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Ph.D. Thesis Booklet

The Impact of R&D on the Economy: A Cross-Country Analysis of Lower Middle Income Countries (LMICs)

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1 INTRODUCTION

R&D is an important engine of innovation, productivity, and long-term economic growth. R&D initiatives have the ability to greatly increase a country's competitive edge in the global market by advancing technology, developing new products, and improving processes. However, the significance of R&D in lower middle income countries (LMICs) is understudied for a while. Lower middle income countries (LMICs) frequently confront structural barriers to economic growth, such as poor infrastructure, limited access to modern technology and hence, low levels of innovation. These nations often devote a lesser proportion of GDP to R&D than high and middle income countries, and they frequently face challenges such as poor institutional frameworks, inadequate human capital, and limited capital investment in innovation. Despite the crucial necessity of R&D for the success of an economy, R&D sector in lower middle income economies has largely escaped policymakers' attention. The goal of the Doctoral research is to find out whether 'Research and Development' impacts directly on the economy of a country or are there other factors that influence its impact.

Over the past few decades, many lower middle income countries have moved beyond low-income status and made significant strides in reducing extreme poverty, creating the impression of strong developmental progress. However, for the more than 100 economies with per capita incomes between $1,100 and $14,000, the ultimate goal of reaching high-income status within a generation remains elusive. Since the 1970s, the median middle-income country's per capita income has stagnated at less than one-tenth of the U.S. level (Doran, McCarthy and O'Connor, 2018). Now, these economies face mounting challenges such as aging populations, rising protectionism, and the urgent need for an accelerated technology transition. Overcoming these barriers and achieving advanced economic status will require unprecedented efforts and innovative strategies.

In order to escape the "*Middle-Income Trap*," (a term coined by the World Bank Group) middle-income nations must make two crucial transitions, according to the World Development Report 2024. To become competitive global suppliers, lower-middle-income nations must abandon an investment-driven strategy and adopt one that incorporates contemporary technology and international business practices. Conversely, upper-middle-income nations need to shift from adopting new technologies to innovating, pushing the boundaries of technology, and reorganizing their energy systems, workspaces, and industries (Bresser-Pereira, Araújo and Costa Peres, 2020). The few nations that have effectively attained high-income status by encouraging entrepreneurship, upending long-standing interests, developing human capital, and modernizing antiquated institutions demonstrate that neither move is effortless. The middle-income economies of today need to take comparable audacious and flexible steps if they are to prosper.

Lower-middle-income countries (LMICs) experience distinct issues that set them apart from high-income and low-income countries, necessitating customized approaches to address their lack of R&D. Because of their "in-between" status, they may not attract the same amounts of private-sector R&D investment as high-income countries or receive the same amount of foreign investment or development assistance as lower-income nations (Salman *et al.*, 2020). Low-income nations with pressing developmental needs or high-income nations with well-established R&D organizations are typically the focus of research. LMICs are therefore frequently disregarded.

Without adjusting insights to the particular dynamics within LMICs, studies may generalize results from high- or low-income nations, creating a gap in my understanding of the particular challenges they confront in developing R&D capacity.

The purpose of this research is to find out the impact of R&D on the economy of Lower middle income countries. Numerous studies has found that this impact is influenced by other factors in the economy such as institutions (Doloreux & Turkina, 2023; Chen & Song, 2024)). Institutions play a key role in the stability of an economy as they regulate different sectors of an economy. The primary aim of the research is to investigate whether R&D performance has an impact on growth among lower middle income countries. It is suggested by Aghion (2018) that the institutional framework could slow growth down at a certain level of development. Due to these institutional structures, R&D, and innovation may not lead to economic growth in middle-income countries. The Research Problem is *"How can investment in research and development (R&D) help drive economic growth in Lower Middle Income economies, and what are the primary barriers and enablers that determine R&D effectiveness in these settings?"*

This study contributes to the growing body of literature investigating the impact of institutional factors on R&D and economic growth. It focuses on Lower Middle Income group countries that are highly affected by the political and economic crises in their settings and must take an example from the High Income group countries in managing their institutions leading to their economic development.

1.1 OBJECTIVES OF THE RESEARCH

1. To explain Research & Development thoroughly

2. To study the literature on different growth models and their relationship to innovation

3. To study the role of institutions and their relationship with economic systems

1.2 QUESTIONS OF RESEARCH

1. What is the role of R&D in economic growth?

2. Does R&D has a direct or indirect effect on the economic growth?

3. What is the significance of institutions in an economic structure of a country?

2 THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

2.1 THEORETICAL FRAMEWORK

From the literature review of the research, I come up to point where I determine the important elements that play a major role in the economic development of the country. Research and Development being the core of the study, is found to have rather an indirect impact on the economic growth. From different studies, I found multiple factors affecting the economic growth of a country and found that R&D itself is affected by the institutions as they play a major role in the regulation, implementation and execution of policies related to all sectors of economy. The institutions affect the R&D sector, the capital markets and human capital. This in turn affect the innovation capability of a country. As an innovation capability is affected, so does the economic growth of a country. On the basis of these theoretical findings, this impact cycle is given the term of ‘R&D Ecosystem’. The term R&D Ecosystem is self-produced as a result of thorough research on the different types of ecosystems. The 3 types of institutions in this Ecosystem that will collectively contribute to the economic development of the country are:

1. R&D Institutions (RDI)

A self-produced term which refers to the organizations (public or private) that focus on scientific research, technological development, and innovation in order to produce new or improve the quality of existing products and services they offer. Includes organizations such as educational institutions, public or private companies and non-profit organizations. The government plays a crucial role in facilitating research and development within a country by allocating funds appropriately to maximize resource utilization.

2. Financial Institutions (FI)

Refer to the organizations that are involved in different financial transactions including savings, loans, deposits, investments etc. in a country. Includes capital market such as Stock markets, banks (commercial and retail), brokerage companies, insurance companies/agencies, credit loan associations/firms etc.

3. Labor Institutions (LI)

Refers to the organizations that determine the quality and education level of the labor force, as well as policies regarding employment and wage-related factors.

The figure 1 below shows my idea of how R&D Ecosystem might look like.

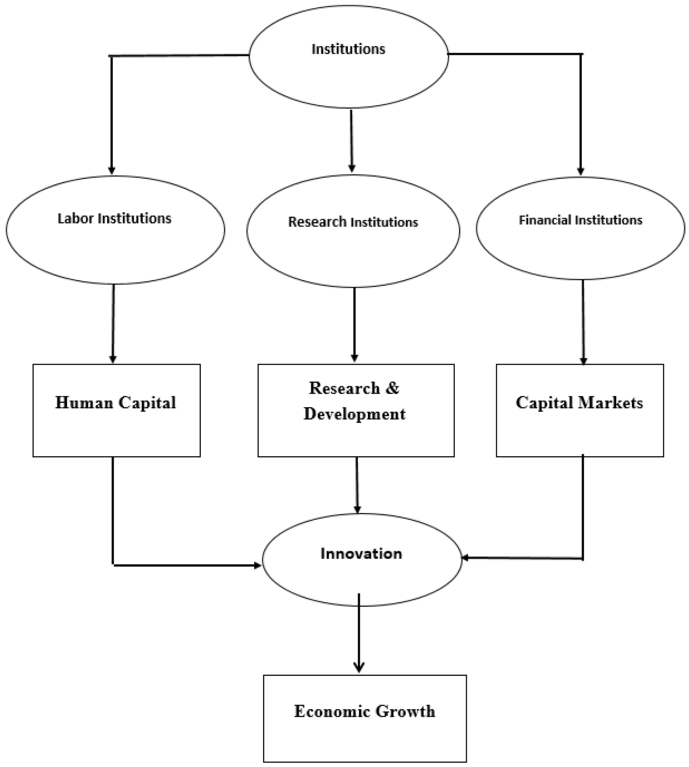

Figure 1: R&D Ecosystem (Theoretical Framework)

2.1.1 Hypothesis Development

Following are the elements of the R&D Ecosystem which will make up the hypotheses of the study:

Institutions

Institutions are an important element of an economy. They regulate the setting in which the economy and society organize themselves by formal and informal check and balance. The formal check and balance means the legal framework which includes law enforcement and the informal constraints means the societal norms and standards (World Economic Forum, 2018). It is the mixture of many components such as security, social capital, corporate governance, transparency, property rights, checks and balance, ethics and performance of public sector of a country. Institutions affect the productivity and economic growth by delivering incentives and lowering uncertainties.

Research and Development (R&D)

Research and development encompasses fundamental research, applied research, and experimental research. R&D expenditures are a key indicator of both the public and commercial sectors' efforts to achieve a competitive edge in science and technology (National Science Foundation, 2018). Estimates of R&D resources are influenced by national characteristics such as the frequency and scope of national R&D surveys across institutional sectors and industries, as well as the sample and estimation techniques used. Due to the fact that R&D frequently involves a small number of key actors, R&D surveys employ a range of methodologies to maintain current registers of recognized actors while aiming to identify new or uncommon participants. As a proportion of GDP, gross domestic expenditure on research and development (R&D) encompasses both capital and current expenditure in the four primary sectors of industry, government, higher education, and not-for-profit organizations (Jones and Galmiche, 2005). So I can derive the following hypothesis from this information:

H1: *Institutions investing in R&D have a significant impact on Innovation in lower middle income countries*

Human Capital

Human capital, as defined by the Chicago School of economics, especially through the writings of (Schultz, 1961) and (Becker, 1964), is the collection of knowledge, skills, competencies, and personal qualities that people possess and which add to their economic worth and productivity. Their views on human capital placed a strong emphasis on spending on mobility, health, education, and training as important factors that influence economic growth and personal incomes.

H2: *Institutions investing in Human Capital have a significant impact on Innovation in lower middle income countries*

Capital Market

Will (2019) defines Capital Market as the system that directs the savings into long-term investment. A capital market utilizes resources for different beneficial uses. An efficient capital market is an important driver of the commercial and industrial growth of an economy. Capital is provided for both short and long-term periods. A capital market fulfills the needs of the long-term debts and investments. Capital market is a fundamental regulating and collaborating system for balanced and free flow of economic resources into the financial system functioning in a country. From this, I can infer the following hypothesis:

H3: *Institutions investing in Capital Market have a significant impact on Innovation in lower middle income countries*

Innovation

The term innovation refers to the generation of new ideas and converting those ideas into products and services. The innovation is the capacity of the individuals to bring creative ideas and delivering those ideas in a meaningful form that could be utilized by other individuals and organizations in a country. It is an important element for productivity and economic growth. Many economies struggle to innovate at a meaningful level due to different factors such as the lack of commercialization opportunities. From this I infer following hypothesis:

H4: *Innovation have a significant impact on Economic Growth in lower middle income countries*

Gross domestic product growth (GDP Growth)

Gross value added is determined as the total of gross value added, manufactured goods and services produced, taxes, and any subsidies not included in the product value. It is estimated without regard for depreciation of produced items or for natural resource depletion and degradation. The change in the size of an economy or the actual income of its population over time is used to determine its growth (He *et al.*, 2019). The Gross Domestic Product (GDP) of an economy is the total value added by all producers. Before depreciation, value added equals the value of producers' gross output minus the value of intermediary products and services consumed in manufacturing. GDP is calculated as the sum of the value added by households, government, and businesses working in the economy at constant prices. GDP is calculated on the basis of all domestic output, regardless of whether income is generated by domestic or international firms.

3 DATA COLLECTION AND METHODOLOGY

To see the impact of different types of institutions on economic growth, I have designed an ecosystem approach in which different institutional factors including that of R&D, Human capital and capital market, each work together to impact the innovation in a country to eventually impact its economic growth. In this research, descriptive research design was used. Secondary sources of data were employed, mainly from World Economic Forum. The World Bank categorized 141 countries into 4 income groups namely; High-Income, Upper Middle Income, Lower Middle Income and Lower Income. I selected the Lower Middle Income Group of countries. It comprises of 32 countries. The reason for selecting this group of countries is that almost all the countries included in this group are exposed to (if not entirely same but) similar economic, political and legal environment. The Quantitative method of data collection is being employed to gather data from the target population. The data for the proposed research is gathered through the direct observation of the World Economic Forum databases and reports present on the organization's official website, through which the data for all the variables has been gathered and the time frame of the data gathered is for the year 2019 on the basis of results from the Global Competitiveness Report. The reason for using the year 2019 is that the that the research was designed to mainly focus on the economic and strategic shortcomings of the countries before the onset of Covid-19 pandemic in early 2020, therefore data belonging to 2019 was exclusively utilized for the study. Six main constructs developed from the research are Economic Growth, R&D, Institutions, Human Capital, Capital Market and Innovation. Economic Growth is the target or dependent variable, and the indicator which will be used for this is GDP Growth and five independent variables are R&D, Human Capital, Capital Market and Innovation. Following are the methods which are used in this study. I used the SPSS software to perform the data analysis.

1. Descriptive Statistics 2. Correlation Analysis 3. Reliability Analysis

4. Factor Analysis 5. SEM Analysis

The statistical methods of CFA was conducted as a preliminary test for conducting SEM Analysis later on to find out the relationship between the dependent and the independent variables.

3.1 CATEGORIZATION OF COUNTRIES

The World Economic Forum (WEF) divides all 141 economies into four different income groups:

1. High Income Group
2. Upper Middle Income Group
3. Lower Middle Income Group
4. Low Income Group

Table 1: Lower Middle Income Group countries (World Economic Forum, 2019)

Angola	Cape Verde	Ghana	Lao PDR	Nicaragua	Senegal
Bangladesh	Côte d'Ivoire	Honduras	Mauritania	Nigeria	Tunisia
Bolivia	Egypt	India	Moldova	North Macedonia	Ukraine

Cambodia	El Salvador	Kenya	Mongolia	Pakistan	Vietnam
Cameroon	Eswatini	Kyrgyz Republic	Morocco	Philippines	Zambia
Zimbabwe					

Lower Middle Income Countries (LMICs)

According to the World Bank Atlas method, economies classified on the basis of their GNI per capita. Using the Atlas methodology, gross national income (GNI) per capita is calculated by dividing the total annual income of a nation by its population. Economies referred to as low-income have a gross national income (GNI) per capita of $1,085 or less in 2021; economies classified as lower middle-income have a GNI per capita that falls between $1,086 and $4,255; upper middle-income economies have a GNI per capita between $4,256 and $13,205; and the high-income countries have GNI per capita of $13,205 and above. According to Gill et al. (2007), middle-income nations are torn between competition from low-wage producers of finished goods and the quickly evolving advanced technologies of wealthy nations. According to the World Bank, 108 nations are currently trapped in the "middle-income trap," including powerful economies like China, Brazil, Turkey, and India. Middle-income nations may find themselves torn between wealthy, inventive nations that dominate technology-intensive industries and low-wage, impoverished nations that dominate more established industries. This is because high-income economies have an advantage in industries that need a lot of capital and technology, while low-income nations often have a relative advantage in labor-intensive industries (Zhou and Hu, 2021). Following graphs cover the comparative analysis of lower middle income countries and the rest of the world on the basis of the indicators GNI, GDP and Population growth as annual percentage.

Generally, LMICs have moderate to high GDP growth frequently powered by industries like manufacturing, services, and agriculture. While other countries, like Nigeria, are stagnating as a result of their reliance on unstable commodities, Vietnam and India have seen steady, rapid growth because of technical improvements and industrial expansion. Vietnam and other export-driven economies rely heavily on global supply chain and manufacturing. Zambia and other resource-dependent nations deal with issues like low diversification and price instability. Significant FDI is drawn to nations with stable governments and welcoming business environments such as Morocco. In countries like Sudan, political unrest discourages investment. A sizeable percentage of the population in several LMICs live below the poverty line. For instance, India still faces income inequality between rural and urban areas despite having made tremendous progress in reducing poverty. Conflicts and a lack of strong institutional frameworks cause Sub-Saharan LMICs to make less progress. LMICs have a variety of educational systems; some, like the Philippines, place a great priority on higher education, while others have difficulty accessing primary education. Because of inadequate infrastructure and resources, health indicators like life expectancy and maternal mortality are frequently low. There are significant differences in governance; whereas some nations, like Ghana, exhibit robust democratic institutions, others, like Myanmar, struggle with authoritarianism and instability. While some states, like Indonesia, maintain relative peace, allowing for development, fragile others, like Yemen, struggle with continual conflicts. Cities like Lagos, Nigeria, and Dhaka, Bangladesh, are under infrastructure strain due to rapid urban growth.

Because of their limited ability to adapt and their reliance on agriculture, LMICs are disproportionately impacted by climate change. While Kenya experiences protracted droughts, Vietnam is confronted with increasing sea levels. Emerging digital hubs include Egypt and India, but other nations lag behind because of a lack of investment in R&D and education.

3.2 VARIABLES

Six main constructs developed from the research are Economic Growth, R&D, Institutions, Human Capital, Capital Market and Innovation. Economic Growth is the target or dependent variable, and the indicator which will be used for this is GDP Growth and five independent variables are R&D, Human Capital, Capital Market and Innovation for which following indicators will be used i.e. Institutions, R&D, Human Capital, Capital Market and Innovation.

Aggregated Constructs

For the computation of the indicators, the Global Competitiveness Index (GCI) of the World Economic Forum (WEF) have adopted the 'Aggregation' method. The scores are calculated from the most disaggregated (indicator) level to the most aggregated (highest) level. Each aggregated level is composed of different components. The overall score for each aggregated level is calculated by taking the arithmetic mean (average) of its component indicators. For individual indicators, prior to aggregation, raw values are transformed into a progress score ranging from 0 to 100, with 100 being the ideal state. In Table 2, I have listed down the most aggregated level provided by the GCI that gives the overall score of all of the components of which the indicator is composed of.

Table 2: Variable Operationalization (Source: World Economic Forum, 2019, World Bank, 2020)

Major Indicator	Abbreviation	Definition	Scale	Periodicity	Reference
GDP growth	GDP	10-year average annual GDP Growth percentage (valued at Purchasing Power Parity or PPP in billion USD)	Weighted Average	**Annual, 2011-20**	**World Economic Forum, 2020**
Institutions	Ins	Regulate the setting in which the economy and society organize themselves by formal and informal check and balance	Score: 0-100 (0=worst, 100= Frontier)	**Annual**	**World Economic Forum, 2019**

Innovation	Inn	The conversion of new ideas into product and services	Score: 0-100	**Annual**	**World Economic Forum, 2019**

Breakdown of Major Variables

In the above chart, I have discussed the aggregated variables taken from the World Economic Forum. In the chart below, I will now list the underlying component variables under each aggregated level that closely support the research literature. R&D, CM, and HC constructs are built from 3-3 different indicators. This type of methodology is being adopted from the World Economic Forum (Schwab, 2019).

Table 3: Breakdown of Major Variables (Source: World Economic Forum, 2019)

Major Variable	Component Variables
Research & Development	• Scientific publications • R&D Expenditures • Research institutions prominence
Capital Market	• Domestic credit to private sector • Financing of SMEs • Venture capital availability
Human Capital	• Mean Years of Schooling • Quality of vocational training • Digital skills among active population

Research & Development

- **Scientific publications (ScP):** calculates the average number of publications and citations at the national level on a 0 to 100 scale from 2016 to 2018.
- **Research institutions prominence (RIP):** evaluates the status and reputation of both public and private research institutes on a 0 to 100 scale (2019).
- **R&D Expenditures (RDE):** Research and development (R&D) spending as a percentage of GDP for the year 2016 or the most recent year available

Capital Market

- **Domestic credit to private sector (DCPS):** The entire amount of funds supplied to the private sector, represented as a proportion of GDP | moving average for 2015–2017.

- **Financing of SMEs (FSME):** Answer to the survey question: "How much can small and medium-sized businesses (SMEs) in your country obtain from the financial sector the funding they require for their operations?" [1 = not at all; 7 = significantly] | The most current period available, or the weighted average for 2018–2019 (Executive Opinion Survey by WEF)

- **Venture Capital Availability (VCA):** Answer to the poll question: "How easy is it for start-up entrepreneurs in your country to obtain equity funding for their innovative but risky projects?" [1 = incredibly hard; 7 = incredibly easy] | The most current period available, or the weighted average for 2018–2019 (Executive Opinion Survey by WEF).

Human Capital

- **Mean Years of Schooling (MYS):** The average number of years that a person who is 25 years of age or older has completed their education, omitting years that they have spent repeating a single grade.

- **Quality of vocational training (QVT):** Answer to the poll question: "How would you rate the quality of vocational training in your nation?" [1 = very poor among the worst in the world; 7 = excellent among the best in the world] | The most current period available, or the weighted average for 2018–2019 (Executive Opinion Survey by WEF).

- **Digital skills among active population (DSAP):** Answer to the poll question: "How much of the working population in your country has basic computer skills, digital reading comprehension, and basic coding knowledge?" [1 = not entirely; 7 = largely] | The most current period available, or the weighted average for 2018–2019 (Executive Opinion Survey by WEF).

4 DATA ANALYSIS

The significant data analysis techniques employed in the research is the reliability analysis and the factor analysis.

Reliability Analysis

Table 4: Reliability Analysis

	Coefficient ω	Coefficient α
RDI	0.789	0.752
FI	0.789	0.771
LI	0.771	0.765
total	0.845	0.879

Table 4 summarizes the reliability analysis of the research. Since all the values of Crobach's alpha is 0.7 and above, the test is considered to be reliable.

Factor Analysis

Model fit

Table 5: Model Fit for Confirmatory Factor Analysis

Chi-square test

Model	X^2	df	p
Baseline model	935.701	36	
Factor model	93.838	24	< .001

Chi-Square test is a statistical method for assessing the discrepancy between observed and expected data. You can also perform this test to see if it has any correlation with the data's category variables. Determining if a discrepancy between two categorical variables is the result of random variation or a relationship between them is helpful. The value of the test in this case is 935.701. The p-value is smaller than significance level, 0.05, so I can reject the null hypothesis because and infer that there is a relationship between the independent variables of the study and the economic growth.

Table 6: KMO Test

Kaiser-Meyer-Olkin (KMO) test

Indicator	MSA
Scientific publications	0.788
RD expenditures	0.902
Research institution prominence	0.890
Domestic credit to private sector	0.949

Kaiser-Meyer-Olkin (KMO) test

Indicator	MSA
Financing of SMEs	0.766
Venture capital availability	0.799
Mean years of schooling	0.874
Quality of vocational training	0.932
Digital skills among active population	0.881
Overall	0.859

Table 7: Bartlett's Test of Sphericity

Bartlett's test of sphericity

X^2	df	p
905.826	36	< .001

KMO is a test conducted to examine the strength of the partial correlation (how the factors explain each other) between the variables. KMO values closer to 1.0 are consider ideal while values less than 0.5 are unacceptable. Recently, most scholars argue that a KMO of at least 0.80 are good enough for factor analysis to commence. In the table above, the probability value of KMO is less than 0.859 which is closer to one and is considered a good value. The Bartlett’s test of Sphericity is used to test the null hypothesis that the correlation matrix is an identity matrix. An identity correlation matrix means your variables are unrelated and not ideal for factor analysis. A significant statistical test (usually less than 0.05) shows that the correlation matrix is indeed not an identity matrix (rejection of the null hypothesis) as represented in the table below. In above table, the probability value of Bartlett’s test is less than 0.05 which is considered to be a good value.

Parameter Estimates

When all other predictors are held constant, parameter estimates represent the change in the response corresponding to a one-unit change in the predictor. A predictor’s coefficient reveals how much of an impact it has on the response; a coefficient close to 0 suggests the variable has minimal effect.

Estimate: Estimates of the model coefficients

Standard Error (Std. Error): The estimates of the standard errors of the parameter estimates

Z-Value: Indication of how close the value is to mean

p-value: probability value of a hypothesis test

Lower 95%: The lower 95% confidence limit for a parameter estimate

Upper 95%: The upper 95% confidence limit for a parameter estimate

Table 8: Factor Loadings

Factor loadings

						95% Confidence Interval	
Factor	**Indicator**	**Estimate**	**Std. Error**	**z-value**	**p**	**Lower**	**Upper**
RDI	Scientific publications	10.014	1.064	9.408	< .001	7.928	12.100
	RD expenditures	25.946	2.037	12.736	< .001	21.953	29.938
	Research institution prominence	18.126	2.367	7.657	< .001	13.487	22.766
FI	Domestic credit to private sector	20.327	2.407	8.445	< .001	15.609	25.044
	Financing of SMEs	13.164	0.957	13.748	< .001	11.287	15.040
	Venture capital availability	13.870	0.878	15.805	< .001	12.150	15.590
LI	Mean years of schooling	13.108	1.693	7.743	< .001	9.790	16.426
	Quality of vocational training	9.787	0.810	12.089	< .001	8.200	11.373
	Digital skills among active population	11.532	0.842	13.691	< .001	9.881	13.183

Scientific Publications: Factor loading represents the correlation between an observed variable (indicator) and the underlying factor in factor analysis. Overall, the factor loading estimate of 10.014 is statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

R&D Expenditures: The factor loading estimate of 25.946 is highly statistically significant, indicating a very strong positive relationship between the indicator and its underlying factor.

Research Institute Prominence: The factor loading estimate of 18.126 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Domestic credit to private sector: The factor loading estimate of 20.327 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Financing of SMEs: The factor loading estimate of 13.164 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Venture Capital Availability: The factor loading estimate of 13.870 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Mean Years of Schooling: The factor loading estimate of 13.108 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Quality of Vocational Training: The factor loading estimate of 9.787 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Digital Skills among Active Population: The factor loading estimate of 11.532 is highly statistically significant, indicating a strong positive relationship between the indicator and its underlying factor.

Factor Covariance

Factor Covariance in factor analysis describe the underlying relationship between the latent factors used in the research. The covariance estimate value ranges from 0 to 1. Values closer to 1 represents strong relationship between the factors whereas the values closer to 0 represents little to no relationship between the factors. Table 10 shows the factor covariance of the model.

Table 9: Factor Covariance

		Estimate	Std. Error	z-value	p	95% Confidence Interval Lower	95% Confidence Interval Upper
RDI	↔ FI	0.664	0.056	11.910	< .001	0.555	0.774
RDI	↔ LI	0.772	0.049	15.774	< .001	0.676	0.867
FI	↔ LI	0.853	0.032	27.022	< .001	0.791	0.915

1. RDI (Research & Development Institutions) and FI (Financial Institutions):

The computed covariance between RDI and FI suggest that they have a relatively strong positive association. The low standard error and high z-value indicate that this estimate is statistically significant and credible. The 95% confidence range (0.555 to 0.774) demonstrates that the actual covariance is considerably different from zero, indicating that the link between the two variables is both positive and strong. In conclusion, the two latent components are positively and strongly connected, with a moderate-to-strong covariance estimate. This implies that changes in one element are likely to coincide with equivalent directional changes in the other.

2. RDI (Research & Development Institutions) and LI (Labor Institutions):

The 95% confidence interval confirms that the real covariance is considerably positive and that the estimate is quite reliable. RDI and LI are significantly and positively correlated. The high covariance value of 0.772, together with the small value of standard error shows there are hardly any chances of sampling error; and substantial z-value, indicates a strong association between these variables with low uncertainty. This is supported by the 95% confidence interval, which shows that the genuine covariance is within a reasonably limited and positive range.

3. FI (Financial Institutions) and LI Labor Institutions:

The two latent components have a substantial, statistically significant positive covariance. The high covariance value of 0.853, modest standard error, and strong z-value suggest that this association is stable and consistent across samples. The small and positive confidence interval verifies the estimate's dependability.

Model plot

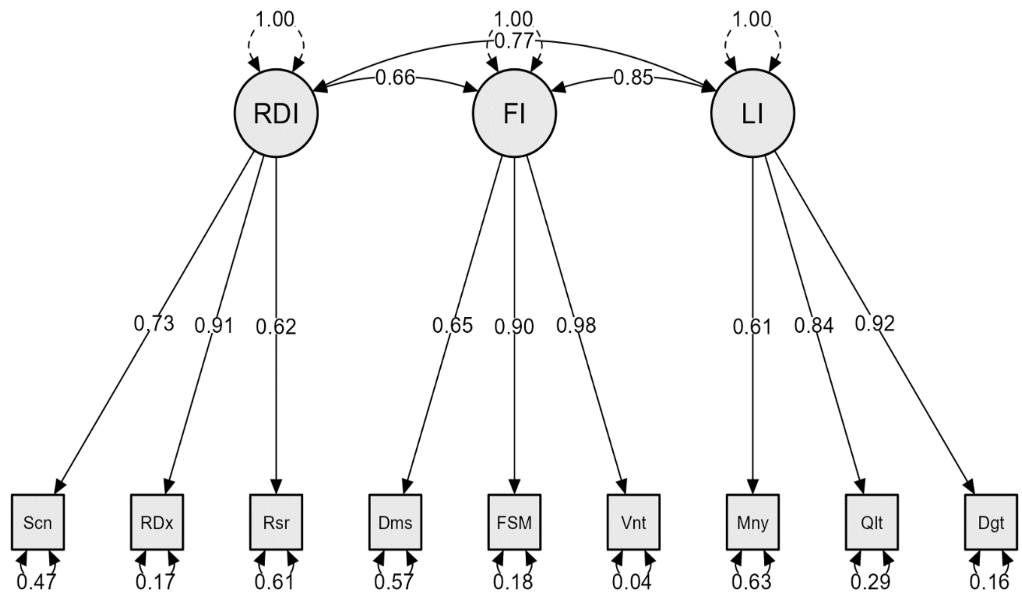

Figure 2: SEM Model Plot

***RDI: Research and Development Institutions**
***FI: Financial Institutions**
***LI: Labor Institutions**

***Scn: Scientific Publications**
***RDx: Research & Development Expenditures**
***Rsr: Research Institutions Prominence**

***Dms: Domesctic Credit to Private Sector**
***FSM: Financing of SMEs**
***Vnt: Venture Capital Availibility**

***Mny: Mean Years of Schooling**
***Qlt: Quality of Vocational Training**
***Dgt: Digital Skills among active Population**

The Model Fit of the Confirmatory Analysis shows the relationship between the observed and latent variables. The circles in the diagram shows the latent variables which are typically used to represent the constructs of the study. The rectangles show the observed variables. The arrow from the latent variable pointing towards the observed variable are called path coefficients which show that the latent variable predicts the observed variable. Higher values show the strong relationship between latent and observed variable. The curved arrows between the latent variables shows the correlation or covariance between these variables. And the small arrows pointing towards the observed variables are the error terms, the value of which represent the amount of variance not explained by the latent variables.

The covariance between RDI and FI is 0.66 which represents the moderately strong positive relationship between the two latent variables. This means if one variable increases, the other tend to increase as well. According to the squared correlation ($0.66^2 = 0.4356$), one latent variable shares

43.6% of its variance with the other latent variable. This demonstrates that although the two latent variables have their own unique variance, they do share a substantial number of factors that influence them. The closer the correlation is to 1, the stronger will be the relationship. Hence, the covariance between FI and LI is 0.85, represents very strong relationship between the two variables.

A path coefficient of 0.73 indicates that the latent factor RDI accounts for 73% of the variance in the observed variable *scientific publications*. This suggests that there is a substantial correlation between the latent and the observed variable. The stronger the relationship, the greater the coefficient. An error term of 0.47 indicates that variables other than the latent variable, such as measurement error or other unmeasured variables, account for 47% of the variance in the scientific publications. Since both the error term and the squared route coefficient account for the entire variance of the observed variable, their sum equals 1. The percentage of explained variance in the observed variable ($0.73^2 = 0.5329$, or roughly 53%) is represented by the route coefficient squared. The error term, or around 47% in this instance, denotes the unexplained variance. As a result, regarding this observed variable: RDI accounts for 53% of its variance. Of the variance, 47% is either not explained at all or is ascribed to measurement error. The degree to which the latent variable predicts the observed variable and the amount of measurement error or unmeasured impacts are indicated by the balance between the route coefficient and error term.

With a path coefficient of 0.91, 91% of the variance in the R&D expenditures (RDE) can be explained by latent variable RDI. This indicates that there is a substantial correlation between the RDE and the latent factor RDI. When measuring the latent factor, the observed variable is quite trustworthy, as indicated by the path coefficient of 0.91. Stated otherwise, the latent construct that underlies the observable variable can be accurately inferred from it. Path coefficients of more than 0.7 are typically regarded as strong. With a rating of 0.91, the predictive power appears to be quite strong. When the error term is 0.17, it indicates that 17% of the variation in the observed variable RDE cannot be explained by the latent variable RDI, measurement error, or other factors. The comparatively tiny error term suggests that RDI accounts for most of the variance of the RDE, leaving only a small amount unexplained. According to the squared path coefficient ($0.91^2 = 0.8281$), the latent variable accounts for 82.81% of the variance in the observed variable. With an error term of 0.17, the remaining 17% of the variance remains unexplained. When taken as a whole, these numbers support a robust model fit for this particular connection, in which RDI accounts for the majority of RDE variability with little error or variance that cannot be explained. An extremely strong correlation between RDI and the RDE is shown by a path coefficient of 0.91. With an error term of 0.17, the model is successfully capturing the connection because it only accounts for a small amount of the variance in the observed variable.

With a path coefficient of 0.62, the RDI accounts for 62% of the variance in the observed variable Research Institute Prominence (RIP). A relatively strong link between RDI and RIP is suggested by a coefficient of 0.62. The observed variable can be predicted by the latent variable with a moderate degree of accuracy. A 0.62 path coefficient shows a significant association even if it is not as strong as coefficients over 0.7, but there is still opportunity for other variables or factors to also play a role in explaining the variance in RIP. An error term of 0.61 indicates that measurement error or impacts from other variables not included in the model account for 61% of the variance in RIP that remains unexplained. A relatively large error term, such as 0.61, indicates that RDI is not explaining a significant amount of the variance in the RIP. This can point to an insufficient model specification, unmeasured parameters, or measurement error. RDI accounts for 38.44% of the variance in the observed variable RIP, according to the squared path coefficient of $0.62^2 = 0.3844$. The remaining 61% of the RIP variance that the model is unable to explain is accounted for by the error term of 0.61.The RDI explains an acceptable portion of the variation, as indicated by the path coefficient of 0.62, which indicates a moderate link between the RDI and RIP. A measurement error or additional factors not included in the model may be the cause of the observed variable's substantial unexplained variation, as indicated by the error term of 0.61. The subsequent constructs, their path coefficients with their respective observed variables are interpreted in the similar way.

SEM ANALYSIS

A. Path Diagram

Figure 3 shows the path diagram of the proposed model. Each box represents the research construct of the model which are measured by the independent variable(s), the circles (round shapes) depict the residual errors for each variable, and the arrows shows the relationship between these constructs. The AMOS output gives results for three models (Berndt, 2020). The Default Model is the model which is proposed by the researcher. The Saturated model is the model that represents the perfect fit by using the maximum number of available parameters. The Independence Model, also called Null Model gives results for the poor fit model by correlating all measured variables with 0, without using latent constructs. Values for the default model will be accounted for in the study.

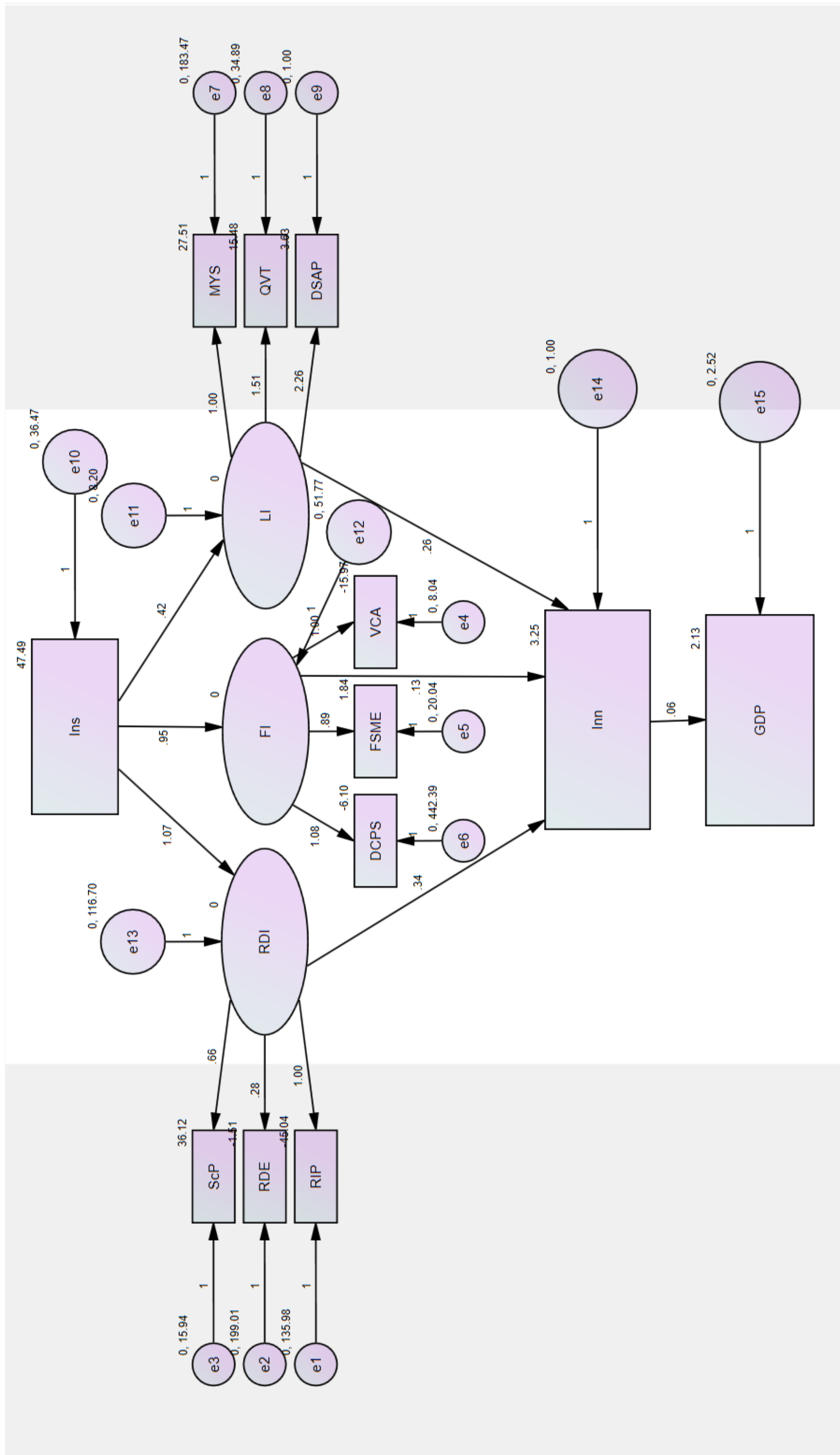

Figure 3: SEM Path Diagram

B. Model Fit Summary

Table 10 shows that the model is fit for testing the hypotheses.

Table 10: SEM Analysis Model Fit Summary

Measure	Estimate	Threshold	Interpretation
CMIN	63.165	-	-
DF	52	-	-
CMIN/DF	1.215	2	Excellent
NFI	0.756	Closer to 1	Good
RFI	0.690	1= Perfect Fit Closer to 1= Good fit	Good
IFI	0.946	1= Perfect Fit Closer to 1= Good fit	Good
TLI	0.926	1= Perfect Fit Closer to 1= Good fit	Good
CFI	0.942	1 = Perfect fit ≥ 0.95 = Excellent fit ≥ .90 = Acceptable fit	Good
PRatio	0.788	No cutoff value	-
PNFI	0.595	0.5 and above	Excellent
PCFI	0.742	0.6 and above	Excellent
NCP	0 to 35.39	-	-
FMIN	2	No cutoff value	-
RMSEA	0.08	0.05 or 0.08	Excellent
AIC	139.16	-	-
BCC	194.05	-	-
ECVI	4.48	No cutoff value	-
MCVI	6.26	No cutoff value	-
Hoelter 0.5	35	-	-
Hoelter 0.1	39	-	-

i. Chi-Square Statistic (CMIN)

Table 11: CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	38	63.165	52	.138	1.215
Saturated model	90	.000	0		
Independence model	24	258.445	66	.000	3.916

The Chi-square value, or CMIN, is used to determine whether a difference between the observed variables and the anticipated findings is statistically significant. In other words, CMIN reveals whether the hypothetical model and the sample data suit the analysis well. The NPAR refers to 'Number of Parameters' for all models (default, saturated, and independence). In this case, The NPAR is 38 for Default model, 90 for Saturated and 24 for Unsaturated. The CMIN refers to the Chi-square value. If insignificant, the model can be considered satisfactory. The Degree of Freedom or DF is used to measure the number of independent values that can deviate without interfering with any model limitations. P refers to the probability of achieving a discrepancy as high as value of CMIN in case the proposed model is correct.

CMIN/DF = discrepancy divided by degree of freedom.

The value of interest here is the ***CMIN/DF*** for the default model and is interpreted as follows:

- If the CMIN/DF value is **≤ 2** it indicates an good fit (Samuels, 2015).
- If the CMIN/DF value is **≤ 3** it indicates an acceptable fit (Samuels, 2015).
- If the value is **≤ 5** it indicates a reasonable fit (Marsh and Hocevar, 1985)

In this case, the CMIN/DF for default model is 1.215 which is considered to be an acceptable fit.

ii. Baseline Comparisons

Table 12: Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.756	.690	.946	.926	.942
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Baseline Comparisons refers to the default, saturated, and independence models that Amos automatically fits for each analysis. NFI, also known as Delta 1, is a measure of how well a model fits, ranging from the independence model (which fits poorly) to the saturated model (which fits exceptionally well). A score of 1 indicates a perfect fit, while models with values below 0.9 can typically be significantly improved (Bentler and Bonett, 1980). RFI stands for Relative Fit Index, which is derived from NFI. Values near to 1 denote a perfect fit, whereas 1 denotes a very excellent fit. IFI stands for Incremental Fit Index, and values near to 1 denote a very excellent fit and 1 a perfect one. The Tucker-Lewis coefficient (TLI), also known as the *Bentler-Bonett* non-normed fit index (NNFI), goes from 0 to 1, with a value closer to 1 signifying a perfect fit and a value closer to 0 a poor fit. According to McNeish & Wolf (2023), the Comparative Fit Index (CFI) has a range of values between 0 and 1, with values near to 1 indicating an extremely good fit and 1 indicating the ideal fit. Here, CFI for the default model represents the value of interest. According to Xia & Yang (2019), a CFI value of 0.95 or less indicates a model that fits the data very well. According to Parry (2020), it is deemed to be extremely good if it is equal to or higher than 0.95, good between 0.9 and 0.95, suffering between 0.8 and 0.9, and poor if it is lower than 0.8. In this case, the value of CFI is 0.94 which is considered to be a good value.

iii. Parsimony-Adjusted Measures

Table 13: Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.788	.595	.742
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

Parsimony-adjusted measures are relative fit indices that have been modified for the majority of the indices described thus far. The higher the fit index, the more complicated the model, as a more straightforward description of an occurrence is often preferred over a complex one. A PRatio score closer to 1 denotes poor model fit, whereas one greater than1 denotes the target model fits the data better than the null model. Effective model fit is indicated by a PRATIO value of 2 or higher

(Bollen, 1989 ;Peter M. Bentler, 1992). The PNFI and PCFI indices are calculated using the Parsimony Ratio (PRatio), which also determines the amount of constraints in a model. Since it varies on the particular model and sample size, there is no set cutoff value for PRATIO. Parsimony Normed Fixed Index (PNFI) is the result of a parsimony modification to the Normed Fixed Index (NFI) (Williams, O'Boyle and Yu, 2020). Acceptable model fit is indicated by PNFI values of 0.5 or higher. The result of applying a parsimony adjustment to the Comparative Fit Index (CFI) is expressed by the acronym PCFI, or Parsimony Comparative Fix Index. Acceptable model fit is indicated by a PCFI value of 0.6 or higher. For PNFI and PCFI, there isn't a single agreed standard or reference value.

iv. Non-centrality parameter (NCP)

Table 14: NCP

Model	NCP	LO 90	HI 90
Default model	11.165	.000	35.394
Saturated model	.000	.000	.000
Independence model	192.445	146.784	245.677

NCP, or non-centrality parameter, is a measure of how incorrect a null hypothesis is. NCP stands for Non-Centrality Parameter, and the lower and upper limits of the 90% confidence interval for the NCP are designated as LO (NcpLo) and Hi (NcpHi), respectively. LO 90 denotes the lower limit of a 90% confidence interval for the NCP using the NcpLo technique. HI 90 denotes the upper limit of a 90% confidence interval for the NCP (NcpHi technique). In this case, the default model's population NCP ranges from 0 to 35.39 with a 90 percent confidence level.

v. Fit Model Index (FMIN)

Table 15: FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	2.038	.360	.000	1.142
Saturated model	.000	.000	.000	.000
Independence model	8.337	6.208	4.735	7.925

FMIN, or the Index of Model Fit, is employed when CMIN fails to achieve a favorable outcome, typically as a result of a higher sample size. FMIN stands for Index of Model Fit, with LO and Hi, the lower and upper limits of the 90% confidence interval, as its boundaries. With 0 indicating the ideal fit, a value nearer to 0 indicates a more accurate fit for the data being observed. Where F0 indicates Confidence interval. LO 90 is lower limit of the FMIN's 90% confidence interval. HI 90 is higher limit of the FMIN's 90% confidence interval. In this case, the FMIN is 2 which indicates a good model. The LO of FMIN is 0 whereas the HI of FMIN is 1.1.4

vi. Root Mean Square Error of Approximation (RMSEA)

Table 16: RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.083	.000	.148	.245
Independence model	.307	.268	.347	.000

RMSEA or Root Mean Square Error of Approximation is the difference between the observed and the anticipated covariance matrix for each degree of freedom (Chen, 2007). The common interpretation of RMSEA values are; values above 0.1 are regarded as poor, between 0.08 and 0.1 as borderline, between 0.05 and 0.08 as acceptable, and values below 0.05 as excellent (Adedia, Adebanji and Appiah, 2021). LO 90 is the lower limit (RMSEA Lo) of the RMSEA's 90% confidence interval. HI 90 is the upper limit (RMSEA Hi) of the RMSEA's 90% confidence interval. PCLOSE is the P-value for the null hypothesis. In this case, the RMSEA for default model is 0.08 which is an acceptable value for the model.

vii. Akaike Information Criterion (AIC)

Table 17: AIC

Model	AIC	BCC	BIC	CAIC
Default model	139.165	194.054		
Saturated model	180.000	310.000		
Independence model	306.445	341.112		

The Akaike Information Criterion, or AIC, was developed by Akaike in 1987 and is used to assess how well a statistical model fits the data sample. The AIC is a score that may be expressed as a single number that is used to assess which model fits the data set the best. Only when compared to other AIC values from the same data set is the Akaike Information Criterion score (AIC) helpful. The AIC value should be as low as possible. BCC stands for Browne-Cudeck Criteria, which is used primarily to examine component structures and apply a heavier penalty for less constrained models. In comparison to AIC, BCC, and CAIC, BIC, BIC or Bayes Information Criterion imposes a heavier penalty on complex models, increasing its propensity to select frugal approaches. Consistent Akaike Information Criterion, or CAIC (Bozdogan, 1987), is only mentioned when the means and intercepts of a single group are not clearly stated. In comparison to AIC and BCC, but less severely than BIC, CAIC imposes a penalty for complicated models. In this case, the AIC value for default model is 139.16 and BCC value is 194.05.

viii. Expected Cross Validation Index (ECVI)

Table 18: ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	4.489	4.129	5.271	6.260
Saturated model	5.806	5.806	5.806	10.000
Independence model	9.885	8.412	11.602	11.004

Expected Cross Validation Index, or ECVI (Browne & Cudeck, 1993), quantifies how well a model can predict the future via a straightforward chi-square transformation, much like AIC (with the exception of the constant scale factor). Expected Cross Validation Index (ECVI) is a measurement of how well a model fits the data. Lower limit of a 90% confidence interval for the population's ECVI is designated as LO 90. For the population's ECVI, HI 90 denotes the upper bound of a 90% confidence interval. MECVI = The MECVI is comparable to the Browne-Cudeck Criterion (BCC) with the exception of a scale factor employed in computation (Browne, 1993). In this case, the ECVI value of the default model is 4.48, the LO90 value is 4.12, HI90 value is 5.27, whereas the MECVI value is 6.26.

ix. HOELTER

Table 19: Hoelter Index

Model	HOELTER .05	HOELTER .01
Default model	35	39
Independence model	11	12

The Hoelter Index is used to determine if the chi-square is significant or not. For the default model, HOELTER.05 determines whether the sample size can be accepted at the 0.05 level. The default model must be rejected if sample size is greater than the value given for it at the 0.05 level. The Hoelter 0.1 determines whether the sample size for the default model may be accepted at the 0.01 level. Accordingly, I can reject the default model if the sample size exceeds the amount set for the default model at the 0.01 level. In this case, the Hoelter 0.5 value for the default model is 35 and Hoelter 0.1 value is 39.

5 THESES OF THE STUDY

SEM analysis was used to test the theoretical framework, and the test results suggest the model has a good fit. The SEM path diagram shows that institutions have significant and positive relationship with R&D, and the capital market (their connection with human capital is also positive, but not significant; P=0.139). To see the impact of different types of institutions on economic growth, I have designed an ecosystem approach in which different institutional factors including that of R&D, Human capital and capital market, each work together to impact the innovation in a country to eventually impact its economic growth. I found significant positive relationships between R&D, and innovation and also between capital markets and innovation; the relationships between human capital and innovation; and innovation and economic growth, however, are not significant. Table 20 shows the logical frameworks of the research.

Table 20: Logical Framework (Source: Author's own calculations)

Sr. No.	Research Objectives	Research Questions	Hypotheses	Results
1	**To find out the impact of Institutions focusing on R&D on Innovation**	**R&D features have a significant impact on Innovation**	**H1**	**Supported**
2	**To find out the impact of Institutions focusing on Capital Market on Innovation**	**Capital Market features have a significant impact on Innovation**	**H2**	**Supported**
3	**To find out the impact of Institutions focusing on Human Capital on Innovation**	**Human Capital features have a significant impact on Innovation**	**H3**	**Not Confirmed**
4	**To find out the impact of Innovation on Economic Growth**	**Innovation has a significant impact on Economic Growth**	**H4**	**Not Confirmed**

5.1 THE RELATIONSHIP BETWEEN R&D AND INNOVATION

To determine the validity of the suggested path, the statistical significance of this path within the model was evaluated during hypothesis testing. This hypothesis was approved since the findings demonstrated a statistically significant positive relationship between research & development and innovation ($r = 0.081$, $p = 0.659$). Middle-income countries with higher R&D expenditures and more scientific publications are likely to have higher levels of innovation. There’s a strong, positive correlation between R&D and research institution prominence, indicating a strong association between R&D activities and prominent research institutions.

Thesis 1: Research & Development have a significant and positive relationship with innovation in LMICs

The first hypothesis that there is a positive and significant relationship between R&D and innovation is supported by the results such that an increase in the former would result in increase in the latter. The estimate result show that with every unit rise in R&D, there is 0.34 unit rise in innovation. Therefore, the results support H1. This backs the earlier literature proposed by Coe et al. (1997), Lichtenberg (2001) and Aghion et al., (2011) that R&D investment is critical for innovation. From this, I conclude that the low R&D score in case of Lower Middle Income countries leads to low innovation. Many Lower Middle Income Countries (LMICs) have undeveloped higher education institutions and research centers that lack the infrastructure, equipment, and resources required for sophisticated research. This reduces their capacity to make meaningful contributions to R&D initiatives. The institutional framework of LMICs frequently lacks substantial networks for collaboration across academics, business, and the government. This seclusion can impede creativity and undermine the efficacy of research endeavors. Educational systems struggle to offer basic education, in addition to advanced scientific and vocational education. Poor access to excellent education impedes the development of a trained workforce capable of performing research and development. Universities in these countries frequently lack the capacity to provide advanced degrees in science, mathematics, engineering, and technology. Without a solid basis in these areas, there is a scarcity of researchers and scientists capable of driving R&D efforts. There may be an overall lack of understanding or appreciation for the importance of science and research in these countries. If the public and governments do not perceive immediate advantages from R&D, there is less incentive to prioritize and invest in it. Inadequate IP legislation and enforcement might discourage investment in R&D since corporations and researchers may be concerned that their ideas will not be effectively protected against infringement. This lack of security may limit desire to develop.

5.2 THE RELATIONSHIP BETWEEN CAPITAL MARKET AND INNOVATION IN LMIC

Capital Markets are found to have a significant and positive impact on innovation as proposed in second hypothesis and confirmed by the results ($r = 0.230$, $p = 0.205$).

Thesis 2: Capital markets have a significant and positive relationship with innovation in LMICs

Capital Markets are found to have a significant and positive impact on innovation as proposed in second hypothesis and confirmed by the results. The estimates show that for every unit rise in financial institutions, there is 0.12 unit rise in innovation. The p value for this relationship is 0.007 which means that there is 0.7% probability that the financial institutions' impact on innovation is by chance. Therefore, H2 is supported by the model results. Transparency in the financial institutions increases investor's confidence and bring about potential capital investments in the future. The results are in line with evidence from early empirical research by Shaw (1973) and (Degong *et al.*, 2021) showing a positive correlation between innovation and liberal financial policy. Capital markets are essential for fostering entrepreneurship by offering the financial support startups and innovative ventures need to succeed (Lerner, 1999). Entrepreneurship, in its essence, drives innovation as entrepreneurs are frequently pioneers in creating new products, services, and business approaches (Schumpeter, 2017). Additionally, innovative firms often capture substantial investments from capital markets due to their potential for significant growth and profitability. Thus, the synergy between capital markets, entrepreneurship, and innovation forms a dynamic framework that promotes economic expansion and technological progress. However, LMICs frequently experience budgetary limits, limiting their capacity to devote considerable resources to R&D. Governments may prioritize more urgent requirements, such as healthcare, education, and infrastructure, over long-term expenditures in research and development. In many LMICs, the private sector is dominated by SMEs, who frequently lack the financial resources to invest in R&D. These companies may prioritize short-term survival above long-term innovation, especially under unpredictable economic conditions. Venture money and other types of private investment in R&D are frequently scarce in low- and middle-income countries. Investors in these nations may be risk-averse, preferring secure investments over backing creative but risky R&D ventures (Khan, 2022). Because LMICs' domestic markets are limited, the high expenses of R&D may not be justified. Firms may find it more cost effective to import innovations or goods created elsewhere rather than engage in domestic R&D. Many LMICs still have fledgling or undeveloped financial markets, which hinder their capacity to successfully fund innovation. A lack of depth, liquidity, and financial instruments might limit enterprises' access to capital. Poor regulatory frameworks, political turmoil, and inadequate investor protection can all hinder capital market operations, deterring investment in high-risk, creative areas. In many LMICs, the domestic investor market is minimal, with little participation from institutional investors. This may limit the access of long-term capital for innovation-driven businesses.

5.3 THE RELATIONSHIP BETWEEN HUMAN CAPITAL AND INNOVATION IN LMIC

The third hypothesis that Human capital is positively associated with innovation is not supported by the results ($r = 0.405$, $p = 0.022$). H3 cannot be confirmed based on the model. The labor markets of many developing nations differ significantly from those of developed countries due to factors including structural rigidities, under-employment, concealed unemployment, and unemployment.

Thesis 3: The relationship between Human Capital and Innovation in LMICs could not be confirmed

The third hypothesis that Human capital is positively associated with innovation is not supported by the results. H3 cannot be confirmed based on the model. The results indicate that the endogenous theories put forward by Lucas (1988b), or Azariadis & Drazen (1990) may not apply to developing countries. While human capital is often perceived as a key driver of innovation, the correlation between them is not always clear-cut. Some research posits that increased human capital, characterized by higher education and skills, can foster innovation by enhancing individuals' ability to devise and execute new ideas (Acemoglu, 2002). Contrarily, other studies suggest that an excessive focus on human capital can inhibit innovation by fostering conformity and curbing risk-taking and creative thinking (Naylor and Florida, 2003). A study by Jones & Williams (1998) indicated that although human capital is crucial for productivity, it doesn't always translate into enhanced innovation. Likewise, research conducted by (Bessen and Hunt, 2007) observed that boosting human capital via education investments didn't consistently correlate with elevated innovation levels across various industries. Hence, while human capital undeniably plays a role in driving innovation, its influence can be modulated by factors like organizational culture and incentives, resulting in a more intricate and multifaceted relationship between the two. Access to high-quality education remains a major barrier in many LMICs. Inadequate financing, inadequate infrastructure, and low teaching quality can all contribute to lower educational attainment and skill levels. Without robust educational systems, it is impossible to have a workforce capable of driving innovation. Talented individuals from low- and middle-income nations frequently relocate to higher-income countries in quest of better prospects, known as 'brain drain'. This limits the pool of qualified individuals available to fuel local innovation, thereby depriving countries of those most capable of supporting economic growth and technological progress. There is a skill gap between the output of the educational system and the demand of the labor market. The Curriculum may not match the requirements of rapidly evolving sectors, particularly emerging businesses such as information technology, biotechnology, and renewable energy, restricting the workforce's capacity to contribute to innovation. Many LMICs fail to invest in R&D. The absence of financing for universities, research institutions, and private-sector R&D efforts stifles innovation. Furthermore, the lack of research facilities, modern labs and innovation centers reduces researchers' and entrepreneurs' capacity to design and commercialize new technologies. Workers in fast changing industry must constantly upgrade their skills in order to stay competitive and inventive. However, many LMICs lack comprehensive systems for vocational education, continuous education, and upgrading skills, all of which are required to retain an innovative and adaptable workforce.

5.4 THE RELATIONSHIP BETWEEN INNOVATION AND ECONOMIC GROWTH

I could not confirm the existence of a positive link between innovation performance and economic growth among the lower middle-income group of developing countries ($r = 0.223$, $p = 0.219$). This result could be interpreted as a sign of a middle-income trap (a growth failure identified by some studies in developing countries) among the lower middle-income group of countries.

Thesis 4: The relationship between Economic Growth and innovation in LMICs could not be confirmed

I could not confirm the existence of a positive link between innovation performance and economic growth among the lower middle-income group of developing countries. This failure adds to the ever-expanding literature of the middle-income trap (CM, Hoang and Yarram, 2024). The existence of the trap is not confirmed by all empirical studies, but the existing results suggest that in developing countries the connection between innovation, and the factors of innovation on the one hand and long-term economic growth on the other hand is not as obvious as suggested by NGT. Countries in the middle-income trap face institutional and political challenges, particularly related to upgrading productivity through human capital and innovation, which require significant investment in institutional capacity (Doner & Schneider, 2016; (Mickiewicz, 2023). The results could be the representation of the middle-income growth failure among developing countries. LMICs usually spend substantially less on R&D than high-income countries. This restricted budget limits public institutions' capacity to undertake research and promote innovation. Governments may not have robust policies in place to encourage R&D, such as tax breaks, grants, or research subsidies. This inhibits both the public and commercial sectors from investing in innovation. Many LMICs' economies are primarily based on agriculture, low-tech manufacturing, or extractive industries. These sectors often have lesser R&D needs than high-tech businesses such as biotechnology, pharmaceuticals, and computer technology. The industrial base may not recognize the need for or have the capacity to absorb sophisticated R&D, since many firms rely on imported technology rather than creating their own. Firms may prioritize preserving established methods and making incremental changes over pursuing radical innovation. This conservative attitude stifles the desire for innovative R&D.

6 IMPLICATIONS AND RECOMMENDATIONS

6.1 IMPLICATIONS

Policy Implications

Research and development, or R&D, is a vital force behind innovation, economic expansion, and social advancement. Effective R&D activities are facilitated by an environment that is shaped in large part by policymakers. The results of the research provide specific policy recommendations that can help organizations and governments foster an atmosphere that is favorable to research and development.

1. My research confirmed that the research and development features have a positive impact on innovation. This implies that governments should devote a sizeable percentage of their budget to R&D endeavors, especially in fields like basic science, public health, and environmental sustainability that are strategically vital but might not draw enough funding from the private sector. In high-risk, high-reward fields where private sector money is scarce, giving grants and subsidies to academic institutions, research centers, and private businesses can foster innovation. By guaranteeing that inventors can profit from their labors, bolstering the patent system to offer strong protection for new ideas promotes investment in R&D. To avoid the monopolies that impede competition, this must be balanced, though. By streamlining and expediting the patent application process, inventors can better safeguard their discoveries and cut down on the time and expense involved in introducing novel technology to the market.

2. The results confirmed positive connection of Capital Markets and innovation. This implies that governments can lower the actual cost of research and promote greater investment from the private sector by providing tax credits or deductions through financial institutions to businesses that engage in research and development. Encouraging corporations to deduct capital expenditures connected to research and development at a faster rate can result in immediate tax benefit, which in turn encourages more investment in R&D capacity. Access to research facilities, tax breaks, and targeted funds are a few examples of this. By offering mentorship, finance, and access to networks, supporting accelerators and incubators that concentrate on early-stage businesses can aid in commercializing innovations.

3. The research results show that while human capital is often perceived as a key driver of innovation, the correlation between them is not always clear-cut in case of lower middle income countries. This implies that to guarantee that the current workforce is capable of adjusting to new technologies and procedures arising from research and development endeavors, policymakers ought to support programs for up-skilling and continuous learning. This can involve collaborations with business and government-funded training initiatives. Governments should place a high priority on STEM (Science, Technology, Engineering, and Mathematics) education in schools and universities. They should also update curricula to incorporate new topics like data science, artificial intelligence, and biotechnology. By supporting international exchange programs for scholars and students, governments may promote global collaboration and expose homegrown talent to cutting-edge research and best practices from around the world. Simplified visa requirements for

researchers and skilled workers can draw in talent from around the world and strengthen the nation's capacity for R&D.

4. The results of the research show a positive connection between innovation and economic growth but the relationship found is not significant in case of lower middle income countries. This implies that to evaluate the effects of R&D investments, governments should create thorough metrics that take into account not only financial returns but also societal advantages like social equity, environmental sustainability, and public health. Matching national standards with global standards can help new technologies be deployed globally and guarantee that innovations resulting from research and development are both globally competitive and comply with international laws. These specific policy ramifications demonstrate the government's complex role in supporting a healthy R&D ecosystem.

Research Implications

Research and development, or R&D, is essential to producing new knowledge, advancing technology, and resolving difficult societal problems. The ramifications of R&D activities for research are extensive, including not just the regions of attention and methodology employed, but also the manner in which research outputs are evaluated and applied.

1. My research confirmed that the research and development features have a positive impact on innovation. This implies that R&D aids in the identification of new disciplines like renewable energy, synthetic biology, and quantum computing that have the potential to have a significant impact on society. Prioritizing these areas in research agendas can help you remain ahead of global developments and meet future needs. Research methods and knowledge from one field can inform and improve research in another, a phenomenon known as the cross-pollination of ideas, which is facilitated by R&D activities and interdisciplinary research. R&D-driven research can aid in foreseeing and preparing for issues that society may face in the future, such as pandemics, climate change, and cybersecurity threats. Prioritizing research in these fields proactively can result in creative fixes before emergencies arise. R&D emphasizes the importance of incorporating user demands and feedback into the research process. This approach can result in innovations that are more applicable and broadly adopted, especially in industries like consumer items, software development, and healthcare.

2. My results confirmed positive connection of Capital Markets and innovation. This implies that Research and development endeavors underscore the necessity of carefully allocating research funds to fields possessing the greatest capacity for inventive breakthroughs and financial gain. This guarantees that funds are allocated to studies that have the biggest possible potential impact. Research can draw attention to differences in access to opportunities, resources, and rewards. In particular, marginalized and underserved populations should benefit from the work of researchers, who should make an effort to incorporate varied perspectives.

3. The research results show that while human capital is often perceived as a key driver of innovation, the correlation between them is not always clear-cut in case of lower middle income countries. This implies that Research and development frequently need cooperation

across organizations, industries, and nations. Building strong research networks that link government, business, and academia can improve the flow of information, resources, and skills. By combining resources and knowledge, consortia and partnerships around particular R&D objectives can support more ambitious and significant research projects than any one organization could carry out on its own.

4. The results of the research show a positive connection between innovation and economic growth but the relationship found is not significant in case of lower middle income countries. This implies that Research and Development (R&D) highlights the significance of converting research into commercially feasible goods and services. This is known as research commercialization. To get inventions onto the market, researchers must concentrate on the useful applications of their research. To transform research results into commercially viable products, efficient technology transfer methods, such licensing agreements and subsidiaries, are essential. Training in commercialization tactics and intellectual property management should be provided to Researchers. R&D promotes applied research that tackles practical issues. This move towards research that solves problems can result in discoveries that immediately enhance public services, private sector businesses, and overall quality of life.

Practical Implications

Research and development (R&D) has many real-world applications and is essential to advancing society, economic growth, and innovation. R&D operations directly affect industries, technologies, and people’s daily lives.

1. My research confirmed that the research and development features have a positive impact on innovation. This implies that R&D can result in the creation of novel manufacturing processes or the enhancement of already-existing ones, which can cut production costs and produce goods of a higher quality. The introduction of automation technology, for example, can speed up production and reduce human error on production lines. Businesses can create distinctive goods or services that set them apart from rivals through research and development. When supported by creative R&D, a compelling USP can significantly increase market share and brand loyalty. Research and development can result in the creation of goods with a global market appeal, giving companies access to new export markets. Innovative goods frequently have a competitive advantage in global marketplaces, particularly in high-tech businesses. Trademarks, copyrights, and patents are three forms of intellectual property (IP) protection that should be incorporated into effective research and development. By doing this, businesses can guarantee the exclusive rights to their inventions, giving them a competitive edge and possible sources of income through licensing or commercialization.

2. My results confirmed positive connection of Capital Markets and innovation. This implies that Research and development (R&D) is the foundation of new product development, resulting in the creation of cutting-edge goods that can address new customer demands or open up completely new markets. Staying ahead of market trends is critical in areas like technology, pharmaceuticals, and consumer products, therefore this is especially vital. By introducing new features, boosting productivity, or cutting expenses, ongoing research and development enables businesses to enhance their current goods. By providing customers

with a better value and ensuring that the product line remains current, this can help sustain a competitive edge.

3. The research results show that while human capital is often perceived as a key driver of innovation, the correlation between them is not always clear-cut in case of lower middle income countries. This implies that Research and development (R&D) operations frequently necessitate a highly trained workforce, which results in the creation of lucrative positions in technical, engineering, and research domains. This makes the labor force more skilled and can lower unemployment, especially in developed economies. As new procedures and technologies are created by research and development, workers must constantly adapt and learn new skills. This increases the need for reskilling and up-skilling programs, which are necessary to keep the workforce competitive.

4. The results of the research show a positive connection between innovation and economic growth but the relationship found is not significant in case of lower middle income countries. This implies that R&D expenditures increase economic activity. R&D-derived innovations have the potential to expand already-existing sectors and launch new ones, hence promoting economic growth. Sustained investments in research and development, for instance, are substantially responsible for the computer industry's rapid expansion. Innovations created by R&D enhance productivity in a number of industries. Because companies can now create more with the same or fewer resources, profitability and incomes rise, which in turn spurs economic growth. R&D-driven innovation can cause outmoded industries or technology to fade away, but it can also provide doors for new ventures to flourish. Long-term economic growth and innovation depend on this process of creative destruction. The research results confirmed R&D may spur social innovation by creating answers to urgent societal issues including inequality, poverty, and educational access.

6.2 LIMITATIONS OF RESEARCH

While my research provides useful insights, there are certain inherent limits that must be acknowledged:

1. In many lower middle-income countries, data on R&D investments, operations, and outputs may be few, incomplete, or inaccurate. This may restrict the accuracy of my analysis and the generalization of my results. Different countries may have different definitions and classifications of what comprises R&D, resulting in inconsistencies when comparing statistics between countries. Lower middle income nations vary greatly in terms of institutional frameworks, levels of industrialization, economic structure, and political stability, and. These distinctions may limit the applicability of my findings to all LMICs. The influence of R&D on economic growth can differ greatly depending on the particular context, such as the existence of complimentary elements such as infrastructure, education, and institutional quality. As a result, my findings may be more relevant to some countries than others.

2. R&D investments frequently have a delayed impact on economic growth, as the advantages of innovation, technical improvements, and greater productivity can take years, if not decades, to materialize. This temporal lag can make it difficult to capture the entire impact of R&D within the scope of my research. R&D can produce non-market benefits such as social welfare improvements, public health advances, and environmental improvements, which are difficult to measure in economic growth models. These factors may be under-represented in my analysis.

3. The World Economic Forum (WEF) indicators are subjective mainly because they are based on qualitative evaluations from surveys that measure perception, such as the Executive Opinion Survey. Business executives and leaders from different nations are surveyed on a variety of subjects, including infrastructure efficiency, innovation capacity, corruption, and institutional quality. These insights are subjective by nature, even while they offer insightful, contextual information that might not be obtained from only quantitative data. Individual experiences, cultural standards, media representation, and national sentiment can all have an impact on the replies, and these factors can differ greatly throughout nations and eras. Additionally, each country may have a different sample size and representativeness of respondents, which could distort the results and cause inconsistent cross-country comparisons. The validity and reliability of these measures are called into question by their subjectivity, particularly when they are incorporated into composite indices like the Global Competitiveness Index (GCI), which are used to rank countries and inform policy choices. As a result, even though the WEF's survey-based indicators provide distinctive viewpoints, it is difficult to critically evaluate their subjectivity when analyzing the results or extrapolating conclusions regarding national competitiveness.

4. Although composite indicators are helpful for summarizing intricate multidimensional phenomena into a single index, they come with a number of methodological issues that may affect the accuracy and interpretability of the findings. The choice and weighting of individual indicators is one of the main problems. The final rankings may be greatly impacted by the subjective judgment or arbitrary.

5. The fact that this study only used data from 2019 rather than using a time-series analysis is another significant limitation of this research. The dynamic character of the relationship between R&D and economic growth over a number of years is not captured by cross-sectional data, despite the fact that it might offer a useful glimpse of the relationship at a certain moment in time. Short-term or one-year data may not accurately reflect the true impact of R&D spending and economic growth because these factors usually take time to manifest. Furthermore, using data from only one year leaves the analysis more susceptible to abnormalities or year-specific external shocks, which could skew the results.

6. Another limitation of this study is the possibility of methodological bias and Type II error. There is a greater chance of missing a real correlation between R&D expenditure and economic growth because of the reliance on cross-sectional data from a single year (2019) and the difficulties posed by poor data quality in lower-middle-income nations. This raises the possibility of a Type II error, in which actual effects might exist but are not statistically

detected because of poor data quality, missing observations, or inadequate dataset variability.

7. A key limitation of this study is the small number of countries (32). The research goal, which was to evaluate R&D ecosystems primarily in lower-middle-income countries, dictated the sample size I used, even though SEM benefits from bigger samples for increased reliability. Type II Error, or false negatives, are more likely to occur with this smaller sample, which means I can miss correlations that already exist. In particular, smaller samples have a lower chance of successfully rejecting a false null hypothesis (i.e., discovering a true effect) at a 5% significance level. This probability is somewhat reduced by the normal distribution of my variables, but there is still a chance that actual impacts will be missed. The CMIN/DF (Chi-Square divided by degrees of freedom) value of my model (1.215) also indicates a strong fit, and exact fit tests like the Chi-Square Test are more accurate in assessing model fit.

6.3 RECOMMENDATIONS FOR FUTURE RESEARCH

1. Future academics should endeavor to establish or advocate for more extensive and standard databases on investments in research and development, outputs, and results in low- and middle-income countries. Collaboration with national statistics agencies, international organizations, and research institutes will be critical for improving the quality, uniformity, and accessibility of R&D data. Combine quantitative data with qualitative insights gained from case studies, interviews, and field observations. This technique can give a deeper comprehension of how R&D influences economic growth in various LMIC environments.

2. Future study should consider Sector analysis, a technique that looks into how R&D affects specific sectors in LMICs, such as manufacturing, agriculture, and services. Analyzing sector-specific trends can help determine where R&D efforts are most productive and where innovation can have a substantial impact on growth.

3. Conduct longitudinal studies to examine the long-term effects of research and development on economic growth, taking into account the time lag between R&D investments and economic consequences. These studies can help to capture the delayed advantages of R&D while also providing insights into long-term economic growth. Future researchers should perform comparison studies among LMICs or between LMICs and high-income nations to uncover best practices, shared obstacles, and successful R&D-led economic growth methods.

4. Future study should look at the social and ethical consequences of R&D-driven economic growth, especially in terms of equity and inclusion. Researchers might investigate how R&D can help reduce poverty, inequality, and social inequities in LMICs. Future Researchers can look at how research and development might help promote sustainable development. Future study might look at how R&D investments connect with the SDGs and contribute to environmental sustainability, social well-being, and economic resilience.

5. R&D output can be measured with several other indicators representing the countries performance better and in a more comprehensive manner such as High-Tech Exports, Innovation Indices such as Global Innovation Index (GII). Future research can measure the R&D output through these indicators as well.

6. Future study should look into how global economic trends including trade policy, foreign direct investment (FDI), and global cooperation affect R&D effectiveness in low- and middle-income countries. Understanding these external influences can help countries improve their position in the global innovation scene. Future Research can look at the impact of international technology transfer and collaboration in increasing R&D capability in LMICs. Future studies should look into how partnerships with developed countries, international organizations, and multinational firms benefit local R&D and economic growth. Addressing these recommendations will allow future researchers to get a better understanding of the link between R&D and economic growth in LMICs, giving significant insights that can be used to improve policy and practice in order to promote sustainable development and innovation.

7. Implementing suggested strategies to enhance research and development (R&D) in lower middle-income nations can make use of a number of resources, such as government financing, private sector involvement, and international cooperation. Budgetary support can be given by governments to areas that are strategically important, such as environmental sustainability, public health, and cutting-edge technology like quantum computing. Though technology is still in its infancy, quantum computing has the potential to transform a number of sectors, including healthcare, banking, and logistics, by resolving complicated issues at previously unheard-of speeds. By investing in high-performance computing infrastructure, forming alliances with international research organizations, and receiving specific subsidies, these nations may promote quantum research. Building a talented workforce also heavily depends on public education; a pipeline of qualified professionals may be ensured by giving STEM education top priority, providing specialized training in cutting-edge sectors, and promoting information sharing through international academic collaborations. In order to encourage technology transfer methods that incorporate regional companies into global value chains, promote innovation clusters, and match R&D projects with national economic objectives, industrial policy can play a crucial role.

Part II: List of Publications related to Dissertation Topic

1. Fayyaz, A. (2021). Dynamic Capabilities in a Nutshell. 4th Smart Communities Academy: Building Smart Communities for the Future/ http://smartcommunities.eu/en/activities/smart-communities-2-0/smart-academy/4-th-smart-communities-academy

2. Fayyaz, A. (2021). Total Quality Management and its Implementation in context of Pakistan. 'Review of Business & Management' TMP Vol. 17, Nr. 2, pp. 45-51. 2021/ https://doi.org/10.18096/TMP.2021.03.04/ http://tmp.gtk.uni-miskolc.hu/index.php?i=4306/

3. Fayyaz, A. (2022). Latest Trends in Social Marketing. *Business and Management Horizons* *https://doi.org/10.5296/bmh.v10i1.19985*

4. Fayyaz, A. (2022). Economic Systems and Institutions. *International Journal of Management and Economics Invention*, *8*(12), 2762–2767. https://doi.org/10.47191/ijmei/v8i12.06/

5. Ayousha, Fayyaz, *Connecting R&D and Growth through a Theoretical Model*/ HANTOS PERIODIKA 4: 2 pp. 291-303. , 13 p. (2023)/ Full document

6. (Accepted for Q2 Journal) Research and Development as a Driver of Innovation and Economic Growth; Case of Developing Economies/ *Journal of Social and Economic Development*/2025

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