UNIVERSITY OF MISKOLC
FACULTY OF ECONOMICS

László Molnár

Analysis of the research and development activity, with special attention to the measurement methods and the influential factors

Theses of the Ph.D. dissertation

NAME OF THE DOCTORAL SCHOOL: **„Enterprise theory and practice" Doctoral School**

HEAD OF THE DOCTORAL SCHOOL: **Dr. István Szintay**
university professor
CSc

SCIENTIFIC SUPERVISOR: **Dr. Karajz Sándor**
university associate professor

Miskolc, 2010

Contents

1. Topicality of the theme

The theoretical economists are concerned about the importance of technological development in the area of economical growth from the beginning, from *Adam Smith* through *Nikolai Kondratyev, Joseph Schumpeter* and *Robert Solow* until these days (*Pakucs* [2003]). In the recent centuries the authors who were engaged in innovation analyzed the most different themes with most various methods. All of them agreed on that the performance in the area of science and technology is one of the determining factor of economic competitiveness and the growth of productivity (*Pitti* [2006]). The case of developed and rapidly developing countries is a good example for this. The more they emphasize the motivation of research and development and innovation activity and performance the easier they can retain and increase their economical strength.

The *European Union* recognizing the threat of lagging behind *United States* and *Japan* declared its strategic objectives in the Lisbon Treaty in spring of 2000. It is written there that the EU will be the most competitive and dynamic knowledge based society in the world by 2010. This society will be able to provide sustainable economic growth, more and better quality workplaces as well as wider social cohesion. One of the most important objectives of Lisbon Treaty, evaluated and mostly seriously criticized by a lot of experts, was in connection with research and development and innovation. This objective was either expressed in numbers in Barcelona summit in March, 2002. On the basis of the numbers it is an expressed objective that the expenditures in the area of research and development have to reach the 3 percent of gross domestic product on the average of the European Union and that the two third of the expenditures must come from business sector in contrast with the one third of governmental expenditures.

Hungary took the following important steps among others in the last years. A law was born in order to reach the assigned goals in connection with research and development and innovation *(Act No CXXXIV/2004*), separated state fund was established to finance research and development and innovation *(Act No XC/2003),* they introduced the compulsory innovation contribution paid by companies which is completed by the state fund that is financed from the governmental budget and determined in annual directives. However, the strategical implementation of the arrangements was done relatively late, only in 2007. The general aim of the scientific, technological and innovation-political strategy is *"to make Hungary such a country in middle term where the driving force of the economy is the knowledge and the innovation and the companies appear with competitive products and services in the global markets" (Governmental Decision 1023/2007. (IV. 5.) page 3).* The strategical document and the annual plans connected *(Governmental Decision 1066/2007. (VIII. 29.), Governmental Decision 1019/2009. (II.19.))* contain the operative tasks in details from which we emphasize 1,4 percent of the total R&D expenditure as a percentage of gross domestic product and 45 percent of the business R&D expenditure as a percentage of total. At the same time the steps taken to motivate the Hungarian research and development and innovation were low efficient. The comparison of the EU and the Hungarian numbers which are in the directives show a lot itself as well if we consider the time passed.

As we have already mentioned before technological development plays an important role in the improvement of competitiveness and economic growth. This statement is especially true in our day at the time of *economic recession and depression*. On long term only high quality research and development and innovation can lead us out from the current financial and economic crisis. Innovation must be considered important on a national economic and corporate level as well in order to occupy a competitive position after getting out of the economic crisis.

It is indispensable to have a constructive ability based on divergent thought, the creativity for successful research and development and innovation. At the beginning 2009 the *European Commission* launched the *European year of creativity and innovation* with the following slogan “Imagine, create, innovate!” The aim of programme series is to attract the attention of people how important role creativity and innovation plays in our own life, self-realization and to reach social welfare, to have success on the area of business and corporate life as well as in the improvement of competitiveness in Europe and in providing sustainable development (*Decision No 1350/2008/EC).*

Budapest has recently had success in a pretty different tender to decide on the headquarter of the *European Institute of Innovation and Technology*. At the beginning of 2008 European Parliament decided to create such an organization which helps with integrating the knowledge triangle efficiently, formed by higher educational organizations, research institutes and the business sector across Europe. The mission of the institute is to change the present educational and research culture, strengthen the ability to make competitive products out of the education and research, reducing the gap between the European Union and its major competitors *(Regulation (EC) No 294/2008)*.

The international and national events, happenings and phenomena can be listed for a long time that prove the actuality of the theme but we hope that the reader could be convinced meanwhile.

2. Objectives of the research

The main goal of our research activity is to create such an *integrated research and development model* which on the one hand will it make possible to measure the corporate R&D activity on the basis of a sophisticated methodology and on the other hand will make it possible to determine the direction and strength of effects of organization influential factors. In order to reach the main goal above mentioned we set up smaller goals which are listed below.

- We would like to give a *summary of the professional literature* about results, conclusions and proposals of the international and domestic, theoretical and empirical researches in connection with the topic which determines the scientific thinking.
- In our opinion the short review of the *international, domestic, and regional tendency* of research and development in the interest of being able to interpret the further results coming from our analysis the micro-level performance. We would like to pay attention to both the input and output indicators of research and development in our study.
- After the review of the relevant references, the international, domestic and regional tendencies of research and development we desire to set up our *model structure* listed in our main objectives, to create its elements and the features of the system of connection among these components. Firstly, as the model is difficult we define the certain parts theoretically.
- Before the empirical testing of the theoretical model it is essential to revise the theoretical and practical instructions of the *sample size determination* in business sector for the suitable generalization.
- Last but not least we wish to *test the model* in practice. The theoretical model can be attacked as far as it did not go through professional testing phase. In this phase certain components are retained while others are rejected. Furthermore the internal connections of the model get parameters. This sub goal is more than only testing the model as we want to have a more detailed picture about the research and development activity of the large businesses in the analysis.

3. Methodology of the research

In order to make the dissertation suitable for the scientific requirements we have to use such methodology that on the one hand meets the expectations of our directives and on the other hand fits the norms of the international and the domestic economics. Thus we put an emphasis on choosing the relevant research methods, qualitative and quantitative techniques and mathematical and statistical analyses all the time.

- Firstly we carried out the full-scale collection, process, analysis and evaluation of the professional literature about research and development therefore to outline the concrete objectives of the research.
- Secondly the international, domestic and regional statistical data-sources were mapped, collected, analyzed and evaluated. With other words it was the secondary research.
- We did not rely on only the theoretical and secondary results to set up the integrated research and development model. That is why we made in-depth interviews not to leave out any relevant factor or internal relation from our own created theoretical conception. Five of the experts were from the central governmental sector and the other five were from the large business sector to which we would like to express our acknowledgements for their professional opinion.
- After the in-depth interviews we accomplished the next phase covering the process of professional literature. However this time we investigated the relevant methodology of the model testing, the theoretical and practical methodology of sample size determination within.
- Finally we finished our work with the business survey. It was introduced by the trial testing of the questionnaire among those research and development experts who had helped us in the model set-up phase. During the quantitative primary research 276 Hungarian large businesses were asked with the help of the final questionnaires and telephone interview as well. The accuracy level of the total sample is ±4,9 percentage point on a 95 percent confidence level. [1] The data analysis was carried out by Excel and SPSS softwares.

[1] The subsample of the large businesses having research and development activity is much smaller. It has altogether 67 companies. On the basis of this subsample we are able to make a generalization on a ±8,8 accuracy level and 95 percent condifdence level. We also would like to express our acknowledgements to every single respondent of the survey.

4. The new and novel findings of the research

We outline the new and novel findings of the overview in connection with research and development and innovation professional literature, analysis of international, Hungarian and regional macrostatistical data, creation of integrated model of development, the methodological preparation of the model testing and representative survey carried out in the sector of the Hungarian large businesses.

4.1. Measurement methods and influential factors of the research and development

Professional agreement is shown in connection the questions regarding the importance of research and development and innovation measurement, evaluation and controlling. The reason is that the techniques of tracking and monitoring based on various methods serve as a basic device to reach development objectives. *In our opinion these methods can be considered developed as for the international comparison, however their micro level adaptation are in the infancy.* The success of the political decision makers and the corporate management is highly determined by their ability to recognise the key areas of the interference which are significant in the area of research and development activity. *Beside the identification of the influential factors eminent attention has to be paid to specify the direction and importance of their effect.*

- The activity and performance measurement of research and development and innovation on macro and micro level have an important role both in the evaluation of realizing the strategical objectives and to find out the competitiveness and economic potential of the countries and the companies.
- We categorized the methods convenient for the measurement of research and development on an international, macro-economic and regional level in four groups. We distinguish indicators grouped by theme, scoreboards handling indicator groups at the same time, composite indicators created from single indices and complex evaluation methods (measurement models). The general critics to highlight in connection with the measurement methods that they are not always suitable for measuring and they do not always measure the research and development. Independently of this they are indispensable devices for theory and practice.
- The most important methods of the corporate and project level evaluation of research and development are the professional reviews, surveys carried out by interviews and questionnaires, half-quantitative methods, quantitative methods, case studies, performance indicators and portfolio techniques *Balogh* [2001]. It is not worth to be loyal as for using only certain methods as these methods can be significantly developed and combinated with each other. It is worth to pay more attention to set up an evaluation system which is the most suitable for corporate and project objectives and priorities, partners and resources.
- The identification of the factors influencing R&D activity is an eminent interest for the political decision makers and the corporate management as well. Direct influence can be practiced through the interference points to improve competitiveness and to grow economy.
- The meaning of innovation politics is more expanded than R&D politics, (similarly to innovation and R&D meanings) The innovation politics is in strong connection with the areas less connected to research and development, so it is hard define precisely the meaning of innovation politics. The national innovation system is such an institutional approach which examines the businesses working with innovation in connection with external institutes, governmental politics, competitors, customers,

value systems starting from the hypothesis that the activity of the innovative companies are dependent from every factors listed above.

- The theoretical and empirical analysis of factors helping and hindering corporate innovation are popular subject of the innovation professional literature. The different international and Hungarian models (eg. *Cooper and Kleinschmidt* [1995], *Montoya-Weiss and Calantone* [1994]) and researches *(Kiss* [2004], *Piskóti* [2006], in: *Vágási et al.* [2006]) leaded to nearly similar result. It is important to outline that the size of the company and time factor, which are relevant in the aspect of success or failure of the product or service innovation, cannot mentioned undoubtfully on the side of the advantages and disadvantages.

To finish with the summary of the professional literature review we defined the following thesis in connection with the methods of research and development and innovation activity and performance.

T1: During our research we examined the methods used for the measure, evaluation, and controlling of R&D activity on international, macro-economic and regional level. We categorized them into four groups: indices, scoreboards, composite indicators and measurement methods. These methods are undoubtfuly developed and modern applications that are not implemented on micro level, so the set up of the evaluation system suitable for corporate and project objectives have a significant role.

The measurement methods of research and development activity based on macro-statistical data are developed without doubt. Let us think about the principal component analysis, genetic algorithms, data envelopment analysis or fuzzy set theory that is known from the mathematical, statistical or informatical set of techniques. However it is rare to meet the application of the methods on corporate or project level. They are less expanded because the lack of the professional knowledge of their usage. Our research is continued in this direction.

4.2. International, macroeconomic and regional analysis of the R&D

The international comparison of research and development performance shows *that the European Union lags behind its main competitors, the United States and Japan. It must not forget the ambitious Asian great power, China either.* In the Community *the traditionally innovative Scandinavian states are in the leading position worldwide.* Apart from them most of the EU countries could not fulfill the objectives written in the Lisbon Treaty until the assigned deadline. *Hungary is also among these countries, for it the original objectives are unreal in spite of its serious efforts in the last years.* In spite of the positive facts drawn in the gloomy picture finding the way permanently, decisions lacking strategically basics, structural weaknesses of the national innovation system, the lack of focus points and dissipating the resources can take our country having historical chance of catching up to the edge of the gap.

- Hungary is behind in input indicators, like governmental budget appropriations or outlays on R&D, R&D expenditures, R&D persons or human resources in science and technology from the leading group of the European Union. The leading position of Sweden and Finland is indisputable in this area.
- In the connection with the output indicators (innovation, patents and high-tech export) can be found also the Scandinavian countries in the first places. Hungary is

in the TOP10 list of the EU countries in connection with the high-tech export as a percentage of total export.

- In the first five years after the political changes the number of R&D units stagnated in Hungary. After that, a period of progressive increase was followed by a digressive period in the past few years. This tendency can be perfectly described by logistic trend function.
- The number of R&D persons dropped dramatically in the mid 1990s and it has slowly increased since then. The same is valid for the research intensity index, which shows the ratio of the number of R&D persons to the total number of employees. In our analysis we proved that there is a close and statistically significant correlation between the number of R&D persons and the total number of employees.
- Similarly to R&D units, R&D expenditure in Hungary started to grow progressively from the mid 1990s. However, the EU recommendation that R&D expenditure has to reach 3 percent of the GDP by 2010 seems practically impossible to fulfill for Hungary. The correlation between the expenditures and the gross domestic product is also strong and statistically significant.
- In connection with financial sources of the research and development we can state, that the Hungarian financing structure of R&D is not suitable for the recommendation of the European Union. The contribution of the business sector is only 50 percent in contrast with two third written in the objectives. The contribution of the governmental sector is 40 percent contrary to one third. The further 10 percent of the R&D budget comes from foreign and other domestic sources.
- The distribution of the Hungarian R&D expenditures by sectors shows that the largest part of the available financial sources is spent by R&D units of enterprises. The most supported activity is the experimental development, the most supported discipline are the technological disciplines, the most supported economic branch is the manufacturing industry, the most supported economic objective is the industrial production and technology in connection with the appropriation of R&D expenditures.
- Analyzing the absolute indicators of research and development (R&D units, total R&D calculated staff number, expenditure in R&D units, total number of research themes and developing tasks, total number of scientific publications), there is no doubt about the first place of Central Hungary, however the further sequence changes from indicator to indicator.
- In the case of the relative indicators (researchers per capita, R&D expenditure as a percentage of GDP, number of scientific publications per capita, number of scientific publications per researcher, expenditure per researcher) the situation is very similar with one exception: the numbers of scientific publications per researcher Central Hungary stand only in the end of the rank.
- The principal component analysis is very good multivariate statistical method for condensing the absolute indicators into one complex index, without any important loss of information. Then an opportunity is offered to line up the Hungarian regions by their R&D weights: 1. Central Hungary, 2. Northern Great Plain, 3. Southern Great Plain.
- For the reduction of data, the principal analysis can also be applied in the case of relative indicators, although here the loss of information can be considered more serious. The final rank on the areas of “effectiveness”, “productivity” principal component of the R&D is obvious as well: 1. Central Hungary, 2. Northern Great Plain, 3. Southern Great Plain.

4.3. R&D Activity Model

After the overview of the professional literature and international statistical data we set up the complex model of the research and development activity. The name of the final conception based on expert opinion is *R&D Activity Model*. The name of the model indicates that the measurement of the research and development activity and the characterization of the effects of influential factors can be possible at the same time. The theoretical model contains measurement sub-models and sub-models of the influential factors.

Schematic structure of the R&D Activity Model

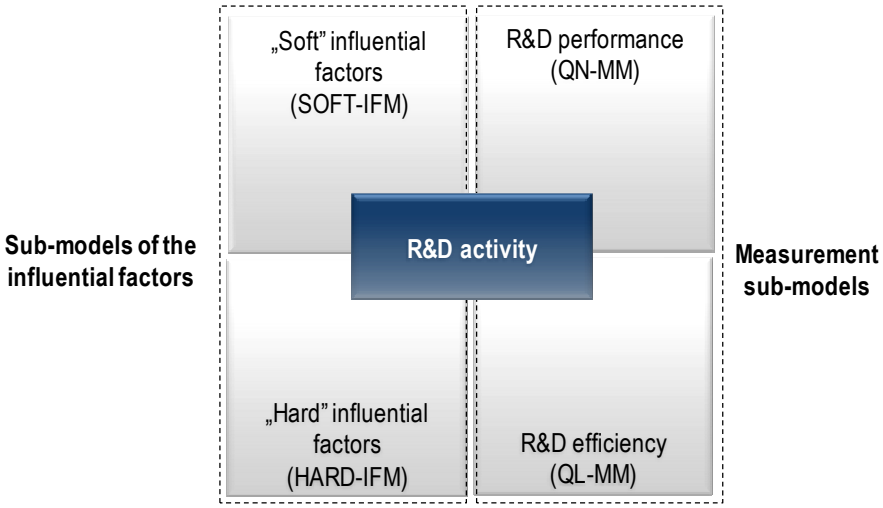


Figure 1: **Schematic structure of the R&D Activity Model**

Source: **Compiled by the author**

We made an attempt to set up the measurement sub-models of the R&D activity in two aspects. The first version of the measurement model of the R&D activity contains only objective and quantitative data which are expressed as allowances in kind (million HUF, person and piece). This version is the so-called Quantitative Measurement Model (QN-MM). In the second version qualitative features dominate in contrast with quantitative data. The base of the structure of this version – so-called Quantitative Measurement Model (QL-MM) – is relative numbers. The largest difference between the measurement models are the variables we used. We distinguish quantitative data and qualitative features. The most important similarity between these models is the source of information because both versions contain such variables that can only come from business surveys.

The structure of the quantitative measurement model is build up by four principal component analyses: *"R&D activity"*, *"input activity"*, *"process activity"* and *"output activity"*. The division into three parts comes from the Faber-Hesen model (*Faber and Hesen* [2004]) which is the first measurement model of the research and development using not only input but output and process variables. We developed the basic idea and certain elements of this model further to work up the principal component analyses of the quantitative measurement sub-model.

The qualitative measurement sub-model similarly to the quantitative measurement sub-model is a connected system of four principal component analyses: *"R&D efficiency"*,

"input efficiency", *"process efficiency"* and *"output efficiency"*. We consider it an important step compared to the basic conception of Faber-Hesen model (*Faber and Hesen* [2004]) that the dimensions of the research and development performance and efficiency are handled on the same logic, but divided categorically from each other.

The factors influencing R&D activity can be categorized into two groups according to the types of variables. The first group contains the so-called "soft" influential factors under which we mean the features of internal processes, organizational structure, corporate strategy, organizational culture and management effecting the corporate research and development activity. The so-called "hard" factors can be put in the second group, that are made up by the corporate demographical features, their field of activity, geographical position, headcount, revenue, form of business, date of foundation and ownership. The further base of the differentiation among the influential factors is the source of information. "Soft" factors can only come from business surveys. "Hard" factors are the data recorded by the registry courts and *Hungarian Central Statistical Office* and they are easily available.

The Model of the Soft Influential Factors (SOFT-IFM) is a connected system of a multivariate linear regression analysis (regression analysis of *"R&D activity")* and five principal component analyses (principal component analyses of *"process"*, *"organization"*, *"strategy"*, *"culture"* and *"support").* We refer to Cooper-Kleinschmidt model (*Cooper and Kleinschmidt* [1995]) at this time which we used further developed to work out the analyses of the sub-models of "soft" influential factors.

The Model of the Hard Influential Factors (HARD-IFM) similarly to the R&D regression analysis of the "soft" influential factors is a multivariate linear regression analysis.

After reviewing the sub-models of the R&D activity measurement and influential factors we set up the R&D Activity Model which is the result of the model creation.

T2: On the basis of the secondary research and professional in-depth-interviews we set up the integrated model of research and development. With the help of it on the one hand the corporate R&D activity can be measured on the basis of a sophisticated method (quantitative and qualitative measurement sub-models). On the other hand we can define the direction and the strengths of the effects of the organizational factors influencing the activity (sub-models of the "soft" and "hard" influential factors). This is called R&D Activity Model.

The R&D Activity Model is the complex system of two measurement sub-models (quantitative and qualitative) and two sub-models of influential factors ("soft" and "hard"). The aim of the measurement models is to evaluate the activity grapping all the three phase of research and development activity (input, process and output) in quantitative and qualitative aspects. The goal of the sub-models of the influential factors is to bring an explanation and to assign those interference points through which the activity on corporate and project level can be increased and the competitiveness can be improved in a direct way. The central element of the model is research and development activity itself which makes a connection between complex system factors of measurement and influence.

4.4. Sample size determination in practice of business survey

The verification of the model created in theory was carried out as a business survey. However for this we found important to review the method of the surveys. The detailed analysis of the theoretical and practical regulations of sampling gave the opportunity to lay

down the theoretical basics and fix the conditions of the practical application of a totally new conception which is the *agglomerative stratification*. The developed method is based on the theory whether the sub-samples are analyzable or not.

After reviewing the statistical methods of sample size determination we set up the following thesis which is the conception of the agglomerative stratification as the result of our methodological analysis:

T3: As the result of our analysis we set up a new sampling method which is the so-called agglomerative stratification. The essence of the method is that we fix first not the size of the total sample, but the size of the sub-samples. We do this to analyze the strata themselves and also the population on an acceptable confidence and accuracy levels. It is expedient to use this stratification method, if the budget of the research gives the opportunity to have a larger sample.

The different methods of stratification known in the professional literature give optimal recommendations to solve the allocation of the total sample to respect the different conditions at the same time. We can rightly call these procedures types of divisive stratification. In the case, when we are responsible for analyzing the sub-samples taken from the strata confidently and accurately it is practical to change the order of the steps. First we have to fix the conditions of the analysis of the sub-samples. Then we have to determine the sample size by strata and have to summarize the samples got. The agglomerative stratification is based on logic different from the classical one. In case of larger total sample size it results sub-samples which can be analyzed on a better accuracy level than the traditional methods.

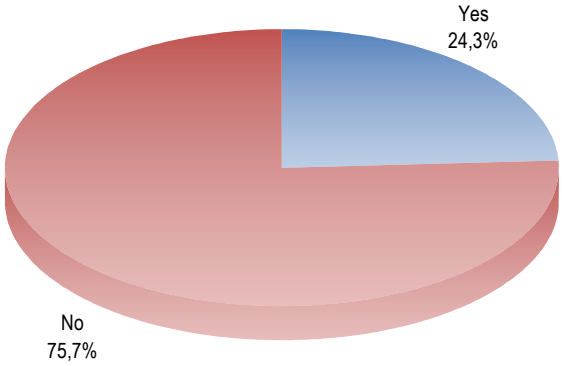
4.5. Analysis of the R&D activity of large businesses

The testing of the model and the analysis of the research and development activity of Hungarian large businesses based on a *representative survey* gave both surprising and less amazing results. First we would like to emphasize the novelty of the research. In our opinion this is a survey concentrating definitely on large businesses. No similar one was carried out in the same topic in Hungary. Of course we know some with similar topic but they assign different target group and methodology.

4.5.1. Characteristics of the large business carry on R&D activity

It turned out about the Hungarian large businesses that only one fourth of them have research and development. The majority of those who have R&D activity concentrate in Budapest and its agglomeration but only in absolute meaning. The industrial sector and the revenue of the corporations are fundamental determinants of the R&D activity. For this reason the key figures of the research and development in the business sector are the industrial corporations. These companies have an effect on their own business relations and knowledge and technology based development of the national economy.

Does your company carry on research and development activity?



Basis: All of the respondents, n=276

Figure 2: **Does your company carry on research and development activity?**

Source: **Compiled by the author**

Does your company carry on research and development activity? (significance table)

	Yes	No
Sector	+ Industry (30,4%); - Trade (4,8%); - Service (14,3%)	- Industry (69,6%); + Trade (95,2%); + Service (85,7%)
Region	+ Central Transdanubia (44,1%); - Western Transdanubia (8,6%)	- Central Transdanubia (55,9%); + Western Transdanubia (91,4%)
Employment	-	-
Change in employment	-	-
Revenue	+ (43 505,8 million HUF)	- (17 969,3 million HUF)
Change in revenue	+ Increasing (34,3%)	-Increasing (65,7%)
Form of business	+ Plc. (57,1%)	- Plc. (42,9%)
Date of foundation	-	-
Ownership	-	-
Total	**24,3%**	**75,7%**

Table 1**: Does your company carry on research and development activity? (significance table)**

Source: **Compiled by the author**

We set up the following thesis summarizing our results regarding the hypotheses on large businesses having R&D activity.

T4: According to the representative survey on Hungarian large businesses we prove a significant connection among the research and development activity, sector, region and revenues. The key figures of the system are definitely the capital intensive Central-Hungarian industrial companies. These determine the knowledge and technology based development of the national economy both directly and indirectly thanks for their business relations.

4.5.2. R&D input activity

The Hungarian large businesses having research and development activity spend 1 percent of their revenue and 3 percent on average of their human resource to enlarge their factual knowledge end develop new applications. Using external sources is not usual. They mostly solve their duties in self-effort. This partly can be traced back to the lack of governmental communication and support system which is non-transparent, bureaucratic, having organizational troubles and forgetting their aims.

R&D expenditure as a percentage of the revenue (T-Test)

One-Sample Test

	Test value=0,03					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Lower
EXP_OBJ_QN_REV	-6,169	47	,000	-,0180192	-,023896	-,012143

Table 2: **R&D expenditure as a percentage of the revenue (T-Test)**

Source: **Compiled by the author**

R&D persons as a percentage of the employment (T-Test)

One-Sample Test

	Test value=0,03					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Lower
RES_OBJ_QN_EMPL	-,957	59	,342	-,0034931	-,0107946	-,003808

1. táblázat: **K+F dolgozók létszámhoz viszonyított aránya (t-próba)**

Forrás: **Saját szerkesztés**

We set up the following thesis summarizing the results of hypothesis testing concerning the R&D input activity of Hungarian large businesses.

T5: According to the representative survey we proved that the R&D expenditure of the Hungarian large businesses is 1 percent of their revenue on average. This shows an increasing tendency in the last years. Two third of the expenditure are costs and more than its half comes from own source. The R&D persons of the enterprises reach 3 percent of their head count. The number of employees working on research and development themes is permanent in the recent years. Two third of them are researchers having university degree and the majority is employed by their own company.

4.5.3. R&D process activity

Different sources of information and co-operations have a significant role in the research and development process. The using of secondary sources and cooperation with research and development units of higher education is the most characteristic for the Hungarian large businesses in this field. The market demand has a significant role in objective system

of with research themes and experimental development tasks. The driver of the processes is to realize the individual and corporate goals through satisfying consumer preferences.

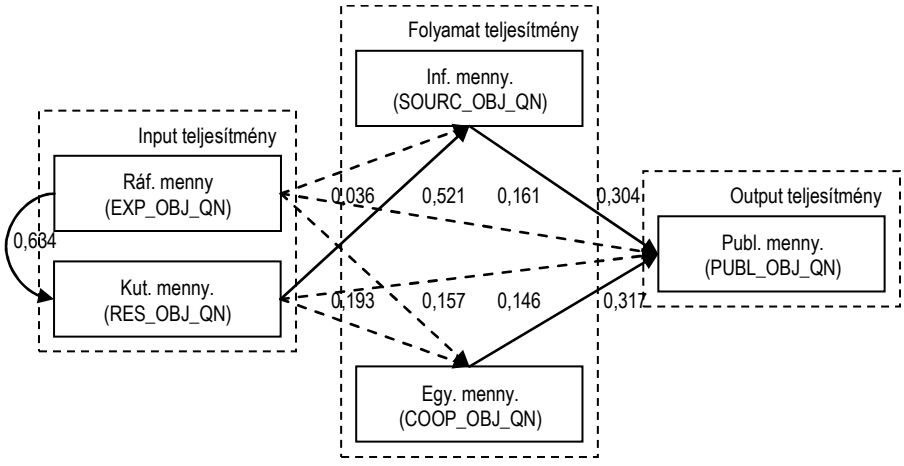
After setting of the hypotheses and testing them we defined the final conclusion focusing on R&D process activity in the form a thesis.

T6: According to our analysis the information applied by the Hungarian large businesses comes mainly from secondary sources (scientific journals, professional/technical studies). The large businesses cooperate with research and development units of higher education (universities and colleges) above all in order to have success in their research and development activity. We explored the relationship between the research themes and experimental development tasks with the help of multidimensional scaling. On its basis we categorized the research and development objectives into three groups: "preferred, direct", "medium-preferred, indirect" and "non-preferred".

4.5.4. R&D output activity

The publication and the patent practice of the Hungarian large businesses lags behind the previous expectations as for its quantitative and qualitative features. Low performance and efficiency can be both explained by business political consideration and a not appropriate application of the available resources. It is obvious that the companies have not always interest in publishing the research and development results neither in publications nor in patents.

Path model of the publication practice

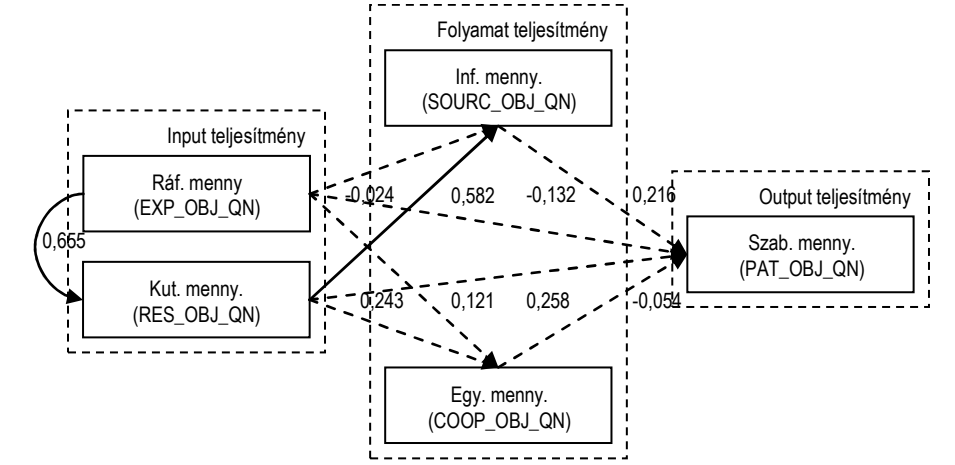


Basis: Valid respondents carry on R&D activity, n=46

Figure 3: **Path model of the publication practice**

Source: **Compiled by the author**

Path model of the patent activity



Basis: Valid respondents carry on R&D activity, n=40

Figure 4: **Path model of the patent activity**

Source: **Compiled by the author**

We set up the following thesis concerning the research and development output activity of the Hungarian large businesses.

T7: According to our analysis the publication and patent practice of the Hungarian large businesses can be considered weak. This is can be traced back both to business political considerations and the non-suitable usage of the resources. With the help of the path model we explored the connection among the input, process and output factors: The amount of the R&D expenditure basically determines the number of publications and patents, however this does not have a direct effect, but it has indirect influence on them.

4.5.5. Analysis of the measurement of R&D activity

We recommend the R&D Performance Index based on quantitative measurement sub-model and the R&D Efficiency Index based on qualitative measurement sub-models to measure the R&D activity which also considers the input, process and output factors. The strength of the composite indicators is that they do not only exist on theoretical level. We fixed their calculation methodology step by step and defined a concrete offer based on results of the business survey for weights indispensable for their application.

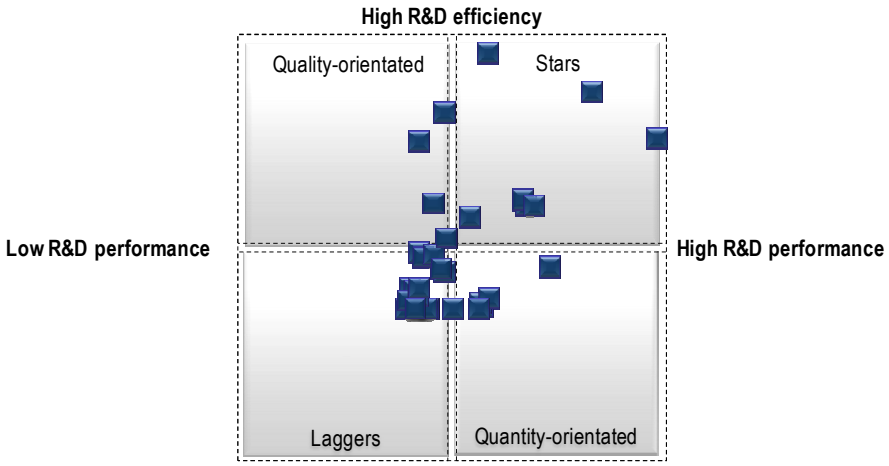
After testing the measurement sub-models of R&D activity (verification, parameters) we summarized our research findings.

T8: After empirical testing the quantitative and qualitative measurement sub-models created to measure the R&D activity we developed the methodology of the R&D Performance Index (R&D-PERFIND) and R&D Efficiency Index (R&D-EFFIND). The newly developed composite indicators are based on more connected principal component analyses. They are both suitable for tracking and monitoring of the research and development activity on micro level and can be used for competitiveness analyses in aggregated form.

4.5.6. R&D Activity Matrix

The R&D Activity Matrix can be created with the help of the newly developed multidimensional indices as axes. This matrix is a portfolio technique capable of the complex analysis of the research and development activity. The Hungarian large businesses having research and development activity can be categorized into four groups excluding each other based on this method. These groups together cover all the companies. We gave the following names to indentify the different categories: stars, quantity-orientated, laggers and quality-orientated.

R&D Activity Matrix



Basis: Valid respondents carry on R&D activity, n=33

1. ábra: **R&D Activity Matrix**

Source: **Compiled by the author**

The following thesis contains the R&D Activity Matrix as an analysis method of the research and development activity.

T9: The R&D Activity Matrix is such a portfolio technique which describes the input, process and output activity of the research and development units both in quantitative (performance) and qualitative (efficiency) aspects. With the help of the newly developed analysis method the Hungarian large businesses can be categorized into four groups: stars, quantity-orientated, laggers and quality-orientated.

4.5.7. Analysis of the influential factors of R&D activity

To conclude the train of thought started with setting up the model we analyzed the kinds of factors influencing the categorization of the companies based on their R&D activity. On the basis of the conclusions deducted from the results we can state the way of becoming star can be found in the improvement of the quality of the research and development processes, modernization of the organizational frames and strategical implementation.

However without the suitable intellectual and financial background the best purpose can only considered as enthusiastic attempt.

Coming to the end of the chapter we set up our last thesis which summarizes the features of the R&D activity categories.

T10: The groups of R&D Activity Matrix are rather different thanks to the following "soft" factors: quality of the R&D processes, state of development of formal or informal research and development organizational unit and the existing of R&D strategy. If these areas are formed, their level is developed and their quality is improved the laggers can become stars in connection with research and development. Further significant difference can be proved between the stars and the laggers on the basis of head count, the revenue and the ownership. The group of stars is formed by foreign companies having larger head count end revenue while the group of laggers has smaller Hungarian corporations.

The R&D Activity Matrix categorized the Hungarian large businesses into four groups from quantitative and qualitative aspects of research and development activity. The way leading to the category of *"stars"* doing both well in performance and efficiency is the question of systematic overview of the internal processes, the improvement of the quality, the reorganization and development of research and development teams and the implementation of the research and development activity into the corporate strategy. For these duties required amount of financial sources and the availability of the employees with excellent experience are indispensable. In Hungary mainly the large businesses managed by foreign owners have the conditions mentioned above.

5. Application of the findings

We hope that the research findings found in the dissertation with special attention to the conclusions of the primary survey will help with solving the planning, executive, and the controlling tasks of the research and development activity on both national and corporate levels at least in a slight degree. According to our previous plans the findings of the research will be applied in the following fields.

- On a national level the results of the representative large business survey can contribute to the optional revision of the scientific, technological and *innovation political strategy*, and more definitely it will promote the professional review of the operative tasks stated in short time organizational plans and the overall planning of tasks of the next years.
- Thanks to the R&D Activity Matrix such an instrument can go to the property of the *technological intensive companies* which is able to give a complex picture of features on research and development performance and efficiency assigning the key areas of growth orientated influence on the basis of both cross sectional (subsidiaries, branch businesses and projects) and longitudinal analyses. The research findings of the factors influencing research and development activity can be useful for those companies which would like to cope with the challenges of globalization and appear with competitive products, services, organisations or marketing in the agonistic market on the basis of both their knowledge and technological abilities. This is especially true when globalization shows its drawbacks, global economic and financial crisis in the present case.
- The whole dissertation can be used as a starting *professional literature* of further theoretical and empirical studies in connection with research and development and innovation. We list the in-depth interview guides and questionnaires that can be considered as outputs for operationalization in the annex of the dissertation for the reason to be used as reference by anybody.
- The further target group of the Ph.D. dissertation contains lecturers and researchers interested in the topic of innovation and research and development. Of course we would like to target the theoretical and practical experts as well. We hope that the main findings will influence the *scientific thinking* of the theme. We desire to introduce the results of the partial analysis written and not written in the dissertation mainly in scientific conferences, lectures and in scientific journals.
- As for the higher education, we cannot leave it out from the list. It is a concrete result that the newly developed methodology in connection with sampling was introduced experimentally in the themes of *"Marketing research and DSS"* subject in marketing master course. The methods of measurement appeared in the lectures of *"Innovation marketing"* subject. We can state that the first feedbacks have been surprisingly positive.

6. Continuation of the research

The dissertation is the substantive summary of our research but it is not its closing. The results raise further theoretical and practical problems which have to be prepared and solved scientifically in the following years. We outline in brief some possible directions of the continuation of the research.

- The testing of the R&D Activity Model in other words the analysis of the research and development activity was carried out on the basis of representative sample of Hungarian large businesses and we excluded the *small- and medium-sized enterprises, research units of the higher education and the governmental research institutes* definitively. We plan to escalate the empirical research to the further participants of the knowledge triangle. Before that the model should be theoretically reviewed and adapted according to the characteristics of the educational and academic sphere.
- It is a larger-scale plan to arrange a research *in other European country* and make a comparative analysis. Slovakia, Poland and Romania are on a similar level of development in the area of research and development and innovation. Thus these countries are easy to reach as for the geographical distance and relations. Hungary and the countries having a traditionally high innovation culture – Sweden, Finland and Germany – would serve with exciting results in the area of research and development performance and efficiency.
- The further content development of the research would be expanded to *the whole process of the innovation* anyway. In our opinion the research and development is the most important but it is not absolutely the necessary part of the innovation chain. The analysis of the innovative organizational behavior considers such factors that are more than the objective of the dissertation. Let us think about survey of the market demand, the specifications of the producing, marketing and sales or the various circumstances of the economic, social, political and ecological involvement.

References

2003. évi XC. Törvény a Kutatási és Technológiai Innovációs Alapról

2004. évi CXXXIV. Törvény a kutatás-fejlesztésről és a technológiai innovációról

BALOGH T. [2001]: A szakértői bírálattól a portfolió-elemzésig, *Magyar Tudomány*, 48. évf. 3. sz. 328-339. old.

COOPER, R. G. – KLEINSCHMIDT, E. J. [2003]: Benchmarking the Firm's Critical Success Factors in New Product Development, *Journal of Product Innovation Management*, 12. évf. 5. sz. 374-391. old.

Decision No 1350/2008/EC of the European Parliament and of the Council of 16 December 2008 concerning the European Year of Creativity and Innovation (2009)

FABER, J. – HESEN, A. B. [2004]: Innovation Capabilities of European Nations Cross-national Analyses of Patents and Sales of Product Innovations, *Research Policy*, 33. évf. 2. sz. 193-207. old.

KISS J. [2004]: *A technológiai innováció szerepe a magyar vállalatok versenyképességében*, Ph.D. értekezés

MONTOYA-WEISS, M. M. – CALANTONE, R. [2003]: Determinants of New Product Performance: A Review and Meta-Analysis, *Journal of Product Innovation Management*, 11. évf. 5. sz. 397-417. old.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT [2002]: *Frascati Manual – Proposed Standard Practice for Surveys on Research and Experimental Development*, Párizs

PAKUCS J. [2003]: *Az innováció hatása a nemzeti jövedelem növekedésére*, Magyar Innovációs Szövetség, Budapest

PITTI Z. [2006]: *A hazai vállalkozások „demográfiai" jellemzői, a vállalati teljesítmények időbeli változása és a K+F teljesítmények szerepe a gazdaság új növekedési pályára állásában*, Tudomány- és Technológiapolitikai, Versenyképességi Tanácsadó Testület, Budapest

Regulation (EC) No 294/2008 of the European Parliament and of the Council of 11 March 2008 establishing the European Institute of Innovation and Technology

SCHUMPETER, J. A. [1980]: *A gazdasági fejlődés elmélete*, Közgazdasági és Jogi Könyvkiadó, Budapest

SZAKÁLY D. [2008]: *Innovációmenedzsment*, Miskolci Egyetemi Kiadó, Miskolc

TÖRÖK Á. [2006]: *Stratégiai ágazat stratégia nélkül?* Savaria University Press, Szombathely

VÁGÁSI M. – PISKÓTI I. – BUZÁS N. [2006]: *Innovációmarketing*, Akadémiai Kiadó, Budapest

Publications

MOLNÁR L. [2010]: *Analysis of Research and Development Input Activity of the Hungarian Large Businesses*, „Scientific Challenges of the 21st Century" 6th International Conference for Young Researchers, Szent István Egyetem, Tanulmánykötet, Gödöllő (megjelenés alatt)

MOLNÁR L. [2010]: *A kutatás-fejlesztés teljesítményértékelése az innovációmarketingben*, „Új marketing Világrend" a Magyar Marketing Szövetség Marketing Oktatók Klubjának 16. országos konferenciája, Budapesti Kommunikációs és Üzleti Főiskola, Tanulmánykötet, Budapest (megjelenés alatt)

PISKÓTI I. – NAGY SZ. – MOLNÁR L. [2010]: *Store Choice Model – The Unio Coop Case in Hungary*, The 6 Senses – The Essentials of Marketing – 39th EMAC Conference, Copenhagen Business School, Tanulmánykötet, Copenhagen, Dánia (megjelenés alatt)

MOLNÁR L. [2010]: *Measurement Methods of Research and Development Activity*, 6th Annual International Bata Conference for Ph.D. Students and Young Researchers, Zlini Tomas Bata Egyetem, Tanulmánykötet, Zlin, Csehország (ISBN: 978-80-7318-922-8)

MOLNÁR L. [2009]: *A kutatás-fejlesztési aktivitás mérési módszerei, különös tekintettel a K+F Teljesítmény Indexre (R&D-PERFIND) és a K+F Hatékonyság Indexre (R&D-EFFIND)*, „Gazdaság és Társadalom" Nemzetközi Tudományos Konferencia, Nyugat-Magyarország Egyetem, Tanulmánykötet, Sopron (ISBN: 978-963-9871-30-4)

MOLNÁR L. [2009]: *Composite Indicators in Regional Comparison of Science and Technology*, 3rd Central European Conference in Regional Science, Kassai Műszaki Egyetem, Tanulmánykötet, Kassa, Szlovákia (ISBN: 978-80-553-0329-1)

MOLNÁR L. [2009]: *Center Versus Periphery – Research and Development in Regional Comparison*, Business Studies, 6. évf. 1. sz. 111-119. old.

MOLNÁR L. [2009]: *A magyarországi kutatás-fejlesztés és innováció (K+F+I) intézményrendszere*, microCAD 2009 International Scientific Conference, Miskolci Egyetem, P szekció: Gazdasági kihívások a XXI. században, Tanulmánykötet, Miskolc (ISBN: 978-963-661-866-7 Ö)

MOLNÁR L. [2008]: *Analysis of the Hungarian Research and Development Potential*, Periodica Polytechnica, Social and Management Sciences, 14. évf. 2. sz. 79-86. old.

MOLNÁR L. [2008]: *Mintavétel a marketingkutatásban, különös tekintettel a divizív és az agglomeratív rétegzésre*, Marketingkaleidoszkóp 2008: Tanulmányok a Marketing Intézet kutatási eredményeiből, Miskolc (ISBN:978-963-661-857-5)

MOLNÁR L. [2008]: *A többszörös korrespondencia-elemzés (MCA) elmélete és gyakorlata*, I. Országos Gazdasági és Pénzügyi Matematikai PhD Konferencia, Budapesti Műszaki Főiskola, Tanulmánykötet, Budapest (ISBN: 978-963-9263-41-3)

MOLNÁR L. [2008]: *Milyen eszközökkel növelhető a magyar nagyvállalatok K+F aktivitása? Egy lehetséges kutatási terv a probléma megoldására*, Doktoranduszok Fóruma, Miskolci Egyetem, Gazdálkodási Szekció, Tanulmánykötet, Miskolc

BERECZKI N. – MOLNÁR L. [2008]: *A gazdasági fejlettség vizsgálata a különleges gazdasági övezetként működő enklávékban*, Marketing Oktatók Klubja – 14. Országos Konferencia, Budapesti Corvinus Egyetem, Tanulmánykötet, Budapest

MOLNÁR L. [2008]: *A korrespondencia-elemzés (CA) elmélete és gyakorlata*, microCAD 2008 International Scientific Conference, Miskolci Egyetem, Q szekció: Kihívások a gazdaságban, Tanulmánykötet, Miskolc (ISBN: 978-963-661-812-4 Ö)

BERNÁTH A. – MOLNÁR L. – SZIVÓS J. [2007]: *A gazdálkodó szerveztek hulladék-termelésének modellezése*, Innovációmenedzsment kutatás és gyakorlat – Szemelvények az Innovációsmenedzsment Kooperációs Kutató Központ projektjeiből, Miskolc (ISBN: 978-963-661-799-8)

MOLNÁR L. [2007]: *A magyar megyék K+F aktivitásának összehasonlítása főkomponens-elemzéssel képzett összetett rangsorok alapján*, Doktoranduszok Fóruma, Miskolci Egyetem, Vállalatelmélet Szekció, Tanulmánykötet, Miskolc

MOLNÁR L. [2007]: *Comparison of R&D Activity of the Hungarian Counties by Complex Ranks Created by Principal Component Analysis*, 6th International Conference of Ph.D. Students, Miskolci Egyetem, C1 Szekció: Gazdaságtudomány, Miskolc (ISBN: 978-963-661-783-7 Ö)

MOLNÁR L. [2007]: *Analysis of the Hungarian Research and Development Potential and Statistical Methods of its Prognosis*, XXVIII. Országos Tudományos Diákköri Konferencia, Doktorandusz Konferencia, Miskolci Egyetem, Gazdaságpolitika szekció, Kiemelt minősítést elnyert dolgozatok, Miskolc (ISBN: 978-963-661-774-5)

MOLNÁR L. [2007]: *A hazai K+F ráfordítások forrás- és felhasználás-szerkezetének vizsgálata*, II. Pannon Gazdaságtudományi Konferencia, Veszprémi Egyetem, Fejlődés és fejlesztéspolitika Szekció, Tanulmánykötet, Veszprém (ISBN: 978-963-9696-29-7)

MOLNÁR L. [2007]: *A hazai kutatás-fejlesztés indikátorai és eredményeinek mérési módszerei, különös tekintettel a K+F aktivitási indexekre*, Tavaszi Szél 2007 Konferencia, Zrínyi Miklós Nemzetvédelmi Egyetem, Marketing és Menedzsment szekció, Tanulmánykötet, Budapest (ISBN: 978-963-87569-0-9)

MOLNÁR L. [2007]: *Analysis of the Hungarian Research and Development Potential and Statistical Methods of its Prognosis*, XXVIII. Országos Tudományos Diákköri Konferencia, Doktorandusz Konferencia, Miskolci Egyetem, Gazdaságpolitika szekció, Tanulmánykötet, Miskolc (ISBN: 978-963-661-768-4)

MOLNÁR L. [2007]: *A divizív és agglomeratív rétegzés elmélete és gyakorlata*, microCAD 2007 International Scientific Conference, Miskolci Egyetem, Q szekció: Kihívások a gazdaságban, Tanulmánykötet, Miskolc (ISBN: 978-963-661-756-1)

MOLNÁR L. [2006]: *Az optimális mintanagyság a kapcsolódó költségek és bevételek relációjában*, Doktoranduszok Fóruma, Miskolci Egyetem, Elméleti Szekció, Tanulmánykötet, Miskolc

BERNÁTH A. – MOLNÁR L. – SZIVÓS J. [2006]: *A gazdálkodó szerveztek hulladék-termelésének modellezése*, Innovációmenedzsment, Tudásteremtés – Tudástranszfer Konferencia, Tanulmánykötet, Miskolc (ISBN: 963-661-729-5)

Annexes

Annex 1: R&D Activity Model

R&D Activity Model

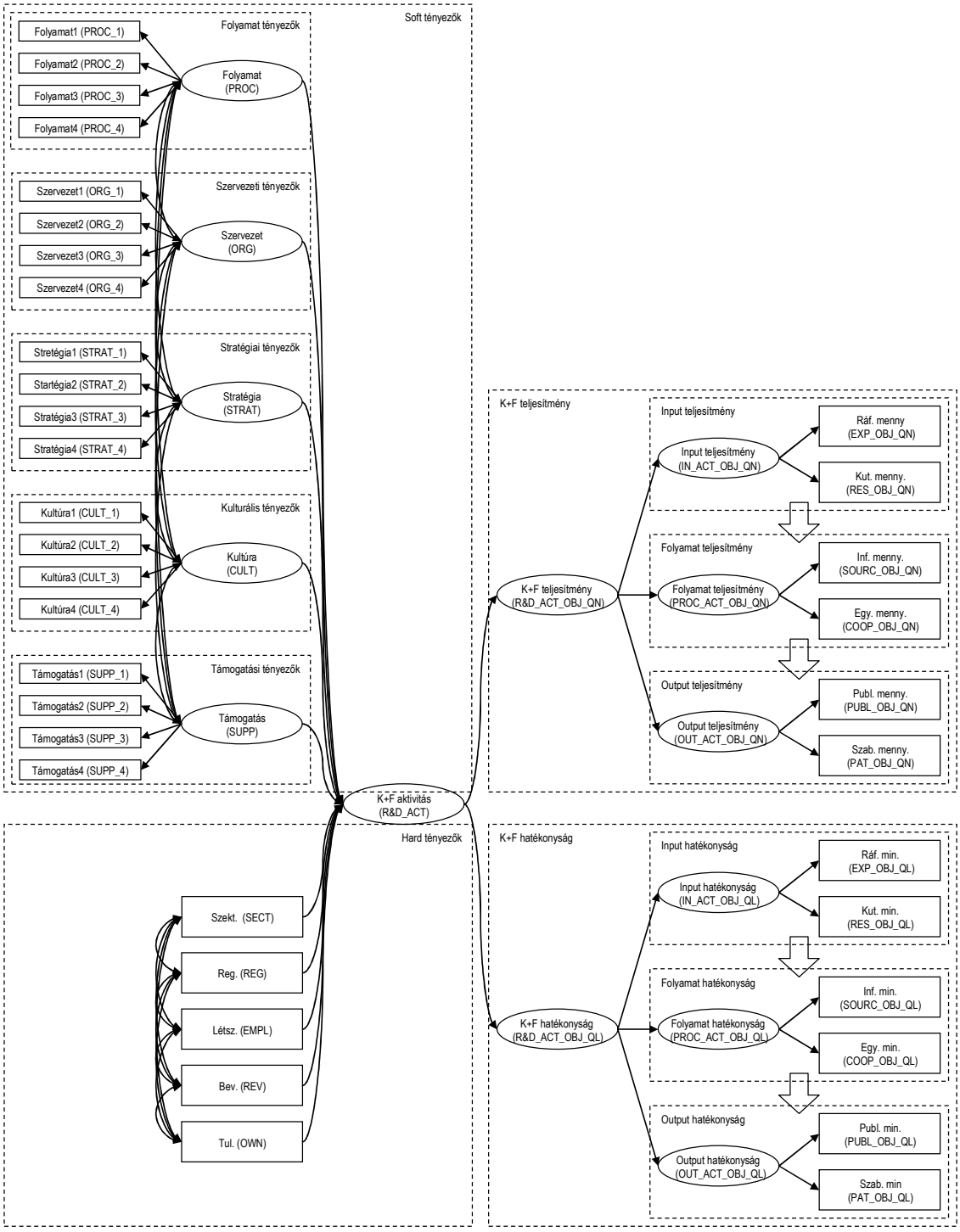


Figure 1: **R&D Activity Model**

Source: **Compiled by the author**

Annex 2: R&D Activity Model (with communalities and component scores)

R&D Activity Model (with communalities and component scores)

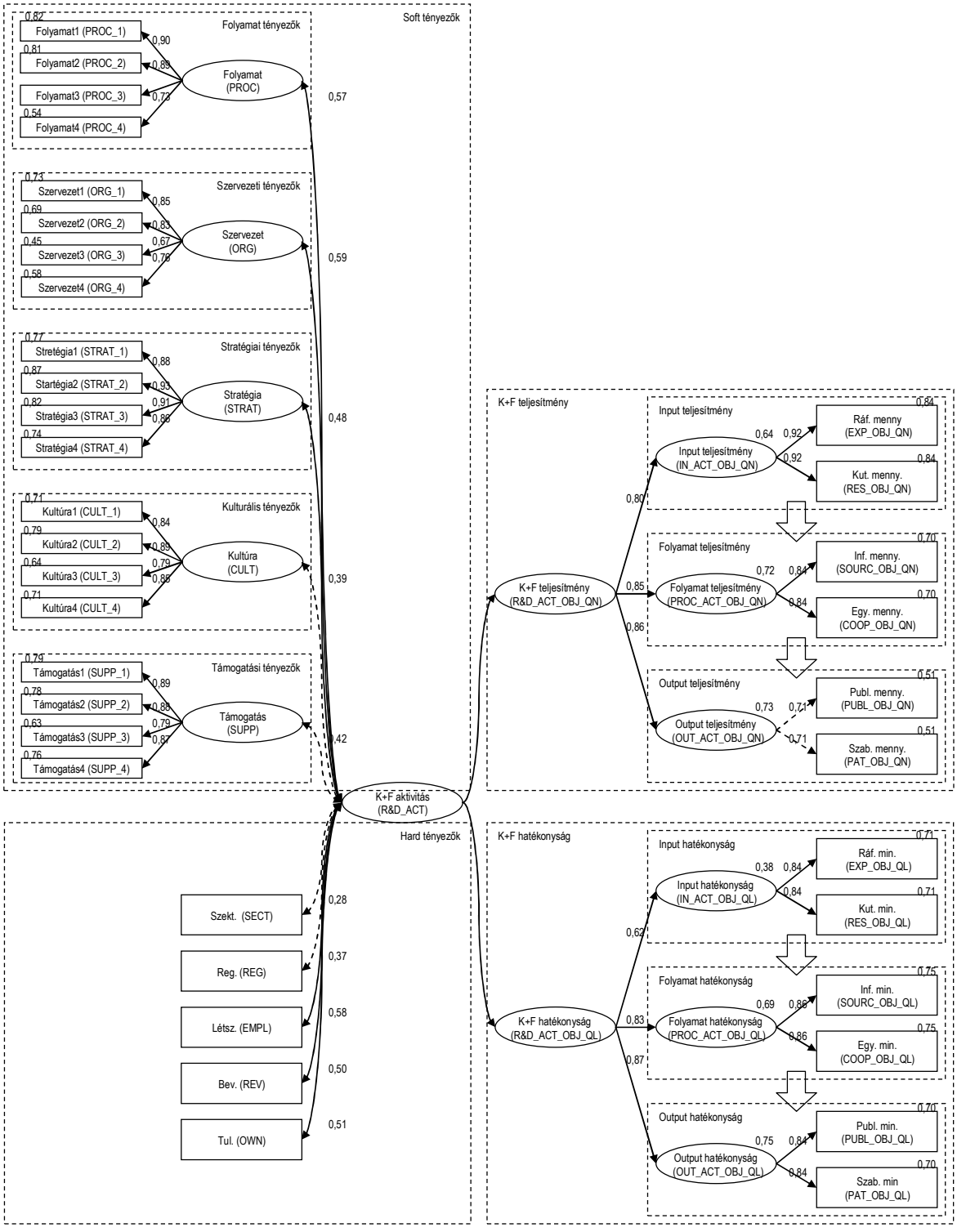


Figure 2: **R&D Activity Model (with communalities and component scores)**

Source: **Compiled by the author**