenue growth of large firms in 2023 was mainly linked to the relaunch of transport infrastructure projects and industrial park developments. These findings indicate that revenue resilience is strongly correlated with organisational size and financial stability.

5.2 Profitability and EBITDA

Between 2019 and 2023, the EBITDA margin declined by an average of 18% among small enterprises, while the decrease for large firms was only 6%. This difference reflects the stronger capital base, technological investments, and digital capabilities of larger companies (HCSO, 2023; McKinsey, 2023). Cost optimisation and improvements in project management partially offset the decline in profitability.

Profitability indicators (EBITDA, ROS, ROA) clearly reflect firms' adaptive capacity. According to the data, the 18% decline in EBITDA among small firms resulted mainly from rising material costs and wage pressure caused by labour shortages. Companies without access to pre-financing or liquidity reserves often recorded losses in 2022. In contrast, profitability among medium-sized and large firms declined more moderately (–6%), due to economies of scale and improved project management. A positive correlation was identified between EBITDA and automation levels: firms using digital tools (BIM, ERP, cost monitoring systems) achieved operating margins 4–5 percentage points higher on average. These results confirm that technological development and efficiency improvements play a stabilising financial role during crisis periods.

5.3 Liquidity and financial flexibility

Liquidity ratios reached their lowest levels in 2022, averaging around 1.1, due to rising energy and material costs and short-term investment pressures. Large firms stabilised their liquidity positions more effectively, thanks to long-term financing strategies and digital project management systems that enabled faster responses to market fluctuations.

Time-series analysis shows that the average liquidity ratio of small enterprises fell below 1.05, indicating operational risk, while large companies maintained levels above 1.3. Improvements in liquidity were mainly driven by cost and inventory management, as well as a higher share of pre-financed projects. Some firms used factoring, advance payment systems, and short-term financial instruments to stabilise cash flow. A negative correlation was identified between liquidity and revenue volatility ($r = –0.61$), suggesting that declining financial flexibility is closely associated with fluctuating revenues. Large firms benefited from longer-term financing sources, diversified supplier networks, and easier access to EU funding, which helped mitigate the impact of shocks.

5.4 Summary

Financial analysis confirmed that firm size, capital strength, and internal adaptive capacity fundamentally shape the impact of crises. Innovation, digitalisation, and efficiency-enhancing investments contributed to maintaining profitability and liquidity, while smaller firms relied mainly on short-term cost reductions to stabilise operations.

Liquidity ratios reached their lowest point in 2022, but crisis management measures quickly produced results. Small firms faced increased operational risk, while large companies maintained more stable liquidity levels. The negative correlation between liquidity and revenue volatility further highlights the importance of financial flexibility. Larger firms benefited from long-term financing, diversified supply chains, and better access to EU resources, which reduced vulnerability to external shocks.

The data presented in Figure 1 illustrate temporal evolution of average, EBITDA, and liquidity ratios of small and large enterprises over the period 2019–2023.

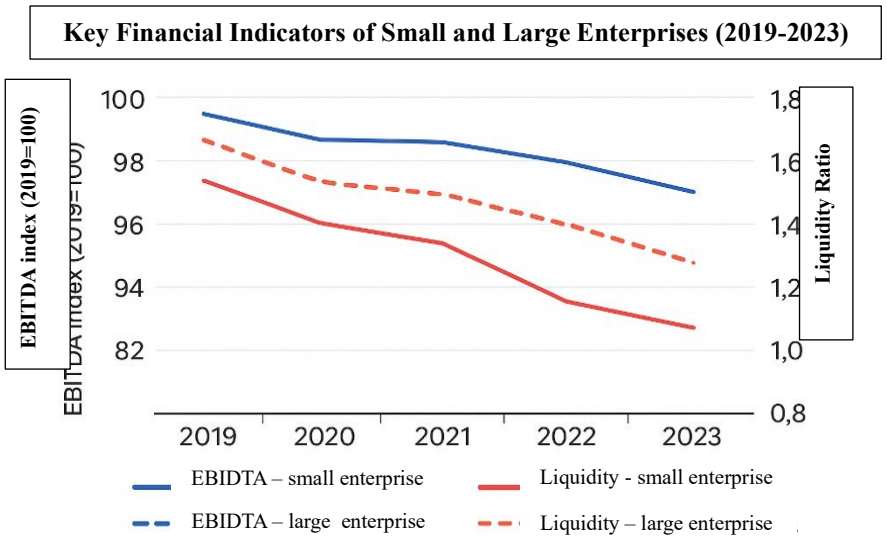

Figure 1. Key Financial Indicators of Small and Large Enterprises (2019–2023)
Source: Own elaboration based on data from Hungarian Central Statistical Office (HCSO, 2023), Hungarian National Bank (HNB, 2023), McKinsey & Company (2023), and Deloitte (2024).

6. Conclusions and policy recommendations

The results show that the resilience of the Hungarian construction industry to external shocks is closely linked to internal adaptive capacity, technological development, and corporate strategic decisions. Firms that invested in digitalisation, technological innovation, and human resource development during the crisis recovered more quickly and maintained their competitiveness.

The study confirms that resilience depends not only on external economic conditions but primarily on firms' adaptive capabilities. Between 2019 and 2023, successful adaptation was driven by digitalisation, technological renewal, and strategic human resource development. Companies that

maintained long-term investment strategies and integrated liquidity management into strategic decision-making performed better during the crisis. These findings indicate that financial stability and competitiveness are not contradictory but mutually reinforcing objectives.

Future development of the construction sector requires coordinated sectoral policies and aligned market incentives. State and EU development programmes should focus on strengthening resilience and long-term operational stability, not merely on increasing investment volumes. Sustainable competitiveness can only be achieved if digital transformation, energy innovation, and human capital development operate as an integrated system.

6.1 Policy recommendations

Strengthening the resilience of the Hungarian construction industry requires targeted policy interventions in financial stability, innovation and digitalisation, human capital, and sustainability. To enhance financial stability, it is essential to expand liquidity and guarantee programmes for SMEs and to develop financing diversification tools that support long-term investment. Improving transparency and predictability in project financing would strengthen crisis resilience and market trust.

In the field of innovation and digitalisation, wider adoption of digital construction technologies – especially BIM, automated data collection, and digital project management – should be encouraged. Targeted funding schemes and data-driven decision-support systems can improve productivity and competitiveness. A national data infrastructure collecting cost, energy, and time-efficiency indicators would support benchmarking and transparent policy decisions.

Human capital development is also crucial. Modernising training and retraining programmes, expanding dual education regionally, and strengthening digital and green skills can help reduce labour shortages. Sectoral career models offering predictable career paths would improve workforce stability. Labour mobility and the integration of foreign professionals should also be supported.

In sustainability policy, promoting environmentally friendly construction technologies and energy-efficient investments is essential. Expanding green public procurement, supporting renewable-energy-based building operations, and integrating ESG criteria into corporate practices would enhance long-term competitiveness and environmental performance. Financial, technological, and human factors must be addressed in an integrated way.

6.2 Future research directions

The findings open several avenues for future research. One key direction is analysing the relationship between technological adaptation and corporate performance, especially how digitalisation and automation affect productivity, project costs, and profitability. Longitudinal studies for 2024–2028 could reveal how innovation investments influence long-term competitiveness.

Another area is labour market flexibility and the effectiveness of training systems. Research should examine how retraining and mobility programmes alleviate labour shortages and identify regional differences. Integrating green and digital skills into training structures is strategically important for both education and economic policy.

Sustainability and ESG compatibility are also emerging research fields. Empirical studies are needed to assess the economic efficiency of green investments, the cost-benefit ratio of energy-efficient construction solutions, and the financial impact of ESG criteria. International comparisons, especially within Central Europe, could help identify Hungary's structural characteristics and competitive advantages.

Finally, evaluating the impact of policy programmes such as GINOP Plus and the Recovery and Resilience Facility would clarify how these initiatives contribute to SME financial stability, innovation capacity, and crisis resilience. Future research should aim not only to analyse current processes but also to build a knowledge base that supports both policy-making and corporate practice.

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Innovation and Digital Transformation Entrepreneurship Attitude effect on MSME's Growth and Competitiveness in Developing Countries

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Abstract: This research aims to carry out a survey on role and contributions of Innovation and digital transformation entrepreneurship attitude (IDTEA) on Micro, Small and Medium Enterprises (MSMEs) growth and competitiveness within developing countries. The study will use surveys to collect data from six developing countries on MSME growth journey using digital transformation and further present it using descriptive and qualitative research methodology. The result of this survey will test all the variables to confirm if they are statistically correlated and have a significant relationship on MSMEs growth and competitiveness from a digital transformation entrepreneurship attitude. This will form a basis of recommending suitable digital transformation attitudes that entrepreneurs, business owners and governments can adopt to enhance enterprise performance, globalization, sustainability, and competitiveness. Entrepreneurs will then be able to develop innovative, best value- added and competitive products, services and solutions, while adjusting their business models, strategies and practices in response to rapidly evolving local and global market conditions.

Keywords: Innovation, Digital Transformation, Entrepreneurial Attitudes, Competitive Advantage, Sustainability, MSME's growth.
Jel codes: M10, M13, O30

1. Introduction

1.1 Background on MSME's

According to the World Bank, Micro, Small and Medium Enterprises (MSMEs) are defined as follows: micro enterprises: 1–9 employees; small: 10–49 employees; and medium: 50–249 employees. However, the local definition of MSMEs vary from country to country, and is based not only on number of employees, but also by inclusion of other variables such as turnaround and assets. MSMEs play an important role in the wider eco-system of firms. Start-ups and young firms, which are generally small or micro firms, which are the primary sources of job creation in many countries and are the driving force of innovation and sustainability in the private sector. There are about 365-445 million MSMEs in emerging markets: 25-30 million are formal SMEs, 55-70 million are formal micro, and 285-345 million are informal enterprises. Small and medium enterprises are fueling the sustainable economic growth of developed, emerging, transitioning, and low-income countries; their survival and sustainability are becoming a crucial issue (World Bank, 2022).

Small and medium-sized enterprises (SMEs) as firms that form the backbone of the economy in Europe, with almost two-thirds of employees in the EU working for a SME, producing over half of all value added in the European economy. SMEs come in three size-bands, micro-sized enterprises which employ between(zero and nine people, small businesses that employ between 10 and 49 workers, and medium-sized businesses that have between 50 and 249 workers. MSMEs hold the potential to transform economies, foster job creation, and promote equitable economic growth if given adequate support European Commission, 2003, World Bank, 2025)

The MSMEs Survey will aim to highlight insights on data driven original insights from the global marketplace on how digital transformation and innovation affects business, economic, and social issues to inform and inspire MSME growth and competitiveness. MSME's are adapting to change faster in operationalizing collaborative digital transformation process that is helping achieve the United Nations Sustainable Development Goals (United Nations, 2018). They are an important element in the implementation of SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation and infrastructure)

Entrepreneurial attitudes can then be described as the mentalities, orientations or perspectives that drive decision-making and behavior in an organizational context. For entrepreneurs and managers in MSMEs, these attitudes can significantly influence their approach to challenges, opportunities, and overall business strategy. Entrepreneurship ability is considered a critical factor of production among the other four factors such as land, capital, labor and Natural resources. It also important to note that entrepreneurial ability is a special type of human resource that organizes the other four factors of production, is the way a business make decisions, innovates, and bears business risk. Entrepreneurial ability is supposed to be rewarded with profit or returns (Cahyadi and Magda, 2021).

We have ten key entrepreneurial attitudes that can be explored to ensure entrepreneurs of MSME's know which attitudes, orientation or mindsets can help align to market needs for their growth and competitiveness. These are: strategic entrepreneurial attitude, risk-taking / averse entrepreneurial attitude, adaptive and non-adaptive entrepreneurial attitudes, customer-centric entrepreneurial attitude**,** innovation and digitization entrepreneurial attitude, learning orientation entrepreneurial attitude, diversity, inclusivity and equity entrepreneurial attitude, collaboration and teamwork entrepreneurial attitude, results-oriented entrepreneurial attitude and ethical entrepreneurial attitude (Cortellazzo et al., 2020)..

From the several entrepreneurial attitudes that define the strategies, behavior and decision making of MSME's in the world today, IDTEA is one of the many entrepreneurship attitudes that this study will be exploring. IDTEA can be explained as a mentality or orientation that encourages creativity and the exploration of new ideas, processes, and technologies to help MSMEs differentiate themselves in the market and develop unique value propositions.

Digital transformation is a key driver of modern economic transformation but is often misunderstood as implementing automation without modifying underlying business operations. True digital transformation extends beyond digitization to incorporate value creation, revenue generation, and business model innovation. Kahveci (2025) studies, explains that digital transformation represents a strategic and operational shift that impacts external relationships, internal business processes, and resource allocation—including physical assets, human capital, corporate culture, and financial resources. Successful digital transformation requires a company-wide transformation (Anshin & Bobyleva, 2021; Gomez-Trujillo & Gonzalez-Perez, 2022; Sousa-Zomer et al., 2020). SMEs, despite their crucial role in global economies, face distinct challenges in adopting digital technologies (DTs) due to resource constraints, skill gaps, lack of awareness, and structural limitations. Several factors influence SME digitalization, including physical infrastructure, human capabilities, organizational structure, owner–manager behavior and external conditions such as market dynamics and regulatory policies (Rossato & Castellani, 2020; Sousa-

Zomer et al., 2020, Illés & Szuda, 2024). These factors highlight both challenges and opportunities for SMEs in adopting DTs. Unlike large enterprises, SMEs exhibit significant heterogeneity, which impacts their digital transformation process. However, there is limited research that systematically outlines the linkage among these factors to provide a practical, structured process for SME digitalization (Kim & Jin, 2024).

This study aims to bridge this gap by developing a framework that identifies and integrates the key enablers of MSME digital transformation, within the entrepreneurial ability and perspective; known as IDTEA, emerging as a modern macro-economic production factor of how MSME's performance can spur competitiveness and growth both locally and in global markets. Prior studies have sorely focused on organizational structures approach (Kuusisto, 2017; Klewitz & Hansen,, 2015; Matt et al., 2015; Kahveci, 2025). Additionally, this research study will seek to establish whether there are causal relationship exists between the innovative digital transformative entrepreneurial attitude and aggregate MSME's growth and competitiveness implying traceability of how different variables interact and whether any actual impact on growth can be identified.

1.2. Objectives of the study and hypotheses

The main study objectives and related hypotheses are summarized as follows:

1. To assess the impact of innovation and digital transformation entrepreneurship attitude on MSME's Growth and competitiveness.
2. To identify Key Elements influencing innovation and digital transformation entrepreneurship attitude within MSME's for their growth development competitiveness.
3. To identify why large corporate firms, leverage on innovation and digital transformation strategies better than MSME's for their growth and competitive advantage. - Measures of Variability
4. To evaluate the real growth of MSMEs from an innovation and digital transformation entrepreneurship perspective through questionnaires real based surveys.
5. To determine the Strategic and Operational Performance, the Global performance and Sustainable performance of an MSME in today's world, how its affected by innovation and digital transformation entrepreneurship attitude.
6. To recommend sustainable digital transformation entrepreneurship models for MSME's to adopt in their business growth cycle competitive dimensions.

1.3. Significance of the study

The research is intended to help the Kenyan government and similar developing nations come up with enabling policies for MSME's Innovation and digital transformation entrepreneurship concept that can increase growth and competitiveness. By impacting positively on sustainable profits and increase incomes for entrepreneurs, business owners, manager and employees, increase production efficiency, increases access to capital investments, strengthens households resilience to economy changes such as inflation and currency fluctuation, counter global supply chain disruptions and positively influence the innovativeness solutions toward climate change hazards

and expand access to human capital IT readiness skills, reduce poverty, unemployment rate, and drive growth in private consumption and investments.

2. Related Literature Reviews and Proposed Hypotheses

Over the past decades, the concept of competitiveness has undergone a significant evolution, shifting from approaches focused exclusively on prices and productivity to more comprehensive perspectives that incorporate innovation, sustainability, human capital, and technological capabilities. In antecedent literature there remains conceptual disintegration and a lack of consensus regarding the theoretical foundations that explain how the digital transformation entrepreneurial attitude can help MSME grow and be competitive. This situation hinders both the comparability of studies and the development of consistent analytical frameworks for the formulation of policies and digital transformation

2.1. Theories of Enterprise Competitiveness in MSME's Perspective:

World Economic Forum in the report on competitiveness states that enterprise competitiveness refers to the ability and opportunity of enterprises to design, produce and sell goods or services in their home environments with a price and quality advantages over their domestic and foreign competitors, both now and in the future. The enterprise competitiveness affected by the environment, price and quality that are the key factors of enterprise competitiveness. Enterprise competitiveness are both of a kind of ability and an opportunity.. Then, in 2000, WEF defined enterprise competitiveness as "a company produces more wealth evenly than other competitors in the world market. (WEF, 2000). Furthermore, the commission of "President's Commission on Industrial Competitiveness" was appointed by President Reagan of America in 1985, defined enterprise competitiveness as: "the ability of enterprises to provide good products and services in the international market under free and good market conditions, at the same time improve the living standards of their country's people. It also defined enterprise competitiveness from the results of enterprise operation with characteristics of welfare economics. However, Spence and Hazard (1988) argued that enterprise competitiveness refers to the ability of a country's enterprises to trade in the international market. The author pointed it out that the trade flow, the technology development and management, industrial policies, domestic management policies, and monopolistic competition all have a profound impact on the enterprise competitiveness. Porter (1985) deemed that the enterprise competitiveness attributed or equated to the competitive advantage of enterprises. The author believes that the competitive advantage of enterprise ultimately comes from the value that the enterprise is willing to create for its customers beyond the cost. Also, the value is the price the customer is willing to pay, and the excess value is generated by offering the same benefit with a lower price than competitors, or by offering the unique benefit to make up for the higher price.

There are two basic forms of enterprise competitive advantages: lower cost and novelty. Visibly, Porter understands and defines enterprise competitiveness mainly from the perspective of competitiveness or competitive advantages in the market performance of an enterprise. It can also be the competitiveness from profit margins. Similar to Porter's definition, it emphasizes the market performance of an enterprise's competitiveness: cost, quality, market share, and profitability. Fujimoto (2018) attributed enterprise competitiveness to enterprise competence, and it can be

investigated from three aspects: the static ability, the improving ability, and the evolving ability. It highlights the dynamic or historical evolution of enterprise competitiveness. Therefore, based on the purpose of this research, the digital transformation attitude of an entrepreneur can be considered as the representative factor of competitiveness in MSMEs.

2.2. Theories of the Growth of SME

Economists base their work on theoretical models that are expected to capture the complex relationships of real-world behavior. There is clear analysis of growth and transformation in the modelling of economic growth based on theories developed. First was the Neoclassical School of thought by Schumpeter in the 1930 and 1940 on entrepreneurial vision of growth engrained within macro-oriented analysis. Then comes Robert Lucas, Paul Romer, Philippe Aghion, and Peter Howitt in the late 1980s and beginning of the 1990s, who discuss knowledge—based growth models referred to as endogenous growth model where knowledge investment and R&D—as the main source of growth and have had profound implications for economic policy. Romer's first model was built on three factors of production: capital, labor, and knowledge. Knowledge was assumed to be accumulated partly through R&D investments of firms, and partly as a result of spillovers from the aggregate stock of knowledge in the economy. Companies' R&D investments were thus internal, but at the same time some of the new knowledge spilled over into the aggregate stock of knowledge. Goods production used knowledge, capital, and labor.

Theories of firm's growth can be nearly synthesized into two aspects: the exogenous growth and the endogenous growth. The exogenous growth theories focus on studying the inference of the external environment on the growth of enterprise and emphasizes the external environment factors, such as the trading market, economic system, industry policy, etc. However, these theories have certain limitations; they ignore the internal. resources, such as knowledge, technology, and resources, which also promote the growth of enterprises greatly. The endogenous growth theories consider the knowledge and the capabilities of an enterprise as the root cause of enterprise growth. However, in the context of economic globalization, external factors also play an important role in enterprise growth.In a subsequent article, Romer (1990) extended his model by positing a more realistic market structure. This model is based on four factors of production—labor, human capital, physical capital, and new knowledge (technology)—which are employed with different intensities in three sectors. In the production of new knowledge (i.e., R&D), only human capital is employed, which also utilizes the aggregate stock of knowledge, i.e., previously accumulated knowledge. The output is a new technology or design that is used together with capital to produce new capital goods (semi-finished products and other inputs). Finally, these differentiated capital goods are combined with labor and human capital to manufacture consumer goods. Production of the three types of goods—new productive knowledge, capital goods, and consumer goods—can take place within a single firm or be distributed across several firms (Braunerhjelm and Henrekson , 2024).

At the same time, the innovation makes existing knowledge obsolete, and firms based on obsolete knowledge are eliminated. In their model they claim to capture Schumpeter's concept of creative destruction, which is partly correct. But at the same time, they focus on very specific and limited types of innovation and entrepreneurship originating in R&D that can most closely be likened to the activity of researchers at a large pharmaceutical firm. In these models, the entrepreneur appears exclusively as an agent who pursues R&D investments where it is assumed that returns on

innovation investments follow an *ex-ante* and objectively known probability distribution. The expected costs and returns of innovations are thus objectively calculable, and the value and economic uses of innovations are known once a new product or technology has been developed. (Braunerhjelm and Henrekson, 2024).

The Industrial Revolution from 19th to 21st century has been defined by transformative innovations, new technologies (IOT and Gen AI) and Business Process Automations. This is no different from digital transformation which is now considered a core competency for entrepreneurship paradigm shift in today's world. Thus, the need to explore tenets of technopreneurship further in this research to see how innovation and digital transformation has impacted on MSME's growth and competitiveness as great agents of macroeconomics environment. Furthermore, entrepreneurship often has a self-reinforcing effect. New discoveries and products generate new opportunities. Economic growth is not primarily about firms growing by a similar percentage or productivity rising in existing jobs because of technological change and more capital per worker. More accurately, growth emanates mainly from churning (firm and job turnover) and restructuring—primarily shifts in production from less to more successful firms within narrowly defined industries, rather than from declining to growing sectors.

Some common ways to categorize growth levels in an enterprise are summarized below.

1. Stage-based models (classic progression)

The stage-based model usually focuses on stage-by-stage perspective to define the different levels of growth in an enterprise such as an MSME. The following are some of the stages that can be explored in research environment.

- Startup or Seed: Ideation, market fit validation, initial raised capital.
- Early-Stage Growth: Product-market fit, customer acquisition ramp, initial revenue generation, scaling operations.
- Scale-Up: Rapid revenue growth, larger market share, formalized processes, expanding teams.
- Maturity: Stable revenue, optimized efficiency, cost control, steady profitability.
- Renewal or Decline: Strategic pivots, new business models, or potential retrenchment if markets shift.

2. Revenue-oriented levels

This type of growth categorization of MSME's is based on the revenue amounts a firm is able to achieve or get during the life cycle of the business month on month, year on year or quarterly. It is divided into the below 5 levels of revenue growth:

- Pre-revenue: Concept validation, prototypes.
- Low revenue: Early customers and pilots.
- High growth revenue: Exponential revenue acceleration.
- Mature revenue: Consistent, stabilized revenue streams.
- Diversified/recurrent revenue: Multiple streams, recurring revenues.

3. Market reach levels

Market reach level is another way of categorizing the growth level of a business based on its expansion model in a region, country or continent. The below are the types of categorizations that a research model can explore:

- Local: Serving a limited geographic area.
- Regional: Several regions within a country.
- National: Coverage across a country.
- Global: International presence and cross-border operations.

4. Organizational complexity levels

In this type of categorization of enterprise growth level, it bases the different level of a firm growth based on operational styles and how they organization structure is designed to meet the different objectives as below:

- Functional silos: Basic departments with limited coordination.
- Cross-functional alignment: More integrated planning across sales, marketing, product, and operations.
- Scaled operations: Large teams, defined processes, formal governance.
- Networked/Modular: Decentralized units or franchises, distributed operations.

5. Capability maturity models (process-focused).

The capability model categories growth into five layered levels based on how processes are structured within an enterprise or an organization.

- Initial/Ad-hoc: Processes are informal and inconsistent.
- Managed: Basic project and process management in place.
- Defined: Standardized processes across the organization.
- Quantitatively Managed: Metrics and data-driven decision making.
- Optimizing: Continuous improvement with optimization and innovation.

6. Customer lifecycle maturity

The Customer lifecycle maturity growth category focuses on how many customers have been acquired and retained over time using the below levels:

- Acquisition-focused: Prioritize new customers.
- Retention-focused: Emphasize lifetime value and churn reduction.
- Expansion-focused: Upsell/c cross-sell and customer ecosystem.
- Advocacy-focused: Customers as promoters and referenceable assets.

7. Business model evolution

The category views the growth of an enterprise based on the business model perspectives to determine the maturity curve as follows

- Product-led Growth (PLG): Self-serve adoption and viral growth.
- Sales-led Growth: Traditional B2B sales motions.
- Platform/ecosystem: Network effects, partnerships, and multi-sided markets.
- Hybrid: Combines elements of multiple approaches.

8. Value chain maturity

The value chain maturity type category looks at how impactful do MSME affect the products and services value chain process, and the buildup stages a firm goes through to mature in the following levels:

- Vertical integration: Owning more stages of the value chain.
- Horizontal expansion: Adding related products/services.

- Diversification: Entering new industries or markets.

3. Innovation and Digital Transformation Entrepreneurial Attitude (IDTEA)

"Entrepreneur" and "entrepreneurship" is defined on the basis of various characteristics and functions the more well-known definitions include Joseph Schumpeter's (an agent that disturbs the equilibrium state of the economy), Frank Knight's (a bearer of uncertainty), and Israel Kirzner's (one who drives the economy towards equilibrium). To these classic definitions, additional ones have been added that are based on the entrepreneur's function/area of activity, for example intrapreneurs, social entrepreneurs, and gig economy entrepreneurs. All definitions emphasize the entrepreneur as an agent of change, a force that drives development. This view returns to Schumpeter's original definition of the entrepreneur as a disrupter of economic equilibrium. We will use the following general definition: entrepreneurs are the *agents of change in the economy* whose actions result in restructuring, market experimentation, and dynamism.

This study further seeks to explain "innovation" which is based on the widely implemented version presented in the *Oslo Manual* (OECD /EuroStat, 2018). Hence, we define "innovation" as *a new or improved product or service, a new form of organization, new inputs or new markets, or a combination of these aspects*. Inventions, scientific findings, or technical discoveries do not necessarily have a market value—as a rule, an entrepreneur, who can identify a market opportunity, is required in order for these to attain a specific market value. Innovation spans most sectors, industries, and economic activities. At the same time, the difficulties of measuring innovation are obvious: R&D expenditure and patents are the most commonly used measures, but they are obviously difficult to apply, for example, to organizational changes, to the identification of new markets, and in the service sector (Nagaoka et al. 2010). In addition, R&D expenditure is an input measure, while we are interested in the return it provides in the form of innovation output. Novelty is not sufficient to "earn" the designation of an innovation; it must also be economically valuable. (Braunerhjelm and Henrekson 2024)

Additionally, the innovative entrepreneurial attitude can be considered as an approach to making products very attractive just through packaging it into attractive labels and brands such as taking simple agricultural produce re-branding or patenting them as bio foods, expensive superfoods. Another approach is by enhanced communication & information scheduling through use of chatbots and virtual assistants to answer clients or customer queries, schedule interviews, and keep applicants engaged throughout the process. There are also innovation entrepreneurial attitude that integrates data-driven Insights of optimizing and embracing AI tools to enhance analytics such as hiring trends, candidate pipelines, and skills gaps matching that are helping businesses anticipate market needs and advise clients strategically. With his kind of entrepreneurial innovation attitude, we shall see more tangible benefits such as Time savings, increased processing times from automation and increased production or service delivery efficiency. In terms of Cost reduction: digital transformation attain more benefits such as reduced operational downtimes, financing costs, supply chain lead times, recruitment and hiring process timelines. Better market identification: with increased percentage of firms' ability to find repeat consumers and expand their market share growth.

3.1. The need for continuous innovation and process digitalization

For continued success, MSME's, need to transform and innovate business models, products, and services to create new revenue streams; operate more sustainably and profitably; and deliver differentiated value-added products, customer, supplier, and employee experiences. Adopting digital technologies is particularly transformative. Globally, the current top priorities for gaining competitive edge are:

- product sustainability improvements
- introducing new products and services
- improving customer experiences.

Business transformation elements focus on three main areas and steps are as follows (Table 1 and Fig. 1).).

Table 1. Three key ingredients for successful business transformation

1. **Put processes at the center**	**2.** **Follow a holistic mindset**	**3.** **Be data-driven and smart**
Processes shall be key elements of your business transformation	It should include process analysis and end-to-end process innovation	Prioritizing while considering people
Position small, incremental improvements that catalyze continuously.	Change management and collaboration and regular progress monitoring	Prioritizing in data systems and processes

Source: own compilation

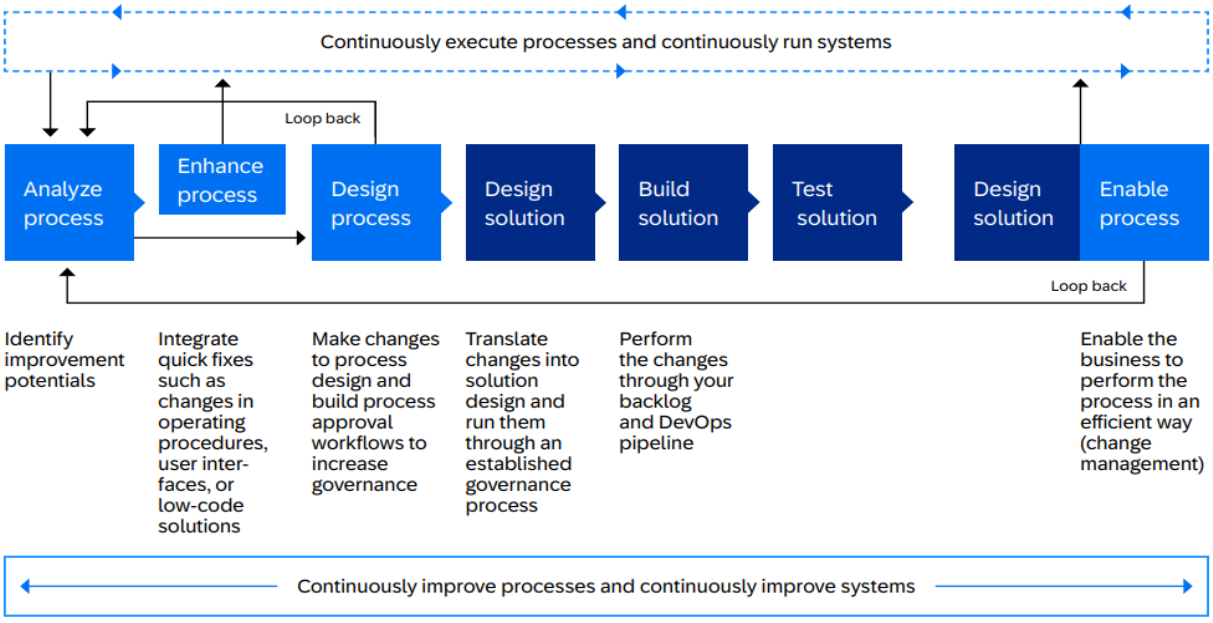

Figure 1. Continuous Innovation and Digital Transformation process flow diagram
Source: own compilation

Innovative digital transformative attitudes can be differentiated or assessed on a scale or level of how diverse they are – in terms of

- Gradual digital transformation attitude- is more of a traditional and cautious transition from one technology to another within the business.
- Spontaneous digital transformation attitude- More of uninformed and influenced by external factors, by software marketing or shift or new trends in the disruptive technology solutions markets.
- Informed and strategic digital transformation attitude.
- Agile digital transformation attitude is where the entrepreneur seeks the best fit digital tools and systems to match with the case scenario or risks and challenges facing the enterprise at any particular time they are more of evolving and adaptable to different scenarios of an MSME' life cycle and operational challenges.

3.2. Innovative Digital Transformation Entrepreneurial Attitude Opportunities

Several benefits of digital transformation are grouped into different categories in the literature. The benefits are sorted nine enablers of business operations:

1. Automating routine steps and tasks, optimized operational workflows, streamlined business processes, and efficient metadata management.
2. Creates new markets accessibility, business collaborations and frontiers for expansion.
3. Enhanced employee, customer and governance teams' experiences, built trust and visibility on organization resources and information.
4. Facilitates rapid financial services and global transactions, to overcome cost of business.
5. Improved integration, interaction, and knowledge sharing while stimulating innovation.
6. Enhanced workforce capabilities, capacity and talent building, and tasks turn-around times.
7. Improved feedback mechanisms and environmental scanning for opportunities, risks and environmental or social requirements.
8. Quick turnaround times for processing products, service delivery as adaptive models simulate the real business environment.
9. Safer, Verified and Quality enhanced products and services due to integrates digital mechanisms for reinforcement and confirmations

MSMEs, despite their crucial role in global economies, face distinct challenges in adopting digital technologies (DTs) due to resource constraints, communication barrier of software versions, tech-skill and knowledge gaps, exposure gaps, level of awareness on digital tools integration with AI, machine learning and other IT systems , rapid or evolving technological changes, demanding user requirements Client / Customer Integration (CI) and Client/ Customer Experience (CX) design system experience and interface build-up , mapping requirements of enhancements , stakeholder engagement. Eyup Kahveci (2025) avers that MSMEs in adopting DTs. Unlike large enterprises, SMEs exhibit significant heterogeneity, which impacts their digital transformation process. However, there is limited research that systematically outlines the linkage among these factors to provide a practical, structured process for SME digitalization. Based on these, Innovation and Digital Transformation Attitude benefits to MSME's are summarized by Fig. 2.

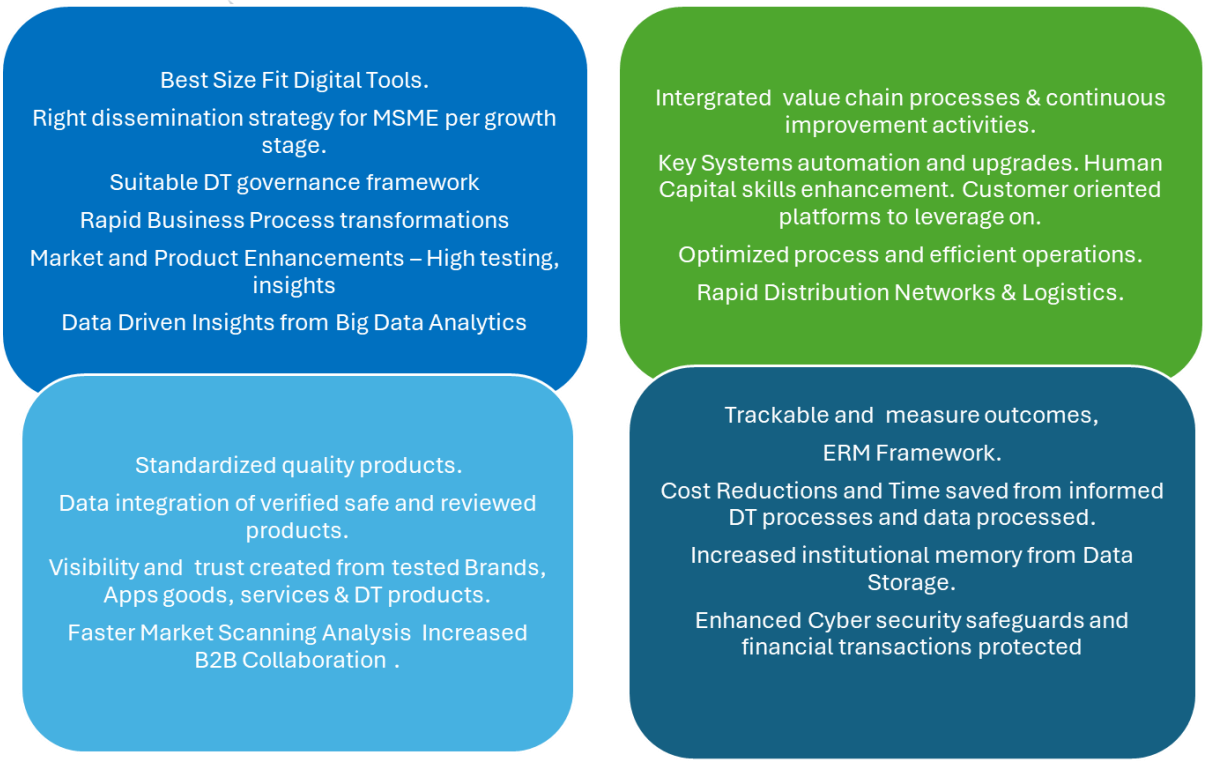

Figure 2. Innovation & Digital Transformation Attitude Benefits to MSME's
Source: Authors' own

4. Research process

Although the research is in the initial stage, it is important to summarize the research steps and main characteristics of data sampling, collection and processing.

4.1. Research Design

This research paper will be focusing on six developing countries, that is Kenya, Ethiopia, South Africa, Nigeria and Indonesia and Bangladesh as a representative sample to collect data using structured closed and open-ended survey questionnaire method to gather insights and data for MSME's operating within as these countries. The method used to select the six countries as a representative number of 44 developing countries as per world bank economic index globally will be based on a convenient and purposeful sampling method to be able to gather data easily and concrete realistic patterns of MSME's growth and competitiveness factors. The questionnaires will be analyzed to try and explain the relationship between MSME's innovation and digitization entrepreneurial attitude and how it impacts their growth and competitiveness in the global economy.

Research design expresses both the structure of the research problem, the framework, the organization, or the configuration of the relationships among variables of a study, and the plan of investigation used to obtain empirical evidence on those relationships. Accordingly, we shall use both descriptive and explanatory research designs to achieve the general objective of the study and

to address the research questions. A descriptive research design will be used to describe aspects of innovation and digital transformation attitudes adopted or undertaken by MSME owners, implementation within MSME, practices and process to test the effect whether positive or negative on the growth and competitiveness of their enterprises in terms of graphs, tables, frequencies, and percentages; meanwhile, an explanatory research design will be used to link the effects of innovation and digital transformation attitude on MSMEs' performance.

4.2. Sample size determination, source of data and data collection instruments

Following the method used by Abdissa et al. (2021), I will use purposeful, convenient sampling based on the stratified simple random sampling technique. This method will be chosen because it obtains a sample population that best represents the entire population being studied. This technique will reduces sample selection bias and therefore ensure that certain segments of the population will not be misrepresented. In the sampling procedure, MSMEs will be categorized into eight strata. This included the agriculture, trade& finance, insurance, hotel and tourism, ICT, transport and logistics manufacturing sectors and construction sectors.
To determine the sample size, this study will adopt Yamane's formula with a 95% confidence level. This method will be adopted since the population is known (finite), and because it allows for correction of the proportion. The calculation formula is shown below, where e = tolerance at the preferred level of confidence, N = study population, and n = sample size, with $\alpha = 0.05$ at the 95% confidence level. The sample size for this study will be established from the at least 70% of the questionnaires of the target population size will be pursued to give an informed representation of the study population.

The research paper will use survey questionnaires as data collection instruments for its primary data source in addition to the secondary sources from national statistics reference bodies, corporate manuals and MSMEs website and financial institutions accounts. The questionnaires will consist of open- and closed-ended questions; with a further use of Likert scale questions to evaluate and score the Sampled MSME's across different economic sectors such as manufacturing, construction, Hotel & Tourism, ICT, agriculture and trade to what extent their firms have adopted digital transformation entrepreneurial attitude to influence their growth and enhance competitiveness in their operations. The questionnaires will be divided into 2 sections. Section 1 of the questionnaire will be aimed at collecting company information, whereas section 2 will analyze responses regarding the impact of digital transformation entrepreneurial attitude on growth and competitiveness.

4.3. Data Analysis Techniques

A five-point Likert rating scale of MSME's growth curve and competitive score card will be established: low (level I), medium (level II) and high (level III). The growth and competitiveness variables will be plotted on a Pearson's R heatmap presented to show the correlation of Growth levels to digital transformation Levels and Competitiveness Level against the digital transformation Levels. The interpretation of using the Likert scale provides valuable information on which domains, such as data-driven culture, innovation, among others, can be enhanced to improve the potential of entrepreneur for digital transformation.

The survey questionnaires developed will be validated to assess the latent traits of MSME's growth curve and competitiveness models within the context of digital transformation. The significance of the three independent variables: MSME growth rate (variable 1) MSME competitiveness levels (variable 2) and Innovation and Digital transformation Levels (variable 3) will be tested using the Chi-test qualitative methodology whether two qualitative variables are independent at a certain level of significance.

Null Hypotheses: $H0$: MSME's growth and Innovation and digital transformation entrepreneurial attitude are independent. $H1$: MSME's growth and Innovation and digital transformation entrepreneurial attitude are NOT independent.

This study will focus on only one of eight MSME's growth models known as classical progression model (Stage-based model) and try to test its relationship with IDTEA to see if there is a positive correlation between the two variables. IDTEA Model has its own factors of assessment within the MSME's perspective, and this will be analyzed further to determine how effective is the IDTEA framework in spurring sustainable economic growth and competitive advantage of MSME's in a in today's rapidly evolving and globally interconnected world. The research results can also be used for enhancing investment readiness of MSME's in developing countries to align with UN-SDG goals and projects in partnership with private sector, United Nations Organizations (UNO's) International and Local Finance Institutions, Development Partners, Foundations and Philanthropy enterprises, NGO's and Government Policy Organs, Professional Member Bodies, among others.

The Study will use ANOVA Methodology to perform f-test of variances on the group variance of relationships between MSME's growth and competitiveness and effects of innovative and digital transformation attitude in one group of developing countries, to the group of least developed countries and to the third group of developed countries. To determine the Null hypothesis, the growth and level of competitiveness will be tested to check if it is the same within all the six developing countries categories and whether H1:one formulated level of MSME's growth and competitiveness level attained due to innovative/ digital transformation entrepreneurial attitude differs from the other grouping of developing countries.

The assumption checks will be noted that will be used during the evaluation of the relationship between growth levels and diversity of digital transformation entrepreneurial attitudes and will be tested using Shapiro test of pairwise normality and investigate further the relationship between competitiveness level and diversity of digital transformation entrepreneurial attitudes.

5. Summary

The study report will offer practical advice for micro, small-medium enterprises (MSMEs) aiming to attain a IDTEA competitive advantage and economic growth. With the help of a IDTEA competitive advantage model, the recommendations in this study can benefit MSMEs to develop a step-by-step digital transformation strategy, guide and elaborate manual to harness innovative knowledge and solutions, digital transformative model and framework and Government policies within MSME's operating environments and different economic actors. As a result, it is a futuristic approach for MSME's, entrepreneurs and governments to dealing with the diverse digital tools, technological support and infrastructure that are necessary for enhanced operational efficiency,

improved decision-making sustainable practices and business models, innovative and data driven insights and strategies in order to maintain consistent growth and competitive advantages across the globe when dealing with disruptive economic, geo-political and environmental challenges.

Digital Transformation will continue to be a necessary enterprise process disruption fundamental to reshaping the way MSME's, firms, Companies and industries operate, compete and create value. Emerging technologies, such as artificial intelligence (AI), the Internet of Things (IoT) and automation, are driving a new wave of industrial innovation, one defined by data-driven decision-making, interconnected systems and unprecedented levels of efficiency. These technologies are optimizing production processes and transforming entire business models, enabling real-time visibility across supply chains, predictive maintenance and mass customization. As the pace of change accelerates, companies that adapt quickly are gaining a significant competitive edge, while those unable to integrate digital capabilities risk falling behind in an increasingly technology-driven economy. Although MSMEs continue to face a number of fundamental barriers to technology adoption compared to large companies in similar industries yet they constitute the structural backbone of economic activity.

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Conceptual Frameworks of Health-Conscious Human Resource Development

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Abstract: Adequate human resources are essential to ensure sustainable corporate operations. Employee well-being and health awareness are not only important on an individual level, but are also fundamental factors in corporate sustainability. As part of sustainable human resource management, health-conscious human resource development aims to create a workplace environment that contributes to healthy and satisfied employees being committed to achieving the organisation's strategic goals and sustainable operation. The aim of this study is to explore the role of wellness programmes as health-conscious human resource development tools in the long-term preservation of the quality of corporate human capital and to conceptually demonstrate how these tools contribute to corporate performance and sustainable operation.

Key words: Sustainability, Sustainable Human Resource Management, human capital, wellness programmes
JEL Code: I31, J24, M14

1. Introduction

Nowadays, one of the key factors in the successful and sustainable long-term operation of companies is having a high-quality, well-trained, healthy and satisfied workforce, because the physical and mental well-being of employees has a direct impact on the performance and competitiveness of the company. Improving the quality of human resources is therefore increasingly becoming a strategic goal for companies. Wellness and spa services were originally associated with health tourism, but in the last decade they have increasingly appeared in the context of workplace well-being and corporate sustainability. The concept of wellness – a combination of the terms "well-being" and ″wholeness" – aims to create physical, mental and spiritual balance in a holistic approach (Helmeczi et al, 2023). The "4R" model of the spa experience consists of relaxation, i.e. rest and stress relief (Relax), reflection, i.e. meditation and contemplation (Reflect), revitalisation, i.e. refreshment (Revitalise), and joy, i.e. happiness and entertainment (Rejoice), highlighting the importance of these areas in improving overall health (Rátz 2004). The model points out that physical and mental regeneration, promoting mental recharging, encouraging inner harmony and supporting the preservation of vitality create the basic conditions for healthy work, thus contributing to the well-being and performance of employees. Boros, Mondok and Várhelyi (2012) emphasise that stress management, relaxation and mental balance are not only individual factors in modern societies, but also factors of economic and organisational significance. In a globalised, rapidly changing economic environment, employee satisfaction, good health and mental stability directly influence the organisation's performance, adaptability and long-term competitiveness. Supporting health preservation, physical and mental harmony and individual well-being is thus becoming an integral part of sustainable corporate governance ( ). It is the responsibility of the company to create a working environment that encourages prevention, a healthy lifestyle and a balanced life. Companies that offer wellness and spa services to their employees as part of their human resource management contribute to increasing employee productivity and job satisfaction, thereby ensuring the long-term sustainability of the company. Szántó (2019) also emphasises that wellness and mental well-being are closely related and that maintaining physical health can only be achieved by involving the psychological and spiritual

dimensions. In line with this approach, corporate health programmes, such as workplace recreation, relaxation areas and other wellness options, not only improve the physical condition of employees, but also strengthen organisational culture and employee commitment, thereby contributing to workplace well-being. The introduction and integration of wellness programmes and spa services into corporate human resource management is becoming an increasingly common practice as a means of supporting employee health awareness and, through this, making corporate operations more sustainable. Figure 1 illustrates the conceptual framework of the research, which highlights the link between employee well-being and sustainable corporate operations in the context of sustainable human resource management and health-conscious human resource development.

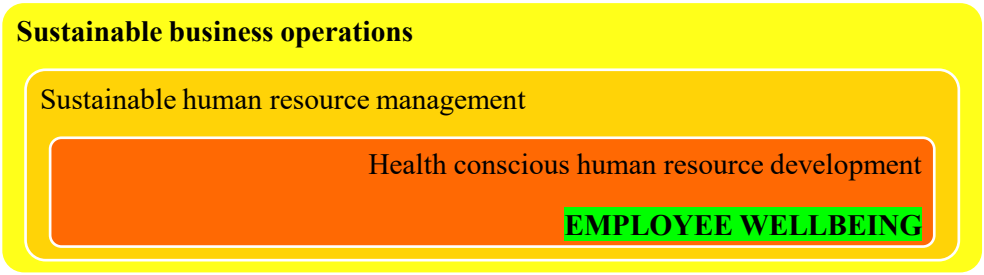

Figure 1. The relationship between employee well-being and sustainable corporate operations
Source: own compilation

The aim of the study is to explore, based on relevant domestic and international literature and corporate best practices, the role that wellness programmes and spa services can play as tools for health-conscious human resource development in the sustainable operation of companies, supporting the development of a health-conscious lifestyle among employees. The study takes a conceptual approach, synthesising previous domestic and international research, with the aim of providing a structured theoretical framework that can help companies to incorporate the human dimension of sustainability efforts more consciously into their operations by treating employee well-being as a strategic objective.

2. Sustainable corporate operations – sustainable human resource management

One of the central elements of sustainable corporate governance today is *sustainable human resource management (S-HRM*). This approach not only focuses on the efficiency and competitiveness of the company, but also considers the long-term preservation and continuous development of the quality of human resources as a strategic resource, taking into account the long-term well-being, satisfaction and health of employees. Bai (2025) emphasises that organisations need to develop not only performance-oriented HR strategies, but also HR policies that support the physical, mental and emotional health of employees in order to ensure a sustainable working environment in the long term. Using the PERMA model, the author highlights the dimensions that need to be considered when developing a well-being-oriented HR strategy. The five-element PERMA model developed by Seligman (2011) is a positive psychology framework that structures the factors necessary for human well-being, emphasising that the individual dimensions complement each other and contribute to well-being in the workplace (Figure 2).

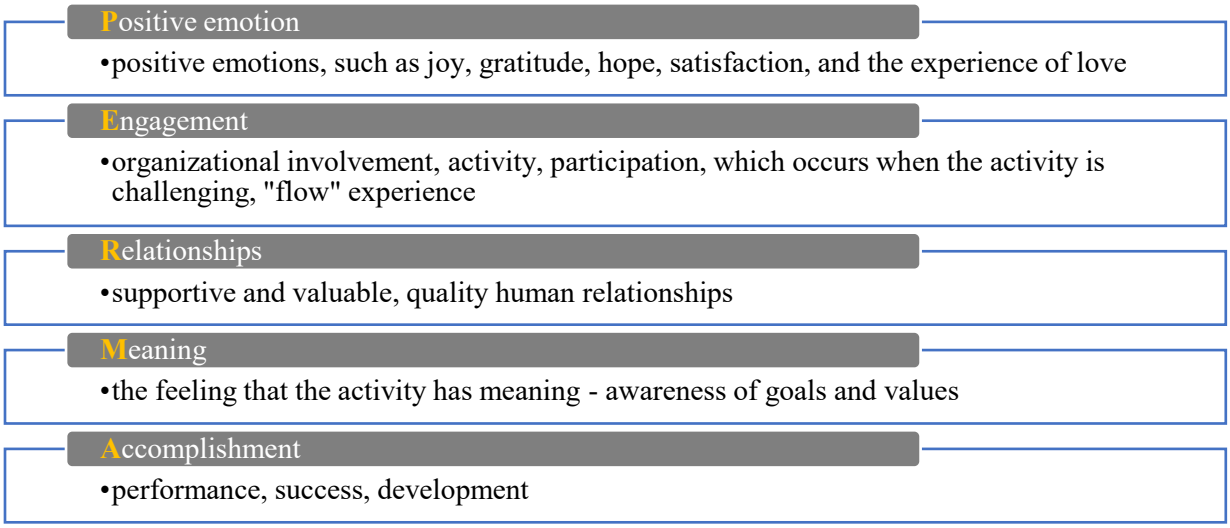

Figure 2. The PERMA model
Based on Seligman (2011), own compilation

One of the basic principles of health-conscious HRM is that the company should view wellness and well-being programmes not as separate benefits, but as strategic tools for increasing employee performance, creativity and loyalty. S-HRM practices, such as flexible working hours, mental health support and ethical HR procedures, can directly contribute to individual well-being and thus to the sustainable development of the company, ensuring that human resources remain sustainable and effective in the long term (Asissiya-Fonceca, 2025).

2.1. The role of human capital in sustainable corporate operations

Human capital is one of the cornerstones of sustainable development, and a well-trained and healthy workforce is a company's most important resource. The quality of human capital, which includes not only the skills of employees but also their health, well-being and opportunities for development, is a key factor in the long-term sustainability of a company's operations. Human resources are not just a cost factor, but a strategic resource whose value is realised when it is able to continuously renew, regenerate and develop itself. This approach is at the heart of sustainable human resource management, which integrates employee well-being, continuous human resource development and social responsibility into corporate strategy (Ehnert, 2009; Kramar, 2014). According to Docherty et al. (2009), the long-term sustainability of corporate performance is determined by the "reproductive capacity" of human capital, which means not only professional development but also the maintenance of physical and mental health. An overworked, burnt-out employee is unable to contribute to the organisation's goals in the long term, so protecting and caring for human capital is both a preventive and a sustainability issue (Grawitch et al., 2006; Cooper & Dewe, 2008). Wellness and spa services fit well into this approach, as they directly support employee well-being and performance through relaxation, stress reduction and physical and mental renewal.

Human capital is not a static but a dynamic resource for the organisation, and its sustainable management options are largely determined by corporate culture and management practices. ,

leaders who adhere to the principles of well-being leadership support the psychological safety and commitment of employees and encourage health-conscious work practices, which improve organisational performance in the long term (Cartwright & Cooper, 2014; Nielsen & Noblet, 2018). Human sustainability can be interpreted in several dimensions, encompassing elements of physical, mental and social well-being. These are in line with the holistic approach to wellness, which is based on the unity of body, soul and spirit. This approach to human sustainability is a people-centred form of sustainable corporate operation.

2.2. Wellness and spa services as tools for sustainable human resource management

Employee well-being and maintaining physical and mental health are key for companies to ensure adequate human capital. Wellness and spa services are human resource development tools that can contribute to maintaining employee health, reducing stress and increasing job satisfaction when integrated into a sustainable corporate operating system, effectively linking corporate social responsibility (*Corporate Social Responsibility, CSR)* and human resource management objectives. Szlávik and Csáfor (2012:207) also emphasise that CSR refers to corporate operations that provide benefits and positive effects for employees, thereby promoting general well-being. Corporate social responsibility can therefore strengthen health promotion programmes, while these initiatives have an impact on the credibility and reputation of the company (Alonso-Núñez et al., 2022). In line with this, ESG-based HR strategies are emerging that actively incorporate environmental and social considerations into human resource management, thereby increasing employee well-being and performance. Modern tools for enhancing well-being in the workplace include "well-being sensing" technologies that automatically or passively collect data on employee status, such as behavioural patterns, physical activity, interactions, situations, signs of stress, devices that can be worn in the workplace, space monitoring sensors or data collection platforms (Kawakami et al., 2023). The authors also point out that while these innovations open up new perspectives in corporate health management, they also raise significant ethical and cultural issues. Wellness and spa services, as part of human resource management, not only serve the well-being of employees, but can also become an important pillar of corporate sustainability in the 21st-century economic and social environment, as they reduce absenteeism, increase productivity and strengthen employee commitment.

3. The importance of health-conscious human resource development

Health-conscious HR development is becoming an increasingly strategic factor in the operation of companies, as it directly affects not only the well-being of employees but also organisational performance. The importance of health-conscious HR development is particularly evident in workplaces where there is a high workload and time pressure. Without the right HR strategies and wellness tools, companies face long-term risks: human capital depletion, turnover, and decreased performance. Research shows that companies that consciously integrate health and well-being programmes into their HR policies realise measurable business benefits. An analysis by Harvard Business Review (Berry-Mirabito-Baun, 2010) showed that health-conscious companies achieve up to 25-30% lower sick leave costs and 2-3 times higher commitment rates. Based on the analysis by Baicker et al. (2010), workplace wellness and health programmes can also bring significant returns, with every dollar invested reducing healthcare costs by $3.27 and absenteeism costs by

$2.73. According to Gallup's (2016/2017) analysis, highly engaged teams have 41% lower absenteeism , approximately 17% higher productivity and approximately 21% higher profitability.

However, the effectiveness of corporate health promotion is not only a matter of programmes, but also of managerial attitudes. Sustainable leadership refers to value-based managerial behaviour that ensures the long-term performance, motivation and health of employees (Avery-Bergsteiner, 2011). Sustainable leaders support recreational initiatives and conscious lifestyles, and their example legitimises a health-conscious culture within the company. Without managerial commitment, the effectiveness of wellness programmes is significantly reduced (Nielsen et al., 2017).

Health-conscious HR development not only results in individual well-being, but also plays an increasingly important role in measuring corporate sustainability. Human capital is now a central dimension of sustainability reporting, and the ESG framework also includes human and social indicators. These include, for example, employee well-being indices, turnover rates, the prevalence of health promotion programmes and workplace stress levels. The latest standards of the Global Reporting Initiative (GRI) (401, 403) make these indicators mandatory, thus making human capital a transparent and auditable part of sustainable corporate governance (GRI, 2021). Human capital is therefore not just a resource, but a renewable source of value that, with the right environment and leadership, can strengthen a company's resilience and long-term value creation capabilities. The human dimension of sustainability cannot be separated from economic and environmental responsibility, because sustainable development cannot be achieved without healthy, committed and reflective employees.

3.1. The importance of workplace wellness programmes

In the modern work environment, the physical, mental and spiritual well-being of employees is also a strategic issue. The role of workplace wellness programmes is becoming increasingly important in the life of organisations, as numerous studies show that well-designed and sustainable health promotion initiatives not only improve the quality of life of employees, but also increase their performance, loyalty and innovation potential. These programmes clearly demonstrate that companies view the health and well-being of their employees as a long-term investment that directly contributes to the competitiveness and sustainability of the organisation. Alonso-Núñez et al. (2022) research on employee wellbeing also pointed out that it is not only important to introduce wellness programmes, but also to embed them in strategy, fit in with corporate values and receive management commitment, thereby highlighting the link between corporate social responsibility (CSR) and sustainable corporate governance (ESG).

The modern approach to wellness is not just about physical well-being, but also includes psychological, emotional and social dimensions, thus building on a balance of physical, mental and spiritual health. Foncubierta-Rodríguez et al. (2024) also emphasise that wellness programmes should include mental health promotion elements and stress management options. The key to the success of workplace wellness programmes lies precisely in this holistic approach. The "4R" model of the spa experience can also be well integrated into the corporate environment, offering employees the opportunity to regenerate and regain their mental balance. Workplace wellness programmes include health assessments and biometric measurements that provide diagnostic data

(e.g. body weight, blood pressure), lifestyle assessments, which use questionnaires to measure health behaviours and risks, and various wellness activities and programmes, such as smoking cessation, stress management, fitness, nutritional counselling, relaxation techniques and training (Jones et al, 2019). Programmes should be tailored to the needs of the workforce, but management support and the development of an appropriate incentive system to increase participation rates are essential for success (, Mattke et al. 2013).

Empirical studies (e.g., Peñalvo et al., 2021; Marín-Farrona et al., 2023; Mattke et al., 2013) generally confirm the beneficial effects of workplace wellness programmes, such as reducing absenteeism, increasing participation, and improving employee satisfaction and health. However, some studies have found no significant effect on mental well-being or clinical health indicators, e.g. the Fleming study, which found that wellness programmes do not necessarily improve mental health (Lee, 2024), and that low participation rates may distort the results, and incentive systems may also hinder the success of the programmes. An opinion piece in The Guardian (2024) also points out that addressing structural workplace stressors (e.g., high workload, long working hours, low control) may be more important than offering wellness programmes to employees.

However, some empirical studies have found no significant effect on mental well-being and health indicators. According to Jones et al. (2019), there was no demonstrable improvement in total medical costs, health behaviour or self-reported health status. It should be noted, however, that low participation rates and methodological limitations of incentive schemes may distort the results (Mattke et al., 2013). Thomas (2024) also points out that addressing structural workplace stressors (e.g., high workload, long working hours, low control) may be more important than offering wellness programmes alone. Overall, wellness programmes are potentially valuable tools, but their effectiveness depends largely on their design, environmental factors and corporate culture.

Wellness and spa programmes have a simultaneous impact at the individual level by promoting health, resilience and well-being, at the organisational level by encouraging better performance, greater loyalty and creativity, and at the societal level by promoting responsible corporate behaviour, ethical operations and health awareness. Through these multi-level mechanisms, wellness not only serves to preserve human capital, but also contributes to the long-term stability and sustainability of the company.

3.2. The effects of wellness programmes

Corporate wellness and spa programmes contribute to sustainable operation in a complex way, as their effects are felt at the individual, organisational and social levels (Figure 3). The literature interprets these effects as an interrelated, synergistic system in which the improvement of human capital quality is linked to the transformation of organisational culture and the strengthening of social health awareness (Grawitch et al., 2006; Cooper & Cartwright, 2014; Szántó, 2019).

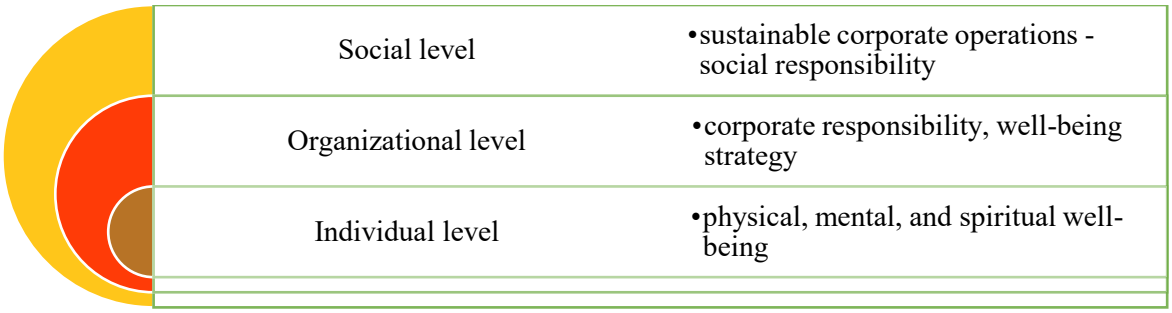

Figure 3. The multi-level impact mechanism of corporate wellness and spa programmes
Source: Own compilation based on Grawitch et al. (2006), Cooper-Cartwright (2014), Szántó (2019)

The three-level model presented in Figure 3 interprets workplace wellbeing in line with the literature in social, organisational and individual dimensions. The social level refers to the external responsibility and sustainable operation of the company, reinforcing corporate responsibility in the social component of ESG (WBCSD, 2022) and contributing to increased community health awareness and resilience (Public Health England, 2019). The organisational level emphasises that organisational culture plays an important role in employee well-being, which is a consequence of the company's internal operations, HR systems, management culture and work organisation. This level may include responsible employment practices, fair pay, people-centred management, psychological safety, well-being strategy, flexible working or mental health policy. Matiscsákné (2017) also points out that responsible HR professionals not only ensure compliance with legislation, but also strive to create a workplace environment where all employees can view their employer with pride and commitment, who creates security for them through ethical operation, compliance with rules and continuous support. Well-designed corporate programmes also reduce insurance costs, increase productivity (Baicker et al., 2010) and strengthen organisational identification (Berry et al., 2010). Creating psychological safety promotes creativity and innovation (Edmondson, 2018), while a high level of well-being contributes to reduced turnover and stronger organisational citizenship behaviour (OCB) (Podsakoff et al., 2014). The individual level focuses on the physical, mental and spiritual well-being of employees, i.e. how they feel during their daily work. Prevention-based exercise programmes, health screenings and nutritional support reduce the number of illnesses and absences (WHO, 2020; RAND, 2014), while mindfulness and relaxation techniques improve stress management and emotional stability (Hülsheger et al., 2013). Spiritual revitalisation based on the 4R model supports inner balance and meaning in work, which increases motivation and commitment (Petchsawang & Duchon, 2012). The essence of the model is that employee well-being can only be sustainable if it is not solely the responsibility of the individual, but is also supported at the organisational and societal levels. Workplace wellness programmes are therefore not merely extra benefits, but play a key role in the long-term sustainability of the company. A system that focuses on well-being serves the health of employees, the operational efficiency of the company and the well-being of society at the same time. When employees are physically and mentally well, not only do they benefit, but so does the company – for example, in the form of greater commitment, creativity and better performance – and ultimately society as a whole (Cooper-Dewe, 2020).

The role of corporate wellness and spa programmes in sustainability is not isolated, but manifests itself through complex psychological, organisational and economic processes. As shown in Figure

4, the literature distinguishes three main effects: preventive, motivational and reputational, which reinforce each other and contribute to the company's long-term performance and value creation (Ehnert, 2009; Kramar, 2014; Cooper & Dewe, 2020).

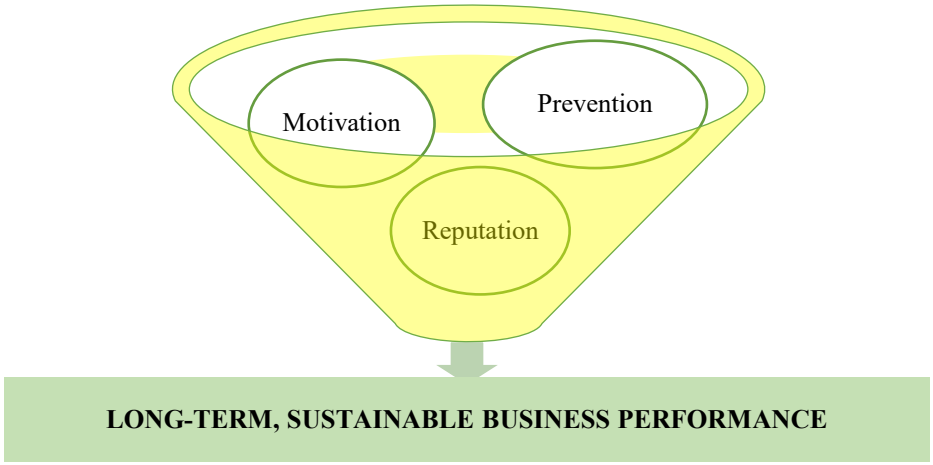

Figure 4. Contribution of corporate wellness and spa programmes to long-term corporate performance

Source: Own compilation based on Ehnert (2009), Kramar (2014), Cooper-Dewe (2020)

The preventive effect is achieved through health maintenance and disease prevention, with exercise programmes, stress management training, health education initiatives and screening tests reducing absenteeism and healthcare costs. According to the JD–R model (Bakker & Demerouti, 2007), these interventions act as protective factors that counteract workplace stress, prevent burnout and increase resilience. Empirical research shows that wellness programmes reduce absenteeism by 1.5–2 days per year, while mental health interventions can reduce workplace stress by up to 23% (RAND, 2014; CDC, 2022).

The motivational effect is also evident on a psychological level, and the dimensions of the PERMA model can be measurably strengthened through targeted wellness programmes. Relaxation techniques, team-building recreation, mindfulness exercises and spiritual-meditative spaces all contribute to increased intrinsic motivation, flow experience and self-efficacy. Some companies have even created spiritual spaces for their employees, recognising that spiritual regeneration is just as important as physical and mental health (Szántó, 2019; Lausanne Movement, 2024). In this way, the wellness experience not only generates mental energy, but also gives existential meaning to work.

The reputational impact is reflected in the company's strategic culture and external perception, lending the organisation a positive image. Well-functioning wellness programmes transform the organisation into a wellbeing ecosystem that not only provides internal health and performance benefits, but also strengthens employer branding and increases corporate credibility in the social dimension of ESG (Berry et al., 2010; WBCSD, 2022). For younger generations, mental health support and a people-centred work environment are already decisive factors in choosing a job (Deloitte, 2021). Thus, human sustainability is increasingly becoming a "hard" performance indicator in the eyes of investors, partners and consumers.

Overall, through their mediated, multi-level effects, wellness programmes not only serve the well-being of employees, but also appear as a vital sustainability factor in corporate operations – in economic, social and psychological terms. The basic principle of sustainable human resource management is that employees cannot be viewed merely as a resource to be exploited in the short term, because the long-term preservation, development and regeneration of human capital is one of the most important strategic values of a company's operations. In this approach, wellness and employee well-being are not ancillary HR tools, but a consciously integrated element of organisational strategy that serves ecological, economic and social sustainability (Ehnert, 2009; Kramar, 2014). International and domestic examples prove that investing in employee well-being is no longer just an ethical or HR consideration, but a clear business rationale, a competitive factor that increases the long-term stability and attractiveness of the company.

The importance of corporate wellness programmes for sustainability can be understood not only at the level of individual interventions, but also in integrated models that combine physical, psychological and organisational mechanisms to demonstrate the multidimensional effects of well-being. According to such models, wellness programmes serve not only to improve the health of employees, but also the long-term viability of the company as a whole. Sustainable HRM – Well-being Nexus interprets human capital as a "natural resource to be preserved"; in this context, wellness is a means of regeneration that ensures the long-term performance of employees (Ehnert, 2009). The Positive Organisational Health Model discusses well-being as an organisational strategy that is inseparable from increasing performance, loyalty and commitment (Grawitch et al., 2006). The Corporate Wellness ROI Model proves on an economic basis that well-designed programmes pay off in three ways: reduced healthcare costs, improved performance and reputational benefits (Berry et al., 2010). Figure 5 summarises the impact mechanisms and sustainability outcomes of wellness programmes that promote sustainable corporate operations at different levels of well-being.

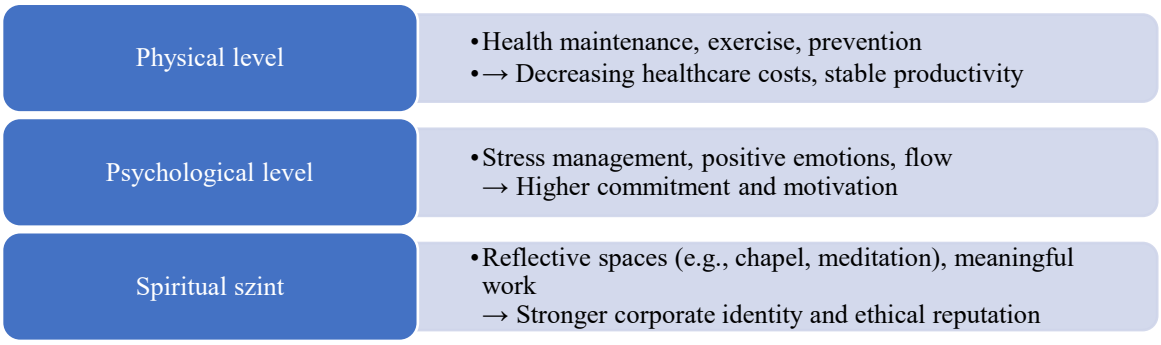

Figure 5. Mechanisms of action and sustainability outcomes of corporate wellness and spa programmes at different levels of well-being

Source: Ehnert (2009), Seligman (2011), Berry et al. (2010), Grawith et al. (2006) and Szántó (2019)

Appropriate wellness programmes not only serve physical and mental regeneration, but also provide a strategic competitive advantage for the company. A modern organisation is not just a place of work, but a value- and health-oriented environment where the physical, mental and spiritual well-being of employees is supported. In this sense, wellness is not merely an additional service, but a human engine of sustainability that serves as a resource and value for the company

in the 21st century. The mechanisms of wellness in sustainable operation can be understood as a complex, multidimensional system. Physical health, psychological resilience and spiritual balance together create a sustainable human ecosystem in which employees are not just workers, but creative, reflective and value-based individuals.Modern companies that are able to create spaces for physical and mental regeneration – whether in the form of sports programmes, meditation zones or quiet prayer rooms – are realising the human dimension of sustainable development. Wellness is thus the moral and health pillar of the corporate culture of the future, the real driving force behind sustainable operation.

4. A practical model of sustainable human resource management: wellness as a strategic tool for health-conscious human resource development

Domestic and international research clearly shows that more and more companies are adopting an integrated human sustainability model in which wellness is not just a supplementary benefit, but an integral, strategic element of corporate culture. These models recognise that one of the cornerstones of sustainable operation is the long-term preservation, development and regeneration of human capital, which is why effective wellness programmes are not seen as an extra benefit, but as a key factor in human strategy. A common element is senior management support, which ensures the credibility and organisational embeddedness of the programmes (Robertson & Flint-Taylor, 2008). In addition, a data-driven approach is essential: tracking indicators of absenteeism, turnover, satisfaction and productivity is indispensable for developing and demonstrating the impact of programmes (Sorensen et al., 2011). The integration of human well-being into CSR and ESG strategies appears as a new quality indicator, providing important feedback on the company's social responsibility not only to internal stakeholders but also to external partners and investors. Employees involved in the design of programmes participate in initiatives with greater commitment and motivation, which further increases effectiveness (Noblet-LaMontagne, 2006). Corporate wellness programmes are therefore operational and strategic tools for sustainable human resource management, which not only support individual health maintenance, but also contribute to the company's economic stability, organisational cohesion and social engagement. Based on secondary research, it is clear that supporting human well-being should be seen not as an expense but as an investment: a capital investment that simultaneously strengthens the company's competitiveness, social legitimacy and environmental responsibility. Wellness is therefore not just a category of tourism or lifestyle, but a key concept in the human dimension of sustainable corporate strategy: it is the connecting element between physical and mental regeneration, committed operation and ethical corporate presence.

4.1. Strategic integration of wellness into HR policy

The successful integration of wellness programmes into a company requires that HR strategy address the three main dimensions of employee well-being in a structured manner: physical, mental and spiritual health. This includes providing sports and ergonomic programmes, making stress management and psychological support available, and creating spaces and activities that promote inner peace, reflection and community belonging. According to the World Economic Forum (2023), the position of Chief Well-being Officer has already appeared among leading companies, indicating that employee well-being management has reached a strategic level. Based on Noblet-LaMontagne (2006), the integration of corporate wellness is supported by four key

pillars: leadership commitment, a data-driven approach, organisational culture integration and community participation. The example set by senior management is a prerequisite for the credibility of the programmes. Measuring absence data, productivity indicators and satisfaction feedback helps to continuously improve initiatives. However, wellness as a value only works if it is part of everyday practice and not just an occasional campaign. Involving employees in planning and feedback increases the relevance and acceptance of programmes. Based on a sustainable human resource management approach, the impact of corporate wellness programmes is sustainable if it is embedded in a self-sustaining mechanism, i.e. employee well-being increases performance, which strengthens corporate results and provides additional resources to maintain wellness programmes (Docherty et al., 2009). Investment in human capital therefore contributes directly to the sustainable operation of the company, in which people are not a cost factor but a long-term competitive advantage. In sustainable HR practices, wellness becomes a strategic tool that combines economic efficiency, employee well-being and social responsibility. A company that elevates physical, mental and spiritual regeneration to an organisational culture not only increases employee loyalty and creativity, but also creates a sustainable value-creating ecosystem. The sustainable company of the future will not only reduce its environmental footprint, but also create a spiritual ecology – where human well-being is the basis for organisational success.

5. Conclusion

Health-conscious human resource development is a prerequisite for sustainable corporate operations. The study highlighted that wellness programmes, as part of a health-conscious HR strategy, are investments that pay off, both in terms of measurable economic indicators and employee satisfaction and corporate reputation. In modern corporate practices, wellness no longer means just supporting physical health, but also encouraging mental well-being, meaningful work and self-reflection. This increases employee energy, satisfaction and creativity, which in turn has a positive impact on company performance.

A workplace environment that supports proper physical and mental health can provide a competitive advantage for companies. Corporate wellness programmes support employee regeneration, encouraging productivity and competitiveness. Successful companies recognise the importance of wellness programmes and use them as a strategic tool. Health, mental stability and spiritual balance are incorporated into HR policy, ESG reports and management communication. Wellness, as an integrated corporate practice, has an impact on three levels: at the individual level, physical and mental health, resilience and self-reflection are strengthened; at the organisational level, loyalty, innovation and reputation increase; and at the social level, the company operates in an ethical, responsible and people-centred manner. Wellness is therefore not a cost for the company, but a profitable investment in financial, social and moral terms. Companies that consciously invest in the health and well-being of their employees have a more stable workforce in the long term, with lower turnover and higher innovation capacity. The introduction of quiet, meditative or spiritual spaces increases concentration, reduces stress and increases job satisfaction. It is also worth measuring the impact of wellness initiatives using objective indicators (absenteeism, satisfaction, productivity, turnover) and incorporating the data into corporate decision-making. Leading by example is key: if senior management also practises a health-conscious and reflective lifestyle, this has a multiplier effect on the entire organisation. Wellness programmes are not PR tools, but part of corporate identity, and transparent, value-based

communication is essential for credibility. Organisations that recognise that employee well-being is their most important resource will not only survive but thrive in a rapidly changing world. The sustainable company of the future will not only operate responsibly but also heal people, communities and cultures alike.

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The Legal, Institutional and Functional Development of The Hungarian Chambers of Commerce And Industry in the 20th Century

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Abstract: Economic chambers are key elements of the institutional background of the market economy and the self-governance of the business sector. The development of the Hungarian chamber system in the 20th century is closely linked to the ideological and practical paradigm shifts in state economic management. The aim of this study is to provide a chronological and analytical overview of the institutional, legal, and functional development of Hungarian chambers of commerce in the 20th century, highlighting how the legal status of chambers (public body, social organization, hybrid model) reflected and influenced their role in economic management and interest articulation during four main periods. Particular emphasis is placed on the failure of the controversial public body experiment after the change of regime and the rationale behind the pragmatic hybrid model introduced after 2000, which created a balance between freedom of association and stable financing of delegated public tasks.

Keywords: chamber, business associations, interest representation
JEL code: K 39, L30, M 48.

Introduction

Chambers of commerce are indispensable players in modern market economies, embodying the dynamic link between entrepreneurial self-government and state regulation. Their institutional existence and functions reflect the political, legal, and economic management paradigms of a given national economy. The Hungarian chamber system of the 20th century underwent a particularly complex development, closely intertwined with radical political changes and successive experiments with economic models, from liberal market economy through planned economy to post-socialist transformation. Accordingly, the legal status of chambers fluctuated between compulsory membership, autonomous public bodies, semi-public bodies under state control, social organizations, and the current hybrid model. An analysis of the functional role of chambers highlights the extent to which the state was willing to grant economic actors the right to self-organization and representation of interests, and what public tasks it delegated to bodies representing the private sector. My goal is to present this development chronologically and analytically, dividing the institutional, legal, and functional evolution of the chambers into four periods. The focus is on presenting the degree of state control, the transformation of interest articulation mechanisms, and changes in financing models.

1. The legacy of chamber self-government (1900–1948)

The operation of Hungarian chambers was first regulated by the first Hungarian chamber law passed in 1868. Following continental public law traditions, this law extended compulsory membership to all merchants, craftsmen, and companies in the Hungarian state, ensuring a public body and municipal character. During the Dual Monarchy and the subsequent Horthy era, the chambers enjoyed considerable autonomy and played a key role in the organization and development of the economy. Their responsibilities ranged from the management of public transport to the establishment of the stock exchange and the National Bank, and they became stable partners of the government.

The civil chamber system was abolished at the end of the 1940s as a result of drastic legal measures. After World War II, the transition to a planned economy abolished the chambers of commerce and industry without legal succession, and their assets were transferred to the state treasury. The economic and social system, based on planned directives and largely state ownership, which was declared by Act XXXIII of 1947 (nationalization of banks) and Act XXV of 1948 (nationalization of large-scale industry), rejected the existence and operation of public law self-governing bodies representing economic actors for ideological reasons. The dissolution was confirmed by Government Decree No. 590/1948. At the same time, however, the Hungarian Chamber of Commerce (MKK) was established in 1948. This institutional paradox – the theoretical abolition of economic self-government and the immediate creation of a new, semi-state body – demonstrates that even a totalitarian state could not do without a body dealing with international trade. The state recognized that foreign market relations and the related information management were indispensable, so it placed the chamber's functions under state control, essentially making it a background institution of the Ministry of Foreign Trade.

2. Asserting interests in planned economy (1948–1990)

The Hungarian Chamber of Commerce, established in 1948, initially operated as a semi-governmental body, with its main task being the development of international trade, primarily as a bridge to Western countries. Initially, only foreign trade companies could become members. The role of the chamber, which had been frozen since 1949, grew only slowly during the forty years of communism. The introduction of a new economic mechanism in 1968 brought significant change, introducing partial reforms to the planned economy system. As a result, after 1967, the Chamber's membership expanded, allowing other companies and institutions, such as manufacturers and service providers, to join. The work of the Chamber was carried out in bodies formed by the member companies, and the main task of the central apparatus was to create and coordinate the conditions for the work of these bodies. The need for more flexible economic management also led to the emergence of regional organizations. One example of this is that regional liaison committees were maintained within the framework of the Chamber, which were adapted to the country's planning and economic environments, such as the establishment of the North Hungarian Liaison Committee in 1976 based on the needs of the member companies of the three northern counties (Borsod-Abaúj-Zemplén, Heves, and Nógrád) based on the needs of their member companies.

2.1. A The legal framework for functional expansion

The legal regulation of the Chamber's role changed in several stages in line with economic policy objectives. In the 1970s, there was a noticeable lack of organizations representing the economy at the international level, so regulation remained strictly foreign trade-oriented. Decree No. 35/1977. (IX. 15.) cautiously opened up the Chamber's scope of action. Its main tasks at that time were to represent the interests of its members in international organizations (e.g., ILO) in matters related to foreign trade, to authenticate documents, to issue certificates of origin, and to ensure the operation of the court of arbitration. The decree clearly stated that the Chamber was obliged to act in accordance with the foreign trade policy of the Council of Ministers, taking into account the powers of the Minister of Foreign Trade. This legal framework limited the Chamber's ability to

represent domestic interests, implying that the planned economy system was functioning perfectly and did not need domestic representation.

The turn toward functional expansion was brought about by Council of Ministers Decree No. 62/1980 (XII. 28.), which significantly broadened the Chamber's scope of responsibilities. This decree introduced three key functions: interest representation (representing the interests of the membership before supervisory authorities), interest mediation (dissemination of economic policy concepts and the collection of corporate viewpoints), and interest reconciliation. Interest reconciliation was of particular importance, as it enabled corporate self-coordination—meaning that conflicts and opposing interests between producers and users, or between main contractors and subcontractors, could be settled without administrative intervention.

In the 1980s, when corporate autonomy became a central concept, the Chamber provided a forum for an "equal" exchange of views between economic units and central supervisory authorities. Through the Chamber's channels, corporate experiences and positions could reach the highest levels of economic leadership, even if the conclusions drawn from these hearings already exceeded the Chamber's direct influence. This functional expansion may be understood as a crisis-management instrument of a softening planned economy. As the system was unable to provide the necessary conditions to stimulate economic activity, and economic difficulties were growing, state leadership was compelled to allow some degree of "intervention" by economic actors in the exercise of economic power. The Chamber thus functioned as a type of safety valve for the regulated management of increasing economic tensions.

2.2. Establishment of the Hungarian Economic Chamber

The development of the Chamber's work, the growth of its membership, and the structural pressures arising from the functioning of the economy necessitated a new, higher-level legal framework. This resulted in Presidential Council Decree No. 11 of 1985 of the Hungarian People's Republic on the Hungarian Economic Chamber. In terms of legal status, this decree constituted a higher-level regulation than earlier Council of Ministers decrees and sought to align the Chamber's actual activities with its legal framework. It is important to note, however, that the decree was characteristic of the one-party legal system: issued by the Presidential Council, it possessed the force of law but lacked the democratic legitimacy of full parliamentary legislation. The regulation declared the Chamber to be a social organization carrying out interest-mediation, interest-reconciliation, and interest-representation activities. Among its tasks, significant emphasis was placed on developing ethical norms, operating permanent and ad hoc arbitration courts, and promoting the development of international economic relations.

By the late 1980s, the Chamber represented, both at national and regional levels, efforts to modernize economic management and improve the income-generating capacity of the economy, advocated for stable regulation and flexible administrative conduct, and devoted special attention to the regulation of inward foreign capital. This institutional valorization became one of the key elements of the economic transition preceding the political system change.

3. Public Body, Compulsion, and Contradictions (1994–2000)

In the years following the regime change, economic policy and legislation set the goal of establishing the institutional framework of a market economy (Karsai, 1999). Within this context, and after more than forty years, policymakers returned to public-law traditions and re-institutionalized public-law economic chambers.

Act XVI of 1994 on Economic Chambers restored the public-law chamber model—consistent with Hungarian public-law tradition and modern European practice—with effect from 1 January 1995. According to the Act, the mission of the economic chambers was to promote the development and organization of the economy, guarantee the security of business transactions, ensure fair market conduct, and support the general, collective enforcement of the interests of economic operators.

A key legal principle was the introduction of compulsory membership, making chamber membership automatic for economic entities. This compulsory measure led to a dramatic increase in membership; by 31 December 1998, the number of registered members in the regional chambers reached approximately 463,000 (MKIK website). However, this short-lived legal solution generated significant contradictions. Although the chambers ambitiously undertook public-law and economic-organizational tasks (including market-organizing and service-related functions), serious challenges undermined the legitimacy of the system.

In the field of vocational training, the Chamber received the public-law responsibility of inspecting practical training sites, yet financing for the performance of this task was inconsistent and delayed (Fehérvári, 2000). Consequently, the Chamber funded the development of its institutional network from membership fees, which led to low acceptance and dissatisfaction among members, especially in the context of compulsory dues.

3.1. A Time of Paradigm Shift

The short-lived system of compulsory membership demonstrated that the mere legal transplantation of the continental chamber model was insufficient without societal acceptance and a stable funding base for public tasks. The political environment quickly questioned the necessity of an organization structured around compulsion. The debate centered on abolishing compulsory membership. Even the Horn government criticized mandatory membership as alien to liberal legal development and contemporary practice. The legal debate reflected divergent governmental views on the functions of chambers (Parliamentary Bills, 1998).

Act CXXI of 1999, adopted by Parliament, abolished compulsory chamber membership as of November 2000. This legal turn ended the post-transition experiment with public-law, compulsory chamber self-governance. The institutional consequences were significant: some administrative tasks previously held by the chambers were removed from economic self-governance, and the chamber's very survival depended on establishing strong, service-based economic interest representation. The dramatic decline in membership (from 463,000 at the end of 1998 to essentially around 43,000 voluntary members—the MKIK website) confirmed that the attractiveness of institutional services and effective interest representation supplanted the former compulsion.

From an organizational perspective, the 1999 Act also mandated unification: the Hungarian Craft Chamber (MKK) was merged into the Hungarian Chamber of Commerce and Industry on 31 March 2000, ensuring proportional representation (33%) for the craft membership within the integrated chamber.

The following table summarizes the main characteristics of the legal shifts of the transition period:

Table 1: Legal developments in the chamber system after the change of regime

Legislation	Period	Nature of Membership	Legal form	Main Function	Legitimacy Problem
Act XVI of 1994	1994–1999	Compulsory / Automatic	Public body (Self-government)	Economic organization, public tasks	Financing difficulties, low acceptance
Act CXXI of 1999	2000–	Voluntary	Public body (Self-government)	Interest representation, services	Dramatic drop in membership, weakened public-law role

source: author's compilation

4. Hybrid Model: Voluntarism and Compulsory Contribution (2000 után)

From the early 2000s onward, the Hungarian chamber system consolidated into a hybrid model attempting to combine freedom of association with the efficient performance of state-delegated public tasks that apply to the entire economy. While Act CXXI of 1999 abolished compulsory membership, it introduced an obligation for economic organizations to register with the territorially competent chamber of commerce and industry. Registered enterprises do not become chamber members; membership remains voluntary.

To secure financing for public tasks, and given the weak financial basis provided by voluntary membership, the legislator introduced the institution of the compulsory chamber contribution in 2012 (through an amendment to the 1999 Act). Each economic operator must pay an annual fee of 5000 HUF as a contribution to the performance of chamber public tasks. Legally, this separates the interest-representation function (pertaining to fee-paying voluntary members) from the financing of public tasks, which apply to the entire economic sphere.

The chamber contribution constitutes a public liability; if unpaid, it is enforced by the tax authority as a tax. This mechanism anchors the hybrid character of the Hungarian chamber model, in which economic self-governance is exercised through voluntary membership (allowing eligibility for office and access to preferential services), while the financing of general economic-organizational functions remains compulsory for the sake of economic stability.

4.1. Core Public Tasks Assigned to the Chambers

In the voluntary membership system, the Hungarian Chamber of Commerce and Industry (MKIK) plays a key role in carrying out state-delegated public tasks aimed at enhancing the security of business transactions, improving competitiveness, and developing human capital. These state-delegated tasks include:

4.1.1. Governance of vocational education and training

Since the regime change, economic chambers have treated vocational training as a priority area, recognizing its decisive role in economic development. Under legal regulations (e.g., Act CLXXXVII of 2011), cooperation among the chamber, VET institutions, and economic organizations is mandatory for fulfilling vocational training tasks. The chamber's role is complex: it participates in national VET governance as a member of decision-preparatory and consultative bodies (Fehérvári, 2000). Furthermore, the chamber determines the qualifications in which master training and master examinations may be organized, participates in examination boards, and maintains registers of practical training sites. This responsibility is central in aligning the educational system with the needs of the economy.

The chambers continue to focus on quality assurance and the incorporation of labour-market needs. The accreditation of practical training sites and the registration of training contracts remain under chamber authority, ensuring appropriate professional training environments for students. This function is indispensable for the functioning of the dual training model, in which practice is provided by economic actors. The chambers also continue to participate in professional examinations, guaranteeing the market recognition of acquired qualifications (Gktv. §12 (2) (b)). Parragh László (2021) emphasizes that in the new VET model, chambers have become the sole official link between occupations and training—a form of economic guarantee of training quality (Parragh, 2021, p. 19).

The strengthened role of chambers within the new VET system has led to a significant increase in the number of students participating in dual training: while 88,000 students participated in dual training in the 2020/2021 academic year at 38,000 training sites, the number surpassed 100,000 in the 2022/2023 academic year following the introduction of the new structure. This growth highlights the chambers' pivotal role, as each training contract is concluded through, and supervised by, the chamber. Employment rates among graduates of dual training remain outstanding: within one year after graduation, placement rates exceed 80% for those who trained in sectoral training centers or business enterprises (Szabó, 2023). This confirms the effectiveness of chamber involvement in aligning VET with real economic needs.

4.1.2. Promoting Fair Market Conduct and Dispute Resolution Functions

Act CXXI of 1999 assigned to chambers key public tasks crucial for building the institutional framework of a developed market economy and strengthening market trust. One of the chambers' main objectives is to promote the security of business transactions, foster fair market conduct, and enforce the general, collective interests of economic operators.
To achieve this, chambers are empowered to develop ethical norms applicable to economic operators and make them publicly accessible. These norms not only enforce moral standards but also contribute to building the trust capital essential in a market economy. This form of self-regulation—as a public-law privilege—is intended to ensure fairness and integrity among members and other actors, particularly where legal regulation is less effective or insufficiently detailed to allow rapid response (Parragh – Róna, 2007).

To enforce compliance with ethical norms and sanction violations, chambers may conduct ethical proceedings and establish ethical breaches. Although these proceedings primarily target chamber members, the law permits their extension to non-members whenever justified by the performance of other public tasks. Ethical proceedings play a significant role in protecting professional authority; for example, ethical condemnation—even if lacking direct coercive legal force—may exert considerable moral pressure and reputational consequences, discouraging unfair conduct (Papp, 2004, p. 18).

Another key chamber function is dispute resolution, aimed at the fast and expert handling of inevitable conflicts arising from fair market conduct. Chambers may conduct conciliation procedures in business disputes not exclusively assigned to other authorities. They also actively support arbitration—an essential dispute resolution forum with specialized expertise—provided the parties have included a valid arbitration clause in their contract. Chambers oversee and finance arbitration courts, ensuring the enforceability of contractual relations and legal certainty. Additionally, chambers are authorized to engage in mediation, seeking consensual, cooperative solutions that preserve business relationships. Chamber-based dispute resolution mechanisms provide specialized decision-making that is often more effective and faster than conventional civil litigation. Arbitration also supports contractual discipline, as arbitral awards have the same legal effect as judicial judgments—critical for economic security and enforceability of transactions (Nagy, 2009, pp. 122–124). Conciliation and mediation are particularly important for SMEs, where speed and the preservation of business relationships often take precedence over litigation (Szabó, 2010, p. 55).

Together, chamber-based ethical and dispute resolution functions ensure a regulated and reliable business environment—indispensable for long-term economic stability and investor confidence.

4.2. Interest Representation / Economic Development Role and Service Provision

In the modern voluntary membership system, the Chamber's role focuses strongly on service provision and interest representation. Leveraging its networked operation, the Chamber provides valuable data and information supporting the preparation of governmental measures and strategies aimed at economic development. Thus, it becomes a significant governmental partner in representing business interests.

The Chamber's information services are extensive, including data on foreign and domestic markets, trading methods, cooperation opportunities, and regulatory changes. Its international activities involve participation as an associate member of Eurochambers, operating the Hungarian National Committee of the International Chamber of Commerce (ICC Hungary), and performing coordination tasks related to EU membership. Mobilizing its domestic and international networks, the Chamber undertakes strategic roles beyond short-term interest representation, including catalyzing small- and medium-sized enterprises into innovation chains and clusters—thus exerting long-term economic development impacts.

5. Summary and Conclusions

The evolution of the Hungarian chamber system in the 20th century demonstrates that the degree of institutional autonomy was closely linked to prevailing legal foundations and the level of political control. The institutional and functional development of the chamber proceeded through five phases:

1. The Traditional Public Body Period (1868–1948): The main feature of the chambers' operation was compulsory membership. The focus of advocacy was on general economic development and ensuring market norms. This era saw chambers act as powerful, self-governing institutions promoting industrial and commercial prosperity.
2. Specialized International Liaison (1948–1985): An initially strictly foreign-trade-oriented, semi-state institution that became indispensable due to the absence of a functioning planned-economy institutional framework.
3. General Economic Interest Reconciliation (1985–1994): Functional expansion toward representing domestic interests (interest reconciliation, self-coordination) and corporate autonomy—serving as an institutional catalyst for reform efforts.
4. Experiment with Compulsory Public-Law Membership (1994–1999): A post-transition attempt to return to public-law roots with compulsory membership. Financing and legitimacy issues made this phase short-lived.
5. Service-Oriented Public Task Provision (from 2000): A shift toward vocational training, ethical norms, and SME support, stabilized through compulsory registration and contribution within a hybrid financial model.

The periodization and legal background of economic chambers between 1900 and 2000 are summarized in the following table:

Table 2: Periodization and legal background of economic chambers (1900–present)

Period	Legal Background	Nature of Membership	Institutional Form	Focus of Interest Representation
Traditional public-body era (1868–1948)	Act of 1868	Compulsory	Chambers of Commerce and Industry (public bodies)	General economic development, market norms
State-socialist era (1948–1985)	Government decrees (MT decrees)	Limited / selective	Hungarian Chamber of Commerce (semi-state entity)	Foreign trade, international relations
State-socialist era (1985–1994)	Presidential Council Decree No. 11/1985	Voluntary	Hungarian Economic Chamber (social organization)	Interest reconciliation, representation of the entire economy
Transition era (1994–1999)	Act XVI of 1994	Compulsory / automatic	Hungarian Chamber of Commerce and Industry (public body)	Public tasks and economic organization
Hybrid system era (from 2000)	Act CXXI of 1999	Voluntary + compulsory contribution	Hungarian Chamber of Commerce and Industry (public body with voluntary membership)	Public tasks (VET, conciliation) and service provision

source: author’s compilation

Institutional autonomy was strongest at moments of strengthened rule of law (e.g., the Acts of 1868 and 1994), when the chamber's functions extended to the broadest forms of economic organization. By contrast, during the one-party era, the chamber's role was top-down, foreign-trade-oriented, and later became an interest-reconciliation forum aimed at easing economic tensions. Legislative developments indicate that the chamber's elevation served reform management while maintaining state control.

The post-transition legal oscillation (compulsory public-body membership followed by voluntary membership with compulsory contribution) revealed that successful operation of a public-body chamber model requires more than legal authority: it requires stable financing encompassing the entire economy and sustained political support, especially for public tasks.

The modern hybrid chamber model (voluntary membership combined with compulsory contribution) reflects political-legal pragmatism. This legal solution ensures the maintenance and financing of state-critical functions—such as VET governance and economic registries—while preserving freedom of association. The future of the chamber's legal and institutional role will continue to depend on its capacity to strengthen economic actors and promote international competitiveness through high-quality services, especially for the SME sector.

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A Comparative Analysis of CSRD Transposition: Strategic Responses in Czechia and Poland

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Abstract: The study compares how the Corporate Sustainability Reporting Directive (CSRD) has been implemented in the Czech Republic and Poland. The CSRD aims to ensure that companies present their sustainability performance in a transparent and consistent way, based on the European Sustainability Reporting Standards (ESRS). The research examines the timeline of implementation, legal specifics, and the impact on companies in both countries. Poland's delayed adoption created short preparation times and significant pressure on businesses, while the Czech Republic's rapid harmonization raises concerns about the quality and reliability of reports. Both countries follow EU requirements, but national differences appear in areas such as reporting format, auditor qualifications, and exemption rules. The analysis highlights that implementing the CSRD is not only a legal task but also a major organizational and technological challenge that fundamentally changes how companies collect and report ESG data.

Key words: CSRD, ESRS, Sustainability report, Legal harmonization, ESG
JEL code: K32, M14, Q56

Introduction

In the last decade, the issue of sustainability has become a central element of the European Union's economic and political strategy. Climate change, social inequalities, and corporate social responsibility are increasingly becoming integral parts of economic decision-making. The European Union recognized that corporate sustainability performance is crucial, hence it launched a comprehensive reform of the corporate reporting framework. The CSRD (Corporate Sustainability Reporting Directive) is the directive on corporate sustainability reporting, which the European Parliament and Council enacted in January 2024, replacing the former Non-financial Reporting Directive (NFRD), with the goal of ensuring companies produce complete, comprehensive, and comparable reports. It is also worth noting ESG (Environmental Social Governance) reporting, which has become prevalent mainly in the context of investments. Increasingly, investors use it to inform their investment decisions, aiming to make sustainable and responsible choices.

"The CSRD seeks transparent, data-driven understanding of companies' environmental, social, and governance (ESG) impacts, risks, and opportunities, as well as the corporate policies, measures, and targets related to them" (CSRD software, 2024). The CSRD systematically organizes and evaluates companies' sustainability and financial performance based on several hundred data points. The standardised data disclosure required by the directive is included in an EU database. The published data is recorded in an EU database, which is key for international investments and partnerships. The CSRD aims to improve transparency, auditability, and accountability in sustainability matters, and to facilitate the integration of ESG factors into companies' strategic processes. The CSRD is more comprehensive, detailed, and accurate than ESG reporting, but is in close alignment with it (CSRD software, 2023).

The EU Member States have transposed the CSRD into their national legal systems at varying paces (Figure 1). Most countries—including France, Hungary, Ireland, and Italy—have already fully implemented the directive. Some Member States, such as the Czech Republic, have taken only partial measures. However, several countries, including Austria, Germany, Luxembourg, Malta, the Netherlands, Portugal, and Spain, have not yet announced the transposition, leading to infringement proceedings being initiated against them. This situation clearly demonstrates that although the EU deadline expired in July 2024, the process of legal harmonization is not progressing at the same speed everywhere. Therefore, as a first step, all Member States should have transposed the directive into their national legal system by July 6, 2024; currently, infringement proceedings are underway against 17 Member States due to delay or incomplete notification (European Commission, 2025).

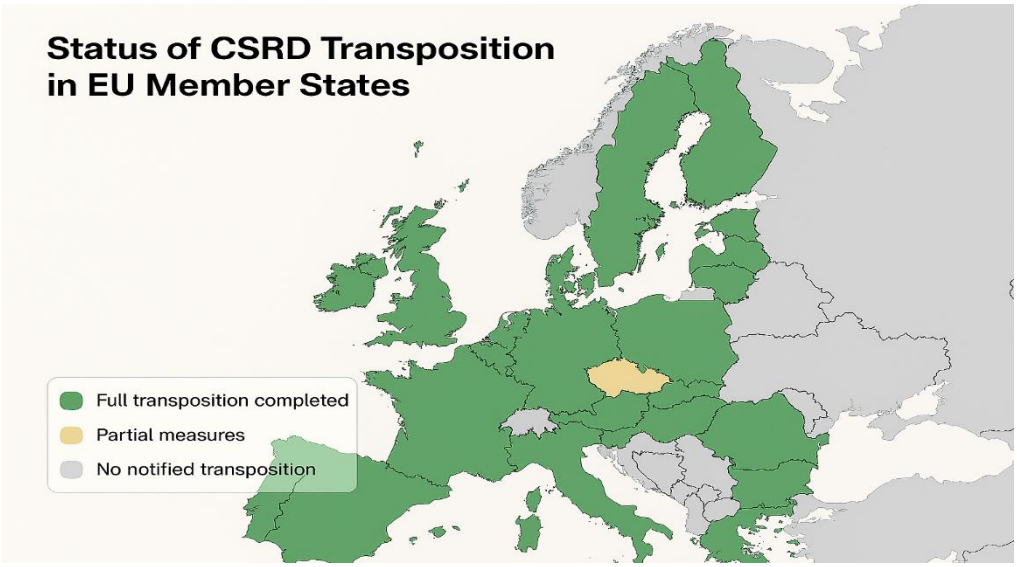

Figure 1. Status of CSRD Transposition in EU Member States
Source: Own editing

1. Characteristics of Sustainability Reporting in Poland

The Corporate Sustainability Reporting Directive (CSRD) creates a European legal framework for the unified, transparent reporting of companies' environmental, social, and governance performance. Poland, although with a significant delay, introduced national regulation, which poses serious challenges for local companies, especially due to the limited preparation time. EU Member States should have transposed the CSRD into their national legal systems by July 6, 2024. In Poland's case, the legislative process was prolonged. The amendment to the Accounting Act was finally adopted on December 6, 2024 (Rödl, 2025). The new provisions mostly entered into force on January 1, 2025 (Crowe, 2025a). This late introduction means that the large companies that would have been obligated to report for the 2024 financial year (the first wave of the EU timeline) were forced to adapt their systems to the ESRS in an extremely short period. The Act implements new sustainability reporting obligations in Polish law, in line with the European Sustainability Reporting Standards (ESRS) introduced by Directive (EU) 2022/2464 of December 14, 2022, amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC, and

Directive 2013/34/EU regarding corporate sustainability reporting (CSRD) (Clifford Chance, 2025).

The Polish legislation follows the criteria defined by the CSRD and introduces the reporting obligation gradually. It first applies to the largest economic actors with the highest responsibility, and then progressively extends the scope of companies based on their size. The main affected groups are the following (DZP, 2024): Public Interest Entities (PIE); Large Undertakings: companies that meet at least two of the size criteria specified in the Act (e.g., more than 250 employees, net turnover greater than €40 million, and balance sheet total higher than €20 million); listed SMEs; and third-country companies (Table 1).

Table 1. Companies Subject to CSRD

Company Group	When is the First CSRD Report Required?	Which Conditions Need to be Met to be Included?
1st Wave — Large companies already subject to NFRD	**2025**: Report for the 2024 financial year (this has not changed).	Public Interest Entities (PIE) and those previously subject to the NFRD.
2nd Wave — Other large companies (non-NFRD)	**2028**: Based on data from the 2027 business year (delayed by two years from the original timeline).	Large Undertaking, if two or more conditions are met: ≥250 employees, Net turnover, ≥~€40M, Balance sheet total ≥~€20M.
3rd Wave — Listed SMEs	**2029**: Based on data from the 2028 year (two-year shift from the original plan).	Listed small and medium-sized enterprises (excluding listed micro-undertakings).
Non-EU Parent Companies / Foreign Companies	Generally **2029** (for the 2028 year) for non-EU companies with larger EU turnover.	Large subsidiaries or branches registered in Poland may also fall under the scope if their parent company is under non-EU jurisdiction and meets the turnover criteria ≥~€150M.

Source: Own editing based on GrantThornton (2024)

In cases where information regarding a subsidiary is included in the parent company's consolidated (group) sustainability report, the subsidiary is exempt from the sustainability reporting obligation. The subsidiary must indicate the use of the exemption in its management report, provide the name of the parent company, and the website address where the parent company's group report will be available within 12 months of the subsidiary's balance sheet date. These documents must be made accessible on the website for at least five years (Clifford Chance, 2025).

The sustainability reports must be audited by a legally authorised auditor (limited assurance level). The goal is to increase the reliability and comparability of the data. The National Audit Oversight Council determines the national standards for the assurance of sustainability reports. The selection of the auditing firm is the responsibility of the body approving the financial statements, unless otherwise provided by law, the articles of association, or other regulation. The CSRD directive aims to standardise reports on sustainable development within a legal framework, covering the impacts on ESG areas. Furthermore, the amended Accounting Act contains provisions for assurance by auditors (Clifford Chance, 2025). The Polish Act automatically grants the right to assurance to auditors. Registered auditors who held the authorisation to audit financial statements on January 1, 2024, automatically become entitled ex lege to provide assurance on sustainability

reports as well (DZP, 2024). Simultaneously, however, it makes it compulsory for them to complete the necessary supplementary training within the timeframe specified by the regulation to retain the right to assurance.

The penalties and sanctions prescribed by law apply exclusively to registered auditors or auditing firms. Furthermore, the Accounting Act separately regulates the criminal consequences of non-compliance related to financial reporting obligations, which may extend to tasks related to sustainability reporting. For example, the Accounting Act specifies sanctions for the delayed submission or failure to submit financial statements. The consequences of non-compliance may include:

- Fines or imprisonment for up to two years, which may be imposed simultaneously on the persons responsible for accounting tasks;
- Fines imposed by the competent commercial court;
- If financial statements are not submitted in two consecutive financial years, the removal of the entity from the National Court Register can be initiated ex officio.

Given the nature of the sanctions, sustainability reporting in Poland is not merely an administrative task but a legal obligation that also entails personal criminal liability for management (Crowe, 2025b).

1.1. Summary for Poland

Poland's transposition dynamic fits the trend in the Central and Eastern European region. Due to the previously low level of application of the less stringent NFRD, companies now face significant infrastructural and capacity development pressure to meet the strict requirements of the ESRS.

Despite the delayed transposition, companies that are already active in the market, listed on international stock exchanges, or have foreign parent companies generally show a higher level of preparedness, as they may have previously applied international standards (e.g., GRI, TCFD). However, for the broader corporate sector, the short deadlines mean that preparation (especially the collection of ESG data, conducting the **double materiality assessment**, and measuring complex **Scope 3 emissions**) poses significant pressure (Seneca ESG, 2025).

2. Sustainability Reporting in the Czech Republic

The Czech Republic transposed the EU's CSRD requirements, aimed at a more transparent and unified presentation of corporate sustainability performance, into its national law primarily by amending the Accounting Act (Act No. 563/1991). The amendment brought a significant change to the corporate reporting system by introducing the sustainability reporting obligation and its detailed regulation, as a new, standardized document containing non-financial information was added alongside the financial statements.

The CSRD was partially transposed into Czech law by Act No. 349/2023 Coll., which amends certain laws related to the consolidation of state budgets (the so-called consolidation package). In this context, the following changes were made: the amended Act No. 563/1991 on Accounting, and Act No. 93/2009 on Auditors and amendments to certain acts, the amended Act No. 256/2004 on Business Activity on the Capital Market (Ministry of Finance of the Czech Republic, 2024).

One of the most important elements of the amendment is the introduction of the legal categories of "sustainability report" and "consolidated sustainability report." From now on, Czech companies of a defined size and type are obliged to present the environmental, social, and governance (ESG) impacts of their activities, the related risks, and results in a separate report. The legislation stipulates that the sustainability report must be prepared according to the ESRS standards developed by the European Commission; thus, companies cannot choose an alternative methodology: the content and formal requirements are unified at the EU level. The amendment further mandates the publication and electronic submission of sustainability reports. Companies must publish the document together with the financial statements and upload it to the European digital data provision platform (European Single Access Point – ESAP). The Act also defines the responsibility of senior officials and the sanctions that can be imposed in the event of failure or inadequate reporting. The report must contain the double materiality assessment: that is, what impact the company's activities have on sustainability, and conversely, how sustainability risks affect the company. The Czech CSRD transposition laws do not define a specific, unified deadline for uploading sustainability reports to the ESAP platform. The regulations primarily focus on establishing the reporting obligation, the content of the report, and the rules for auditing. Sustainability reports must be prepared annually, the first reports relate to the 2024 financial year, so they are expected to be submitted in 2025 according to the relevant procedures (AKVK, 2025).

The Czech Act No. 349/2023 Coll. introduces the sustainability reporting obligation within strict frameworks, while also prescribing detailed exemptions. Exemptions from the reporting obligation include "simple" financial institutions that are classified as small and non-complex credit institutions under EU prudential rules. Captive insurers and reinsurers, as well as certain investment funds, are also exempt. Furthermore, the Act includes a consolidation exemption: if a subsidiary belongs to the consolidation group of another company registered in an EU country, and the group parent company already publishes the consolidated sustainability report, the subsidiary is not obliged to prepare its own sustainability report, provided that it documents this appropriately (e.g., names the parent company, provides a link to the consolidated report, and indicates that it "has no separate obligation").

According to the Act, subsidiaries that belong consolidated to a group registered in a third country are also exempt, provided that the foreign parent company publishes a sustainability report that complies with EU standards, and the subsidiary's annual report contains the necessary references (e.g., links, parent company name, etc.). A further exemption is that entities that already prepare a consolidated sustainability report are not required to issue a separate, standalone report—that is, the consolidating company's report covers them.
A significant element is that the Accounting Act extends the audit obligation to the sustainability report. Companies must have the report verified by an independent auditor or an accredited assurance provider, who issues a separate opinion on the report's compliance and reliability. This requirement moves the entire system towards checked and assured sustainability data provision.

The Czech tax authority supervises the compliance with the transposed CSRD obligations. In case of non-compliance, sanctions can range up to 3% of the company's assets if a violation occurs related to the preparation of the sustainability report, while failure to prepare the report entirely can result in a fine of up to 6% of the company's assets. The currently effective legislation generally complies with the CSRD requirements regarding the transposed obligations, with the exception of

the broader classification of insurers as public interest entities. In contrast, the proposed draft legislation is fully aligned with the EU Directive (Kinstellar, 2024).

The Act introduces the reporting obligation gradually, aligning with the CSRD. First, from 2025, large Public Interest Entities (e.g., listed companies with over 500 employees) become affected. From 2026, all large undertakings that meet two of the following indicators must prepare a report: more than 250 employees, at least €40 million net turnover, or at least €20 million balance sheet total. In the third phase, from 2027, the obligation is extended to listed small and medium-sized enterprises, excluding micro-undertakings. With this, the Czech Republic fully follows the CSRD-prescribed schedule. The Czech law, effective from January 1, 2026, modifies the categories related to company size, thus the scope of those obliged to report will also change. For example: Large accounting entities will be considered, from January 01, companies that meet at least two of the three criteria: if assets exceed CZK 600 million, turnover exceeds CZK 1.2 billion, or they employ more than 250 employees.

The timeline for the Czech CSRD transposition was originally planned in two phases: the first phase started in 2024, and the second would have begun in 2025. However, the EU-level Omnibus package influenced the Czech implementation, so a part of the reporting obligations is shifting: the new 1,000 employee threshold is valid from 2025, but the 2nd phase—for large companies/groups—is expected to be an obligation only from the 2027 financial year (reporting in 2028).

2.1. Summary for Czechia

In terms of CSRD transposition, the Czech Republic shows a faster legislative transposition pace in the Central and Eastern European region. This difference likely reflects the legislator's intent to pursue rapid harmonization and meet deadlines. The rapid introduction is legally progressive but raises several practical challenges for the corporate sector. Due to the previously low level of reporting practice under the NFRD, Czech companies, especially SMEs, show lower levels of corporate commitment to collecting and processing ESG data. The sudden, rapidly introduced, complex ESRS requirements may overload internal resources and increase the risk of initial errors. The main risk of this is that the quick implementation may compromise the quality and reliability of the disclosed data. The already weaker ESG infrastructure in the region cannot adequately support the suddenly increased data demand, which hinders the fundamental goal of the CSRD: bringing comparable, reliable sustainability information to the market. The Czech transposition model is characterised by speed, which, however, reflects the lack of market preparedness.

Overall, the amendment to the Accounting Act is fully aligned with the EU expectations: it introduces the sustainability report as a new legal category, stipulates the ESRS-based content requirements, mandates auditing and digital publication, and sets out the phased introduction of the reporting obligation. The changes serve to increase corporate transparency and the deeper integration of sustainability aspects into the operation of the Czech economy. The Czech Republic did not omit many key elements from the EU CSRD: the incorporated rules are very close to the Directive (audit obligation, double materiality, reportable topics). At the same time, the transposition is gradual, not subjecting all companies to the obligation at once, which provides a transition. This clearly exemplifies that the introduction of EU directives is not automatic and

identical in all Member States, but countries often use a phased introduction tailored to national specificities.

3. Similarities and Differences in Czech and Polish Legal Practice

In both Poland and the Czech Republic, the regulation of CSRD sustainability reporting was transposed into practice as an amendment to the Accounting Act. In Poland, the amendment was adopted only on December 6, 2024, instead of July 6, 2024, so the CSRD regulation is effective from January 1, 2025, and is being introduced gradually in two phases. The first phase of transposition applies to financial companies that were already subject to the Non-Financial Reporting Directive and must comply with the CSRD requirements from 2025. The regulation was adopted in December 2023 and entered into force on January 1, 2024. The second phase applies to all groups that have a CSRD reporting obligation but must comply with this only from January 1, 2026 (for the financial year 01.01.2025). The requirements are introduced by the new Accounting Act, which entered into force on January 1, 2025. In the Czech Republic, the transposition of the EU directive did not involve the creation of an entirely new, separate sustainability act, but rather the supplementation and amendment of the existing legislation regulating financial reporting, the Accounting Act, which was adopted at the end of 2023 and entered into force on January 1, 2024.

Table 2. Comparison of Czechia and Poland

Dimension of Difference	Poland	Czech Republic
Reporting Format	Mandatory XBRL format	Mandatory unified XHTML/XBRL format
Taxonomy/ Digital Requirement	Not mentioned	National authorities' own taxonomic requirements also apply.
Auditor Accreditation	Separate accreditation, special qualification requirements for auditors	Auditors may hold separate ESG-accreditation (stricter qualification condition).
Parent Company Exemption	No deviation mentioned	Subject to special rules: only with EU-compliant consolidated report; national verification procedure required for equivalence with non-EU parent companies.
Implementation Schedule	No deviation mentioned.	Detailed implementation schedule with specific Czech calendar steps..
Sectoral Requirements	No deviation mentioned.	Supplementary ESG requirements for certain sectors (banks, insurers, investment firms), and exemptions for smaller institutions.

Source: Own compilation

Poland took the EU principles into account (number of employees: more than 250, net turnover: more than €40 million, balance sheet total: higher than €20 million) but converted the Euro to PLN and formulated an exemption for subsidiaries whose parent company's consolidated report includes the sustainability report of the subsidiaries.

In the Czech Republic, from 2025, large Public Interest Entities (e.g., listed companies with over 500 employees) become affected. From 2026, all large undertakings that meet two of the following indicators must prepare a report: more than 250 employees, at least €40 million net turnover, or at least €20 million balance sheet total. In the third phase, from 2027, the obligation is extended to listed small and medium-sized enterprises, excluding micro-undertakings. However, the EU Omnibus package influenced the Czech implementation, so a part of the reporting obligations is shifting: the new 1,000 employee threshold is valid from 2025, but the 2nd phase—for large companies/groups—is expected to be an obligation only from the 2027 financial year (reporting in 2028).

Poland designated auditors for the assurance of the sustainability report, who must acquire special qualification. The Czech regulation mandates the auditing of sustainability reports, involving an independent auditor or an accredited assurance provider.

The laws of both Poland and the Czech Republic state that the reports must be prepared according to the ESRS developed by the European Commission. Companies subject to the reporting obligation must apply uniform ESRS standards, so alternative methodologies are not selectable for companies.

The comparative analysis of the Czech Republic and Poland highlights that the transposition of the Corporate Sustainability Reporting Directive starts from unified foundations but at a different pace in the Central and Eastern European region. Both countries bear the legacy of the low level of previous NFRD application, which results in significant catch-up pressure regarding the new ESRS standards. Consequently, a strategy of literal adoption is likely in the legislative approach of both nations, minimising unnecessary national tightening beyond the original requirements.

The Polish and Czech sustainability reporting regulations are fundamentally closely aligned with the European Union directives, but national specificities appear at a few points. The differences are illustrated in Table 2.

The main difference lies in the speed of adaptation. The Czech Republic prefers a faster pace of legislative transposition, which, although advantageous from a legal harmonization perspective, results in lower corporate commitment levels due to the unpreparedness of the corporate sector (especially SMEs). This speed poses a serious risk to the quality and reliability of the initial reports. In contrast, Poland's slower legislative process may cause delay, but could allow for more thorough preparation by large, international market players (who have higher experience). That is, the Czech Republic sacrifices speed, and Poland sacrifices potential depth, while both models strive to ensure reliable ESG data in the region.

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A paradigm shift in the interpretation of disability

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Abstract: The paradigm of disability interpretation has undergone significant changes in recent decades, shifting from a medical model focusing on individual deficiencies to a social model. This approach sharply distinguishes between the concepts of impairment—as an individual's physical or mental difference—and disability. The latter is caused by structural, physical, and attitudinal barriers in society, as well as restrictions on participation. The social approach focuses on ensuring accessibility, inclusion, and equal participation, recognizing that disability is a human rights issue. Achieving acceptance requires breaking down negative stereotypes and stigma, especially in the case of people with psychosocial disabilities and autism spectrum disorders, where attitudinal barriers often outweigh physical barriers.

Keywords: persons with disabilities, changed work capacity, equal opportunities, accessibility.
Journal of Economic Literature (JEL) code : I23, I24, I28, J14, K15.

Introduction

The definition of disability and the interpretation of the situation of people with disabilities are as old as human civilization itself, but their complexity continues to pose a constant challenge for the social sciences, law, and medicine. Disability is not merely a biological fact, but a dynamic social construct that arises from the interaction of normative expectations, environmental barriers, and personal abilities. To understand the complexity of the phenomenon, it is essential to have theoretical frameworks and models of disability that reflect the prevailing attitudes and scientific views of a given era. The aim of this study is to present the paradigm shifts in the interpretation of disability through complementary models established throughout history. Starting from the moral model, we move through the individualistic approach of the medical model to the holistic view of the social, northern relational, biopsychosocial, and human rights models. The development of these theoretical frameworks reflects a shift in emphasis from the flawed individual to the obstructive environment and legal guarantees. The study analyzes the theoretical foundations of the models, legal definitions, and the main clinical types of disability, supporting the idea that scientific understanding is essential for creating an inclusive society that ensures equal opportunities for all.

1. A The Evolution of Disability Models

The interpretation of the concept of disability and societal attitudes towards persons with disabilities have undergone significant transformations across various eras and cultures. To visually illustrate these divergent perspectives, various disability models have been established, clearly reflecting the prevailing ideas and approaches of the given society. These models demonstrate how the examination of disability has been shaped and become increasingly comprehensive over the years. It is important to note that the chronological order does not signify strict replacement, but rather an expansion of acquired knowledge and an increasingly complex understanding (Könczei-Hernádi, 2011; Sándor, 2018; Dunás-Varga et al., 2021). These models transcend the mere definition of the concept, serving as interpretive frameworks that encompass different approaches to individuals.

1.1. The Moral Model

The earliest known approaches to disability are interpreted within the framework of the Moral Model. In this view, disability was often considered a physical manifestation of some transgression or sin, or a test of faith. Accordingly, disability was seen to have a cause initiated by a higher power, which rendered the person with a disability either guilty or, occasionally, God's chosen (Kálmán-Könczei, 2002).

However, even at this stage, the necessity of care was recognized. Persons with disabilities were considered to be in need of assistance, which was initially the responsibility of the family, then the immediate community, and finally, proportional to population growth, the society and the state (Könczei et al., 2015). Alongside its mystical interpretation, this model also highlighted that these individuals possess specific, unique needs.

1.2. The Medical or Individual Model

In the 20th century, with the development of medical science, the Medical (or Individual) Model gained ground. This model viewed disability as a "defect of the body," a kind of problem that must be prevented or, if already present, cured. The medical perspective, much like the moral model, defined disability as the individual's personal problem that must be remedied by professionals (Könczei-Hernádi, 2011). This approach dominated for a long time, viewing disability as an "illness" from which those affected needed to be cured.

1.3. Social Models

The Social Models originate from the diverse approaches of disability studies and activists. They share the common ground of viewing disability as a social construct that does not exist in isolation. The significance of these models lies in their shifting the definition of the concept from the level of the individual to the level of social processes, emphasizing that disability should be approached from a social and cultural rather than merely a biological perspective (Könczei-Hernádi, 2011). It ceased to be viewed as a problem to be solved medically and became the subject of social-level scrutiny.

1.3.1. The Societal Model

A radical response to the Medical Model, originating in Great Britain (Barnes, 1999; Shakespeare, 2018). It is built on three main pillars: the critique of the Medical Model, the protection of human rights, and the removal of social barriers and restrictions (Nagy et al., 2009). The model became popular among disability policy activists and political decision-makers (Goodley, 2017), promoting the rejection of treating disability as an "illness" and initiating the protection of human rights and the overcoming of barriers.

1.3.2. The Minority Model

Prevalent primarily in North America, this model sharply opposed ableism, which had created a concept of a "perfect presumed body." Consequently, it viewed persons with disabilities as an

oppressed, discriminated minority group. This model led to the development of "people first" language (Goodley, 2017), which means placing the person before the adjective (e.g., *people with disability* as opposed to *disabled people*) (Hernádi et al., 2016).

1.3.3. The Cultural Model

This model analyzes disability from a cultural and literary perspective. Its objective is to explore how culture portrays and acts upon disability, thereby contributing to the image of disability formed within society (Goodley, 2017).

1.4. The Nordic Relational Model

This model, widespread in Nordic European countries, questions the dominant nature of the Social and Minority Models. Its stance is that disability arises from the interaction between impairment and the disability-producing effect of the environment (Vissi, 2022). Its basis is the normalization principle of the 1960s (Nirje, 1994), which aims to provide persons with disabilities the same living conditions (through welfare measures) as those enjoyed by the majority of society (Tossebro, 2004).

1.5. The Bio-Psycho-Social Model

Established by the International Classification of Functioning, Disability and Health (ICF), created by the WHO in 2001. According to the ICF definition, disability is the result or outcome of a complex relationship that arises between a person's health condition and personal factors, and the external factors representing their environment (WHO, 2001, p. 17). The goal of the ICF is to create a unified, neutral-language, universal framework that brings together the medical and social models (Goodley, 2017).

1.6. The Human Rights Model

This model is fundamentally established by the UN Convention on the Rights of Persons with Disabilities (CRPD), issued in 2006. It examines disability from the perspective of securing universal human rights. According to Article 1 of the Convention, the full and effective participation of persons with disabilities in society is hindered by the interaction between the person's long-term physical, mental, intellectual, or sensory impairment and various barriers (United Nations, 2006). The model prohibits all forms of exclusion and discrimination (Halmos, 2019).

1.7. The Post-Model

The Post-Model emerged as a response to critical currents within disability studies, which argued that the social models (Social, Minority, and Cultural) provided too narrow a framework for interpretation (Könczei et al., 2015). As articulated by Könczei and Hernádi (2011), the Post-Model goes beyond closed models, possessing a flexible structure and being capable of considering the constantly changing factors of the world (Könczei-Hernádi, 2011).

1.8. The Economic Model

This model approaches disability from the perspective of production and contribution to the labor market. It fundamentally examines the extent to which disability affects an individual's ability to work and thereby the economic well-being of society. Its primary goals are to minimize the cost of disability benefits and promote the labor market integration of affected individuals. According to this view, disability is a burden on the economy, and the goal of rehabilitation is to restore productivity (Oliver, 1990).

1.9. The Affirmative Model

This relatively new model defines disability not in terms of deficits but of resources and positive identity. It views persons with disabilities not as those in need of help, but as a diverse and culturally rich group. It emphasizes disability culture, collective identity, and the idea of "celebrating life." This sharply contrasts with the Social Model's negative approach, which merely portrays impairment as "unfortunate" (Swain and French, 2008).

1.10. The Socio-Political Model

While similar to the Social Model in many respects, the Socio-Political Model specifically focuses on the relationship between disability and power structures. It identifies disability as the result of marginalization, oppression, and political discrimination, emphasizing the need for legal and political reforms. It highlights that the lack or limitation of political rights for persons with disabilities perpetuates their disadvantaged status (Rioux and Valentine, 2006).

Summary of Model Significance: The distinction between the different disability models—especially the Medical and Social Models—is crucial for modern disability policy and practice. The significance of the Medical Model lies in its legitimizing medical intervention and rehabilitation to minimize impairment. However, by defining the problem solely as an individual deficiency, it obscured social responsibility and fostered segregation. In contrast, the Social Model provides the theoretical foundation for disability rights movements. It created the conditions for the rights-based approach, which is also the basis of the CRPD. The shift between models provides legislators and service providers with a normative framework that seeks not to "fix" the individual but to identify and eliminate systemic flaws and attitudinal barriers. This paradigm is essential for achieving full inclusion and the enforcement of equal rights at all levels of society.

2. The Legal Definition of Disability

The definition of disability is not uniformly defined in a single piece of legislation but is based on functional criteria tailored to different benefits and rights. The basic framework is provided by Act XXVI of 1998 (on the rights of persons with disabilities and the guarantee of their equal opportunities), which designates a person with a disability as an individual who lives with a long-term or permanent substantial health or mental impairment, and this hinders their full, equal participation in society. Act XXVI of 1998: A person with a disability is someone "who lives with a long-term or permanent sensory, communicative, physical, intellectual, psychosocial

impairment—or any accumulation thereof—which, in interaction with environmental, social, and other significant barriers, limits or prevents effective and equal participation in society."

Even more definitive is the UN Convention on the Rights of Persons with Disabilities (CRPD), promulgated by Act XCII of 2007, which interprets disability as the result of the interaction between impairment and a barrier-creating environment. The CRPD is a paradigm-shifting document that addresses disability as a human rights issue, demanding the prohibition of discrimination, the introduction of supported decision-making (to ensure autonomy), and the requirement of reasonable accommodation.

Act XCII of 2007 (CRPD): "Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which, in interaction with various barriers, may hinder their full and effective participation in society on an equal basis with others."

The Fundamental Law of Hungary also stipulates that Hungary shall promote the full and effective participation of persons with disabilities in society and ensure the prohibition of disadvantageous discrimination. Furthermore, Act CXXV of 2003 on Equal Treatment and the Promotion of Equal Opportunities specifically prohibits direct and indirect discrimination based on disability, thus providing comprehensive legal protection for those affected. The purpose of the regulation is to ensure accessibility and equal access to services, in line with the Human Rights Model.

3. Types of Disability

It is generally true that persons with disabilities face diverse limitations, as well as unique and special needs, which complicate their lives as full members of society. To overcome these challenges, precise identification of the heterogeneity of functional limitations is essential. A taxonomic distinction of disability types—which includes neurodevelopmental, sensory, physical, systemic, and psychosocial dimensions—is warranted and necessitates targeted interventions. The goal of this chapter is the systematic presentation of these fundamental categories, from which the specific needs of differentiated support strategies, legal entitlement systems, and personalized reasonable accommodation obligations can be derived. This approach is a prerequisite for effective resource allocation and comprehensive social participation.

3.1. Autism Spectrum Disorder

A developmental disorder that causes unique social and communication difficulties (efiportál, 2021), occasionally requiring external assistance (Autista Segítő Központ, 2024). Across this wide spectrum, the degree of functioning varies greatly, leading to different levels of support needs (Lord et al., 2020).

3.2. Speech Impairment / Communication Disorders

In addition to traditional speech impairment, this category includes comprehension and expression disorders (e.g., aphasia, dysphasia), which stem from a disruption in language processing and hinder the efficiency of information exchange in social interactions (Király and Csányi, 2012).

3.3. Intellectual Disability

Depending on the severity, there is a significant limitation in cognitive functions and adaptive behavior (Kálmán and Könczei, 2002). The exercise of the person's right to self-determination can be supported to varying degrees (full legal capacity, limited legal capacity).

3.4. Hearing Impairment and Deafness

Damage to the auditory organ (congenital or acquired) causes communication difficulties (Csányi et al., 2012). A distinction can be made between the Deaf community, who use sign language as a full-fledged language, and the hard of hearing, who rely on residual hearing and/or compensatory devices (hearing aids, cochlear implants).

3.5. Visual Impairment and Blindness

Visual performance is between 0–33%, or the visual field is significantly narrowed (Vakok és Gyengénlátók Borsod-Abaúj-Zemplén Megyei Egyesülete, 2024). Daily life is assisted by Braille, guide dogs, and specialized information and communication technologies, access to which is a fundamental issue of equal opportunities in the EU.

3.6. Physical Disability (Mobility Impairment)

Physical damage to the musculoskeletal system permanently hinders functional abilities (Mesterházi, 2000). This includes congenital anomalies, paralysis resulting from accidents (e.g., spinal cord injury), and progressive musculoskeletal diseases (e.g., muscular dystrophy) (WHO, 2001).

3.7. Psychosocial Disability (Mental Health Disorders)

A complex functional disorder that, in connection with a mental disorder, impedes customary daily activities and participation in the community (Baran et al., 2020, p. 2). This includes chronic states of severe depression, bipolar disorder, and schizophrenia that fall under the scope of disability systems and require sustained social support (WHO/ICF, 2001).

3.8. Specific Learning Disorders

In addition to dyslexia, dysgraphia, and dyscalculia, this includes dyspraxia, which means difficulties in motor coordination and planning, causing significant barriers in educational and work processes (Gyarmathy, 2017; Csépe, 2006).

3.9. Neurodevelopmental Disorders

In addition to Attention Deficit Hyperactivity Disorder (ADHD) and Tourette Syndrome, this includes other executive function disorders that cause persistent, severe difficulties in purposeful behavior, time management, and organizational skills, requiring equal treatment from a functional capacity perspective (Barkley, 2015; Rosta, 2021).

3.10. Chronic Internal and Systemic Disabilities

These are long-term health impairments that are not solely related to the motor or sensory system but cause a significant reduction in functional capacity due to the functioning of internal organs. Examples include severe kidney failure, chronic liver diseases, more severe forms of heart failure, and advanced stages of HIV/AIDS (WHO/ICF, 2001). These conditions create disability due to the need for continuous medical care and reduced load capacity.

3.11. Severe Chronic Pain Syndromes

Such as fibromyalgia, Chronic Fatigue Syndrome (ME/CFS), or Complex Regional Pain Syndrome (CRPS). These syndromes involve severe, persistent pain or fatigue that is invisible to the external observer but significantly restricts work, social participation, and self-care (Nijs et al., 2012; Linton and Shaw, 2011). They are increasingly being recognized as legal disabilities in EU jurisprudence.

3.12. Neurodegenerative and Progressive Disabilities

In addition to the previously mentioned Multiple Sclerosis (MS), this includes Parkinson's disease, Amyotrophic Lateral Sclerosis (ALS), and Huntington's disease. These diseases progressively destroy the nervous system, leading to the continuous loss of movement, cognitive abilities, and speech, generating a growing need for comprehensive, personalized support (Riedel and Latt, 2008).

3.13. Immunological Disabilities

Individuals who have undergone organ transplantation or suffer from severe, chronic autoimmune diseases requiring immunosuppression (e.g., lupus) live with persistently reduced load capacity, risk of infection, and continuous medical monitoring (European Transplant Society, 2019). These conditions qualify as disabilities due to the limitations they impose on participation in the workplace and society.

3.14. Environmental Disability Due to Chemical Sensitivity

Severe cases of Multiple Chemical Sensitivity (MCS), which, due to extreme physical reactions to everyday chemicals, make it impossible to stay in public buildings, offices, or on public transport. This exclusion results in an environmental disability in EU legal practice (based on the Social Model), as the hindrance stems from the inappropriate design of the environment (Ashford and Miller, 1998).

3.15. Multiple Disabilities

Not a separate type, but a combination of the above: disability extends to multiple areas (e.g., vision, mobility, and intellectual capacity), where a special condition arises due to a biological impairment in at least two developmental areas (Gruber, 2020).

The detailed, professional distinction between disability types is of fundamental importance in both legal and professional terms. The essence of this is that disability is not a homogeneous phenomenon, and the functional limitations and support needs of each type differ radically. The primary goal of categorization is to ensure targeted intervention, which allows for the selection of personalized rehabilitation programs and assistive devices. Secondly, this distinction ensures equitable treatment and the legal basis for entitlements (e.g., disability benefits, reasonable accommodation), which is essential for full social participation.

Conclusion

The interpretation of disability has shifted from the initial mystical-moral and then the individual-focused medical approach to one emphasizing social responsibility and human rights. Society's task is to ensure inclusion, equal opportunities, and the elimination of discrimination, recognizing that persons with disabilities have unique and special needs. Breaking down social stigmas is fundamentally important, as "the nature of the stigma is not that it is visible, but that it is indelible: one does not wear it like a bad coat, but like one's skin: one cannot shed it oneself" (Goffman, 1981, p. 193).

The legal definition of disability in Hungary is based on functional criteria (Act XXVI of 1998), but Act XCII of 2007 marked a paradigm shift, interpreting disability as a human rights issue—the interaction of impairment and a barrier-creating environment. The legislation demands the prohibition of discrimination and reasonable accommodation, yet in domestic practice, decisions regarding entitlements rely on the percentage of health impairment/work capacity determined by expert committees, thereby neglecting the significance of eliminating environmental barriers and supported participation.

A broad spectrum of disabilities can be identified, and the categorization of types is aligned with the functional area of the impairment. The recognition of different types is essential for providing personalized, inclusive support, in line with legal requirements for equal opportunities.

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Labour market reserves: the situation and integration of people with changed working capacity and disabilities in Hungary

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Abstract: Nowadays, helping disadvantaged and undereducated social groups catch up through training and increasing their employment is a relevant and important task from both a social and economic perspective. In light of the nationwide labour shortage, the importance of educating and training people with disabilities and people with changed work abilities as labour market reserves has come to the fore, serving a dual purpose: on the one hand, it is an essential moral obligation in line with the principles of social cohesion and equal opportunities, and on the other hand, it is a vital economic investment for the national economy.

Keywords: people with disabilities, equal opportunities, accessibility, changed work capacity
Jel code: I23, I24, I28, J14, K15.

Introduction

Helping disadvantaged and undereducated social groups catch up through training and increasing their employment is a pressing and important task from both a social and economic perspective. The size of the two target groups is also significant in terms of numbers: according to the European Parliament's 2022 report, approximately 87,000,000 people in the EU are classified as disabled. Thus, in Europe, as in the United States, they represent one of the largest minorities after the elderly. Around the world, people with disabilities are at a significant disadvantage in the labor market, forming an undereducated and underemployed group. This is also true in Hungary, where, despite an improving trend, their employment rate lags significantly behind that of the majority of the economically active population. Discriminatory attitudes towards this group of workers are partly responsible for their low employment rate.

1. Ensuring the rights and equal opportunities of persons with disabilities

The Fundamental law of Hungary sets out the inviolable and inalienable fundamental rights that apply not only to persons with disabilities, but to every human being. Below, I would like to highlight the most important points concerning persons with disabilities. Article XII of the law refers to the right to freely choose one's work and occupation, as well as the right to engage in business, while Article XV refers to equality before the law and legal capacity, emphasizing that it is prohibited to discriminate against persons with disabilities. Article XVII of the Fundamental law points out the importance of employers creating a suitable environment not only for healthy employees but also for those with disabilities. Finally, article XIX mentions the importance of providing social security for persons with disabilities. Based on the above, we can see that Hungary cares for persons with disabilities, as they are mentioned in several points of the Fundamental law.

Before examining the enforcement of the rights of persons with disabilities and the realization of equal opportunities, it is necessary to clarify what rights they have and what we mean by equal opportunities. Several pieces of legislation in the Hungarian legal system refer to the rights of persons with disabilities, among which Act XXVI of 1998 defines the rights of persons with disabilities and the various means of enforcing those rights, and aims to ensure equal opportunities

for persons with disabilities. The law defines the rights of persons with disabilities in five areas and aims to achieve equal opportunities by regulating five additional areas. It is therefore clear that Hungary considers it important to support disadvantaged persons, in this case persons with disabilities.

The aforementioned Act CXXV of 2003 is also closely linked to equal opportunities, with Chapter III setting out the requirements for equal treatment. This law therefore does not allow persons with disabilities to be discriminated against and aims to ensure that everyone is treated equally.

2. The labor market situation of persons with disabilities in Hungary

In relation to Hungary, I would like to present the labor market situation of persons with disabilities, their highest level of education, and their economic activity. Data from the 2022 census conducted by the Hungarian Central Statistical Office (KSH) on the labor market, examining the educational attainment and economic activity of persons with disabilities, provide a more comprehensive picture of their situation and opportunities in economic life. People with disabilities lag behind in terms of education. The highest level of education attained by people with disabilities is only the 8th grade of elementary school (84,113 people), i.e., 33.08% of respondents. In second place are people with disabilities who have a high school diploma (57,730 people), accounting for 22.70%. Those with a university or college degree number only 30,306, or 11.92% (KSH, 2023). The above data is shown in Figure 1.

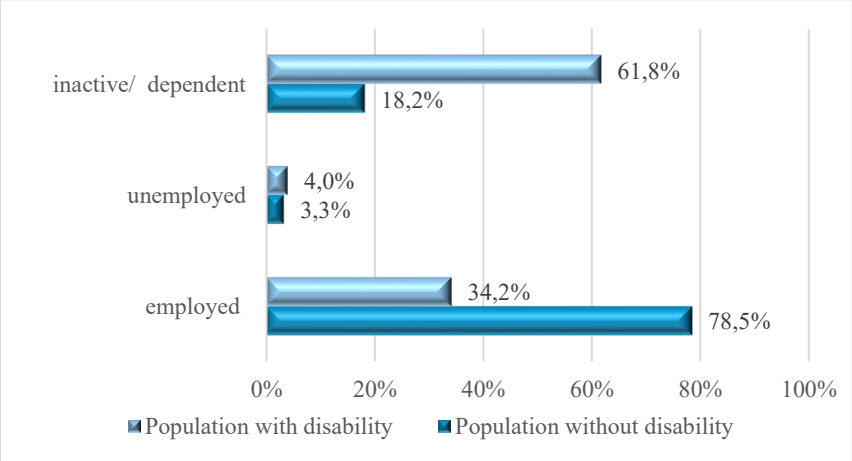

Figure 1. Highest level of education attained by persons with disabilities
Source: Own compilation based on data from the Hungarian Central Statistical Office census

Based on these data, we can see that people with disabilities start from a disadvantaged position in the labor market, as their qualifications are not sufficient for most positions, since a high school diploma, and now a university or college degree, is considered a basic requirement for applying for a position. The above is particularly relevant for those in intellectual professions. There may be several factors behind low educational attainment, including the type of disability the person has, and the level of self-confidence and belief in one's own abilities is also critical. This attitude influences how capable the individual considers themselves to be of obtaining a higher education qualification and how they perceive the opportunities available to them. If they take advantage of these opportunities, they can achieve their goals and live a full life like other members of society.

During its census, the Hungarian Central Statistical Office (KSH) also assessed the economic activity of people with disabilities in 2022. Based on the responses, a total of 273,558 people suffered from some form of disability in that year. Within this population group, the number of employed persons was only 59,224 representing 21.65%, while the number of unemployed persons was only 3,893, or 1.42%. Based on these figures, one might think that the labor market situation for people with disabilities is not so unfavorable, but it should be noted that among the 273,558 people with disabilities, the largest proportion are inactive job seekers and dependents, who number 210,441, or 76.92% of the focus group examined (KSH, 2024). From this, we can conclude that although the above-mentioned people are not unemployed, as they all have an income, this income does not come from work, and the employment of people with disabilities is not adequate. The data can be seen in Figure 2.

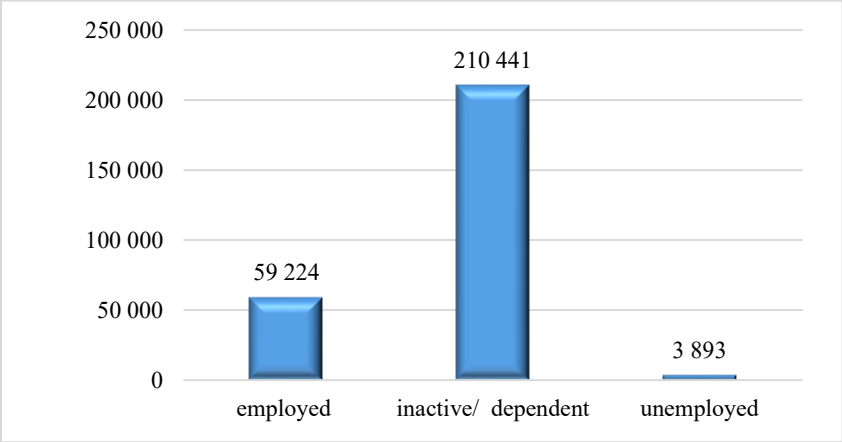

Figure 2. Economic activity of people with disabilities (2022)
Source: Own compilation based on data from the Hungarian Central Statistical Office census

Within the topic of economic activity, Figure 3 shows how the economic activity of people with disabilities compares to the Hungarian population as a whole one and a half years later, in the first quarter of 2024.

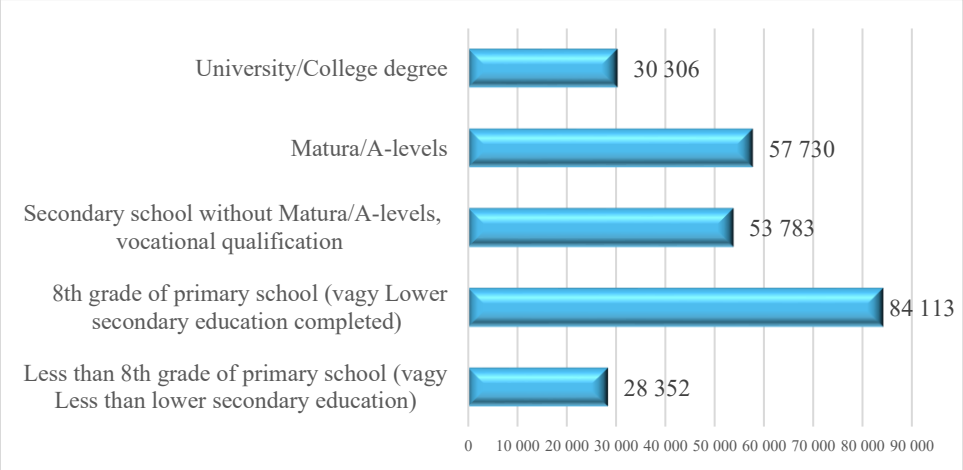

Figure 3. Economic activity of healthy and disabled members of the population (2024)
Source: Own compilation based on data from the Hungarian Central Statistical Office

It can be seen that while employment among healthy members of the Hungarian population (aged 19-64) is 78.5%, among members of the population with disabilities this figure is only 34.2%, meaning that healthy members of the population are employed to a greater extent than members of the population with disabilities. Unemployment among healthy members of the population is 3.3%, while among members of the population with disabilities, this figure is 4.0%. The difference between the two groups is relatively small, but it should not be overlooked that, for example, the number of inactive job seekers is higher among people with disabilities (61.8%) than among healthy members of the population (18.2%). The above data clearly show that the labor market gap remains a significant challenge and that activating the restricted population is essential to freeing up labor reserves.

2.1. Interpretation of the concept of persons with changed working capacity in the context of employment

In addition to individuals with disabilities, it is also essential to mention persons with changed working capacity, as these two categories are closely related. However, it is important to note that the concept of persons with changed working capacity is not the same as that of persons with disabilities, as the former is related to the field of employment (Neiger et al., 2017).

According to Act IV of 1991 (on the promotion of employment and the provision of benefits to the unemployed), a person with changed working capacity is someone who has a physical or mental disability, or whose chances of finding and keeping a job are reduced due to physical or mental impairment following medical rehabilitation. According to this definition, persons with disabilities can also be classified as persons with changed working capacity, but this interpretation must be examined specifically in the context of the labour market.

As part of the government's efforts to improve the labor market situation of people with changed working capacity, Act CXCI of 2011 was passed, which regulates employers' obligation to pay rehabilitation contributions. Under this law, "employers are required to pay a rehabilitation contribution to promote the occupational rehabilitation of persons with changed working capacity if they employ more than 25 people and the number of persons with changed working capacity employed by them does not reach 5% of the total number of employees." By enacting this legislation, the state has taken the first significant step towards improving the quality of life of persons with changed working capacity, including persons with disabilities. In doing so, it encourages employers to provide job opportunities for disadvantaged members of society.

In addition, there is an employer incentive system consisting of elements that encourage employers to hire employees with changed working capacity, thereby promoting their greater participation in the labor market. This comprehensive system consists of four main parts: subsidies, discounts, services, and other incentives (Cseh, 2014).

In summary, we can see that initiatives are being taken to integrate people with disabilities into society and, within that, into business life. However, in order to increase their employment rate, two factors are necessary: on the one hand, the state must intervene more strongly to promote their situation in the labour market, either by imposing stricter regulations on economic actors or by providing higher subsidies to employers of persons with disabilities. On the other hand, it is

necessary to train people with disabilities and develop their skills so that they can fill positions that are suitable for both themselves and the companies that employ them. It is important to mention that although there are already companies that have taken this path and employ disadvantaged people with disabilities, who in some cases start from a disadvantage, their number is still negligible in the business sector.

2.2. Definition, forms, and labour market significance of rehabilitation

In connection with the employment of people with disabilities, the question arose as to what might be behind the low employment rate among people with disabilities and what solutions are currently available to remedy this disadvantageous situation. At this point, it is worth mentioning rehabilitation, which is an organized activity provided by society to disabled or handicapped persons in order to help them integrate into the community more easily with their remaining abilities. All persons with disabilities are entitled to rehabilitation, which may include medical, educational-therapeutic, or occupational rehabilitation (Neiger et al., 2017). According to another approach, the concept of rehabilitation is nothing more than the reacquisition of skills, abilities, and knowledge that persons with disabilities have lost or that have been compromised as a result of the onset of a disability (Lord, 2009).

The aim of occupational rehabilitation is to promote the employment and long-term employment of people with changed work capacity, taking into account their existing health impairment, illness, or disability (Érték vagy!, 2021). Thanks to occupational rehabilitation, it can be observed that earning an income is not the only benefit of employment for people with changed work capacity (including those with disabilities), as the job they have obtained represents a sense of achievement for them, the workplace environment allows them to experience a sense of community and feel useful. This gives them hope for a more fulfilling life and helps reduce their feelings of illness. Vocational rehabilitation is an excellent opportunity to promote the employment of people with changed working abilities, including people with disabilities, and also offers them the opportunity to develop individually and become full members of society.

Support for rehabilitation-oriented employment is continuously provided through legislative and financial incentives. The amount of the rehabilitation contribution increases every year on January 1 due to the rise in the minimum wage. The contribution rate is nine times the minimum wage per person per year, which amounts to HUF 2,401,200 per person per year in 2024 (NAV, 2024). This obligation applies to employers with more than 25 employees if they do not meet the 5% mandatory employment level, so the increase provides an even stronger incentive for employers to hire people with changed working abilities. Today, 150,000 people with changed working abilities live on wages. Overall, their employment rate has risen significantly, from 18% in 2011 to 44% in 2022 (Tapolczai G., 2023).

The reasons why people with changed work capacity find it more difficult and take much longer to find a job may include: reduced skills, impaired abilities, low self-esteem, and social prejudice. The social model also supports the fact that social prejudices pose much greater barriers to persons with disabilities and health impairments than would be expected from their individual circumstances alone. According to this model, it is not the health condition of the individuals concerned that causes the problem, but the fact that societies do not seek to help people with

disabilities overcome their disadvantages, so it is not the condition of the individual but the environment that makes them "disabled" (Cseh, 2014). Thus, the high unemployment rate among people with changed work capacity may not only be due to their inability to work, but also to the aforementioned exclusionary and judgmental attitudes, as well as behavior that creates barriers..

Employer commitment is therefore an important factor in improving the labour market situation of people with changed work capacity, as the members of the target group can only overcome the existing barriers if society and individual companies commit to helping them and creating an inclusive environment so that people with changed working abilities, including those with disabilities, have the opportunity to develop their skills in the world of work.

3. Integration opportunities for persons with disabilities

The social integration and inclusion of persons with disabilities is one of the most important challenges of 21st-century social policy, legislation, and ethical thinking. Throughout history, the perception of disability has long been dominated by the medical model, which treated disability as a biological deficiency in the individual that needed to be cured, repaired, or segregated. This approach led to the development of large, closed institutions that essentially excluded those affected from full social life (Oliver, 1990).

In contrast, modern thinking focuses on the principle of the social model. According to this, disability is not an attribute of the individual, but the result of barriers arising from the environment—discriminatory attitudes, physical barriers, and the inflexibility of social structures (Török, Zászkaliczky 2015). The most important legal manifestation of this paradigm shift is the UN Convention on the Rights of persons with disabilities, which promotes inclusion rather than integration, which also means transforming society as a whole, institutional systems, and services to ensure full participation and equal opportunities (UN, 2006). Inclusion opportunities focus on three main areas, which together ensure the conditions for independent living.

3.1. Inclusive education

It is most effective in the early stages of the integration process. Its aim is to enable children with special educational needs to learn in mainstream educational institutions under the same conditions and with the necessary support services. Inclusive schools do not discriminate, but adapt teaching methods and the environment to the needs of the child (Booth and Ainscow, 2016). Critical elements of implementation include adapting curricula, teaching materials, and assessment methods to individual learning styles and paces, as well as close cooperation between special education teachers, developmental teachers, and mainstream teachers. However, the challenges are significant: a lack of teacher training, overcrowded classrooms, and a lack of inclusive culture in many institutions hinder quality inclusion. Literature data indicate that inclusive approaches and support structures also need to be developed in Hungarian higher education (Zsobrák and Keller, 2025).

3.2. Supported employment

Participation in the labor market is essential for self-esteem, economic independence, and social status. Low labour market participation is a serious problem for society as a whole. The key to the solution may lie in a supported employment model that differs from traditional sheltered employment. Its aim is to place people with disabilities in the open labor market, with continuous, personalized support, ensuring economic independence and autonomy. Its main features are: a workplace mentor helps with job search, learning workplace skills, and communicating with employers. The emphasis is not on prior segregated training, but on rapid placement and providing the necessary training and adaptations. Rehabilitation contributions and tax incentives encourage employers to hire these individuals (Wehman, 2013). Challenges in this area include negative employer attitudes, lack of information, and uneven quality and availability of rehabilitation services. The emancipatory goal is to uncover and eliminate hidden exclusionary mechanisms that prevent people with disabilities from participating as equal employees (Svastics, 2023).

3.3. Independent living

The third cornerstone of social inclusion is participation in community life and accessibility. This is where supported housing comes in, as one of the keys to independent living is the gradual elimination of large segregated institutions and their replacement with community-based, small-scale supported housing, which allows residents to access local services and enjoy greater independence. The aim of supported housing is to develop the skills of those affected, enabling them to actively participate in the labour market and form social relationships (Nyitrai, 2020). However, to achieve this, legislation must also guarantee physical accessibility (built environment, transport) and information and communication accessibility (digital platforms, information). The latter is particularly important for equal participation in the digital society. This change in perspective puts individual self-determination at the center, where residents themselves can decide on important issues in their lives.

Summary

People with disabilities and reduced working capacity represent a significant but often untapped potential for the labour market. Increasing their employment is not only a social obligation but also in the economic interest of the national economy. The key to unlocking this hidden potential lies in targeted, high-quality, and marketable training. Such training helps individuals meet the challenges of the open labor market, reducing skills gaps and increasing their employability. However, effective integration requires the continuous development of the legal framework, transparency in the rehabilitation contribution system, a positive change in employers' attitudes, and an increase in the adaptive capacity of training institutions. Only a complex support system and a smooth transition between training and employment can achieve the full social and economic integration of these individuals in Hungary.

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The impact of mobbing on corporate competitiveness: The role of management

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Abstract: Maintaining corporate competitiveness increasingly depends on the quality of the organizational climate. Toxic work environments reduce engagement, productivity, and retention, while persistent psychological harassment (mobbing) elevates HR costs and erodes organizational knowledge. Management plays a pivotal role in recognizing and mitigating these effects through leadership practices that support collaboration, innovation, and resilience. Chronic stress suppresses creativity and problem-solving, undermining competitive advantage, and a deteriorated team atmosphere weakens operational efficiency. Poorly managed mobbing damages employer branding and hinders talent acquisition, whereas supportive cultures enhance long-term performance. This paper, based on a literature synthesis and a case study, examines the economic consequences of workplace mobbing and highlights management's critical role in reducing its harmful impact. Effective anti-mobbing strategies yield both ethical compliance and measurable economic benefits, strengthening organizational competitiveness.

Keywords: organizational climate, innovation, competitiveness, management, mobbing
JEL Codes: M00, M12,

Introduction

One of the most important strategic goals of modern companies is to maintain and increase competitiveness, which is shaped by several internal and external factors. Globalization, digitalization, and dynamic changes in the labor market require increased flexibility and adaptability from economic actors. In this complex and challenging environment, the role of human resources as a determining factor in long-term success is becoming increasingly important. The efficiency and innovation capacity of organizations are closely related to the quality of the workplace atmosphere and the extent to which employees feel supported, involved, and valued.

In recent years, both domestically and internationally, more and more research has focused on examining destructive behaviors in organizational cultures, particularly workplace bullying. Mobbing (psychological terror) is an interpersonal conflict in which one or more employees are systematically and continuously subjected to psychological pressure from colleagues or superiors. Although the phenomenon often remains hidden, its impact extends to many aspects of organizational performance: employee commitment declines, internal communication deteriorates, turnover increases, and creativity declines. All of these directly threaten competitiveness by increasing operating costs, weakening innovation potential, and damaging the employer's brand image.

Management plays a key role in recognizing, preventing, and addressing mobbing. The organizational culture created by managers—especially the values of openness, trust, and cooperation—significantly influences whether the workplace environment can provide a healthy, supportive framework for functioning. Exploring these relationships is particularly important given that the consequences of mobbing are often hidden within the organizational functioning of,

and thus a lack of preventive management practices can result in a long-term competitive disadvantage (Budavári-Takács 2020).

The structure of this study consciously follows a logical arc that serves both to demonstrate the relevance of the topic and to establish the methodological basis for the research. First, a detailed case study is presented, which uses a vivid example to highlight the practical manifestations and organizational consequences of mobbing. This is followed by a description of the methodology used to process the literature, the search strategy, the selection and exclusion criteria, and the principles of systematization. Following the methodological foundation, the study focuses on a systematic analysis of the results of desk research, revealing the mechanisms through which mobbing directly and indirectly affects corporate competitiveness.

Presentation of the case study

Although the phenomenon of workplace psychological terror (mobbing) has received increasing attention in international literature in recent years, there is still little empirical research available in Hungary that examines the effects of mobbing on organizational performance using a large sample. Mobbing is a difficult-to-detect and identify, hidden phenomenon that often falls outside formal corporate reporting and diagnostic systems. As a result, in the absence of domestic case studies, this paper illustrates the organizational and economic consequences of mobbing based on a clinical case study from Germany.

The case studied comes from the patient records of the AHG Clinic in Berus, Germany—the European Center for Psychosomatic Medicine and Behavioral Medicine—which has been providing specialized care for patients affected by workplace psychological terror for many years. (Schwickerath & Holz 2014)

The subject of the case is a 46-year-old male employee who worked for a long time at an industrial manufacturing company. According to the clinical diagnosis, he suffered from reactive depression (ICD-10: F43.21), bilateral hearing loss (ICD-10: H91.9), and lumbar spine syndrome (ICD-10: M54.9). The worsening of his symptoms was caused by the constant provocative and humiliating behavior of his colleagues, which led to a psychological breakdown. The employee spent nearly a year and a half on sick leave. Upon returning to work, the mobbing continued, with colleagues openly humiliating him, treating him as an intern, and in some cases resorting to overtly harassing, symbolic aggression (such as replacing his sandwich with a moldy one).

The employee initiated conflict resolution, but his attempts were unsuccessful. The increasing stress level and feeling of isolation ultimately justified clinical intervention. The patient received complex therapy, which included psychotherapeutic treatment, stress management, and support for returning to work, with a particular focus on occupational health consultations.
As a result of the therapy, the employee's condition stabilized and he was successfully reintegrated into another department of the company, where his new colleagues provided him with a supportive environment. The positive results of the one-year follow-up confirm that, with appropriate managerial and health interventions, the damage caused by mobbing can be mitigated and the employee can be reintegrated into productive organizational functioning.

This case clearly illustrates that mobbing is not just an individual psychological problem, but a phenomenon with serious economic and organizational consequences, the recognition and management of which is a strategic task for management. The stakes are not only the restoration of individual health, but also ensuring organizational efficiency and long-term competitiveness.

Methodology

The present study aims to provide a systematic, transparent, and reproducible review of the literature in the context of a multidisciplinary examination of workplace mobbing. The use of *the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)* methodology was justified because this internationally accepted procedure ensures scientific reliability, transparency in source selection, and consistency in the analysis process (Moher et al., 2009). PRISMA is particularly suitable for examining complex phenomena in humanities and social science research that lie at the intersection of several disciplines, in this case, psychology, law, and management.

A key advantage of this method is that it guides researchers through the process of *identification, screening, selection, and involvement* in a structured manner, eliminating repetition and distorting effects. This is particularly important in the case of workplace mobbing, which is characterized by differing theoretical approaches and uncertainties in definition (Salin 2003). PRISMA enabled the systematic selection of relevant studies and the thematic synthesis of qualitative data, as a result of which the research identified three main dimensions: the interaction between *psychological-individual factors, legal-institutional frameworks, and organizational-managerial dynamics.*

During the analysis, 35 sources were identified, of which 20 were ultimately found to be eligible based on the criteria. The corpus thus formed covers both the international and Hungarian aspects of the topic, ensuring scientific validity and the possibility of comparative analysis. Thanks to the application of the PRISMA framework, the study is not only thematically organized but *also* provides *methodologically valid and reproducible* results, contributing to a standardized approach to research on workplace psychological terror and laying the foundation for future empirical studies.

The concept, forms, and occurrence of mobbing

Psychological terror in the workplace, also known as *mobbing,* is systematic, repeated, and persistent psychological aggression directed by one or more persons against a specific individual in the workplace environment. During this process, the victim gradually becomes vulnerable, loses social support and work performance, which in the long term has serious psychological and health consequences (Klein 2021; Zapf & Einarsen 2011).

According to Leymann's (1990) classic definition, mobbing is characterized by hostile forms of communication and behavior that occur at least once a week and last for at least six months. The phenomenon differs from occasional conflicts in that it is systematic and accompanied by power imbalances. (Klein 2021). According to Tóth & Solymosi-Szekeres (2023), the goal of mobbing is psychological isolation, which can take the form of direct verbal or nonverbal insults, gossip, sarcasm, or indirect methods such as withholding information or ignoring the employee.

Various types of mobbing are known in the literature:

- *Vertical mobbing,* when the harassment originates from a higher position in the hierarchy (mainly from managers);
- *Horizontal mobbing,* which occurs between colleagues at the same level;
- *Strategic mobbing***,** which has a conscious organizational goal (e.g., cost reduction, preparation for dismissal) behind it (Einarsen et al 2011).

As a result of digitalization*, cyber-mobbing* or online harassment has also emerged as a new dimension, which takes place through electronic communication tools (e-mails, chat platforms, social media) (Coyne et al 2017). This increases the hidden nature of harassment, as it is often beyond the direct control of the employer.

Due to *the hidden nature* of the phenomenon, it often goes underreported or unnoticed at the corporate level, especially when the manager is also involved in the harassment. The situation is further complicated by the fact that in many cases, organizational culture and internal regulations do not provide adequate tools for recognizing and dealing with mobbing. There is currently no comprehensive legislation in Hungary that explicitly addresses psychological terror in the workplace, so the problem is primarily left to internal corporate standards and management awareness (Tóth & Solymosi-Szekeres 2023).

The impact of mobbing on corporate competitiveness

Workplace mobbing not only hurts individual well-being and mental health but also poses a significant long-term risk to organizational performance and competitiveness. The consequences of psychological harassment manifest themselves in complex ways at multiple levels of corporate operations, from employee engagement to reduced innovation capacity to damage to the employer brand.

Declining employee engagement and productivity

A toxic workplace atmosphere directly undermines employee motivation and emotional commitment to the organization. The constant presence of psychological abuse destroys work morale, hinders teamwork, and leads to a decline in individual performance (Czifra & Csukonyi 2024). An atmosphere of mistrust significantly reduces employees' voluntary contributions, such as creative ideas or proactive behavior (Salin 2003), which hinders the organization's development.

Increasing turnover and human resource costs

Increased turnover as a result of mobbing and a negative workplace atmosphere not only entails direct recruitment and training costs, but also leads to *a loss of organizational knowledge* in the longer term, which seriously affects the company's intellectual capital (Czifra & Csukonyi 2024; Hoel & Cooper 2000). Talented employees are often the first to leave a workplace environment burdened by harassment, which further exacerbates the loss of resources and reduces competitiveness.

Damage to the employer brand

The presence of psychological harassment in the workplace undermines the employer brand of the organization in the long term. A lack of transparent communication and ethical leadership can create a negative impression in the labor market, making it difficult to attract and retain highly skilled workers (Einarsen et al 2011). Damage to the employer brand can lead to a decline in recruitment efficiency and a weakening of the company's competitive position.

Decline in innovation capacity

Organizational innovation requires an open, supportive corporate culture in which employees feel safe to share their opinions and ideas. Mobbing, on the other hand, creates an atmosphere of fear, isolation, and uncertainty, which hinders creative thinking, problem solving, and collaboration—all of which lead to a decline in innovation potential (Nielsen & Einarsen 2012).

Increased patient numbers and health problems

As a result of psychological stress and humiliation, psychosomatic symptoms such as sleep disorders, anxiety, and chronic fatigue are becoming more common among employees, leading to longer-term sick leave and labor force loss (Tóth & Solymosi-Szekeres 2023). chronic fatigue—are becoming more common among employees, resulting in longer-term sick leave and workforce attrition (Tóth & Solymosi-Szekeres 2023). Continuous stress and burnout threaten not only the well-being of the individual, but also the operational stability of the company (Zapf et al 1996). All this increases corporate health care costs and social security contributions, while reducing the number of productive working hours.

According to an EU survey (Eurofound 2010; Szabó 2018), 50-60 percent of days lost due to illness can be attributed to workplace stress. According to a survey by the European Agency for Safety and Health at Work, €136 billion (1 % of GDP) is lost annually in the EU, of which HUF 440 billion is lost in Hungary due to production losses caused by untreated workplace stress.

This causes problems and can mean additional costs for employers, who have to find replacements for absent workers and ensure continuity of work.

Another serious consequence of excessive workplace stress is *large-scale labor migration.* New employees must be found to replace those who leave, and of course, they must be trained, which entails high costs, damages the company's external reputation, and undermines cooperation among employees. (Szabó & Juhász 2019)

Mobbing is not only an ethical or labor issue, but also *a serious economic risk* that undermines the company's competitiveness, reduces operational efficiency, and causes long-term reputational damage. It is the responsibility of management to recognize and address the signs of mobbing, as prevention is essential not only from a human rights perspective but also from a business strategy perspective.

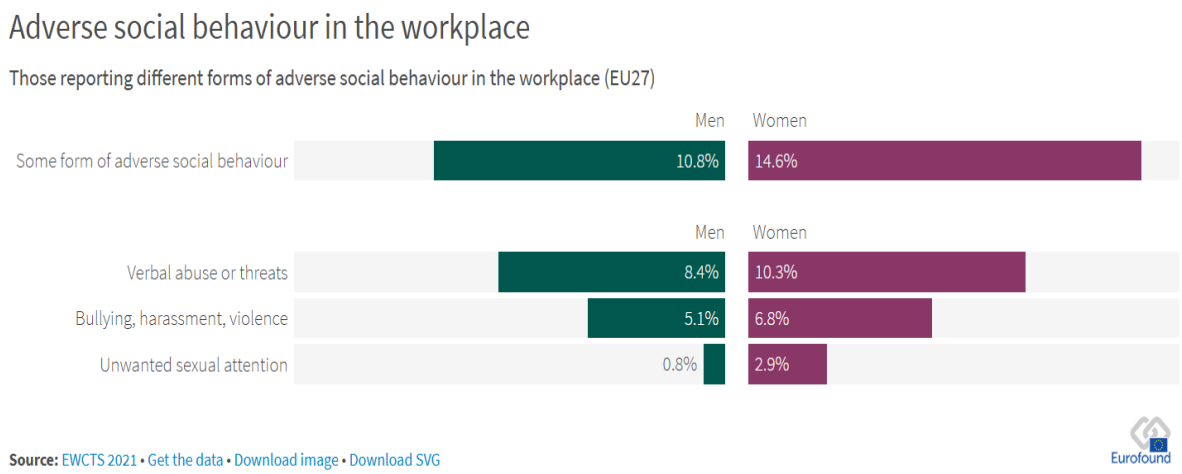

Figure 1. Negative social behaviors in the workplace
Source: Eurofound (2023)

The role of management in preventing and dealing with mobbing

Management plays a key role in preventing, recognizing, and dealing with workplace bullying. Managers are responsible not only for managing organizational performance but also for creating a supportive corporate culture that encourages employee cooperation and innovation and ensures dignified working conditions (Czifra & Csukonyi 2024).

Workplace bullying and toxic leadership directly threaten corporate competitiveness. Managerial behavior fundamentally influences whether an organization is able to retain talented employees, encourage innovation, and achieve long-term sustainable growth.
Areas of management responsibility:

- *Creating a supportive corporate culture:* Managers must create an organizational environment that minimizes the risk of mobbing and promotes a healthy workplace atmosphere (Tóth & Solymosi-Szekeres 2023).
- *Defining ethical standards and behavioral expectations:* Clear ethical guidelines and behavioral norms contribute to the prevention of toxic behavior and the maintenance of a positive organizational culture (Czifra & Csukonyi 2024).
- *Applying effective conflict management strategies:* Early recognition and appropriate management of conflicts are key to preventing further escalation of mobbing.
- *Proactive action against mobbing:* The active involvement of managers in recognizing and managing harassment prevents staff turnover, reduces human resource costs, and maintains the organizational knowledge base.
- *Ensuring employee well-being and commitment:* Protecting the mental health of employees and strengthening their long-term commitment is necessary for a sustainable competitive advantage (Maxwell 2015).
- *Regularly measuring the workplace atmosphere:* Regular monitoring of the organizational atmosphere allows for the early detection of toxic behavior and the development of targeted interventions (Czifra & Csukonyi 2024).

- *Strengthening HR processes:* The treatment of employees should be treated as a priority in the processes of leadership selection, performance evaluation, and leadership development in order to filter out toxic leaders (Kusy & Holloway 2009).

The relationship between toxic leadership and mobbing

Toxic leadership is a significant risk factor in the development and persistence of workplace mobbing. Toxic leaders typically exhibit unpredictable behavior, set unrealistic expectations for their subordinates, and are prone to intimidation, shifting responsibility, and refusing to cooperate (Padilla, Hogan, & Kaiser 2007; Czifra & Csukonyi 2024). These behavioral patterns destabilize employee communities, weaken organizational cohesion, and provide fertile ground for various forms of mobbing.

According to Padilla et al. (2007)'s "toxic triangle" theory, destructive leadership flourishes when three conditions are met: the presence of a destructive leader, the existence of susceptible followers, and a favorable organizational environment (with weak control mechanisms and a sense of threat). In unstable market environments and performance-oriented organizational cultures—where performance is placed above all else—toxic leadership is often not only tolerated but even covertly encouraged (Maxwell 2015).

Patterns that support toxic functioning can also appear at the level of organizational structures. Kusy and Holloway (2009) found that if an organization does not sanction toxic behavior, and even rewards destructive leaders who focus on results with career support or promotion, toxicity can become embedded at the systemic level. In this case, toxic norms are not limited to individual leaders but become widespread, seriously damaging the organizational culture, innovation capacity, and long-term competitiveness.

Toxic behavior tolerated by the organization can lead to uncertainty, fear, and weakened employee loyalty. This indirectly contributes to increased turnover, decreased productivity, and damage to the employer brand, which ultimately generates economic losses. The spiral of mobbing that results from toxic leadership is not only a series of individual tragedies, but can also cause measurable performance deterioration, cost increases, and loss of market position at the organizational level.

In light of this, leadership selection, performance evaluation systems, and corporate ethical regulations play a particularly important role in preventing toxic behavior. It is the task of management to measure and evaluate leadership effectiveness not only in terms of financial indicators, but also in terms of how people are treated and how they align with organizational values.

The “Management Intervention Model for Addressing Workplace Mobbing” illustrates a multidimensional framework that positions managerial responsibility at the center of organizational efforts to prevent and mitigate workplace harassment. The model conceptualizes mobbing not as an isolated interpersonal issue, but as a systemic organizational challenge that requires coordinated managerial action across several interconnected domains. At the core of the framework lies *Management Responsibility*, emphasizing that leaders hold the primary mandate

to shape organizational norms, allocate resources, and establish the conditions necessary for psychological safety.

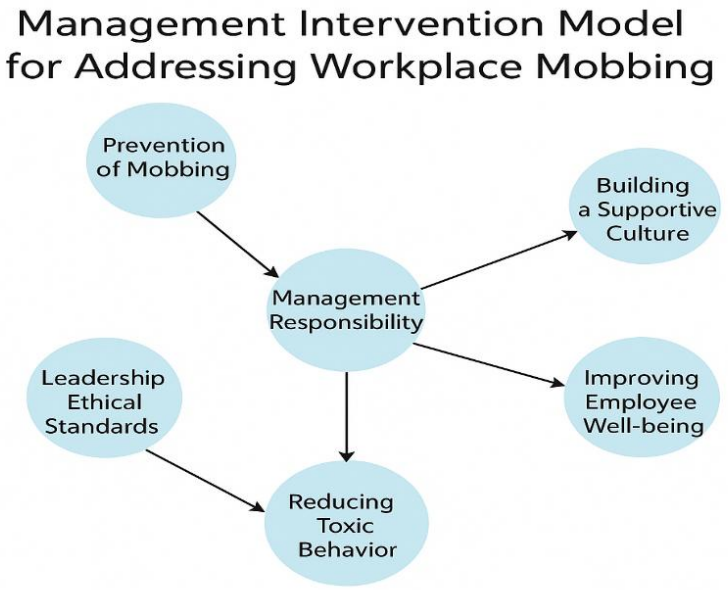

Figure 2. Management intervention model for dealing with mobbing
Source: own compilation

One critical component of this leadership responsibility involves the *Prevention of Mobbing*, which highlights the importance of proactive strategies such as awareness-raising, early detection mechanisms, and continuous monitoring of workplace dynamics. By implementing structured conflict-management processes, managers can intervene before harmful behaviors escalate into persistent harassment. Closely linked to prevention is the establishment of *Leadership Ethical Standards*, which underscores that leaders must model integrity, fairness, and respect. Ethical leadership functions as a normative anchor, reinforcing behavioral expectations and reducing tolerance for toxic interactions.

The model also incorporates the importance of *building a Supportive Culture,* recognizing that organizational climate significantly influences the likelihood of mobbing emerging. A culture that values trust, cooperation, and open communication enhances psychological safety and discourages exclusionary or aggressive behaviors. This cultural dimension is complemented by *Improving Employee Well-being,* reflecting the understanding that supportive working conditions, access to assistance, and attention to psychosocial risk factors contribute to employee resilience and reduce vulnerability to harassment.

Finally, the model presents *Reducing Toxic Behavior* as a direct managerial obligation. This includes corrective actions, accountability mechanisms, and the consistent enforcement of organizational norms. By addressing toxic behavior decisively, leaders not only protect individual employees but also strengthen long-term organizational health and performance. Overall, the model demonstrates that effective mobbing prevention requires an integrated managerial approach,

where ethical leadership, supportive culture, and employee well-being mutually reinforce one another within a coherent intervention system.

Legal framework

The legal framework surrounding workplace mobbing within the European Union establishes clear obligations for employers and confirms that the protection of employee dignity is not only an ethical expectation but a legally enforceable requirement. The cornerstone of this framework is Council Directive 89/391/EEC, which sets out the fundamental principle that every employee has the right to safe and healthy working conditions that respect their human dignity. This directive obliges employers to implement preventive measures, continuously assess psychosocial risks, and ensure that the organizational environment does not expose workers to physical or psychological harm. Although the directive does not explicitly use the term "mobbing," the jurisprudence and interpretation of occupational safety regulations increasingly encompass psychological harassment as a form of risk to health and safety.

Recent scholarship further reinforces this stance, highlighting that employers bear direct responsibility for preventing, identifying, and addressing workplace harassment. Tóth- Solymosi - Szekeres (2023) emphasizes that the duty of care embedded in EU and national legislation extends to all forms of psychosocial hazards, including mobbing. Their analysis shows that failure to act against harassment may result not only in internal organizational consequences but also in legal liability. Similarly, Bányai et al (2016) underline that the employer's obligation to provide a safe work environment includes the establishment of transparent reporting mechanisms, the investigation of complaints, and the implementation of targeted preventive strategies.

In this regulatory context, mobbing is increasingly understood as a violation of both occupational safety norms and fundamental rights connected to human dignity. As a result, member states' legal systems—through labour codes, equal treatment acts, and occupational health and safety regulations—are progressively tightening their requirements for employers. Consequently, organizations must incorporate anti-harassment measures into their governance systems, risk assessments, and HR policies, ensuring that legal compliance, employee well-being, and organizational responsibility form an integrated framework.

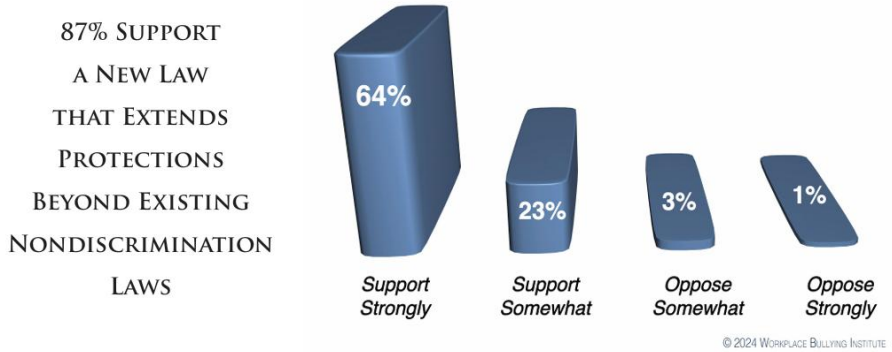

Figure 3. Need for new legislation
Source: Workplace Bullying Institute

Conclusions

Workplace mobbing threatens corporate competitiveness in complex ways, through direct and indirect mechanisms. Declining employee commitment, increased employee turnover, damage to the employer's brand, and a decline in innovation capacity can all be direct consequences of persistent psychological abuse in the workplace (Czifra & Csukonyi 2024; Nielsen & Einarsen 2012).

Management plays a key role in preventing and effectively managing mobbing. Proactive leadership behavior should include the development of a supportive, trust-based corporate culture in which open communication, cooperation, and ethical behavior are core values (Einarsen et al 2011). The use of effective conflict management strategies, regular monitoring of the organizational climate, and protection of employee well-being all contribute to the prevention of mobbing.

Recognizing and addressing toxic leadership is also essential to mitigating the negative effects of mobbing. The presence of toxic leaders not only undermines the health and performance of individual employees, but also jeopardizes the overall functioning of the organization in the long term (Padilla, Hogan, & Kaiser 2007). Leadership selection and performance appraisal systems should be able to filter out toxic behavior patterns and encourage supportive, inclusive leadership practices.

Effective action against workplace bullying is not only an ethical and legal obligation, but can also bring significant economic benefits to the organization. Reducing turnover, reducing sick leave, increasing productivity, and creating a positive employer brand all contribute to maintaining long-term competitiveness. A strategic approach to human resources management thus becomes an essential factor in ensuring sustainable organizational success.
Overall, it can be said that the prevention and management of mobbing is not only a human resources issue, but also an economic and strategic priority for modern companies.

Recommendations for further research

Future research should explore in more detail the specific effects of different forms of mobbing (e.g., cyberbullying) on competitiveness, as well as the characteristics of mobbing in different industries and company sizes, and their implications for competitiveness. In addition, the development and impact assessment of effective organizational interventions and prevention strategies against mobbing may also be an important area for further research.

In summary, *management plays a key role in preventing and addressing workplace bullying.* This includes fostering an *ethical and supportive culture, recognizing and addressing toxic behavior***,** and implementing *HR processes* that promote a positive atmosphere. Mobbing seriously *damages a company's competitiveness* by reducing productivity, increasing turnover, and damaging the employer brand. Effective management action is essential for sustainable success.

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Evolution of Motivations for Engaging Management Consulting Services in Northeast Hungary, 2001-2025

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Abstract: The initial quarter-century of the new millennium has been characterized by substantial transformations, including Hungary's accession to the European Union in 2004, the global financial crisis of 2008, the COVID-19 pandemic from 2020-2022, and the subsequent protracted Russo-Ukrainian conflict coupled with an energy crisis. These events have profoundly reshaped the economic landscape, exerting significant influence across all business entities. This study aims to investigate the evolving external and internal drivers for engaging management consulting services. The analysis will be based on questionnaire surveys administered to clients in 2001 and 2005-06, semi-structured in-depth interviews conducted in 2011-12 and 2015-16, as well as in 2020-21, and the preliminary findings from empirical research initiated in 2025.

Keywords: management consulting, drivers for engagement, Northeast Hungary, empirical research
JEL code: L84, M53, O15

Introduction: Definition of management consulting

Management consulting is a discipline focused on generating organizational value through the application of specialized knowledge, techniques, and tools. The nomenclature of the consulting profession exhibits considerable heterogeneity within both domestic and international academic discourse, with a multiplicity of conceptualizations and definitions prevailing (Tokár-Szadai 2012). This study, along with its foundational empirical investigations (Tokár-Szadai, 2022), adopts the framework proposed by Kubr, whose definition posits management consulting as: an independent, expert service provided to organizations and their leaders with the aim of helping organizations achieve their goals, identify and solve problems, seek out and exploit new opportunities, acquire the necessary knowledge, and implement changes (Kubr 2002, 10). This perspective underscores the pivotal role of consultants in furnishing information and expertise, thereby mitigating uncertainty during the processes of decision-making and implementation.

Drawing upon prior scholarly work (Glückler-Armbrüster, 2003; Mitchell-Moutinho-Lewis, 2003), the process of consultant selection and engagement is characterized by three principal forms of uncertainty (Pemer-Werr, 2013):

- Performance Uncertainty: This pertains to the client's difficulty in ascertaining expected outcomes, differentiating between competent and incompetent consultants, and forecasting the professional credentials and long-term viability of a consulting firm (Glückler-Armbrüster, 2003).
- Relational Uncertainty: Acknowledged by various researchers (Maister, 2003; Sturdy, 1997), this dimension involves client apprehension regarding the extent to which consultants will prioritize client interests over their own.
- Psychosocial Uncertainty: The engagement of an external consultant to achieve organizational objectives can engender apprehension and skepticism among internal stakeholders (Bergholz, 1999). This can manifest as employee resistance to collaboration, information withholding, and cynicism, all of which may compromise project success (Mitchell, 1994).

Effective mitigation of these uncertainties necessitates that managers embrace and advocate for the utilization of consultants among themselves and their teams (Bäcklund – Werr, 2008).

Management consulting encompasses a broader domain than traditionally defined management disciplines. Professional organizations advocate for a multifaceted understanding of the field. The evolving and expanding client requirements continually broaden the scope of consulting activities, leading to a concurrent shift in their strategic focus. Table 1 presents the current categorization system of the European Federation of Management Consultancies Associations (FEACO), established in 2014, which reflects contemporary changes and trends observed within the consulting market.

Table 1. Service lines of management consulting from 2014 based on the FEACO classification system

Strategy consulting - Strategy development and planning - Business planning and modelling - Market analysis - Governance of major organization redesigns (including company-wide transformation, restructuring programmes, strategic advice in major financial transactions)	**People and change consulting** - Human resource consulting, change management - Improvement of the people 'element' of an organisation (through HR strategies performance measurement, benefits, compensations and retirement schemes) - Talent development programmes - Executive coaching
Operations consulting - Business Process Reengineering (BPR) - Cosstumer/supplier Relations Management (CRM) - Turnaround/cost reduction - Purchasing/supply management (manufacturing, R&D, product development and logistics)	**Technology consulting** - IT strategy consulting - Strategic support to decisions related to the planning and implementation of new technologies for business applications, including IT Network & Security and Data Centre architecture.
Sales and marketing consulting - Sales and marketing consulting, - Sales and channel management, - Product portfolio management and branding, - Digital marketing	**Finance and risk management consulting** - Support organisations in analysing and redefining their planning, budgeting and performance management models; - Support organisations in improving their capabilities in measuring and optimising enterprise risks (credit, market, operational, environmental, quality etc.) - Support addressing regulatory requirements and developing compliance management.
Other management consulting - Outsourcing - Other professional consulting	

Source: FEACO 2014-2024 https://www.feaco.org/consulting-in-europe/annual-survey/

Vogelsang (1992) posits that management consulting is a complex undertaking, characterizing this all-encompassing practice as 'Universalberatung', which translates to universal consulting.

Empirical research

The empirical investigation was conducted in two phases. The initial phase, undertaken in 2001 and between 2005 and 2006, employed a questionnaire survey methodology. Subsequently, from 2011 to 2012, 2015 to 2016, and 2020 to 2021, the research utilized semi-structured in-depth interviews. The current empirical research, commencing in early 2025 and scheduled for completion in 2025-26, is in its preliminary stages, with only initial findings currently available. The questionnaires and question frameworks underpinning this research were developed with reference to instruments employed in prior international studies. During their construction, emphasis was placed on ensuring that each thematic area was addressed from multiple perspectives to enhance the reliability of derived conclusions. The empirical investigation comprised two distinct components, as illustrated in Figure 1.

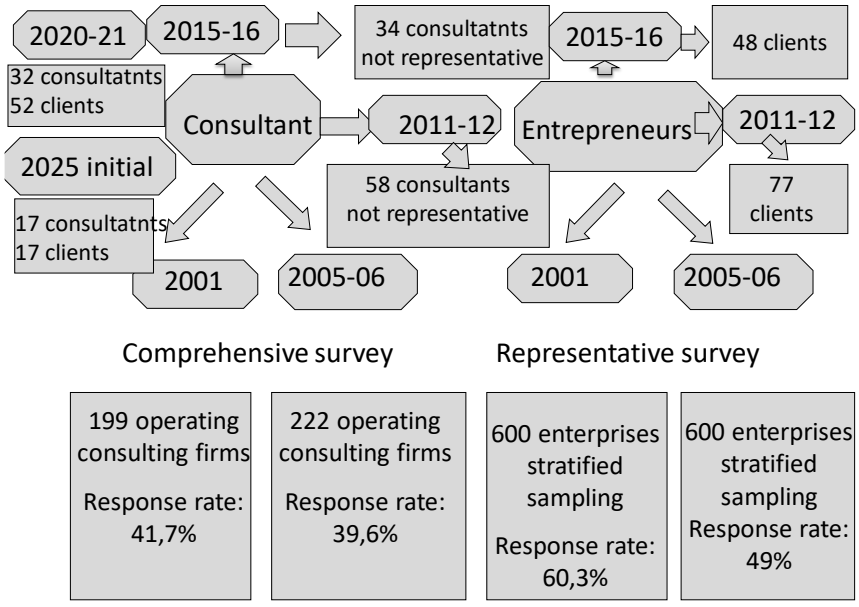

Figure 1. Structure of empirical studies
Source: Author's own work

The research undertaken in 2001 and during the period 2005-06 comprised two distinct components. The first component involved a survey of operational businesses within Borsod-Abaúj-Zemplén County to ascertain their engagement with consulting services. Companies were selected from activity-based registers, with geographical distribution and activity proportions being key considerations, employing a simple random sampling methodology. In 2001, 362 usable questionnaires were collected, followed by 294 in the 2005-06 period. (The response rates were 60.3% in 2001 and 49% in 2005-06.) While non-returned questionnaires may have led to a slight underrepresentation of service-sector businesses and a minor overrepresentation of industry and trade sectors in 2005, these variations were not statistically significant and closely mirrored the overall county ratios.

The second component of the research focused on consulting firms themselves. In 2001 and 2005, a comprehensive survey was administered to all consulting companies registered under TEÁOR code 7414 (using the TEAOR'03 classification) and situated within Borsod-Abaúj-Zemplén County. The number of consulting firms operating in the county was recorded as 199 in December 2000 and 222 in 2005. All these entities were contacted. In 2001, 83 consulting firms responded to the questionnaire, and in the 2005-06 period, 88 firms participated. The response rate for consulting firms was lower than that of the surveyed businesses, approximating 40% (specifically 41.7% in 2001 and 39.6% in 2005-06).

During the academic years 2011-12, 2015-16, and 2020-21, as well as in 2025, the selection of consultants and their respective clients was conducted through a non-probabilistic sampling technique, specifically the 'snowball' method (ELTE 2025). This methodology involved the initially selected consultants identifying and recruiting their clients, who in turn facilitated the inclusion of other companies and their associated consultants within the survey. Consequently, this approach enabled a comparative analysis of consultant self-perception, including their competencies and the outcomes of their work, in contrast to client evaluations of these same consultants. Furthermore, the process aimed to identify any disparities and their underlying causative factors. The participating companies (clients) encompassed a diverse range of industrial sectors, as depicted in Figure 2.

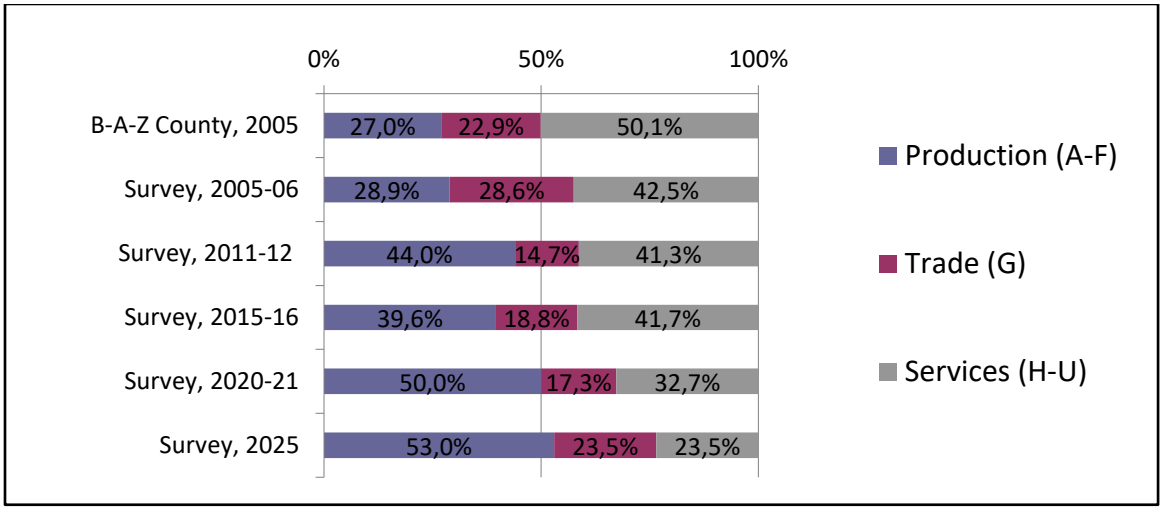

Figure 2. Distribution of the companies surveyed (customers) by main activity (%) (2005-06, 2011-12, 2015-16, 2020-21, 2025)
Source: Author's own work

Companies were categorized as consultants if they offered business management and management consulting services, as defined by TEÁOR'08. The primary activity classification was not a mandatory criterion; however, in-depth interviews were conducted with individuals providing consulting services. Regarding geographical scope, a singular criterion was applied: either the consultant or their client was required to be located within the northeastern Hungarian region, specifically within the counties of Borsod-Abaúj-Zemplén, Heves, Nógrád, Szabolcs-Szatmár-Bereg, or Hajdú-Bihar. The entrepreneurs and their consultants engaged in the semi-structured in-depth interview research predominantly hailed from Borsod-Abaúj-Zemplén county (as depicted in Figure 3).

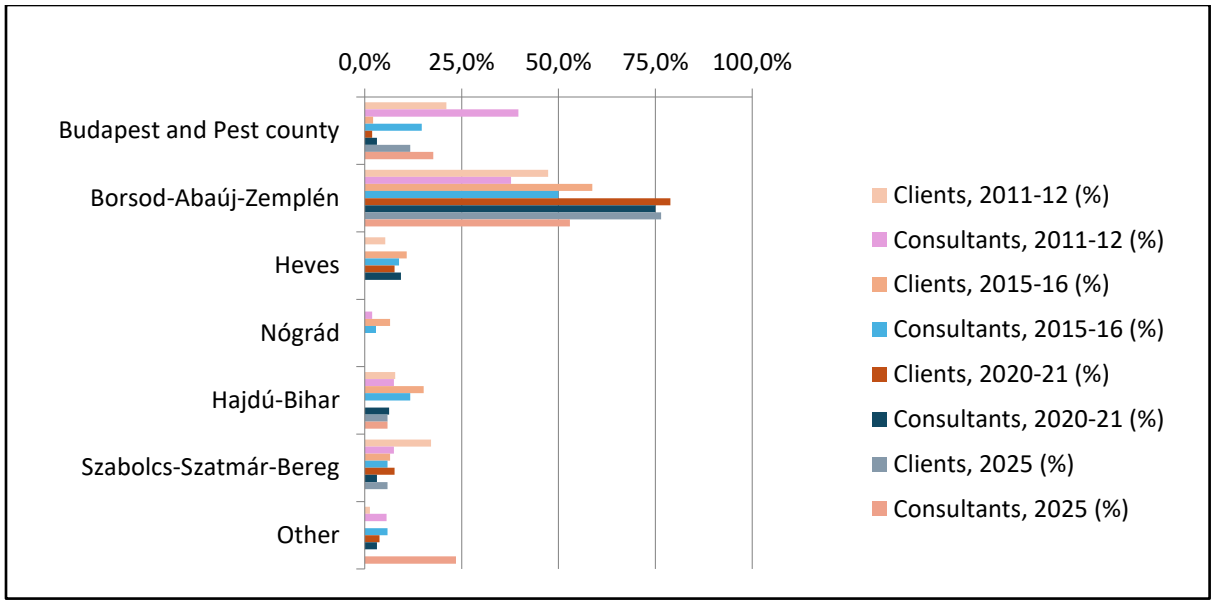

Figure 3. Distribution of consultants and their clients by location (%) 2011-2012, 2015-16, 2020-21, 2025

Source: Author's own work

During the 2020-2021 period, in response to the exigencies imposed by pandemic-related restrictions, semi-structured, in-depth interviews were administered remotely via Zoom and Skype. These interviews involved 32 consultants and 52 clients. As of early 2025, in-person interviews were conducted with 9 consultants and 9 clients, while 8 consultants and 8 clients participated in online interviews. While complete comparability with prior surveys is not definitively assured, discernible trends can be extrapolated. Figure 4 delineates the demographic composition of the surveyed client sample with respect to company size.

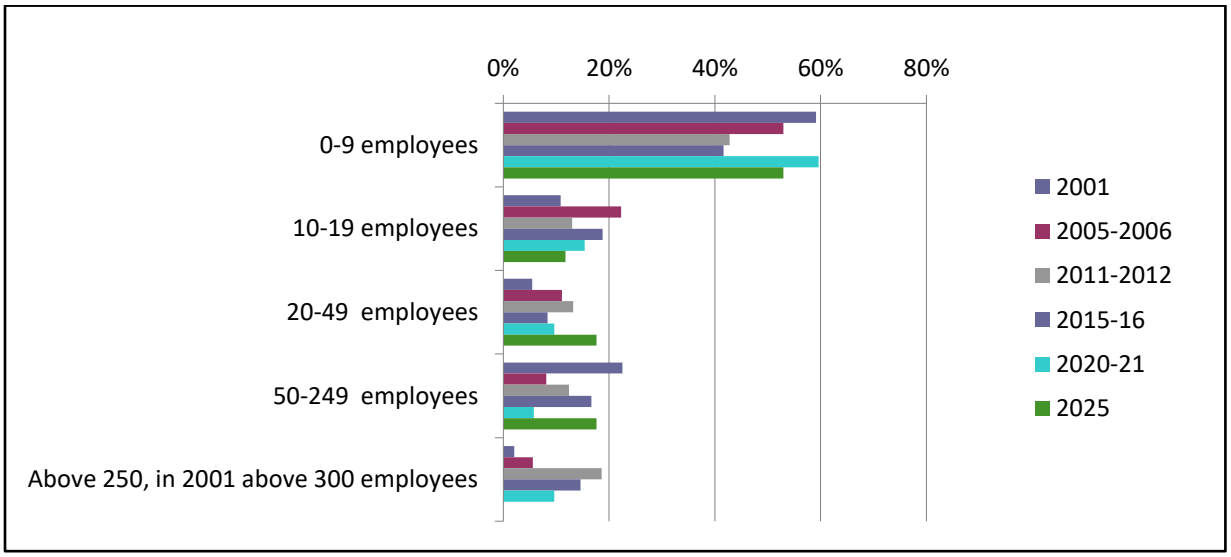

Figure 4. Distribution of survey-participating consultants by employee count across selected years: 2001, 2005-2006, 2011-2012, 2015-2016, 2020-2021, and projected for 2025.

Source: Author's own work

The propensity to complete the questionnaire was markedly higher in larger enterprises, leading to their disproportionate representation across all sampled groups. To enhance evaluability, a deliberate deviation from achieving representativeness by size category was undertaken in 2001 and 2005-06. This decision was predicated on the observation that larger companies possessed greater financial capacity and a higher disposition to utilize the service. Consequently, their overrepresentation was deemed justified, reflecting their more extensive experience within the domain. In the survey periods of 2011-12, 2015-16, 2020-21, and early 2025, the sampling was restricted to clients of selected consultants, which predictably resulted in a significant overrepresentation of larger companies. While the surveyed entities encompass all size categories within the completed questionnaires (with a notable absence of large companies in the 2025 data), Figure 4 illustrates that micro-enterprises constituted the principal participants in all six survey iterations.

Data derived from the questionnaires were processed utilizing the SPSS 30.0 statistical software package. The analytical procedures employed included cross-tabulation (independence testing), analysis of variance, and correlation analysis, with a significance level of 5% adopted in accordance with conventions within social science research. In order to facilitate comparison with prior questionnaire surveys, the structure of questions posed during in-depth interviews mirrored that of previous questionnaires. However, these interviews afforded respondents a greater opportunity to articulate their perspectives comprehensively on each inquiry. The evaluation of the in-depth interviews was conducted through text analysis.

External reasons for using management consulting services

The rationale for engaging consultants can be categorized based on their genesis. A subset of these justifications originates from the external environment, imposing constraints upon organizations:

- Legal Mandate: The engagement of consultants may be stipulated by legal requirements, as observed in scenarios such as the appointment of an asset supervisor during bankruptcy proceedings, a liquidator in dissolution processes, or for the auditing of corporate financial statements.
- External Stakeholder Influence: External entities, including financial institutions such as banks or international organizations providing project financing, may recommend or necessitate the involvement of independent consultants as a prerequisite for future contractual agreements.
- Organizational Capacity Limitations: Enterprises may lack the requisite internal capacity to execute all necessary functions, thereby compelling the utilization of external expertise.

Figure 5 illustrates the external circumstances that motivated the engagement of management consultants, as perceived by entrepreneurs who utilized such services.

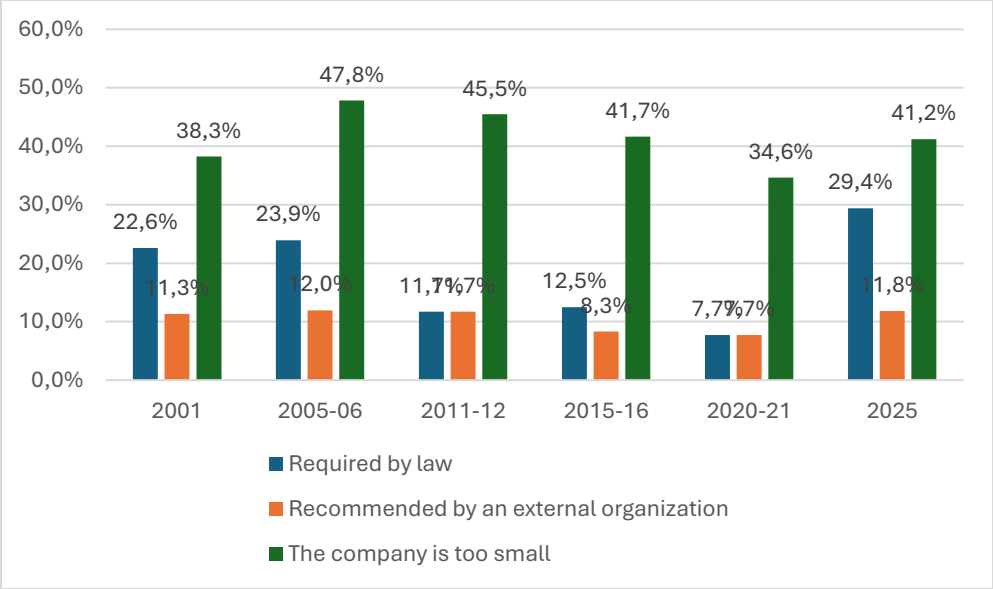

Figure 5. External reasons for using consulting services, as a percentage of companies that used the service
Source: Author's own work

According to the survey data, organizational size[8] has consistently emerged as the predominant determinant for the engagement of consulting services across all observed data collection intervals over the preceding quarter-century. Small and medium-sized enterprises (SMEs) are increasingly dependent on specialized expertise in various domains, including but not limited to finance, law, and marketing. The acquisition and retention of such expertise on a permanent basis are often untenable for these entities, necessitating its procurement on a temporary, task-specific foundation. Notably, over one-third of the surveyed firms indicated that this attribute significantly influenced their decision-making process regarding the utilization of external consulting support.

In 2001, legal requirements constituted 22.6% of stated reasons for clients utilizing services; however, this factor has significantly diminished in importance over the past two decades, accounting for only 7.7% of cited reasons in 2020-21. Auditing is traditionally considered distinct from consulting activities. Nonetheless, empirical evidence from recent decades indicates a frequent intermingling of these two functions, particularly within large auditing firms. For instance, around the turn of the millennium, the U.S. Securities and Exchange Commission (SEC) identified 8,000 instances at PriceWaterhouseCoopers (PwC) where firm employees and partners held equity in companies for which PwC served as the auditor (Kurcz A, 2000). This revelation prompted the divestiture of consulting divisions from major auditing firms, aiming to safeguard the impartiality of audit assessments by preventing them from being evaluated by individuals who might lack objectivity. Following the abatement of significant consulting and auditing scandals in the early 2000s, these firms gradually reintegrated consulting services into their offerings towards the end of the decade. These services are now provided in a non-audit capacity, with the endorsement of their respective audit committees, generating billions of dollars in consulting revenue (Gross A. C – Poór J, 2008).

[8] Within defined parameters, a company's size may be regarded as a constant attribute, subject to incremental expansion.

Preliminary findings from our most recent survey indicate a substantial rise in individuals seeking counsel for legally mandated purposes over the preceding five-year period. As of early 2025, over one-third of surveyed clients identified this as a contributing factor. It is crucial to acknowledge that these are provisional results, and the reliability of the data pertaining to this specific area is currently low, precluding the derivation of broad generalizations. Furthermore, this same factor emerged as the most prevalent reason within the other category among participants in our in-depth interviews conducted in 2025. Several interviewees specifically highlighted the dynamic nature of legislative amendments as the primary impetus for their need to seek professional advice.

Internal reasons for using management consulting services

A further contributing factor to these general reasons is observed in the internal motivations of organizations that leverage the specialized expertise and attributes of external consultants to enhance their competitive standing.

- An external consultant offers objectivity and is not susceptible to operational blindness. Prior to making a decision, it is judicious to subject proposed concepts to external scrutiny and solicit an impartial evaluation from a consultant.
- The consultant possess specialized knowledge, acquiring information from a specialist advisor that would incur significantly higher costs and diminished efficacy if obtained through internal resources.
- The scarcity of qualified corporate specialists for decision-making and the execution of corporate actions or projects, coupled with the limited resources of small businesses that preclude independent project undertaking, necessitates the engagement of external expertise.
- The utilization of external consultants can facilitate the mitigation of persistent temporal constraints.
- Consulting serves as a crucial nexus between theoretical knowledge and practical application, facilitating the corporate integration of novel scientific discoveries.
- An experienced, independent consultant can facilitate the identification of root causes of organizational challenges (Németh-Papp 1995).
- The contemporary business landscape, characterized by deregulation, globalization, and rapid technological advancement, presents a complexity that precludes any single entity from possessing the comprehensive information and expertise requisite for achieving and sustaining competitive advantage.

This approach is corroborated by McKinsey (Bower, 1982), who articulate the utilization of consultants based on the following six contributing factors:

- Consultants possess expertise that the client organization lacks.
- They are privy to methodologies that have demonstrated efficacy in other contexts.
- They allocate adequate temporal resources to the rigorous examination of the issue at hand.
- They possess relevant professional qualifications and experience.
- They maintain objectivity and impartiality.
- They are capable of devising actionable strategies that promote the successful adoption of their recommendations.

Figure 6 illustrates the internal motivational drivers for engaging management consultants, as articulated by entrepreneurs who have utilized their services.

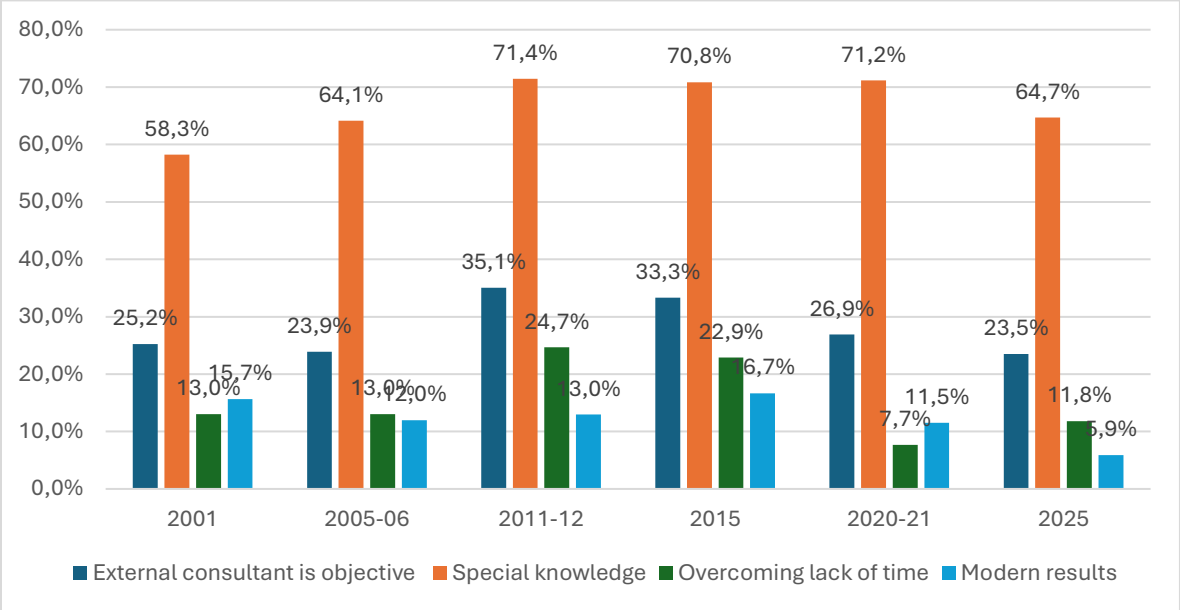

Figure 6. Internal motivations for using consulting services, as a percentage of companies that used the service

Source: Author's own work

The predominant factor motivating entrepreneurs to engage consultants lies in their specialized knowledge and experience. It is economically more advantageous to procure the services of a specialized external consultant than to maintain full-time personnel for specific tasks. The significance of consultants' specialized expertise demonstrated a consistent upward trend throughout the initial decade of the study. Specifically, in 2001, over half of entrepreneurs utilizing consultancy services cited specialized knowledge as the primary reason. This proportion increased to two-thirds in the 2005-06 period, and by 2011-12, nearly three-quarters of entrepreneurs indicated that specialized knowledge was their primary driver for seeking external assistance. During the second decade of the study, this trend plateaued before experiencing a decline in the latter five years. Nevertheless, based on preliminary findings from early 2025, specialized knowledge remains the foremost rationale for engaging consultants, with approximately two-thirds of surveyed consultants highlighting its importance during in-depth interviews.

The paramount characteristic of consultancy is independence. Consultants are obligated to furnish unbiased support across all scenarios, to articulate truths candidly, and to formulate recommendations that are both honest and objective, irrespective of any potential repercussions on their personal interests. The impartiality afforded by external consultants represents a significant impetus for clients engaging their services, having been identified as the second most crucial determinant for service utilization over the examined two-and-a-half-decade period. The perceived importance of this attribute saw an ascent in the initial decade of the study, reached a plateau in the mid-second decade, and subsequently experienced a marginal decrement. In the 2011-2012 period, over a third of clients cited objectivity as their motivation for seeking external

consultation. Furthermore, during and in the aftermath of the COVID-19 pandemic, approximately a quarter of respondents reiterated this rationale.

The third most significant rationale cited pertained to the mitigation of temporal limitations. The prominence of this factor ascended during the initial decade of the survey, with one quarter of entrepreneurs referencing it in 2011-12. This was followed by a period of stasis in the mid-decade, culminating in a subsequent decrease. Consequently, it is unsurprising that during the periods of lockdown and remote work necessitated by the COVID-19 pandemic, temporal constraints did not present a challenge.

A survey indicated that between 12% and 16% of the clientele engage consultants to implement novel, cutting-edge scientific discoveries. Notably, in the aftermath of the 2008 global economic crisis, the proportion of clients prioritizing innovation and perceiving consultants as a valuable resource remained consistent, notwithstanding prevailing adverse conditions. However, a discernible reduction in this trend has been observed during and subsequent to the COVID-19 pandemic. This decline is attributable to the energy crisis and economic volatility engendered by the conflict between Russia and Ukraine. (It is important to acknowledge that the data for 2025 is preliminary, possessing a low degree of reliability, and should therefore be interpreted as indicative rather than definitive.)

Special reasons depending on the general economic situation

Historically, the prevailing perspective, established through observations by the American Society of Consulting Engineers (Poór, 2005), posited that the consulting industry exhibits resilience against economic volatility. Analysis of long-term business trends indicated that client demand for consultants stemmed from two primary drivers:

- During periods of economic expansion, organizations typically possess the financial capacity to procure external knowledge and resources, as well as to engage consulting services. Concurrently, consultants can assist these firms in strategic capital allocation, which may substantially influence the growth of their consulting engagements.
- During periods of economic downturn and crisis, numerous corporations, organizations, and institutions engage consultants with the objective of achieving cost reductions. This strategic imperative aims to ensure organizational viability and to secure the financial resources necessary for subsequent investment and development upon economic recovery, thereby facilitating sustained competitiveness (Kelley, 1986).

Figure 7 depicts the temporal evolution of Gross Domestic Product (GDP) alongside the growth of consulting turnover from 1998 to 2023.

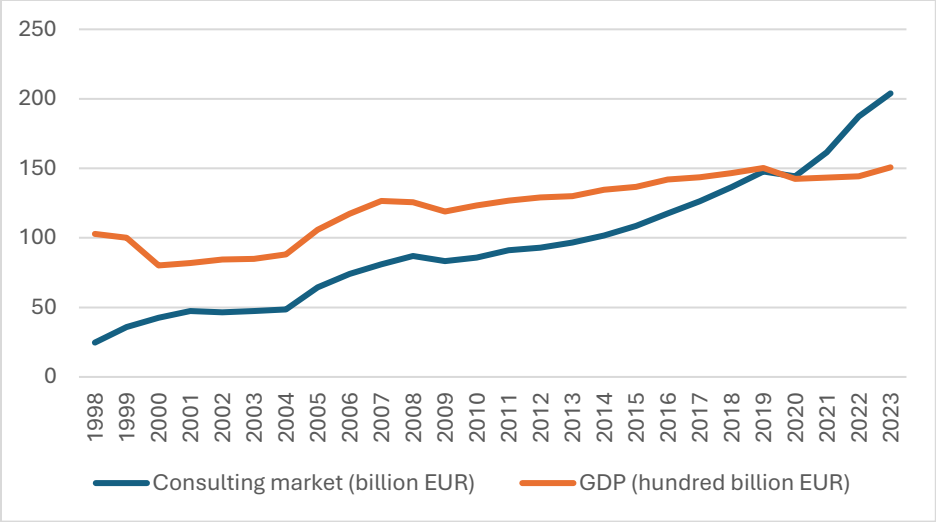

Figure 7. Volume of the European consulting market and GDP between 1998 and 2023
Source: Author's own work based on FEACO Survey of the Management Consultancy market 1998-2024

Results of a correlation analysis based on FEACO data from 1998 to 2023: there is a strong positive correlation between GDP and European consulting turnover (r=0.876 p=0.0)[9], therefore, FEACO's surveys of the consulting market do not support the above hypothesis. The economic situation does indeed have a positive effect on the demand for consulting services, but the impact of recession is negative: less money is spent on consulting.

A notable anomaly emerged at the commencement of the 2020s. Data indicates that during the COVID-19 pandemic-induced restrictions, a contraction and stagnation in Gross Domestic Product (GDP) did not correlate with a commensurate decline in the demand for consulting services. Specifically, following a 2.2% reduction in European consulting turnover in 2020, the subsequent period from 2021 to 2024 witnessed annual turnover growth ranging from 7% to 16% (FEACO 2025). The implementation of pandemic restrictions and the widespread adoption of remote work arrangements precipitated a significant demand for online consulting, a modality previously considered feasible only within a severely constrained scope.

Summary

The findings indicate that the motivations for engaging consulting services have remained largely unchanged over the examined two-and-a-half-decade period. The primary driver for entrepreneurs seeking external consultancy is the specialized knowledge and experience offered by consultants. Our survey data reveals that over two-thirds of entrepreneurs utilizing consulting services identified specialized knowledge as a significant factor in their decision-making process. Furthermore, engaging a specialized external consultant is often more cost-effective than retaining full-time employees for the same activities. The significance of company size as a rationale for engaging consultancy services is particularly pronounced among smaller enterprises. Survey data

[9] Pearson correlation (GDP-consulting turnover)=0.876 P=0.0 There is a 100% reliable correlation (strong, positive) between the two variables.

indicates that firm size constitutes the second most influential factor driving the decision to hire a consultant. This trend is attributable to the expanding reliance of small and medium-sized enterprises (SMEs) on specialized expertise across various domains, including but not limited to finance, legal affairs, and marketing. Such specialized knowledge is often acquired by SMEs on a contingent basis for the execution of discrete operational tasks. Preliminary findings from our 2025 survey reveal that nearly half (41.2%) of entrepreneurs who have previously utilized consultancy services cited their business size as a primary consideration. Furthermore, 23.5% of respondents indicated that the objectivity offered by an external consultant was a contributing factor in their hiring decision. In comparison to prior survey outcomes, a notable proportion of respondents, exceeding a quarter (29.4%), highlighted in qualitative interviews that frequent legislative amendments served as the principal impetus for seeking external consultancy assistance.

A robust positive correlation exists between Gross Domestic Product (GDP) and European consulting turnover. Economic expansion demonstrably enhances the utilization of consulting services, leading to increased expenditure by a larger clientele. Conversely, economic downturns negatively impact this sector, resulting in reduced spending on external service providers. Notwithstanding these trends, the proliferation of online consulting modalities during the COVID-19 pandemic mitigated the expected decline in demand for consulting services, which was otherwise consequential to GDP contraction precipitated by restrictive measures. Consequently, substantial growth in consulting turnover was observed, with the exception of the year 2020.

It is important to acknowledge that the semi-structured in-depth interviews conducted herein are not statistically representative. Consequently, they are not amenable to the formulation of generalizable conclusions, nor can their comparability with prior representative questionnaire surveys be fully assured. Nevertheless, these interviews are valuable as exploratory research, facilitating the identification of trends and directions of change, which can subsequently inform and guide future empirical investigations.

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Integrating Sustainability into Business Modeling: Permaculture as a Regenerative Framework in Business Modeling

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Abstract: This study aims to examine the integration of sustainability and regenerative thinking into modern business modeling, with a particular focus on the limitations of the Business Model Canvas (BMC) and Lean Canvas (LC). The research uses a theoretical and conceptual approach that applies the ethical and systemic principles of permaculture to the logic of business development. The methodology is based on comparative content analysis and conceptual synthesis, with the assistance of artificial intelligence (AI). The results show that permaculture can be integrated into BMC/LC models on three levels: as a preparatory approach, as a complementary system, and as a framework for transforming into an alternative, regenerative paradigm. The study contributes to the theoretical renewal of sustainable business modeling and identifies new research directions for the development of AI-supported, ethics-based design methods.

Keywords: Sustainability, regenerative business modeling, permaculture, Business Model Canvas, Lean Canvas, systems thinking, Scales of Permanence
JEL Code: Q56, M13, O31

1. Introduction

Striking a balance between sustainability and economic viability is one of the most complex challenges of our time, both socially and economically. Traditional business modeling, particularly the Business Model Canvas (BMC; Osterwalder & Pigneur 2010) and Lean Canvas (LC; Maurya 2012), has become widely used in the toolkit of business development and innovation management in recent decades. These models primarily examine the economic pillar of sustainability, while treating the environmental and social dimensions as secondary at best (Bocken et al. 2013; Joyce & Paquin 2016). According to the most widely accepted definition, "sustainability" refers to strategies that meet present needs without compromising the opportunities of future generations. In contrast, the "regenerative" approach seeks to actively restore and enhance systems, aiming to achieve positive ecological and social impacts.

This study aims to examine the sustainability limitations of BMC and LC and to present a possibility for how they can be supplemented or transformed along the lines of system-oriented, regenerative design principles that also take into account long-term ecological and social sustainability. The study focuses on the permaculture design system (Mollison 1988; Holmgren 2002), which, based on ethical principles and the functioning patterns of natural ecosystems, offers an alternative to sustainable and regenerative economic models that can provide a model opportunity for situation analysis and development strategy formulation at both the corporate and community levels. The aim of this study is not to give a detailed description of BMC and LC, nor to empirically validate a new model; rather, it is to conduct a critical and analytical evaluation, as well as a conceptual extension, of these models. It aims to develop a theoretical and ethical framework that facilitates the integration of regenerative thinking into business modeling practices.

The research is timely because the concept of sustainability often appears in economic discourse as a tool for corporate competitiveness or as a PR tool, rather than as a goal of social and ecological regeneration (Raworth 2017; Mang & Reed 2020). In contrast, the regenerative approach follows the logic of self-sustaining systems embedded in the natural environment (Raworth 2017; Mang and Haggard 2016). This study aims to connect these two worlds - the economy-centered logic of business modeling and the holistic systems approach of permaculture - and to outline a new, integrated framework for planning sustainable and regenerative businesses.

2. Methodology

The study is based on theoretical and conceptual analysis, as well as comparative analysis, aiming to explore the possibilities of integrating sustainability and a regenerative approach into modern business models. Since the Business Model Canvas (BMC) and Lean Canvas (LC) are the most widely accepted tools for 21st-century business development and innovation, the fundamental question of the research was to what extent these models are capable of addressing the holistic dimensions of environmental and social sustainability, and how the ethical design system of permaculture can contribute to the practical application of these dimensions in business models.
The methodological basis of the research was a literature content analysis that compared the structural, conceptual, and ethical elements of the BMC and LC models with the moral and systemic principles of permaculture (Holmgren 2002; Mollison 1988). During the analysis, we examined the concept of sustainability through different approaches - weak, strong, and regenerative (Daly 1990; Elkington 1997; Raworth 2017) - to explore how permaculture can extend these models toward a regenerative economy.

The methodology consisted of three interrelated analytical steps:

1. *In the critical literature review*, we explored the theoretical foundations and sustainability constraints of the Business Model Canvas (BMC) and Lean Canvas (LC) models based on the literature (Osterwalder & Pigneur 2010; Maurya 2012; Bocken et al. 2013; Joyce & Paquin 2016, Illés, 2019).
2. *During the conceptual synthesis*, we analyzed the concept and development of sustainability based on the ideas of various scientific trends - ecological economics, regenerative design, and permaculture (Holmgren 2002; Costanza et al. 1991; Mang & Reed 2020).
3. *During system-based modeling*, we proposed mapping and integrating the ethical and design principles of permaculture and the Scales of Permanence (Yeomans 1958) into business modeling, particularly into BMC and LC structures.

During the research, we also used artificial intelligence (AI) tools to support scientific synthesis. AI-based text analysis and structuring support helped to systematize the literature sources, identify conceptual relationships, and build a coherent content structure. AI did not replace human interpretation or scientific judgment, but acted as an assistant in text creation and analysis, particularly in comparing conceptual systems, developing definition matrices, optimizing chapter structure, and translation.

The advantage of the chosen approach is that it enables the systematic coordination of the theoretical dimensions of business models, sustainability, and regeneration, offering an

interdisciplinary framework that links economic rationality with ecological and ethical considerations.

3. Literature review: Criticism of Business Model Canvas and Lean Canvas

In modern business planning and strategic management, the Business Model Canvas (BMC) and Lean Canvas (LC) have become extremely popular frameworks. The Business Model Canvas, developed by Alexander Osterwalder and Yves Pigneur (Osterwalder & Pigneur, 2010), is a strategic management tool that enables companies to visually represent, evaluate, and develop their business models using nine fundamental building blocks.

Ash Maurya's adaptation of the Lean Canvas (Maurya 2012), designed specifically for startups and innovative projects, places greater emphasis on the problem, solution, key metrics, and unfair advantage, while simplifying and accelerating the planning process. While the BMC is used to describe and analyze an existing business model comprehensively, the LC focuses on reducing uncertainty and rapid iteration, especially when introducing new products or services.
One source of Lean Canvas is the Business Model Canvas, and another is Eric Ries' book and methodology, "Lean Startup," which revolutionized the way startups are launched and developed. The term "lean" originates from the Japanese roots of "lean manufacturing" (Toyota Production System) and encompasses principles such as minimizing waste, continuous improvement, rapid experimentation, responding to customer feedback, and creating genuine value for customers. Ash Maurya has applied this "lean" approach to business model design.
The main similarities and differences between the two models are summarized in Table 1:

Table 1. Comparison matrix between Business Model Canvas and Lean Canvas

Feature	Business Model Canvas (BMC)	Lean Canvas (LC)
Origin/ Author	Alexander Osterwalder & Yves Pigneur (2010)	Ash Maurya (2012), an adaptation of BMC, was born in response to its criticism
Main purpose	Comprehensive business model design, visualization, and analysis	Rapid validation and iteration of the model for startups and innovative projects
Main focus	Business logic, value creation, delivery, and collection	Problem-solving, product-market fit, risk reduction
Target audience	Large enterprises, SMEs, consultants, strategists	Startups, innovators, product developers
Key elements	*Customer segments, Value proposition*, *Channels*, Customer relationships, Resources, Key activities, *Key partners*, *Cost structure, Revenue streams*	Problem, Solution, KPIs, Unfair advantage, *Key partners*, *Value proposition, Customer segments, Channels*, *Cost structure, Revenue streams*
Area of application	Comprehensive strategic planning, analysis of existing models, and business transformation	Development of new products/services, market entry, validation, and uncertainty minimization
Attitude	More traditional, more detailed	Rapid, iterative, "build-measure-learn" cycle

Source: Own compilation, based on Osterwalder & Pigneur (2010), Maurya (2012)

The sustainability limitations of BMC and LC

Although the Business Model Canvas (Osterwalder & Pigneur 2010) and Lean Canvas (Maurya 2012) are undeniably valuable tools for business innovation and planning, they have been criticized for their ability to integrate the environmental and social dimensions of sustainability (e.g., Bocken et al. 2013; Geissdoerfer et al. 2018; Joyce & Paquin 2016). An analysis of the scientific literature reveals that these models primarily focus on economic value creation, often at the expense of environmental and social impacts (Stubbs & Cocklin 2008).

Although some of the nine building blocks of the Business Model Canvas (e.g., "Key Partners," "Value Proposition," "Customer Relationships") may be indirectly related to environmental or social dimensions, the model fundamentally focuses on economic value creation (Joyce & Paquin 2016; Geissdoerfer et al. 2018). Accordingly, researchers argue that sustainability considerations are structurally underrepresented in the BMC, which justified the subsequent creation of the "Triple Layered Business Model Canvas" (TLBMC) (Joyce & Paquin 2016).

Underrepresentation of the environmental dimension

Several researchers (e.g., Bocken et al. 2013; Geissdoerfer et al. 2018) emphasize that BMC and LC do not explicitly incorporate environmental considerations. The "Key Resources" block primarily describes the physical, intellectual, or human capital relevant to the company. Still, it rarely addresses the origin of the resources, the method of extraction, the ecological footprint of the manufacturing process, or the environmental impact of the product life cycle. This approach ignores the concept of "natural capital" and does not encourage businesses to incorporate the principles of the circular economy (recycling, reuse, regeneration) into their business models.

It is important to note that although the "lean" philosophy behind Lean Canvas promotes the minimization of waste, this concept primarily interprets waste in terms of operational efficiency and economic value creation (e.g., unnecessary production, waiting, transportation, errors), rather than primarily from an environmental or social perspective (Womack & Jones 2003). The term "lean" and the principles behind it have their roots in the Toyota Production System (TPS). This methodology optimizes manufacturing processes and eliminates waste, primarily to improve productivity and quality (Ohno, 1988). Thus, the application of lean principles does not, in itself, guarantee environmental sustainability, but may result in certain ecological benefits as a byproduct. In addition, it is crucial to recognize that the efficiency achieved through lean principles can sometimes have unexpected consequences, such as increased resource utilization elsewhere, which can lead to additional environmental burdens. For example, energy savings in the production process may lead to increased material use in other processes, potentially offsetting the longer-term ecological benefits. This challenge can be particularly acute when designing "green" or "sustainable" business models, where environmental performance can be a key value proposition.

Shortcomings in the social dimension

The "Customer Segments" block primarily focuses on the economic value of customers, neglecting the broader range of stakeholders, including employees, suppliers, local communities, and even future generations (Upward & Jones 2016; Joyce & Paquin 2016).

The "Customer Relationships" block primarily focuses on transactional relationships, with fair labor practices, addressing social inequalities, or supporting local communities rarely or never being addressed.

BMC and LC do not generally set out explicit ethical or governance principles that are key to socially responsible corporate operations. These models do not facilitate the systematic integration of corporate social responsibility (CSR), ESG (Environmental, Social, Governance) considerations, or shared value initiatives; as a result, these dimensions often appear as optional additions rather than integral parts of the business model.

The short-term focus of the economic dimension, the neglect of regenerative sustainability, and the risk of greenwashing

Both the BMC and LC models are fundamentally optimized for profit maximization and short-term financial returns. The "Revenue Streams" and "Cost Structure" blocks focus on traditional financial metrics without considering long-term dependence on ecosystem services or social costs. This focus does not encourage businesses to review whether their business model is a net consumer of resources or capable of regeneration, i.e., producing more useful returns than are needed to operate (Holmgren 2002). Traditional models treat the concept of growth as the default, often ignoring the planet's limited resources and the inherent growth constraints of sustainable economic systems.

This shortcoming also creates the risk of greenwashing. Since BMC and LC do not enforce deep environmental and social responsibility within their business models, companies can easily apply these tools without making real and significant changes to their sustainability performance. As a result, they can present their business models as "green" to the market, while their core operations continue to harm the environment or exacerbate social inequalities (Lyon & Montgomery 2015). The phenomenon of greenwashing undermines consumer confidence and hinders the spread of truly sustainable businesses, which is why it is critical that business modeling frameworks explicitly address this risk.

In summary, although the Business Model Canvas and Lean Canvas are practical tools for creating economic value and driving innovation, they are of limited use for the holistic and integrated management of environmental and social sustainability, and they carry the risk of greenwashing. This shortcoming underscores the need to explore complementary or alternative frameworks that facilitate a deeper integration of these dimensions when applying business models.
However, to effectively assess the shortcomings of existing models and the potential of possible alternatives, it is essential to review the definitions and evolution of sustainability.

The conceptual framework and evolution of sustainability

In recent decades, the concept of sustainability has become one of the most widely used categories in science, but it has also taken on multiple meanings, with different disciplines using it in different ways: in economics, it primarily refers to determining the limits of growth; in environmental science, it refers to maintaining ecological balance; and in the social sciences, it refers to the issue

of intergenerational justice. This chapter aims to review the main trends in the definitions of sustainability and to present their shift towards a regenerative approach.

Early approaches to sustainability (e.g., Brundtland 1987; Pearce et al. 1990) aimed to strike a balance between human well-being, economic growth, and the conservation of natural resources. Later theories often interpreted these three dimensions as a "triple bottom line" (Elkington, 1997), where economic, social, and environmental considerations were considered equal in principle; however, in practice, economic logic remained the dominant consideration. The literature, therefore, distinguishes between weak and strong sustainability (Solow 1993; Daly 1990). Weak sustainability is based on the substitutability of natural and human capital, while strong sustainability considers ecological constraints to be primary.

Table 2. Main types of sustainability approaches

Approach	Typical logic	Main goal
Weak sustainability	Natural capital is replaceable by human capital	Sustain economic growth
Strong sustainability	Natural capital limits human activity	Preserve ecological integrity
Regenerative approach	Mutual reinforcement of nature and society	Renew ecological and social systems

Source: Own compilation based on Solow (1993), Daly (1990), Mang & Reed (2020), Holmgren (2002).

Sustainability approaches can therefore be placed on a spectrum, ranging from the economy-centric "weak" version to "strong" and "regenerative" models that emphasize the primacy of ecological systems. The latter no longer seek merely to mitigate adverse impacts, but to actively restore and develop systems. According to the theory of regenerative sustainability, economic activities can be considered sustainable if they also generate positive ecological and social benefits (Mang & Reed 2020; Wahl 2016).

In this sense, the permaculture approach offers a systemic and ethics-based framework. Its ethical pillars - Earth Care, People Care, Fair Share - define a design logic in which human economic activity is understood as part of ecological systems rather than above them (Holmgren 2002). The regenerative approach thus considers active restoration and adaptive growth as fundamental principles, rather than "damage minimization," and measures long-term system stability in terms of maintaining ecological balance (Mang & Reed 2020).

This approach differs fundamentally from mainstream business modeling practices, which typically focus on creating economic value and enhancing competitiveness. Accordingly, the next chapter examines how permaculture principles can be linked to business modeling structures (BMC, LC) and how regenerative logic can become an integral part of business thinking.

4. Permaculture as the basis of a regenerative approach

Permaculture was initially designed to promote self-sustaining agricultural ecosystems (Mollison & Holmgren 1978). Over time, however, the concept has evolved beyond agricultural practice and

developed into a complex systems approach that seeks to align a broader spectrum of human activities - economic, social, and ecological processes - with patterns found in nature (Holmgren 2002). Permaculture is not just a method, but an ethical and design philosophy - an ethical design system - based on synergies between human and natural systems.

The three principles of permaculture - Earth Care, People Care, and Fair Share - serve as both an ethical compass and a practical design framework:

- Earth Care focuses on the preservation and regeneration of natural systems
- People Care prioritizes the well-being of communities and social structures based on cooperation, while
- Fair Share emphasizes the equitable distribution of resources and the avoidance of overuse.

These three principles are not hierarchical, but reinforce each other, reflecting the logic of reciprocity and feedback (Ferguson & Lovell 2014).

The permaculture design methodology is based on observing natural ecosystems and mapping their patterns and relationships. A key aspect of permaculture-based design is that each element of the system should serve multiple functions, while various elements should provide each function. This principle makes the system as a whole self-regulating, resilient, and adaptive (Mollison 1988). The design principles include optimizing energy flow, increasing diversity, minimizing waste, and implementing "closed-loop" economic and ecological processes. These principles can also be inspiring for business modeling, as they translate the principles of sustainable management of complex systems into the language of decision-making (Wahl 2016). At the same time, we can observe parallels between the ethics of permaculture and the ESG (Environmental, Social, Governance) based organization of economic systems.

Permaculture is therefore not merely an ecological concept, but a systemic way of thinking that focuses on interrelationships and long-term stability. One of the key concepts of the regenerative approach is that the system not only strives for balance but is also capable of self-renewal, where feedback and change are not disruptive factors but rather drivers of development. This approach, in contrast to linear economic models, assumes a cyclical and learning structure (Mang & Reed 2020).

The regenerative approach can be summarized in three basic principles:

1. *Wholeness:* human systems are part of nature, not outside it
2. *Reciprocity:* every action has an effect on the system as a whole
3. *Regeneration:* the system is capable of maintaining and developing its own resources

These principles can also be applied in a business context, for example, in areas such as community value creation, the circular economy, or positive social impact (Raworth 2017).

Permaculture interprets value creation through the concept of *yield*, which extends beyond the economic sense of profit to encompass broader aspects of value. While *profit* is a short-term indicator of financial surplus, yield is a broader category that encompasses all the feedback benefits of the system, serving long-term functioning and stability (Mollison 1988; Holmgren 2002). Permaculture is therefore not anti-profit, but profit-transformative: profit appears as an indicator of the state of the system as a whole, rather than as an ultimate goal.

The third concept, *surplus*, is a central element of ethical principles (Fair Share), which refers to the yield produced by the system but not necessary for its own operation - the part that can be reinvested in the community, the environment, or future generations. In this sense, surplus is not a moral gesture of profit distribution, but a self-sustaining mechanism of the system: a condition for reproduction and regeneration.

This triple logic - yield, profit, surplus - creates an opportunity to reinterpret corporate value creation. In the business sphere, social and ecological returns can appear alongside profit as indicators of long-term viability. Thus, the enterprise seems not as a value extractor, but as a value reinvestor in the economic and ecological system (Raworth 2017; Wahl 2016).

The logic of permaculture thus forms an ethical and practical bridge between sustainability and business models. The principles of ecological patterns, diversity, resilience, and feedback provide a new perspective on understanding corporate value creation. Accordingly, the next chapter examines how the principles of permaculture can be integrated into the structures of the Business Model Canvas (BMC) and Lean Canvas (LC) and how they can contribute to the theoretical and practical development of regenerative business modeling.

5. Integration opportunities between permaculture and business models

Permaculture is not only an ethical and philosophical framework, but also a complex design methodology that translates the operational logic of natural systems into human-scale decision-making and organizational development (Holmgren 2002). This method aims to ensure that the planned system, whether ecological, social, or economic, produces more useful outputs than are required for its operation (Mollison 1988).
The following subsections demonstrate how permaculture design tools can be applied to business modeling and organizational development practices, particularly by complementing the logic of the Business Model Canvas (BMC) and the Lean Canvas (LC).

Adaptability of the 12 principles of permaculture to business systems

David Holmgren's (2002) twelve principles of permaculture are derived from observing patterns in nature and modeling sustainable energy flows. These principles are universal design guidelines that can be applied in complex, adaptive systems, including business organizations and economic ecosystems (Capra & Luisi 2014; Hahl & Rikkonen 2020).

1. Observe and Interact (Observe and Interact)
Understanding natural systems is based on observation and feedback. In business, this corresponds to data-driven decision-making and stakeholder analysis, which are essential for understanding complex systems and adaptive strategic planning (Meadows 2008; Senge 1990).

2. Catch and Store Energy
Permaculture systems store energy and resources in a regenerative way. The business equivalent is intellectual capital, knowledge sharing, and the development of human and social capital (Bocken et al. 2014). The long-term sustainability of companies depends on their ability to retain

and reuse energy—knowledge, innovation, and financial reserves (Senge 1990). At the same time, this element can also refer to the optimization of actual energy use in economic systems and businesses.

3. Obtain a Yield
The value of the system is determined by sustainable yield. For businesses, this means achieving multi-level value creation - economic, social, and environmental (Elkington 2018; Raworth 2017) and extends beyond the principle of profit maximization.

4. Apply Self-Regulation and Accept Feedback
Natural systems are self-regulating. In the business sphere, this can take the form of ESG management, internal audits, quality assurance, and ethical and transparent corporate governance (Porter & Kramer 2011).

5. Use and Value Renewable Resources and Services
The use of renewable energy and resources is a fundamental principle of the circular economy (Geissdoerfer et al. 2017). In the business sector, this means the integration of renewable energy sources, recycled materials, and circular supply chains (Bocken et al. 2014).

6. Produce No Waste
There is no waste in nature, where every output is the input of another subsystem. In a business context, this means applying a zero-waste strategy, industrial symbiosis, and circular economy tools (Ellen MacArthur Foundation, 2019; Jackson, 2011).

7. Design from Patterns to Details
Patterns in nature are structures characteristic of complex adaptive systems. In business modeling, this involves identifying, analyzing, and strategically planning system-level patterns - such as value streams and relationship networks - and then refining the details (Meadows 2008; Capra & Luisi 2014).

8. Integrate Rather Than Segregate
Relationships and collaborations between elements increase resilience. By having one element perform multiple functions, or multiple elements perform one function, our system becomes resilient, adaptable, and therefore stable. This principle requires integrating the system's elements and mapping the network of relationships. In a business environment, this involves building multidisciplinary teams, value chain partnerships, and stakeholder ecosystems (Senge 1990; Porter & Kramer 2011).

9. Use Small and Slow Solutions
Permaculture supports gradual development and local optimums. In business, this embodies the concepts of lean innovation, pilot projects, and incremental development (Maurya 2012; Hahl & Rikkonen 2020).

10. Use and Value Diversity
Biodiversity increases the stability and adaptability of a system. At the business level, this is a tool for leveraging diverse human capital, product portfolio diversity, and market flexibility (Bocken et al. 2014; Elkington 2018).

11. Use Edges and Value the Marginal
The boundary areas of nature (ecotones) are particularly productive (e.g., due to greater diversity). In business innovation, this means the importance of interdisciplinary collaborations, new markets, and marginal segments from which new value can be created (Raworth 2017; Jackson 2011). Valuing edges and transitions draws attention to marginal areas whose value is not taken into account by strictly profit-oriented business models, but which are particularly important in a sustainable model due to their social and equal opportunity impact (e.g., employment of people with disabilities, the elderly, support for atypical work).

12. Creatively Use and Respond to Change
Change is a constant in nature, not a threat but an opportunity. In the business world, this translates to agile management, an adaptive organizational culture, and continuous learning (Senge 1990; Hahl & Rikkonen 2020).

Together, these principles form the basis of a regenerative business paradigm that goes beyond traditional sustainability models. While the triple bottom line concept (Elkington 1997) seeks to minimize harm, permaculture aims to maximize and recirculate positive returns, creating business models that restore natural and social systems while remaining economically viable (Raworth 2017; Hahl & Rikkonen 2020).

System functions and elements: Multiple functions, multiple components, redundancy

In permaculture, each element must fulfill multiple functions, and each function must be fulfilled by various elements (Holmgren 2002). This principle enhances the system's resilience, as the failure of a single component does not lead to its collapse. In a business context, this principle is known as functional diversity and redundancy, which can serve as the basis for risk management and organizational learning (Senge 1990). This principle deepens the Lean Canvas 'Key Metrics' and 'Unfair Advantage' blocks from the perspective of system resilience.

Relationships and placement between elements

One of the most important design principles of permaculture is to arrange the elements of the system in a way that supports each other. Zoning is based on the frequency of human intervention: things that require frequent attention are placed closer to the central zone, while those that require less attention are placed further away (Mollison 1988). In contrast, "sectors" map the direction and intensity of external influences (energy flows, risks) (Yeomans 1958).

In business, this approach is similar to the logic of stakeholder mapping, organizational ecosystem mapping, and value chain analysis (Capra & Luisi 2014). Zoning can be adapted, for example, to the analysis of the BMC's "Customer Segments" and "Customer Relationships" blocks: the most

intense customer relationships are located in the inner zones. In contrast, the less frequent but strategically important relationships are located in the outer zones.
Sector analysis can be equated with the tools of PESTEL analysis and environmental scanning, which reveal the external factors (e.g., legislative changes, social trends, natural risks) that have the most significant impact on the company (Meadows 2008).

Input-output analysis: Closed cycles and "waste as a resource"

One of the basic principles of permaculture is that waste is not actually a loss, but rather a resource for another process. This idea is also one of the cornerstones of the circular economy (Geissdoerfer et al. 2017), and it is reflected in the principles of the Blue Economy, where by-products are transformed into new value streams based on models derived from the functioning of natural ecosystems (Pauli 2010).

In the case of business models, this analysis can be applied between the BMC blocks "Key Resources - Key Activities - Value Proposition - Channels":

- where losses occur (material, energy, time, information) and
- how can this be transformed into a new value stream (e.g., new use of by-products, recoding of knowledge, incorporation of customer feedback)

This approach is also consistent with the ESG (Environmental, Social, Governance) framework, as input-output transparency enables the measurement of net resource impact and regenerative performance (Raworth 2017).

Aligned with the Lean Canvas "Problem" and "Solution" blocks, permaculture input-output thinking can help identify hidden resource waste and develop closed-loop processes.

5.5. Scales of Permanence in Business Modeling

The Scales of Permanence (SoP) - Permanence Scale (Yeomans 1958) was used initially in landscape planning as a diagnostic and decision-making tool to help determine the extent to which different elements of the landscape - such as climate, topography, water, or soil - can be modified and how they relate to each other hierarchically. According to the model's logic, the highest levels (e.g., climate) can only be influenced to a limited extent, while the lower levels (e.g., soil, microclimate, interventions) offer a greater scope for change (Holmgren 2002).
When designing based on the Scales of Permanence, it is also worthwhile to consider how changes to individual dimensions impact the other elements.

The applicability of the method in business modeling is shown in Table 3. Of course, Yeomas' elements can only be interpreted to a limited extent in economic systems, and in some cases, their hierarchical order may also change, so individual assessment is necessary to make them truly applicable at the corporate level.

Table 3. Ten elements of the Scales of Permanence in business modeling

Yeomans' element	Original meaning	Business-organizational analogy	Possible application / analysis aspect
1. Climate	Regional climate, which determines all other factors	Macroeconomic and regulatory environment, geopolitical trends	Analysis of external, little-influenced factors (PESTEL)
2. Topography	Topography and landforms	Market and competitive environment, industry structure	Competitive map, market positioning, strategic terrain modeling
3. Water	Essential carrier of energy and life	Finance and information flow	Cash flow, knowledge flow, organizational energy, and data flows
4. Road network	Infrastructure of movement, transport, and logistics	Supply chain, internal and external networks	Supply chain mapping, partnership infrastructure
5. Vegetation (forests)	Biodiversity of the landscape	Human capital, innovation capacity, organizational culture	Competence and knowledge map, diversity strategy
6. Buildings	Human structures, buildings	Organizational structure, management, and decision-making systems	Governance models, organizational architecture
7. Fences, borders	Borders, separations, protective elements	Organizational and legal boundaries, intellectual property, and ethical constraints	Risk management, data protection, ethical compliance
8. Soil	Basis of fertility and regeneration	Organizational culture, values, trust, and learning	Cultural diagnosis, value-based leadership, internal learning ecosystem
9. Microclimate	Local environmental conditions (shade, wind, water, light)	Group dynamics, work environment, and psychological safety	Team climate survey, wellbeing, adaptive workspaces
10. Permanent human interventions	Land use and ongoing human impacts	Operational processes, daily operations, and maintenance	Process optimization, Kaizen, and daily operational efficiency

Source: Own compilation based on Yeomans' Scales of Permanence (1958)

Element-based SWOT analysis

Unlike traditional SWOT analysis, which treats the entire organization as a single entity, the Scales of Permanence approach allows SWOT to be performed separately for each element, and enables the company to identify accurately:

- Its strengths and weaknesses at a given level (e.g., "soil" = organizational culture, "water" = cash flow and information flow),
- as well as the external opportunities and threats associated with a given element (e.g., "climate" = regulatory changes, geopolitical trends).

The resulting SWOT map for each element provides a much more accurate picture of intervention than the traditional, aggregated model. For example, if a company is strong at the "vegetation" level (human capital) but weak at the "soil" level (culture, trust), intervention must first strengthen the foundation before human capital development can produce truly sustainable results (Senge, 1990; Meadows, 2008).

Network of relationships and interactions

Scales of Permanence is not a linear model, but a network model: the individual elements interact with each other. A change in one layer can trigger a chain reaction in the other layers.
For example:

- If the "soil" (organizational culture) changes, it can affect the "microclimate" (work environment) and the "vegetation" (human capital),
- If the "fences" (ethical and legal frameworks) are loosened, this affects the security of the "water" (information flow),
- If the "topography" (market structure) changes suddenly, this restructures the entire corporate "road network" (supply chains).

Mapping this network of relationships - even visually - enables regular impact and feedback analysis (feedback mapping). This approach adheres to the principles of systems thinking (Capra & Luisi 2014). It is suitable for identifying the most effective points of intervention, aligning with Donella Meadows' (2008) concept of "leverage points."

Application in business modeling

SoP-based analysis can be integrated into the Business Model Canvas (BMC) and Lean Canvas (LC) structures as a diagnostic layer.
For example:

- In relation to the "water" element, the BMC's "Key Resources" and "Channels" blocks can be examined: where is energy, information, or money leaking?
- The "fences" element can help redefine the LC's "Unfair Advantage" block in terms of an ethical and legally secure competitive advantage.
- The "microclimate" element can be assigned to either the "Customer Relationships" or "Key Activities" blocks, where the organizational environment and team dynamics significantly influence the quality of operations.

The SoP hierarchy provides the deep structure of the BMC and LC models, helping to understand which elements are stable, which are sensitive, and where intervention is warranted to make the system function regeneratively.

Permaculture design tools and principles are therefore not just metaphorical analogies in business life, but concrete decision-support and strategic planning frameworks. The logic of "more functions, more elements" increases organizational resilience, "zoning" and "sector analysis" support strategic focus, and "input-output analysis" facilitates circular processes. At the same time, "Scales of Permanence" provides a new perspective on the hierarchy of intervention points. Together, these tools form the theoretical and practical framework for permaculture-based business modeling, which we will examine in the next chapter in comparison with the BMC and LC structures.

6. Possible levels of permaculture integration

The integration of sustainability and regenerative approaches into business modeling is becoming increasingly urgent, as current economic frameworks are unable to address complex ecological and social challenges (Geissdoerfer et al., 2018). The Business Model Canvas (BMC) and Lean Canvas (LC), as the most widely used tools for corporate value creation, are primarily based on linear logic, where the definition of value is based on profitability and growth. Incorporating the principles of permaculture provides an opportunity to integrate sustainability at the system level into business modeling on an adaptive and ethical basis.

The connection between permaculture and business models can be understood on three levels:

1. *At the preparatory level,* permaculture appears as a design approach. The logic of observation, pattern recognition, and feedback facilitates the recognition of system boundaries, risks, and dependencies in the early stages of business modeling. Here, permaculture does not modify the structure of BMC/LC, but complements the interpretive framework in which the decision-maker operates.
2. *At a complementary level*, permaculture integrates new dimensions into business models. The fields of "key resources" and "cost structure," for example, can be supplemented with concepts such as ecological capital, social networks, or community values. The value proposition can be extended to include ecological and social returns that enhance the company's long-term resilience (Joyce & Paquin 2016). At this level, permaculture does not replace but rather reshapes the content of the BMC/LC elements.
3. *At an alternative level,* permaculture represents a complete paradigm shift: the business model can be understood not as a closed economic system, but as a living ecosystem. Value creation here is a reciprocal process, where profit reflects the well-being of the system as a whole, rather than individual capital accumulation (Mang & Reed 2020). In this approach, the company's goal is not only growth, but also the promotion of ecological and social regeneration - that is, maximizing "positive returns" by recycling "surplus" (Holmgren 2002).

Table 4 summarizes the possible correspondences between permaculture and BMC/LC:

Table 4. Connections between permaculture and business models

Permaculture Principle	Compatible BMC/LC element	Potential business applications
Earth Care	Key Resources / Cost Structure	Natural capital conservation, circular resource management
People Care	Customer Segments / Relationships	Community value creation, social inclusion
Fair Share	Revenue Streams / Value Proposition	Redistribution of returns, ethical profit model
Closed Loop	Key Activities	Waste minimization, energy flow optimization
Diversity	Key Partners	Increasing resilience, multidimensional collaborations

Source: own editing based on Holmgren (2002), Joyce and Paquin (2016), Mang and Reed (2020)

7. Limitations and further research directions

The primary objective of the study was to develop a theoretical and conceptual framework that examines the integration of sustainability and regenerative thinking into business modeling. Consequently, the research is primarily theoretical in nature and does not rely on empirical data collection or case studies from corporations. This approach allowed for a deeper exploration of the connections between different theoretical approaches (ecological economics, regenerative design, and permaculture). However, at the same time, it limits the practical validity and generalizability of the results.

The limitations of the research can be interpreted on several levels. However, these limitations also represent opportunities for future research that may lead to new directions. How can the sustainability elements of BMC and LC models be empirically examined in different industries? How can the principles of permaculture be integrated into corporate-level decision-making when examining economic and social efficiency? The question also arises as to how the application of AI could be further developed to support the development of sustainable business models, taking into account the diversity of regions and industries.

There are several directions for future research:

1. *Empirical validation* - Practical application of permaculture-based business modeling in a specific organizational or regional context. The examination of Renewable Energy Community (REC) business models may be particularly promising. One possible direction is to use the example of the Alsómocsolád Renewable Energy Community to show how the completed Business Model Canvas could be supplemented with permaculture design principles (e.g., Scales of Permanence, yield/profit/surplus logic, closed-loop processes) and optimized according to regenerative criteria, what would provide an opportunity to demonstrate the concrete applicability of the permaculture-based framework and confirm the practical relevance of the theoretical model.
2. *Case studies and experimental models:* Identifying businesses that operate according to regenerative logic and incorporating their experiences into the theoretical framework.

3. *AI-based knowledge modeling:* A deeper examination of the role of artificial intelligence in supporting sustainability innovations, business models, and systems thinking.
4. *Ethical and educational dimensions:* Exploring how the ethical system of permaculture can be incorporated into entrepreneurial training and decision-making processes.

Overall, the primary contribution of this research is to establish an interdisciplinary connection between business modeling, sustainability, and permaculture. Future studies will need to reinforce this connection with practical experience, empirical data, and measurable impacts, promoting the integration of a regenerative approach into the functioning of economic systems.

8. Conclusions

The study aimed to explore how the principles of sustainability and regenerative thinking can be integrated into business modeling, with particular regard to the limitations of the Business Model Canvas (BMC) and Lean Canvas (LC). The analysis revealed that these models primarily focus on economic value creation and market competitiveness, with sustainability dimensions mainly appearing as tools for achieving these objectives. Permaculture, on the other hand, represents a holistic, ethical, and systemic approach that seeks not to optimize the economic system, but to embed it ecologically and make it regenerative.

Based on the results of the research, permaculture can contribute to the renewal of business modeling in three ways:

- *As an ethical dimension*, it creates a new value hierarchy in which economic decisions are subordinated to social and ecological responsibility.
- *As a design system*, it provides us with a tool for understanding and adaptively managing complex, multi-level corporate systems.
- *As a philosophical foundation*, it integrates the principles of regeneration, reciprocity, and self-regulation into business thinking, thereby promoting long-term systemic stability.

The use of artificial intelligence (AI) in the research process not only provided technical support but also represented a new way of exploring connections between knowledge systems. AI-based analysis helped identify conceptual networks, maintain structural coherence, and highlighted how human interpretation and artificial knowledge support can contribute to theoretical innovation in a complementary way.

Overall, the study contributes to the reorganisation of the sustainability discourse by interpreting regenerative thinking not only as a goal but also as a systemic design principle. Permaculture-based business modeling offers the opportunity for corporate strategies not only to cause less harm but also to generate positive ecological and social benefits.

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Can Sustainability and High Returns Co-Exist? Venture Capital and Quality Signaling in Startup Investment

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Abstract: Sustainability-oriented investing has accelerated significantly in venture capital (VC) markets, driven by climate imperatives, institutional investor preferences, and regulatory shifts. Yet the question remains unresolved: can sustainability-oriented startups deliver competitive financial returns, particularly in high-risk, noisy and early-stage environment? This paper advances a theory-driven analysis focusing on a simplified relationship between ESG (Environmental, Social, Governance), quality signals and early-stage VC decision-making. Drawing from convergence versus conflict ESG theoretical, signaling theory, and venture capital decision-making literature, the paper assessing sustainability as a standalone signal, which could be used for future research on correlation between high returns and ESG signals in early stages. ESG alone can reduce information asymmetry and increase transparency, which is crucial for early investment decision-makings. This conceptual paper proposes a future empirical agenda to measure ESG-oriented startups as quality signals and their effect in investment decisions.

Key words: ESG, sustainability, venture capital, Venture capital decision-making, signaling theory, quality signals
JEL codes: G24, M14, Q56, D82

Introduction

Over the last decade, sustainability and Environmental-Social-Governance (ESG) considerations have transitioned from niche concerns to mainstream investment priorities. Global ESG-labeled assets surpassed $25 trillion in 2023 (www.grandviewresearch.com, n.d.) and continue growing, with climate-focused venture funds and impact VC strategies emerging.

The evolution indicates that there is a gap for ESG integration into non-financial indicators into evaluations to manage risk and create value on the long run. Valuating the impact of ESG integrations can be tricky because it can be the driven from institutional policy requirement or compliance mandate. Often referred to as “ticking the ESG box”. The paper explores academic literature on Venture Capital decision-making techniques, especially in the early stages where information is scars and there is not financial track record. How quality signals can reduce information asymmetry and be a reliable tool for investors to assess the potential of the companies adding ESG or sustainability into signaling theory. The research aims to bridge two streams of literature: the first on ESG and sustainability as strategic and financial drivers, and the second on venture capital decision-making, signaling theory, and entrepreneurial characteristics.

The paper proceeds as follows: The next section reviews existing literature on the “Convergence vs. Conflict” debate in ESG and sustainability, addressing the ongoing discussion on whether ESG integration complements or contradicts financial performance objectives. The next part examines the venture capital investment decision-making process. And last but not least quality signals such as entrepreneurial status, and third-party affiliations which might be beneficial to test whether sustainability stands as a valuable, standalone signal or more of a moderating, amplifying variable to the previously mentioned two variables. The final part develops testable hypotheses and possible

framework for testing the hypothesis and discusses the potential implications for entrepreneurial finance and policy design.

Research question

Can early-stage startups that have adopted ESG or sustainability policies achieve superior financial returns in venture capital markets, and does such sustainability orientation function as a quality signal in early-stage VC decision-making?

Why This Question Matters

- VC fuels technological and industrial transformation.
- ESG adoption is rising rapidly among institutional LPs (Limited Partners) (i.e. investors who contributes capital to a private equity or venture capital fund in exchange for a share of the profits, but does not participate in the fund's day-to-day management.
- Debate over whether sustainability is value-creating or value-diluting remains unresolved.
- The relationship between ESG-focused early-stage VC investments and traditional VC performance remains empirically ambiguous.

Literature background

To shed light on the academic work that has addressed to the topics of venture capital investment decision making, quality signals which involves entrepreneurial attributes and lastly ESG and sustainability factors which can be considered as quality signals for future research. This chapter consists of the relevant literature according to these fields.

Investing into young ventures is a high risk undertaken by different investment funds, Business Angels, and Venture Capitals. With new prototypes, still in the development phase and with lacks financial information, startup companies face a steep commercial failure rate (Aldrich and Fiol, 1994; Tushman and Rosenkopf, 1992). This can be traced back and connected with other core problems with early-stage capital investments, which is, the difficulty of evaluating the companies because of the high environmental uncertainty and lack of track record or even revenues (Penrose, 1959; Shane and Stuart, 2002). In the next phase, I will investigate VC decision makings on a wide scale, paying special attention to different ESG attributes or factors used by them in early-stage financing periods. The literature consists of positive, negative and even neutral effects of ESG implications policies on performance or even investment decisions.

Convergence vs. Conflict Debate on ESG and Sustainability

Investment into ESG activities and ESG focused companies is one of the key sectors investors focusing on. According to "Grand View Research" ESG Investing Market is surpassed the 25 trillion mark in 2023 and projected to reach roughly 80 trillion by 2030 with a year-on-year growth rate of 18.8% (www.grandviewresearch.com, n.d.). There are special investment entities, fund management firm focusing specifically on ESG, Impact investing or sustainability, which in this case represents a screening criteria not a quality signal with its purpose of decreasing information asymmetry and increase the level of possible investment decision. Some articles contributed to the

academic literature by examining ESG performance in the business itself or it's stocks (Hu et. Al, 2023).

Building on ESG performance effect on the capital market information and information flow (Wanyi et. al, 2025) found empirical evidence by analyzing the Chinese market and assessing higher ESG performance results more accurate public information. Which could support the use of ESG, more specifically a sustainability signal in early-stage investment decision making or capital allocation. Other important factor could benefit from a clear sustainability signal. Managers or founders raising funds want to increase the chances of securing a deal and might hide information or motivated to not to be fully transparent. Bao et. al. (2019) found evidence that managers motivated by equity tent to hide negative information. The information asymmetry, hiding of certain information have a negative, amplifying effect on decision-making, in stages where information is already scars. However, the mentioned articles suggest that ESG monitoring, considerations increase transparency. Beside the information that an investor receives can increase the performance itself. The next articles reviewed whether there is a link or not or multiple effects of sustainability to reach superior returns on investments.

At the business itself Hsu et al. (2023) and Baker et al. (2022) found green firms performed poorly compared to other non-green or not fully sustainable counterparts. On the other hand (Pastor et. al, 2021) has concluded positive relationship between ESG return. There is also the neutral effect of any ESG investing return, compared to other averages or return (Atz et. al., 2021). Based on the literature which are focusing more on later stage investments, it is unclear whether a sustainability or ESG initiatives would affect returns. Better governance could improve the general course of business and by doing so improve the financials, but this is just a fraction of the overall performance. (Atz et al., 2021) also suggested a key element measuring ESG metrics could be inconsistent or dependent on other factors, measured differently. One author examined carbon emissions. (HSU et al., 2023) analyzed US stock returns relative to their emission and found positive relationship. This is however highly dependable on disclosure and might result biased conclusions. To sum up ESG investment and investment return relations some authors have found empirical evidence in positive correlation, some negative and neutral. The findings usually consist of other factors and exploring different sectors, usually in a more mature market. From VC perspective is also important to assess the motive itself. (Amel-Zadeh and Serafeim, 2018) argues that the main motivation is financial, investors assess ESG from financial performance perspective.

Also, a global survey conducted among institutional investors explains that investors implement ESG practices to foster long-term success. The goal is to reduce risk and create value at the same time (Capucci, 2018). On the other hand, early-stage investors, like BA (Business Angles), which are closer to early-stage VCs care less about the ESG criteria assessing a firm and focusing more on other qualities and market data to make the right decision (Botsari and Lang, 2020). For entrepreneurial finance and early-stage investments, from a European survey (Block and Benz et al., 2025) found that VCs considers climate issue and its ethical consideration as the number one motive. Once because LP (Limited Partners) and other stakeholders demand it. This is a biased approach, because investors are not considering the factor as value driver, but rather a requirement for the fund itself.

Lastly, the reviewed literature demonstrates that ESG investing has become a major force in long-term value creation. Evidence suggests that higher ESG performance can enhance transparency and reduce information asymmetry (Wanyi et al., 2025). However, the relationship between ESG performance and financial returns remains inconclusive, with studies reporting positive, negative, and neutral outcomes (Pastor et al., 2021; HSU et al., 2023; Atz et al., 2021). These inconsistencies often stem from differences in ESG measurement standards. From a venture capital perspective, ESG considerations are gaining attention but remain secondary to traditional financial and market criteria (Botsari and Lang, 2020). Further research is needed to clarify ESG's signaling role in entrepreneurial finance and to establish more consistent metrics for assessing its impact on decision-making and performance at the end.

Venture Capital Investment Decision-making

External financing of startups has always been a great academic topic to examine with both theoretical and practical challenges. It's been an important source of funding for new nascent enterprises to grow and to get the necessary capital that the entrepreneur's funding could not cover. Since VCs are facing high uncertainty and limited information or in other terms information asymmetry especially in early stages of finance, they rely highly on the observable characteristics or quality signals. In other words, they try to draw a conclusion about those attributes of the firm, available for them at the time. Though many articles and publications are focusing on evaluating business plans, firm characteristics and identifying different criteria in firm evaluation (MacMillen et al., 1985, 1987; Gartner, Starr, Bhat, 1998; Shepard, 1999), only a smaller fraction of articles has been written about the importance of entrepreneurial characteristics, such as status, reputation or the firms ESG efforts, policies within the venture capital decision making process.

It's known that Venture Capitalist are savvy professionals but given the significant rate of failing new startups, there is still room for improvement in VC screening processes in order to reduce risks. (Hall and Hofer, 1993) contributed to the topic with many different points. Firstly, they found that previous studies were more focused on a different set of criteria only, with no respect of various stages or phases of the decision-making procedure. Secondly, by studying especially VCs evaluation processes in early-stage of investment periods, in which this paper is also going to examine, they could create a more multistage set of criteria to make the decision. They found that in contrast to proposal screening by MacMillan et al. (1985, 1987), decision makings criteria like strategy of the proposing new venture, different financial factors, and entrepreneurial characteristics are not used in the assessment of the firms. However, they have found that while entrepreneurial characteristics are relatively unimportant in proposal screening protocols as well as in the overall financial decision, there were exceptions. When the investors assessed a poorly built business plan, they assumed might not consciously the competence of the entrepreneur for building a profitable firm. This suggest that entrepreneurial attributes are important and measurable for venture capitalists. Secondly, the proposed strategy was rejected in the screening stage, one possible reason for this is a highly uncertain and noisy environment which results a limited amount of suitable information (J. Hall and C. W. Hofer, 1993). While, on the other hand, it seemed to have a significant role later in the evaluating stage where venture capitalists have more time to examine the proposed strategy along with the review and assessment of different financial information. Therefore, it can be assumed that other entrepreneurial characteristics like

the status of the entrepreneur have greater signaling value in the early-stage and getting more attention from investors even though they are not fully aware of it.

Thirdly, the article shed light on the role of financial information in business evaluation process. Empirical evidence showed financial information in the proposed ventured did appear to be a minor criterion (Hall and Hofer, 1993). The possible explanation for this, that it can be a same as it was with the proposed business strategy. Venture capitalists usually execute an in-depth analysis of financial data later in the assessment stage (Hall and Hofer, 1993). While the statistics observed that the characteristic of the entrepreneur is not major criteria in Venture Capitals decision making there were another exception, which require a greater attention. (Hall and Hofer, 1993) highlighted that the extremes in entrepreneurial competence are recognized and valued highly in the decision-making process. More specifically, the article proved that different entrepreneurs and founding teams, who have already launched startups successfully in the past, enjoyed greater attention from external investors. All in all, the paper supports the thesis on examining more entrepreneurial characteristics in early stages of investment rounds.

By following the academic works on the topic, bearing the importance of such characteristics, formal professors at the University of Amsterdam (Vinig and De Haan, 2005) also investigated the screening process and the importance of entrepreneurial characteristics in VC decision making. More precisely different criteria in the screening phase between the US and the Dutch venture capitals. This scenario is highly significant in this case because the empirical investigation shows that Us and Dutch VCs have similarities in ranking the top criteria of the screening process. They both listed the entrepreneur as their core aspect in the screening phase. US investors ranked the others, such as Product, Market and Financial data on the same level. On the other hand, Dutch VCs ranked Product and Market as their second most important attribute and put Financials as their least important category (Vinig and De Haan, 2005). Findings in the same paper suggest that the process which investors diced how to screen the firms depend on active- and passive deal flow approach. In which, the passive deal flow approach suggests, that Venture capitalists are relying on different social events within the industry, and lure through advertising and network events to receive business plans and by those opportunities. This approach is used by incubators in the technological sector. The other method is the active deal flow which states that the new nascent venture is looking for investment opportunities through their network. These findings are important from signaling perspective as well as backing up the theory that incubators or other third-party affiliation might boost the signaling values of the new venture.

Other authors like Hsu (2007) also showed empirical evidence that VCs decision-making is inflicted by the characteristics of the entrepreneur is a major part of the evaluation process. This could be educational background or success of previous startups, different experiences. The study is especially important among the literatures in several dimensions. It both shed light on startup valuation by VCs and shows empirical evidence on the positive relationship between higher venture' valuations and social capital as well as prior entrepreneurial experience. (Hsu, 2007) surveyed 149 technology-based early startups on how external sourcing of VC funds reflects firm's quality. First Hsu (2007) proves, that indeed prior experience of the entrepreneur (especially one who delivered a financial success as well) can increase the likelihood that the firm receives external VC financing. It contributes also to a previous study by Burton's et al. (2001), which states that Venture Capitalists prefer entrepreneurs with prior career experience and expecting higher

competence from them to create value for the firm. Those are suggesting that VCs in early stages are more likely to alienating risks in one major way, in which they back entrepreneurs whose 'done it before'. A clearer signaling effect can in early phase financing can be now suggested based on the literature review. (Hsu, 2007) investigated how human capital can affect the development of the social capital. It is a complementary effect what (Coleman, 1988) examined and not only suggesting another signaling value for external capital providers like VCs or PE firms but can also contribute to an interrelation model between different signals. The core question in this paper also states the idea that ESG factors might not be considered as a standalone signal but rather an amplifying factor to other signals in decision-making and finding high potential startups which later than deliver superior return. For instance, professional experience (as human capital) could not only mean that the entrepreneur or founding staff know how to build business but also can contribute to who they know (building social capital) and how they conduct business as well (eg.: ESG policies from the start) representing a complementary effect, reinforcing each-other.

To conclude this specific section, VCs in early stages of funding paying significant attention to the heterogeneity among entrepreneurs. Getting back on the track, on how outside investors, and more specifically VCs are screening firms. Baum and Silverman (2004) approached the question, based on prior signaling literature (eg.: Spence, 1974) as well as VC investment decision making (eg.: Shepard et al., 1999) together. Based on their investigations, (Baum and Silverman, 2004) identified three broad segments in the valuation of new nascent ventures. In order, alliance capital, intellectual capital and last but not least, the already mentioned human capital, as equally important parts. Firstly, they referred alliance capital as a relatively important aspect in early years. Alliances can provide multiple advantages including accessibility to knowledge (Baum and Silverman, 2004).

These advantages are particularly beneficial when information asymmetry is high. Other scholars also studied alliances. Investors are highly relying on more indirect indicators like alliances (and the quality of them), to assess the ventures (Stuart et al., 1999). This article also shows empirical evidence that firms in the biotechnology industry with outstanding partnerships are getting greater attention and higher valuation at IPO stage (Stuart et al., 1999). The same effect could be expected in earlier phase, because the alliances may amplify other signals, provide a standalone third-party signal or both. These external endorsements are suggesting that professional actors, such as university incubators assessed the firm positively before, and validated its quality.

Besides alliance capital, there is intellectual capital. The paper is not typically focusing this part of the assessment; however, many scholars (eg.: Audretsch, 2012; Hsu and Ziedonis, 2013) have paid a significant attention on intellectual property, patents and its signaling value and it is important to mention in the topic of venture capitalists' decision making. Renowned scholar, (Audretsch, 2012) have investigated the importance of patents application and prototyping as quality signals. Most of the new innovative ventures try to deploy or adopt a protective barriers or mechanisms, which ensures their competitive advantages. From legal as well as financial perspective, patents can serve as quality signals (Long, 2002; Conti et al., 2013; Audretsch, 2012). Granted patents have more substantial effect than pending patents, but only for young startups and during early financing rounds (Greenberg, 2013). A positive correlation has been found between patent stocks and the amount received from VCs and higher IPO pricing (Hsu and Ziedonis, 2013). Other studies also focused this research area, especially patents as signaling variables. Pre-VC

patent filings are correlated with larger VC fundings and lower the failure rates. Furthermore, it increases the likelihood of a possible investment (Conti et al., 2013). Thus, intellectual capital is critical among the signals, beside human and alliance capital.

Empirical investigation resulted evidence that top management teams and leaders with greater responsibilities, and lastly, leaders who are also presidents in other biotechnology firms get more VC financing (Baum and Silverman, 2004). Thus, entrepreneurial activities are vital to acquire external sources, the article, however, states some weak effects and leaves room for further investigation. The number of roles the president takes is positively related to VC financing, yet the represented coefficient is insignificant (Baum and Silverman, 2004). This can be traced back to one of the standard practice of VCs, in which they apply their own management practices to the startup. On the other hand, the study shows, for example, that entrepreneurs with prior failures are also less likely to obtain financial resources from VCs (Baum and Silverman, 2004). Other scholars find similar evidence on how prior career experience of the founding team or manager can positively foster this effect (Burton et al., 2001; Gulati and Higgins, 2003; Hoenig et al., 2014). In Sum, the literatures suggest that VCs are both savvy investors in identifying potential in the firms or in other words picking the right startups but also taking a "couching" role as one of the articles refers to it, via their management expertise they provide (Baum and Silverman, 2004). We could assume they might have interest in experiences under certain conditions in startups or in earlier rounds of funding.

Examining the quality signals in early stages of financing can be crucial and beneficial for both entrepreneurs as well as for investors, but it involves highly uncertain factors and high risks as it was discussed before. Positive association of patent applications and alliances with firm valuation was found, and both could lower this risk in investments. Venture capitalists are structuring their deal in high respect with the classic economic notion of risk and reward. They consider several aspects, such as Strategy, Finance and the Entrepreneur itself in the assessment of the venture. The articles in the review are highly, empirically corroborate with this statement. The mentioned signals could boost the probability of getting the necessary resources to survive and grow, but what other signals can be taken into consideration?

Literature on Quality Signals.

Investing in a startup or first stage ventures is an immense risk undertaken by Venture Capitals, but quality signals could reduce this risk. We discussed the high commercial failure rate before, and the environmental challenges the entrepreneur faces in this specific period. (Penrose, 1959) and Shane and Stuart (2002) scrutinized the evaluation challenge and concluded that difficulty for Venture Capitalist to evaluate firms, originating from the lack of performance track record. (Stinchcombe, 1965) refers to it as a liability of newness. However, this information asymmetry can overcome or reducible by several ways as in our case by examining different quality signals. As a contribution, (Stuart et al.,1990) VCs are using and relying on every possible source of information and taking in account all the observable information that can be gathered about the new venture. VCs spend a substantial amount of time and effort on seeking and assessing these entrepreneurial characteristics and other signals to estimate the quality and potential of the young firms (Amit et al., 1990; Hall and Hofer, 1993). Other signal in the case of this paper would mean ESG practices or sustainability signals to present more transparency and information to investors.

Hereafter, I would like to describe and give a brief overview of quality signals. The importance of signals has been long time recognized by many scholars. They are especially important under the effect of information asymmetry (Meyer, 1979; Spence, 1973). (Spence, 1973) in his publication identified signals as such activities or traits of the actors (on purpose or accidentally created) which helps others to receive valuable information. For instance, a price tag or warranty on a certain product might help the customer to assess the product quality. According to (Spence, 1973), signals should also be observable to be efficient. Visibility is a key factor of signaling, since when outside investors cannot recognize the signal, they might lose an opportunity. (Spence, 2002) beside (Janney and Fiolta, 2003) found that, however, signals are usually sent intentionally, both entrepreneurs and investors can send signals without aware about it. The key aspect, on the is visibility and the question is that are those signals present a value or with third party endorsements a far more superior signal can be created? Scholars are particularly paid attention on different affiliation and their signaling role. Given the relatively scarce information a new venture can provide, different form of affiliations with newly created firms can enhance the market value (Podolny, 1994; Gulati and Higgins, 2003, 2006; Pollock and Gulati, 2007; Pollock et al., 2010). Other signals like patents and research alliances have been argued to serve as highly valuable endorsers of the venture's technology (Audretsch et al., 2012; Hsu, 2011; Conti et al., 2013; Hoenen et al., 2014; Hsu and Ziedonis, 2013; Long, 2002). (Baum and Silverman, 2004) compared different startups from a specific industry with and without patent application and patent grants, the outcome was also clear that those startups with protection could acquire more external capital that those without it. Other empirical examination on information technology startups from an incubator revealed that there is also a positive relationship between the number of patents filed and the amount of capital, the new venture received (Conti et al., 2013). All these articles and findings demonstrate that patents are indispensable in many cases, functioning in two ways, to deliver competitive advantages and to protect intellectual property. New ventures can also signal their value through the characteristic of their management team, their actions, such as market presence (Higgins and Gulati, 2006). These finding are more relevant to the paper, hence the ESG policies are involving different standards and practices the investors might investigate. Others have found that prestigious executives and directors can be beneficial endorsers (Pollock et al., 2010). "Bet on the jockey, not the horse" as many refers to in business circles. Other signal like team experience was mentioned as signal in this regard as a high-quality technology is more likely to attract investors and increase the probability of successful funding. Some of the scholars have argued that this form of quality signal is one of the cores evaluating criteria to venture capitalists (Franke et al., 2008). This trait can be identified by management related experiences, leadership experience (Franke et al., 2008), or as in terms of this research project the experience of successfully launched prior startups (Gompers et al., 2010). Many examples and types of signals were discussed and mentioned in the first phase of the literature review. Before the more specific introduction of the independent variables and before the hypothesis development, signaling interactions should be discussed.

While quality signals are highly valuable endorsements for VCs to obtain information, it is crucial to keep in mind their interactional effect as well. This is highly relevant in case of sustainability or ESG signal. In this research, ESG and other signals are going to be investigated in a complex manner. Other simultaneous signals, like third-party affiliations could also fit and work together perfectly with other signals (Plummer, Allison, and Connelly, 2015), furthermore, it might activate

such signal, which is possible to remain unnoticed (Plummer, Allison, and Connelly, 2015). (Spence, 1973) described signaling theory, but how investors are making sense and assess information those signals? Literature by (Weick, 1996) explains this "sensemaking" phenomenon. The article clarifies how actors are processed the data available and act upon with respect to the obtained knowledge. Still, VCs are facing enormous challenges in navigating through ambiguity. Third party affiliations might help to rise above the noisy environment and examine the relevant signals.

Lastly, scholars have identified two major categories of quality signals. One group is signed to the characteristic of the signaler, and the other is referred as activity of the signaler (Higgins and Gulati, 2006; Pollock and Gulati, 2007). Signaler characteristic all the hardly observable resources the new firm has. These symptoms that VCs are looking for in a quality venture is the firm's human and social capital (Beckman, Burton, O'reilly, 2007). This group are going to enjoy greater attention in this work. Signaler's actions, on the other hand, should be mentioned as well. These actions are costly, but reliable tools to signal quality. Introduction of a product, or prototyping, different patent applications can demonstrate the firm's value (Hsu and Ziedonis 2013).

Possible Frameworks & Hypotheses development for future research

The following chapter of the study consists of the empirical design and possible research approach. First, the instrument of the research of the vignette experiment design and data sources.

The early-stage financial rounds are well suited for the type of experiment a vignette can provide. The characteristics of the hypothetical startup companies can reflect reality and are close to a real business proposal in a compressed, simplified version. We can develop on the right signals we would aim to assess. In this case a company which engaged in sustainable business practices or firms with established ESG integration versus firms without ESG orientation or non-ESG-oriented firms. Also, it would be beneficial to develop other moderating variables to describe how companies can present ESG attributes or entrepreneurial attributes and/or third-party affiliations to boost the signal. The background information for the vignettes would be adopted and redefined based on (Steiner; Atzmüller and Su, 2016) and (Wason, Polonsky and Hyman, 2002) papers. Venture capital decision making criteria can be narrowed down, because new ventures are usually lacking in financial information but other managerial or entrepreneurial attributes, agreements, patents and other organizational or social capital can be screened and measured.

All the vignettes would be similar in the first section, where the scenario is introduced to the respondents and the background of the companies are stated. In the scenarios, respondents are faced with a situation where a new venture is seeking early-stage capital from them and now they must evaluate the firm and decide, based on the available information. The available information would consist of sustainability attributes of the firm, entrepreneurial aspect based on experience and other moderating variables such as third-party affiliations to shed light on sustainability as standalone quality signal and as part of a bundling effect.

Data sources as follows:

- Venture capital sample (Pitchbook / Crunchbase)
- ESG proxies (certification, patents)

Discussion

This conceptual paper set out to explore whether ESG, more specifically sustainability practices can function as credible quality signals in early-stage venture capital decision-making, and how such signals might relate to the final financial performance or EXIT value. The preceding sections have shown that while ESG integration has become a dominant discourse in institutional investing, its effect on early-stage financing remains theoretically underdeveloped. As reviewed, the "convergence vs. conflict" debate suggests no clear consensus on whether sustainability enhances or diminishes financial returns or can create superior returns compered to non ESG practicing firms. Simultaneously, research on venture capital decision processes underscores that, at the earliest stages, investors rely heavily on observable quality signals such as founder experience, alliances, and intellectual property. By linking these domains, this paper argues that sustainability could serve as a standalone signal or may operate as a complementary or amplifying signal when bundled with entrepreneurial or third-party endorsements.

The proposed vignette-based research design follows this logic and try to create an academic trail which might be worth analyzing. Sustainability as a value may depend on visibility, credibility, and by reputable third parties. Future research for instance can assess whether sustainability certifications, incubator affiliations, or transparent disclosures enhance the reliability of the firm and not just an investment criteria for certain fund allocating capital in environmental impact related targets.

Conclusion and Limitations

This paper contributes to ongoing academic debates by synthesizing literature on ESG, signaling theory, and venture capital decision-making and by proposing a theory-driven framework for empirical testing. It suggests that sustainability-oriented startups may signal reduced information asymmetry and stronger governance, but whether such signals translate into superior returns or even meaningful investor assessment frameworks remains an open question.

Several limitations rely within the experiment itself and the measurement of startup success. It is necessary to refine and develop hypothesis and variables in a structured and well-defined manner to avoid any bias. The proposed vignette experiments, while methodologically suitable, may not fully capture the complexity of the topic. Nevertheless, by outlining these limitations, this paper could offer a foundation for understanding of how sustainability and high returns may or may not co-exist or even measurable.

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