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Changes in research and development after crisis in selected countries

Abstract. This article deals with the value of research and development (R&D) indicators before, during and after the economic crisis of 2008-2009. Higher R&D intensity and higher R&D manpower are found to be predictors of improved firm performance. On the example of four countries with various level of R&D, we try to show if crisis influences this area of economy in the selected countries, namely, Germany, Finland, Slovakia and the Czech Republic. We analysed the period of 2006-2014, as the indicators of the year 2015 are still not available, paying particular attention to Slovakia. For the analysis, such indicators were chosen: expenditures on research and development per inhabitant and as a per cent of GDP; number of university graduates; number of companies in high-technology sector and total high-tech trade (export and import) as a per cent of total trade. According to analysed indicators, the leading countries in research and development were Finland and Germany. Slovakia reached the worst results in expenditures to R&D. Another conclusion of our research was that the crisis does not cause significant changes in research and development area. Despite the fact that in the years 2008 and 2009 there were lower values of some R&D indicators compared to the other years, the crisis did not make a serious impact on analysed sphere.
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Зміни в науково-дослідній діяльності обраних країн ЄС після кризи

Анотація. У даній статті аналізуються показники наукових досліджень і розробок (R&D) до, під час і після економічної кризи 2008–2009 рр. На прикладі чотирьох країн з різним рівнем R&D ми досліджуємо кризовий вплив на цю галузь економіки в окремих країнах, а саме, в Німеччині, Фінляндії, Словаччині та Чехії. Ми проаналізували період 2006–2014 рр., звертаючи особливу увагу на Словаччину. Згідно з аналізом показників, провідні країни в галузі наукових досліджень і розробок – Фінляндія та Німеччина. Словаччина досягла гірших результатів у витратах на R&D. Висновком нашого дослідження було те, що криза не викликала істотних змін в області фінансування наукових досліджень і розробок.
Ключові слова: дослідження і розробки; високотехнологічний сектор; вища освіта.

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Изменения в научно-исследовательской деятельности выбранных стран ЕС после кризиса

Аннотация. В данной статье анализируются показатели научных исследований и разработок (R&D) показателей до, во время и после экономического кризиса 2008–2009 гг. На примере четырех стран с различным уровнем R & D, мы исследуем кризисное влияние на эту область экономики в отдельных странах, а именно, в Германии, Финляндии, Словакии и Чехии. Мы проанализировали период 2006–2014 гг., обращая особое внимание на Словакию. Согласно анализу показателей, ведущие страны в области научных исследований и разработок – Финляндия и Германия. Словакия достигла худших результатов в расходах на R&D. Выводом нашего исследования было то, что кризис не вызвал существенных изменений в области научных исследований и разработок.
Ключевые слова: исследования и разработки; высокотехнологичный сектор; высшее образование.

1. Introduction and Literature Review

We examined various scientific approaches to research and development (R&D) stimulation in different countries with the purpose of competitiveness increase, namely, the works of T. Beckman (1997) [1]; I. Brinkley (2006) [2]; G. Dosi and L. Soete (1998) [3]; P. Drucker (2004) [4]; J. Fagerberger (1996) [5]; J. Houghton and P. Sheehan (2000) [7]; J. Kelemen et al. (2007) [10]; T. Matsumura, N. Matsushima and S. Cato (2013) [14]; I. Prodan (2005) [17]; T. Sasaki (2016) [19]; P. J. Sher and P. Z. Yang (2005) [20]; A. Morozumi and F. J. Veiga (2016) [16]; G. Leu and H. Abbass (2016) [13]; F. Langot and M. Lemoine (2016) [12].

We agree with the conclusion of M. Mazzucato (2015) that there should be more debate about actual composition of investment; how to invest strategically in key areas, such as research and development, education and human capital formation that will increase gross domestic product (GDP) in the future (bringing the debt/GDP ratio down as a consequence); and how to engage in a debate about the direction of change so that such investments will result in growth which is not only smarter (innovation-led) but also inclusive and sustainable [15].

The interest in the relation between technology and competitiveness dates back to the so-called neo-technological trade theories of the 1960s concerning technology gap, product cycle etc. (Dosi, Soete, 1988) [3]. Since these issues were first introduced by Posner (1961), Vernon (1966) (In: Fagerberg, 1996) [5] and others, economic theory has changed considerably. Trade theorists started to apply the insights from models of imperfectly competitive markets to the analysis of international trade and world-wide competitiveness. Differences across countries in the efficiency of R&D and other technological activities have also been emphasised by the recent literature on national systems of innovation (Fagerberg, 1996) [5], competition and competitiveness growth through the creation of innovative products and technologies [11], human capital quality, and the stability of the economic environment and the quality of businesses management. For example, Morozumi and Veiga (2016) [16] state that empirical results based on a newly assembled dataset of 80 countries over the 1970-2010 period of time suggest that particularly when institutions prompt governments to be accountable to the general public, capital spending promote growth.

Competitiveness does not just show business success but also the success of the national economies. Sher and Yang (2005) [20] studied the effect of R&D clustering on innovation and thus, on firm competitiveness. They found out that higher R&D intensity and higher R&D manpower are found to be predictors of improved firm performance (Sher, Yang 2005) [20]. Countries are free to create competitive advantages and improve their position through innovative and inventive potential. It concerns dynamic competitive advantages based on human capital (Kotulic et al., 2015), educated workforce and a high level of active scientific and research potential (Kollar, 2013; Dubravska, Sira, 2014). One of the possibilities to support innovation activities in the European area is the optimal adjustment of the tax system in the context of promoting economic growth and competitiveness. Authors Langot and Lemoine (2016) [12] suggest fiscal competition by amending tax laws that would lead to the creation of competitive advantage, leading to an increase in production and an increase in global opportunities.

The relation between the degree of competitiveness and R&D expenditure was discussed by Matsumura, Matsushima and Cato (2013) [15]. They come to conclusion that when the market is more or less competitive, R&D activities are intensified. The results of Fagerberg (1996) [5] prove that both direct and indirect R&D have a significant positive impact on competitiveness. Indirect R&D from domestic sources appears to be more conducive to competitiveness than indirect R&D from abroad. The research conducted on a sample of Japanese manufacturing firms shows how financial cash flows affects firms' research and development investment where firms substantially increased cash holdings and reduced outstanding debt. Sasaki (2016) found that R&D-cash flow sensitivity among financially constrained firms is larger for financial cash flows than for operating cash flows [19].

A higher level of competitiveness of the economy is affected by the following factors:

- Innovation and Technology.
- The quality of human capital.
- Stability of the macroeconomic environment.
- The degree of internationalization of the economy.
- Quality management of enterprises (Kollar, 2013).

Nowadays, competition between countries is taking place within the newly forming knowledge economy of the 21st century, embracing new approaches, concepts, strategies and tactics which deep incorporation of technology and information into business processes took in. The knowledge economy is often associated with the term «new economy», designating a series of new rules or events that significantly change the economy and come about the same time. Probably, not only for the reason of changes related to information technology use, most of such changes, however, are subject to the development of these technologies (Kelemen, 2005) [10].

The definition of the «knowledge economy» is not uniformed. In the different sources we can find various explanations of this concept. We agree that the knowledge economy describes a new stage in the development of society, the essence of which is sustainable economic growth based on information, knowledge and innovation.

Knowledge is an independent force, which is a crucial factor in many social, economic, technological and cultural changes [2]. As reported by Drucker (2004) [4], knowledge is a crucial economic resource. According to Beckman (1997) [1], knowledge resides in the process of thinking about information and data, in their arrangement and analysis in order to become comprehensible and usable.

The knowledge economy is developing in two leading forces. The first one is the growing knowledge-intensity of economic activities and the second one is the globalization of economic events [7]. Furthermore, we noted that it is also supported by other factors - the use of information technology and constantly increasing rate of technological change. The pace of change in human activity significantly affects the acquisition of knowledge and the creation of a new category of the acquiring knowledge-based cognitive task analysis via exercise and as an autonomous knowledge-discovery as demonstrated in research of Leu and Abbass (2016) [13] in their paper concluding with the emergence of a fourth category of knowledge acquisition methods, which are based on red-teaming and co-evolution.

The most important component of the knowledge society is the growth of education, especially tertiary one (Hard, 2008). Assessment of this type of education is examined by E. Hvizdova Jr. (2014). She complements that scientific research itself, and, recording and communicating research results through publications, tertiary education has become enormous and complex. It is so complex and specialized that personal knowledge and experience are no longer sufficient tools for understanding trends or for making decisions at university [9].

In the knowledge economy, a competitive environment offers a challenge for higher education institutions to create a favourable and more competitive environment in coordination with businesses, so that potential candidates for study have the access to truthful and timely information (Radvanska et al., 2014). The success of the organization and the national economy is based on the effectiveness of these activities.

2. Purpose of the study and Methodology

The aims of the article are to define the changes and common tendencies in research and development after the global financial crisis of 2008-2009, and to investigate whether the R&D expenditures correlate with a number of graduates in tertiary education. We analysed four countries. Two of them are knowledge economy leaders (Germany and Finland). We compare the situation in knowledge leading countries with Slovakia and the Czech Republic. We were interested in Slovakia, investigating what level of knowledge economy development it has obtained so far. The Czech Republic was chosen due to similar economic performance to Slovakia, but with different R&D strategy.

We analysed the period of time of 2006-2014 as the indicators of the year 2015 are still not available. The data were obtained from Eurostat and from scientific articles dedicated to above mentioned area. For the analysis, such indicators related to R&D were chosen:

- expenditures on research and development per inhabitant;
- expenditures on research and development as % of GDP;
- number of university graduates;
- number of companies in high-technology sector,
- total high-tech trade (export and import) as % of total trade.

To answer the hypotheses identified, the correlation analysis has been used (Hindls et al., 2007 [6], Rimarcik, 2007 [18], and Husek, 2007 [8]). The aim of the analysis is to identify significant dependence (relationship tightness) among two or more variables. Correlation coefficient evaluates the level of linear statistical dependence. It takes values in the interval <-1, 1>.

Prodan (2005) [17] in his study identifies positive correlation between research and development expenditure and patent application. We were inspired by his findings and have tried to explore correlation between R&D expenditures and number of graduates in tertiary education.

Hypothesis: We assume that there is a functionality between R&D expenditure and number of graduates in tertiary education. Hypothesis will be verified via correlation and its final value. We will calculate it through the statistic programme Statistica.

3. Results

In this part we analyse the situation in research and development area in selected countries. Highlighted parts of the tables represent the years, when the crisis appeared.

We can see from table 1 that the biggest amount of research and development expenditures per inhabitant were in Finland and Germany. During the whole analysed period, these expenditures were growing in Germany, the Czech Republic and Slovakia. The crisis did not affect them. The highest amount was in Finland. In the years 2012-2014, the amount of R&D expenditures in Finland was falling down, but still reached the highest values compared to other three countries.

European Commission through strategy document Agenda Europe 2020 defines that the R&D expenditures must be 3% of GDP by the year 2020. We can see from table 2 that only in Finland this aim was fulfilled. The lowest values were obtained in Slovakia. Achieved values were below 1%. Comparable economy of the Czech Republic spends 2% of GDP on R&D.

In tables 3 and 4, we can find a number of graduates per thousand inhabitants. In both years, data in analysed countries were similar. Doctoral level was achieved by about 1 graduate per 1000 inhabitants. Tertiary education was achieved by 16-22 graduates per 1000 inhabitants.

Findings presented in table 5 show a number of companies in high-technology sectors. We find out that the least companies in the mentioned sector were in Finland. Even in Slovakia, there are more companies claimed to specialise with high-technology, approximately 12,000, compared to 9,000 in Finland. The overwhelmingly more companies were registered in Germany, more than 105,000, and a number of such businesses during the reporting period was increasing.

Other important findings are shown in the tables 6 and 7, in which we can see the amount of export and import in high-tech trade as % of total trade. The biggest amounts in high-tech

Tab. 1: **Total R&D expenditure per inhabitant, EUR**

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Czech Republic	125.6	149.3	175.6	193.3	184.6	200.3	243.4	273.9	285	294
Germany	675.6	713	746.9	809.2	817.2	855.1	923.5	966.6	972.1	1,026
Slovakia	36.2	40.3	46.9	56.7	56.3	77.2	86.9	108.3	112.9	123.6
Finland	1,045.3	1,096.2	1,183	1,296.3	1,274.1	1,302.7	1,332.7	1,264.9	1,231.7	1,194.6

Source: Own processing according to Eurostat data

Tab. 2: **Total R&D expenditure as% of GDP**

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Czech Republic	1.17	1.23	1.31	1.24	1.30	1.34	1.56	1.79	1.91	2.00
Germany	2.42	2.46	2.45	2.60	2.72	2.71	2.79	2.87	2.83	2.84
Slovakia	0.50	0.48	0.45	0.46	0.47	0.62	0.66	0.81	0.83	0.89
Finland	3.33	3.34	3.35	3.55	3.75	3.73	3.64	3.42	3.29	3.17

Source: Own processing according to Eurostat data

Tab. 3: **Graduates per 1 thousand inhabitants**

2013	Tertiary education (levels 5-8)	Bachelor's or equivalent level	Master's or equivalent level	Doctoral or equivalent level
Czech Republic	16.9	9.2	6.9	0.8
Germany	17.2	10.2	5.8	1.2
Slovakia	17.6	8.3	8.2	1.1
Finland	21.6	13.5	6.9	1.2

Source: Own processing according to Eurostat data

Tab. 4: **Graduates per 1 thousand inhabitants**

2014	Tertiary education (levels 5-8)	Bachelor's or equivalent level	Master's or equivalent level	Doctoral or equivalent level
Czech Republic	16.6	9.0	6.7	0.9
Germany	18.7	11.2	6.3	1.2
Slovakia	16.8	7.8	7.9	1.0
Finland	21.9	13.7	7.0	1.2

Source: Own processing according to Eurostat data

Tab. 5: **High-technology sectors - number of companies**

	2008	2009	2010	2011	2012	2013
Czech Republic	33,071	34,984	33,476	33,816	33,965	33,992
Germany	89,537	89,925	92,559	99,008	100,724	105,609
Slovakia	2,916	x	9,731	12,121	12,247	12,782
Finland	8,455	8,510	8,806	9,065	9,338	x

Source: Own processing according to Eurostat data

Tab. 6: **High-tech trade import as a percentage of total**

IMPORT	2007	2008	2009	2010	2011	2012	2013	2014
Czech Republic	15.5	15.1	17.4	19.0	17.4	16.9	16.4	17.2
Germany	14.1	13.3	14.9	15.6	14.0	14.0	14.0	14.5
Slovakia	10.3	9.8	10.6	10.9	12.7	15.3	16.5	16.5
Finland	15.0	13.5	14.0	11.3	9.9	9.9	9.5	10.0

Source: Own processing according to Eurostat data

Tab. 7: **High-tech trade export as a percentage of total**

EXPORT	2007	2008	2009	2010	2011	2012	2013	2014
Czech Republic	14.1	14.1	15.2	16.1	16.4	16.1	15.1	15.3
Germany	13.0	12.4	14.0	14.0	13.5	14.2	14.2	14.2
Slovakia	5.0	5.2	5.9	6.6	6.6	8.2	9.6	9.7
Finland	17.5	17.3	13.9	10.0	8.0	7.3	6.2	6.6

Source: Own processing according to Eurostat data goods and services exporting as % of total export were surprisingly in the Czech Republic and then in Germany in amount of 14-15%. Also, in the area of import we can see that 3 countries (the Czech Republic, Slovakia and Germany) gained similar results. All mentioned countries gained the import values in high-tech trade according to total import from 14 to 17%.

When we verify the hypothesis, we make correlation between R&D expenditure and graduates in tertiary education. We find medium close correlation between these variables. According to this finding, we cannot say that between R&D expenditure and graduates in tertiary education are no relationships.

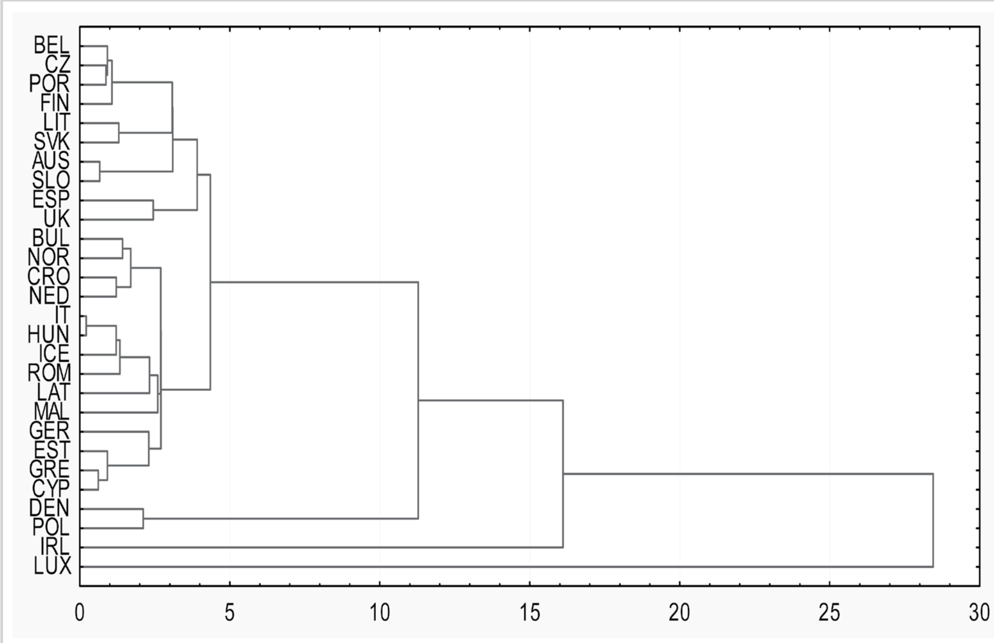

Fig. 1: **Cluster analysis of total R&D expenditures as % of GDP for EU-28 in 2014**
Source: Own processing in Statistica according to Eurostat data

According to results from the cluster analysis of total R&D expenditure as % of GDP for EU-28 using data from 2014 (figure 1), any of four analysed countries reach significant values. The aim of this analysis was to decompose a set of objects on several homogeneous subsets so the objects belonging to the same cluster are «the most» similar. The similar results were obtained between Finland and the Czech Republic forming one cluster.

4. Conclusion

According to analysed indicators, we may assert that the crisis did not cause significant changes in research and development area as it could have been expected. Our analysis shows that Slovakia reached the worst results in expenditures into R&D, which means that it has not met Europe 2020 Agenda of 3% of GDP spendings on R&D yet, contrary, for example, to Austria which already realised this ambitious aim.

The leading countries in research and development among investigated were as anticipated Finland and Germany. However, in some indicators, the Czech Republic and Slovakia were competitive to those leaders.

We found medium close correlation between R&D expenditures and graduates in tertiary education. Hence, tertiary education is one of the factors connected with R&D expenditures.

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