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INTERACTION BETWEEN R&D AND ECONOMIC INDICATORS IN LITHUANIA

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Abstract

Innovation in many countries around the world has long become a key engine for economic development, enabling high level of productivity and the quality of life. However, various qualitative studies on correlation between research and development (R&D) performance and economic performance in different countries carried out by E. Poole, J. T. Bernard, J. Adams, M. I. Nadiri and others show that it is difficult to carry out the monitoring and evaluation of R&D performance or innovation, as the benefits of academic activity are disaggregated and of qualitative nature and has a long cause-effect chain.

The article focuses on economic efficiency of R&D performance,- there are the principal possibilities for identifying the impact of R&D performance on main economic indicators in Lithuania using the methods of mathematical statistics determined.

Keywords: R&D performance, innovation, economic efficiency of R&D performance.
JEL Classification: O31, O32, O47.

Introduction

Innovation in many countries around the world has long become a key engine for economic development, enabling a high level of productivity and the quality of life. This is reflected in the main documents of a country which set out the main directions of development. In 2000 in Lisbon the European Council has set the main strategic objective of the EU – to become the most competitive and dynamic knowledge-based economy in the world, one of the goals being 3% of the gross domestic product (GDP) of each member country spent on R&D. Lithuanian Innovation Strategy for the year 2010-2020 sets out the following strategic objectives: by 2015 to become a service delivery centre of Nordic-Baltic region, and by 2020 – an innovation centre of the Northern Europe with summary innovation index (SII) equal to EU average. However, various qualitative studies on correlation between R&D performance and economic performance in different countries carried out by E. Poole, J. T. Bernard, J. Adams, M. I. Nadiri and others show that it is difficult to carry out the monitoring and evaluation of R&D performance or innovation, as the benefits of academic activity are disaggregated and of qualitative nature and has a long cause-effect chain. It is also evident that the correlation between R&D performance and economic growth is highly dependent on the size of a country, its level of development, traditions, legal and normative infrastructure, R&D policy and its implementation system and many other factors. Thus, each country is unique and requires a separate study revealing the economic efficiency of R&D performance or its impact on economic growth, as well as the country's identity and factors affecting R&D performance.

The *aim of the article* is to determine the principal possibilities for identifying the impact of R&D activities on main economic indicators in Lithuania, using the methods of mathematical statistics. In order to achieve this aim, the following objectives were set:

1. To identify indicators evaluating R&D and innovation level and to verify the possibility to ensure their statistical reliability.
2. To create hypotheses of relationship between R&D and economic development indicators and to check their adaptability to Lithuanian economic development conditions.

Scientists evaluating R&D and innovation level (Shanks, S., Zheng, S., E. Poole, J. T. Bernard, and other) propose for such studies a number of indicators: a number of patents, business investment to innovation, country's innovation index, publications, number of researchers and etc. This study was based on six R&D performance indicators in Lithuania as independent variables with different connections to business. Lithuanian macroeconomic indicators – gross domestic product and employment growth rate – were chosen as dependent variables. The selected period for study was between 2003 and 2011.

The article presents Pearson correlation coefficients for each of these connections. The main result of the article is the presented weighted values of coefficients of the impact of Lithuanian R&D performance indicators on main economic indicators and the analysis of these results.

Links between R&D and innovation activities

Concepts "research and experimental development" and "innovation" are sometimes used interchangeably, but in fact they mean different things. *Research and experimental (social, cultural) development* is defined as a systematic creative activity for understanding nature, humans, culture and society, and the use of such activity results. R&D covers three activities – fundamental research, applied research and experimental development (Research Activities 2010, 2011). *Innovation*, in turn, is defined as entrepreneurial management instrument through which changes are used as an opportunity to create new business, product or service, and to get higher profits (Drucker, 2006). Innovation concept is based on the aspects of creating value, exploring opportunities and competitive advantage, i.e. innovations are usually associated with their added value. Innovative activities are successful commercialization of new technologies, ideas and methods, presenting to the market new or improved products and processes (Gecas at al., 2000).

The main difference between R&D and innovation concepts is the difference between the "goals" of the two activities. The main objectives of scientific activities are, in particular, creating new knowledge and their application to further research. The second objective is the dissemination of new knowledge through education and striving to use them in the economy and social life. R&D activities do not necessarily lead to innovation. It can be directed to a deeper assimilation of new knowledge, rather than the application of knowledge in a short run. Also, some R&D projects fail and can not provide useful results. According to Shanks and Zheng (2006), R&D activities are insufficient to explain innovation because many companies do not need to perform R&D projects in order to introduce new technologies, also because there exist other, non-technological ways to implement innovation. As a result, scientific literature divides innovations by their very nature and character into science-based and experience-based innovations (Edquist, Hommen, Tsipouri, 2000; Cardinal, Alessandri, Turner, 2001).

And yet, although in theory the two concepts are clearly separated and defined differently, in real life R&D and innovation activities are not easily dissociated from one another, because new knowledge received through R&D activities are often based on innovation. It should be also noted that interinstitutional cooperation is characteristic of innovation activities, i.e. cooperation with scientific institutions, institutes, innovation centres and etc. Most of the authors (Leber et al., Twiss, Bright, Price, Baker), analysing innovation activity processes, in their models or theories refer to the importance and certain place of scientific institutions, research or knowledge in innovation activities. In summary it can be stated that links between R&D and innovation are not linear, they are complex, and therefore indicators of these activities are significantly related.

Indicators characterizing R&D performance in Lithuania.

Main indicators of R&D performance in Lithuania are annually presented in Statistics Lithuania reports. The following are five indicator groups characterizing R&D performance:

1) Main science and technology indicators.
2) R&D personnel.
3) R&D expenditure.
4) Careers of doctorate holders.
5) R&D indicators in the European Union.

Meanwhile, one of the most common indicators of innovation activities in Europe, also used for generic comparison of countries, is summary innovation index annually presented in Innovation Union Scoreboard (Innovation Union Scoreboard 2010, Pro Inno Europe.). This index covers eight indicator groups and 25 different indicators in total. The analysis of Lithuanian R&D indicators and summary innovation index showed that most them are concurrent, i.e. calculating the innovation index, the main national R&D indicators are included: number of persons with higher education, number of postgraduate students, number of publications and other indicators that do not have direct connection with business or added value, as stated in definitions of innovation. Meanwhile, characterizing Lithuanian R&D performance, indicators defining innovation performance of business are also presented. This only confirms our statement that if in theoretical level the concepts of R&D and innovation are clearly separated, in real life their indicators are closely related and are not clearly separated.

Studies on R&D performance productivity

The productivity of R&D performance is examined in a number of studies, carried out at different levels: corporate, sectoral or national. Most of the authors (Nadiri, 1993; Wang & Tsai, 2004; Doraszelski & Jaumandreu, 2006; Khan, 2006; Artz et al., 2010; Sedziuviene & Vveinhardt, 2010; Gumilar et al., 2011, Wang & Wu, 2012, etc.) have examined the issue at corporate or national economy sector levels for a more explicit R&D input and output connection. Most of their studies confirm that R&D plays an important role in total factor productivity growth. The main research results: the elasticity of R&D productivity ranges from 8% to 85%, depending on the scope of activity, selected research data, measurement methods, selected period or R&D funding source.

There are not that many studies on national level examining the interaction between R&D and economic indicators. The main conclusions of these studies: investments into R&D are the most important component for economic growth and development in a long run; however, links between R&D performance and productivity growth are so complex that they can not be described directly or based on empirical studies (Heng, Choo, 2002; Zheng, 2006; Shanks, Pessoa, 2007; Coccia, 2009; Ho, Wong, Toh, 2009; Wang, 2010; etc.). Without questioning the correctness of this statement in principle, it should be noted that there is a lack of comprehensive research at this level in Lithuania.

When summing up research results on economic productivity of R&D at the national level, one can refer to the conclusion presented in the OECD Economic study which analyses the issues of R&D performance productivity. It says that there is a lack of studies in the field due to the complexity of evaluating economic impact of this activity because R&D performance indicators are not directly related to the main economic indicators used for countries' assessment. However, it is emphasized in the study that this performance has a significant effect on the quality of life and an indirect impact on business and economic development (Guellec, Pottelsberghe de la Potterie, 2001).

Research on interaction between R&D and economic indicators in Lithuania

In order to investigate the influence of R&D performance indicators to the selected national economic indicators – GDP and labour productivity – it is necessary to evaluate the time interval between the dynamics of indicators. The research covers a period of one year, i.e. we investigate the interaction of R&D indicators of 2003-2010 with national economic indicators of 2004-2011. For determining this relationship, correlation analysis method is used where six Lithuanian R&D performance indicators are chosen as independent variables:

1) Population aged 25–64 with tertiary education *(ISCED 5-6)*.
2) R&D personnel.
3) R&D expenditure.
4) R&D personnel in business sector.
5) Patent applications filed.
6) Innovation index of Lithuania.

The selected R&D indicators differ in their nature, i.e. they can be divided into three groups according to how directly the activities they describe are related to the creation of any kind of added value, economic benefits of the company, industry of the country. The first and the second indicators can be attributed to the first group of R&D indicators, which define R&D potential rather than the connection with business or the created direct economic value. The third and the fourth indicators can be attributed to the second group which has an averagely direct link with business. While the third group, which has the strongest direct link with business and fast economic benefits, includes the number of patent applications and innovation index.

The study poses two hypotheses:

1) R&D activities in Lithuania have a positive effect on national economic growth, i.e. the correlation between all R&D indicators and economic indicators is positive.

2) The weakest correlation is between the values of the first R&D indicators group and economic indicators; the second group has average correlation, while the third has the strongest.

Table 1 presents the values of selected Lithuanian R&D indicators in 2003-2010.

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Table 1. Main R&D indicators in Lithuania

R&D Indicator/Year	2003	2004	2005	2006	2007	2008	2009	2010
Population aged 25–64 with tertiary education, thousands	417,5	452,5	473,2	479,1	516,9	541,7	551,9	579,8
R&D personnel	14534	16436	16323	16379	18467	18598	18428	18257
R&D expenditure, LTL million	381,8	472,7	542,0	657,8	803,1	890,1	765,0	755,6
R&D personnel in business sector	781	1309	1559	1561	2523	2578	2148	2873
Patent applications filed	N/A	13310	11840	9792	6847	6894	4925	4757
Innovation index	0,26	0,25	0,27	0,24	0,26	0,23	0,24	0,23

Source: Statistics Lithuania, Innovation Union Scoreboard 2010

For depended indicators reflecting economic growth of the country we have chosen two economic indicators. First and foremost – gross domestic product (GDP), a most common macroeconomic indicator. The second one is labour productivity indicator, closely related to scientific, experimental or innovation activities at theoretical level. Their values are presented in table 2.

Table 2. GDP and labour productivity in Lithuania

Year	2004	2005	2006	2007	2008	2009	2010	2011
GDP, LTL million	62997,4	72401,9	83227,1	99229,3	112083,7	91914,0	95074,3	105062
Added value for one hour actually worked at current prices (LTL)	22,1	24,0	27,2	31,0	34,7	31,4	33,8	N/A

Source: Statistics Lithuania

The dependence between different variables is calculated by Pearson correlation coefficient r_{xy} (1), where the values of independent variables "x" are Lithuanian R&D indicators, and dependent variables "y" – national economic indicators, namely GDP and labour productivity.

$$r_{xy} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \cdot \sum (y_i - \bar{y})^2}} \quad (1)$$

Main research parameters and results are presented in tables 3 and table 4.

Table 3. Interaction between R&D and GDP indicators in Lithuania

R&D indicators group	No.	Relationship investigated		Correlation coefficient, r_{xy}
		Independent indicator, x	**Dependent indicator, y**	
I	1	Population aged 25–64 with tertiary education *(ISCED 5-6)*	R&D	**0,78**
	2	R&D personnel		**0,80**
II	3	R&D expenditure		**0,84**
	4	R&D personnel in business sector		**0,84**
III	5	Patent applications filed		**-0,76**
	6	Innovation index of Lithuania		**-0,38**

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Table 4. Interaction between R&D and labour productivity in Lithuania

R&D indicators group	No.	Relationship investigated		Correlation coefficient, r_{xy}
		Independent indicator, x	Dependent indicator, y	
I	1	Population aged 25–64 with tertiary education *(ISCED 5-6)*	Labour productivity	**0,90**
	2	R&D personnel		**0,87**
II	3	R&D expenditure		**0,91**
	4	R&D personnel in business sector		**0,89**
III	5	Patent applications filed		**-0,93**
	6	Innovation index of Lithuania		**-0,40**

Research findings and analysis

As shown by research results, the first hypothesis raised in the article was confirmed only in part. The correlation between the first two groups of indicators and Lithuanian economic indicators is positive and quite strong, i.e. increasing values of the first four R&D indicators result in increasing national economic indicators – GDP and labour productivity. It goes to confirm that R&D performance is related to economic prosperity and has a strong influence on the latter. Meanwhile, the correlation of the last two R&D indicators (submitted patent applications and innovation index of Lithuania), which at theoretical level are most directly related to economic processes and should have the strongest correlation, is negative.

The second hypothesis stating that the correlation between the values of the first R&D indicators group and economic indicators should be the weakest, while the second should be average, and the third should have the strongest, was not confirmed.

These results could be explained in several aspects.

Research results were without a doubt influenced by global economic crisis, which, as we know, had a strong influence on the majority of economies, and their main macroeconomic indicators. This only confirms the idea that correlation between two indicators depends on a number of factors simultaneously and it is difficult to indicate which are the most important. It is therefore appropriate to investigate additional correlation, with narrower national macroeconomic indicators as independent variables, for example separating traditional and high technology industry, also adjusting time interval between the indicators.

There is no doubt that negative correlation dependence of the third indicators group can be influenced by both objective and subjective reasons. The number of submitted patent applications is obviously decreasing. This means that one of the main innovation factors in Lithuania is actually not working, thus it is necessary to find out what causes the loss of this factor impact. Possible reason can also occur in the very calculation of indicator values. There is a stronger negative correlation between the number of patents and the selected economic indicators. A more in-depth investigation of the value of patent indicator shows that 50 to 70 percent of the value of this indicator is composed of enlarged European patent applications or international trademark protection applications. This means that it is only the protection of patent or trademark, created and existing not necessarily in Lithuanian market, in Lithuanian territory, and not the introduction of specific innovation product or its improvement into Lithuanian market. Thus, in order to clarify the results obtained, there is a need to additionally research the relationship between patent applications and economic indicators, excluding extended indicators from patent indicator, i.e. leaving only national applications. That would give a more accurate reflection on innovation activities of Lithuanian companies and organisations. Meanwhile, a low impact of the second indicator – innovation index of Lithuania – to the GDP makes question the validity of this indicator and for its objectivity to be grounded an exceptional attention must be paid.

Another reason of such results can be the correlation method itself. There are several reasons why it can not be concluded that there is a stochastic relationship between two random variables considering only the size of correlation coefficient. First, statistical sample volume should be taken into consideration. Determining correlation is mathematical method where the sample of eight years (years from 2003 to 2010) in theory is relatively small. However, in real life eight years is a sufficient period of time for collecting data, as a larger volume of data would cause yet another credibility issues – comparability of the indicators due to changing calculation methods or the occurrence of other factors influencing the investigated variables. It is also necessary to pay attention to the complexity of the correlation relationships themselves, i.e. such

relationships are generally very complex, and resultative indicators depend on a number of factors simultaneously and it is difficult to indicate which are the most influential. This requires a research of additional factors influencing R&D performance or its individual aspects in Lithuania.

Conclusions

In modern world R&D and innovation performance are considered to be one of the priorities for country's development; it is reflected in economic development strategies of different countries or communities. This article explores the relationships and links between R&D and innovation performance, and their economic efficiency. The main objectives of the article were to analyse and define the links of theoretical R&D and innovation concepts, and to investigate and evaluate the interaction between the selected R&D activities and Lithuanian economic indicators.

The main summarized results of the article.

1) Although in scientific literature R&D and innovation concepts are often used interchangeably, at theoretical level the two activities are different and clearly dissociated. The essential difference between R&D and innovation concepts is different "objectives" of the two activities. The main objectives of scientific or R&D activities are, in particular, creating new knowledge and their application to further research. The second objective is the dissemination of new knowledge through education and striving to use this knowledge in the economy and social life. Meanwhile, the meaning of innovation is always connected with added value, entrepreneurship, new business, product or service. The notion of innovation is always based on the aspects of creating value, exploring opportunities and competitive advantage where final and sole objective of such activity is increased economic benefit. Two types of scientists can be identified according to how they differentiate R&D and innovation activities. Some of them (Shanks, Zheng, Edquist, Hommen, Tsipouri, Cardinal, Alessandri, Turner) make a clear distinction between the two activities both in theoretical and practical level, and argue that innovative activities do not necessarily require R&D activities. Meanwhile, the other group of scientists (Leber et al., Twiss, Bright, Price, Baker) propose that new knowledge received through R&D activities are based on innovation. In their innovation models or theories the latter group of scientists always indicate the importance and a certain place for science institutions, research and knowledge. Therefore, it could be summarized that the relationship between the two concepts is complex and not necessarily linear.

2) If in theoretical level the concepts of R&D and innovation activities are quite clearly distinguished, then the analysis of indicators of both activities showed that they are strongly interrelated and are not clearly separated. Both describing the country's scientific potential and R&D performance, indicators of innovation activities are presented, and calculating national innovation indexes the major part of indicators are precisely indicators of country's scientific potential or R&D performance. The problem is that the number of indicators characterizing the level of innovation presented in low and that the statistical data is very much limited.

3) To research the impact of R&D performance on Lithuanian economic indicators, six indicators of R&D performance in Lithuania were chosen as independent variables. Each of the indicators by their nature has different relationship to business. As depended variables Lithuanian macroeconomic indicators were chosen: gross domestic product and labour productivity indicator.

Two interaction hypotheses were named in the study:

1) R&D activities in Lithuania have positive impact on country's economic growth.

2) R&D indicators with weakest relation to business have the lowest correlation with economic indicators, while those with the strongest relation to business have the highest.

The results obtained partly confirmed the first research hypothesis, while the second one was rejected. The correlation among the indicators of the first two groups and Lithuanian economic indicators is positive and strong, i.e. increasing values of the first four R&D indicators also result in increasing national economic indicators – GDP and labour productivity. It confirms that R&D performance is related to economic prosperity and has a strong influence on it. Meanwhile, the relationship between the third group of R&D indicators and economic growth indicators was negative during the research period. There might be several reasons for that. Firstly, the correlation method has its shortcomings in terms of difficult and complex correlation relationships, and due a small size of the sample. Another reason may be the informative capability of indicators themselves. For example, more than half of the value of the indicator – the number of patents – is composed not of national but international patents number. This means that it is only the

protection of patent or trademark in Lithuanian territory, and not an increasing level of innovation in Lithuanian companies or organizations.

The hypotheses testing based on correlation analysis allows stating that:

- Lithuanian statistical reporting system does not allow a detailed description of qualitative and quantitative level of R&D and innovation.
- It should be taken into account that there is number of factors that may affect the results of analysis when using the methods of mathematical statistics. These include:
  - Different absolute values may result in bias, thus apart from the absolute values analysis it is also appropriate to use indicator growth rate analysis.
  - It is necessary to evaluate the time interval between the level of innovation, R&D and the dynamics of economic growth indicators.

Technically the analysis of R&D indicators impact on economic indicators can be successful for comparative analysis among the countries. However, within the country it is necessary to identify the peculiarities of different branches, company clusters or research, innovation centres' development and their determining factors. It is also necessary to evaluate the possibilities of statistical base development and the development of applied mathematical – statistical methods. The research and its findings revealed the importance of assessing R&D and innovation performance, and that the relationship of the two activities with economy is a very complex issue that requires further in-depth studies.

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