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.

Keywords: Research and Development; High-tech Sector; Tertiary Education

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Changes in research and development after crisis in selected countries

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Изменения в научно-исследовательской деятельности выбранных стран ЕС после кризиса

Аннотация. В данной статье анализируются показатели научных исследований и разработок (Р&D) до, під час і після економічної кризи 2008–2009 рр. На прикладі чотирьох країн з різним рівнем Р&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, проведені країні в галузі наукових досліджень і розробок – Фінляндія та Німеччина. Словаччина досягла гірших результатів у витратах на НДР. 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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Аннотация. В данной статье анализируются показатели научных исследований и разработок (Р&D) до, во время и после экономического кризиса 2008–2009 гг. На примере четырёх стран с различным уровнем Р & 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 Р&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.
I. Introduction and Literature Review


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 emerging 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, 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]. Companies are able to create competitive advantages and improve their position through innovative and inventive potential. It concerns dynamic competitive advantages based on human capital (Kotlic et al., 2015), educated workforce and a high level of active scientific and research potential (Kollar, 2013; Dubravská, 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. Authors Came (2018) [2] to create competitive advantages and 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 affect firms’ research and development investment where firms substantially increased cash holdings and reduced outstanding debt. Sasaki (2016) found that R&D-cash flow sensitivity at constrained firms is larger for financial cash flows than for operating cash flows [19].

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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
According to the cluster analysis of total R&D expenditures as % of GDP for EU-28 in 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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