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R&D Investments, EPO Patent Applications and the Economic Heterogeneity within the EU

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Abstract: In addition to internationalization and growing volumes of international trade in goods, the importance of expenditure on research and development (R&D) has grown significantly. National patent protection has become rather insufficient with increased international trade in goods, which has resulted in the importance of the international patent protection. The main aim of the article is to analyse the relation between R&D investment and the number of patent applications filed with the European Patent Office (EPO) after the year 2000, when the EU's Lisbon Strategy was launched. The authors have focused primarily on the differences among the EU macro-regions, which are based on the socioeconomic models. Conclusions imply that one percentage point of R&D expenditure generates roughly 100 EPO applications and the findings also show that individual macro-regions have the identical scattered data. However, dispersions in the individual groups of the EU Member States after the year 2000 differ. The EU Member States are starting to vary significantly in the intensity of R&D support also within each macro-region, thus disparities increase within the EU. Therefore, the attitude to GERD is considered to be an important factor contributing to the greater economic disparities within the EU.

Key words: EU, EPO application, economic growth, GERD, internationalization, R&D

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Introduction

Investments in R&D play an increasingly important role in generating the economic growth in developed economies, including all EU Member States. The European Union is aware of the importance of such investments, and therefore at the European Council in 2002 under the Lisbon Strategy already stipulated that Member States should invest 3% of their GDP in this area in order to maintain competitiveness and long-term economic stability. Nevertheless, the attitude of the EU Member States towards this area is rather heterogeneous and a number of the EU Member States puts significantly less means in this area. At the same time, the trend of internationalization as well as the increasing intensity of international trade in goods have been showing a stronger trend in the past two decades. A large share of production is currently exported abroad, often

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to several markets at a time. As a result, the importance of international patent protection for the exported production is growing, which is why the product is protected in several countries at the same time. The number of patent applications, as well as the number of patents, is also considered to be one of the indicators of international competitiveness, economic strength, technical development and the state of research and development (OECD, 2016). The aim of the article is therefore to analyse the relation between R&D investment and the number of international patent applications, particularly applications filed with the European Patent Office (EPO) after the year 2000, when the Lisbon Strategy was launched. In this article, we will test the hypothesis of whether the volume of investment in R&D has a positive effect on the number of the EPO patent applications. Given the number of EU Member States, the EU macro-regions division based on the social models of Esping-Andersen (1990), Sapir (2005) and Dolwik and Martin (2014) will be applied.

1. Theoretical framework

The relations between R&D investment, the intellectual property (IP) protection, the number of international patent applications and the economic growth define the theoretical background of this article. This research paper is based on the assumption that patent applications are the output of investment in research and development. This type of investment is contributing increasingly to the economic growth, especially in the developed economies.

First, we focus on the theories that explain the reasons for the R&D investment. Already in the mid-1950s, the economists Solow (1956) and Swan (1956) explained the motivation in terms of the so-called new growth theories. According to their conclusions, the long-term economic growth is determined by endogenous factors, with government policy having a significant effect on long-term growth. The new growth theories are further divided into two groups. While the first group focuses on the concept and measurement of capital, the latter includes research and development models (the so-called R&D Models). R&D models, e.g. Romer (1990) or Grossman and Helpman (1991), are based on microeconomic analysis and incentives for research and development. These theories try to answer questions about why companies invest in R&D or how innovations in one company affect the company's background and competitors. We consider innovations as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations“ OECD (2005). In the other words, the innovation, especially in the form of a patented product, service, etc., is improvement of the company’s output, which shall guarantee the temporarily monopolistic position on the market. This occurs due to the delay between the implementation of knowledge in other companies or business branches. The existence of patents or other IP protection also further stimulates the acquisition and knowledge dissemination, as the information in the patent claims is then available to other potential inventors (Maskus, 2000).

The long-term relation between the IP protection and the economic growth is explained, for example, by Gould and Gruben (1996), Thomson and Rushing (1999) or Park and Ginarte (1997). Park and Ginarte (1997) confirmed the relation and the benefits of IP protection in the period of 1960-1990 on a wide sample of countries, and according to their conclusion, the IP protection affects economic growth indirectly by means of input accumulation as investment in both research and development and physical capital as well.

Thompson and Rushing (1999) analysed this particular relation in more than fifty countries worldwide in the period of 1970-1985. Their conclusions also show the positive influence of trade openness on patent protection. The study also confirmed that investment in infrastructure and the level of IP protection are joined vessels. Gould and Gruben (1996) analysed the relationship between trade regime and the IP protection. Their analysis focused on the growth rate in 1960-1988. Within this period, numerous countries, especially the ones in Latin America, opened their economies, which enabled a sharper focus on the trade regime issue. Based on their cross-country analysis, the authors confirmed that this link is slightly stronger in relatively open economies. According to their conclusions, the stronger intellectual property rights protection corresponds to higher economic growth rates in a sample of countries.

However, Faiveley et al. (2004) concluded that the link between the IP protection and economic growth operates differently in terms of intensity depending on the economic development of economies. The authors examined the impact of the protection of intellectual property rights on economic growth in almost 80 countries by means of the threshold regression analysis. The positive impact of the protection of intellectual property rights on economic growth was confirmed primarily for low and high-income economies, but not for medium-income economies.

Similar findings came from Schneider (2005), who researched the link between the IP protection and economic growth between the years 1970 and 1990 in nearly fifty countries around the world. According to her conclusions, the level of the IP protection positively influences the degree of innovation. Nevertheless, this link is more pronounced in developed economies, mainly due to the size of their market and infrastructure.

Lederman and Maloney (2003) focused on the analysis of conditions that stimulate investment in R&D on a sample of Latin American, South Asian, USA and EU Member States. Their conclusions also show that the volume of finances, the protection of intellectual property rights, the ability to mobilize the government resources and the quality of research institutions are the main reasons why R&D efforts are rising with the level of economic development. These conditions further stimulate the research and development. On the one hand, R&D in practice is strongly concentrated in a small number of developed countries, providing these countries with higher competitive advantage for future economic growth. On the other hand, it also reduces the economic convergence of less developed economies.

Focusing on Europe, which is considered one of the high-income and R&D centres of the world economy, several studies also prove the spill over of knowledge and innovation as the output of R&D investment. Rodrigez-Pose and Crescenzi (2008) outlined three approaches to analyse the links between these factors. Historically, Maclaurin (1953) represented the linear approach and his analysis focused primarily on the relation between R&D and patents, where the relationship between patents and economic growth is an obvious result. The second approach is called an "innovation system" and it focuses on the study of territorially established institutional networks supporting or reflecting the creation of innovation. For example, Lundvallem (1992) or Morgan (1997) represent this approach which was popular between the evolutionary economists due to the qualitative approach. The latest approach mentioned by Rodrigez-Pose and Crescenzi (2008) is to extend and assimilate innovations across national borders or regions and was popular between economists and geographers and is represented by the research papers of Sonn and Stoper, (2008) or Cantweel and Iammarino (2003).

Rodrigez-Pose and Crescenzi (2008) analysed the relations between R&D investments and economic growth combining all the approaches mentioned above. The analysis focused on the regional level and verified the outcomes for the EU-25 at the regional level, where regional knowledge highly improves regional growth performance in the neighbouring regions as well. Nevertheless, based on their calculations, the influx of knowledge and innovation, represented by investment in R&D, is geographically limited. At the same time, their strong impact on the distance, which reaches more than 200 km within European countries, was confirmed. Funke and Nierbuhr (2005) proved similar findings on the example of the former West Germany regions between the years of 1976 and 1996. However, according to their findings, the regional growth is positively correlated with the R&D activity of neighbouring regions, although the half-distance turns out to be 23 km. They consider this distance to be a limitation so the geographical extent of knowledge spillovers is relatively bounded. This indicates that also within a relatively small region such as Europe relatively large disparities can persist derived from the different attitude to the R&D investment between countries.

The disparities between European regions were analysed by Armeanu et al. (2017). They aimed at empirically investigating the drivers of sustainable economic growth in EU-28 countries and concluded that total expenditure on research and development and employment rates of recent graduates are positively related with real GDP growth in EU-28 countries. Further, the governments should encourage innovation and create business opportunities via suitable regulations. Calegari et al (2017) explored the heterogeneity behind the production of innovation at the regional level. Their findings suggest that R&D expenditures lead to patents, while non-R&D expenditures drive the innovative sales. However, the study found relatively weaker effects on innovation in the regions belonging to the New Member States and in Convergence regions. On the other hand, significant spillover effects in these regions were found. These conclusions indicate that the faster diffusion of knowledge can accelerate the process of technological convergence in Europe.

The issue of intellectual property protection is analysed at corporate level as well. For example, Greenhalgh and Rodgers (2006) focused on the rate of financial returns on patent protection investments in the patent activities of British companies between the years of 1989 and 2002. The study found a significantly higher rate of financial return when businesses patented with the European Patent Office, compared to patenting with Great Britain only. These findings indicate the importance of international patent protection in conditions of increasing internationalization and intense flows of international commodity exchange. On a sample of more than 160,000 British companies that have been established since 2001, Helmels and Rodgers (2010) also found that patent protection or trademarks in newly established British firms have become a significant factor influencing the company's future existence. Sandner and Block (2011) confirmed the positive impact of IP protection on the value of the company at financial markets. Trademarks in particular are viewed as an effective tool to at least partially appropriate the value of marketing investments.

Pluvia Zuniga and Guelec (2009) analysed the situation of patent protection within 600 European and 1,600 Japanese companies by means of questionnaire surveys. According to their conclusions, small and middle-sized enterprises in Europe face problems with obtaining a patent, with information barriers being the biggest obstacle to getting a patent. They also conclude that one third of European companies established since the year 2000 regard patent protection as an important aspect to convince potential investors to provide these enterprises with finance for their further development. These findings indicate a growing importance of the IP protection on the corporate level. However, the SMEs, which create most of the economic output, face the informal obstacles to protect their innovation properly, which limits the innovation potential of the developed economies.

The theoretical framework shows that the issue of investment in research and development has a positive impact on the IP protection. Moreover, the studies have repeatedly confirmed the relation between this type of investment and the economic growth, both at the level of states, regions and businesses as well. However, the conclusions point out a different intensity of relations depending on the economic level, where more economically advanced EU regions benefit more from this type of investment, mainly due to related determinants such as market size, investment in related infrastructure or the quality of research institutions.

The EU Member States, which belong among the most economically developed economies in the world, should gain a significant profit from R&D investments. The EU has been aware of the importance of this type of investment in the long term. In 2000, the Lisbon Strategy was adopted and legislated at the European Council in order to increase EU competitiveness by the year 2010 (European Communities, 2000). In 2002 in Barcelona, a quantifiable target was added to the Strategy, according to which R&D investment (GERD) should reach 3% of GDP per year, two-thirds of this new investment should come from the private sector (European Communities, 2002). Considering the situation in the EU of that time, this step was a rather ambitious target since the EU spent 1.78% of GDP on R&D when the Strategy was launched in 2000. Only Finland and Sweden exceeded the target of 3%. Many of the EU Member States of that time (i.e. Ireland, Spain, Portugal, and Greece) spent less than 1% of GDP on R&D (Eurostat, 2017). From this point of view, we can assess the Lisbon strategy as not very successful. The High Level Group report (2004) considered the EU's investment in the R&D insufficient and little understood. The report also highlighted the fact that up to 40% of labour productivity growth is generated by R&D spending and that there are significant spillover effects into other areas of the economy. In 2009, the European Commission (2009) stated the following: "The EU needs to increase its research efforts by pooling resources, jointly developing major research infrastructures across the EU".

This was one of the impulses to initiate the follow-up Strategy Europe 2020 launched in 2010, when 1.98% of GDP was invested in R&D within the EU. At present, this area has grown slightly in terms of volume of money. The EU as a whole invested 2.0% of

GDP in 2015, which represents a growth of 0.22 of percentage point compared to the year 2000. The countries currently reaching the 3% of GDP for research and development are Denmark and Austria, with Germany targeting 2.89% of GDP. The situation varies considerably among the EU Member States. On the one hand, there are EU Member States that have met this goal in the long term, but at the same time there are still nine EU Member States that invested less than 1% of GDP in research and development in 2015 (Eurostat, 2017). It follows that countries show a very different approach towards this type of investment.

Nevertheless, the Strategy modification of the targets was arranged. They were divided into the national and supranational level. The supranational goal remained unchanged at 3% GDP. The national targets were set to reflect better the particular Member States' situation (EC, 2011). The spread between them is comparatively wide. For example, Cyprus, which invested 0.44% GDP into the R&D in 2010, was set to invest 0.5% GDP. On the contrary, Finland and Sweden, who are R&D‘s investment champions, should invest 4% of GDP until 2020 (Eurostat 2017). In all the Member States, the aim of the investment is to improve the conditions for innovation, research and development and the number of patent applications as included in the official EU's recommendation to improve the competitiveness and long-term growth potential (EU, 2015). On the other hand, even the modification of the targets to make them national does not mean they are fulfilled. As Ruser and Anheier (2014) state, "meeting respective national targets is not a question of financial capacity alone. Instead complex political issues, like forging mutually beneficial research alliances between the public and the private sector, arise". The number of patents as a marketable innovation does not have to correlate fully with the R&D spending. There was a growth in EPO applications in all the Member States after 2010. However, the growth was more considerable in countries with larger R&D investment and the gap between (North) West and South (East) remains remarkable. For example, in 2014 137 EPO patent applications were recorded in Belgium, compared to only 6 patents in Bulgaria (Eurostat, 2017).

In our view, the national targets, which are set more realistically, can stimulate the patent activities in the event that there is a suitable environment and cooperation between public and private research activities. As Lederman and Maloney (2003) state, "the R&D returns in developing countries are above those for industrialized countries." However, the poorer EU Member States invest less due to the weak industrial R&D infrastructure; there is little to no R&D funding from any diversified industrial line of business (Albu, 2011), which results in the lower level of patent applications.

Given the number of EU Member States, the authors have decided to regard the countries as macro-regions based on Esping-Andersen (1990), Sapir (2005) and Dolwik and Martin (2014)[2] social model division. This division reflects the different approaches

[2] The Anglo-Saxon model (Great Britain, Ireland) is characterized by a low level of government interventions, the decisive role of the market and the concept of a minimal state. The Continental model (Austria, Germany, France, Belgium, Luxembourg, the Netherlands) is based on the basic idea that preventing social problems is more effective than addressing them. The objective of such a model is a high level of social protection and employment. The Scandinavian model (Finland, Sweden, and Denmark) is characterized by egalitarian tendencies and high redistribution of the

of individual states towards this type of investment within macro-regions; thus, the expenditures on R&D have the highest priority in the northwest of the EU (Scandinavian and Continental models), whereas the priority declines towards the southeast (the Mediterranean and Balkan models).

2. Methodology and outcomes

This section will analyse the relationship between the gross expenditures on R&D within the EU (GERD) and the number of the EPO patent applications in the individual EU Member States. The number of patent applications as well as the number of patents is considered one of the indicators of international competitiveness, economic strength, technical development and level of research and development (OECD, 2016).

Patent protection is one of the traditional and most important intellectual property protection institutes (OECD, 2009). Research activities and investments are closely linked to the patents since the patent protection is a long-term way to increase the rate of financial return invested in the development of new products (e.g. Griliches (1984), Jaffe (1986) or Bilbao-Osorio and Rodrigéz-Pose (2004). Also, according to the Eurostat (2016), “patents provide a valuable measure of the exploitation of research results and of the inventiveness of countries, regions and companies.”

The argument for the IP protection has been demonstrated at both national and corporate levels. Based on the studies mentioned above, patent protection has a rather positive impact on the profitability of companies, the long-term existence of the company and the attractiveness for potential investors. However, due to internationalization accompanied by intensified international commodity exchange, the national patent protection is not a sufficient guarantee of financial return, and therefore, the importance of international patent protection (OECD, 2016) is growing.

One alternative of the international patent protection is the EPO patent, which the authors have adopted for further analysis on the grounds of the data availability within Eurostat across the EU, unlike the indicator regarding the number of PTC applications registered only by the OECD.

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national product. Social security concerns essentially all population groups, resulting in the cost of a system which can only be financed through high employment. The Southern European model (Spain, Italy, Greece, Portugal, Malta, Cyprus), also called the Mediterranean model, is defined by higher income inequality, and social systems do not reach the parameters prevalent in most of the original EU countries. The problem is strict legislation to protect workers' rights, creating rigidities in the labour market. The post-communist, or the so-called Central European model (the Czech Republic, Slovakia, Poland, Hungary, Slovenia) and Baltic model (Estonia, Lithuania, Latvia) take on the elements of the continental and liberal model with regard to its time of origin. The Central European model is closer to the continental model, while the Baltic model is predominantly liberal. The model of the Balkan states (Romania, Bulgaria, and Croatia) combines the liberal model as for the amount of money invested together with the Mediterranean in terms of distribution.

Several authors have examined the delay between R&D incentives and productivity growth; generally or specifically for some branches of industry, see e.g. Lee, Choi (2015) or Sandu, Ciocanel (2014). Also, statistical or economical similarities may be an inspiration for the choice of the lag. The time delay of two and three years between GERD and the number of patent applications has been adopted, as research of a new product is usually a long-term process. The survey period for the number of patent applications is 2003-2014, from which the latest actual data for the EPO application is available; the GERD indicator is given the time delay for the period 2000-2012. The dataset contains 28 observations but in some analyses this number is adjusted due to methodological reasons. This contribution aims to reveal macroeconomic effects and disparities among several approaches to economic policies rather than microeconomic effects for a company.

The authors decided to analyse a diverse set of different statistical methods, which aim to verify the above theses and hypotheses altogether. First of all, this is a regression analysis, where the unknown parameters of the linear model are estimated and analysed by the ordinary least squares numerical method (the OLS). The suitability of the model is focused on the basis of a standard F-test, the most often used while comparing statistical models, which corresponds to the decomposition of variability of the dependent variable to the model and the residual variable. Partial parameters are tested by t-tests, where the significance and relevance of the model directive is also considered to be a correlation coefficient significance test. This test is applied and regarded as a guideline in determining the power and direction of potential dependence. The additional Durbin-Watson test aims at detecting possible autocorrelation in the residuals. Considered significance level for all analyses is 5%, but in many cases, tests are much more powerful and also meet 1% of the alpha (the so-called type I error).

The results of the analyses are very appealing. At the chosen delay of both two and three years, there is a statistically significant dependence of the number of patent applications on the amount of R&D expenditure (GERD) throughout the monitored period. The basic data on the dependencies mentioned are summarized in the following Table 1.

At first, close attention could be paid to the parameters of the resulting models. In all cases, the constant parameter in the regression line (the intercept) is negative. Therefore, its interpretation, although it is regarded as a statistically significant parameter, does not make much sense. For example, the latest regression line is in form: EPO(2014) = -79.31 + 104.22*GERD(2012) for two years' delay; EPO(2014) = -78.38 + 105.15*GERD(2011) for three years' delay. Certain sense could be seen in the fact that few percentage points of investment in R&D are required to produce a minimum number of patents.

Even more compelling, however, seems to be the regression coefficient of given models, a directive indicating how many patent applications will bring one percentage GERD point on average. As it could be remarkable, this indicator fluctuates around the value of 100 applications. In the period pursued, this indicator also increased slightly, where there are four applications in the four-year period, and one application for the three-year period.

Table 1. Regression analysis of EPO/GERD dependence

Two years delay			Three years delay		
Years	F-Ratio	P-Value	Years	F-Ratio	P-Value
2005/2003	136.35	0.0000	2006/2003	141.49	0.0000
2006/2004	139.36	0.0000	2007/2004	195.48	0.0000
2007/2005	199.34	0.0000	2008/2005	178.62	0.0000
2008/2006	164.86	0.0000	2009/2006	176.75	0.0000
2009/2007	160.17	0.0000	2010/2007	199.60	0.0000
2010/2008	162.97	0.0000	2011/2008	148.45	0.0000
2011/2009	129.63	0.0000	2012/2009	155.07	0.0000
2012/2010	133.40	0.0000	2013/2010	136.76	0.0000
2013/2011	87.98	0.0000	2014/2011	75.25	0.0000
2014/2012	71.54	0.0000			

Source: Own computations based on EUROSTAT (2017)

All regression models created are statistically significant even at a 1% level of significance. Besides, the t-tests for individual parameters are meaningful as well, although their meaning has already been critically evaluated and discussed above. To sum up this section, it should be noted that although the time factor was fixed by the authors in the assumption of the delay of two and three years, and therefore the assumption of apparent correlation is not an a priori consideration, the serial correlation in residues is excluded by the Durbin-Watson test in all partial regression analyses.

It can, therefore, be stated that a statistically significant dependence of the number of international patent applications filed on R&D expenditures (GERD) has been revealed. This relationship is thus relatively powerful and positive. The resulting effect of investment in this area is a subject to some delay. This delay was not statistically investigated and researched as its detection is rather complex and uncertain with such a diverse set of data. Nevertheless, the authors assume that it is about a two to three-year delay.

Limits restricting the verifiable value of the results include the fact that not all applications for international patent protection are ultimately granted the patent protection. Despite this, the number of patents granted is not registered in the Eurostat database. Moreover, the financial return of individual patents may vary considerably as well. This distinction could only be detected at the enterprise level by means of a questionnaire survey which, however, exceeds the scope of this article. The issue of effectiveness and the scale of research and development are considered the last limiting aspects, where the number of patent applications granted may be different for the same amount of funding, either because of a different research management system or due to the different sectoral specialization of the individual European economies.

Despite the limits mentioned above, the authors consider the analysis of the development of the GERD indicator and the number of EPO patent applications after

2000 to be an appropriate way of identifying developments and differences in the area of international patent protection in the individual EU Member States.

For the sake of depth analysis, the authors consider the analysis of disparities or homogeneity within and between groups of monitored states important as well. In the following set of analyses, therefore, the Analysis of variance, the so-called ANOVA, will be used. This method, which consists of the decomposition of dispersion of the variables examined into intragroup and intergroup sources, will allow the internal and external differences within and between the individual macro-regions (models) of the examined group to be revealed. In order to verify the assumption of normality, the Kolmogorov-Smirnov test will still be performed, since the partial sets of data are of a small scale. Homoscedasticity of subsets (meaning “same variance”) will be verified by the Bartlett's test. The considered level of significance for all analyses is 5%, however, in many cases, the tests are much more powerful and also meet 1% of the alpha error (the so-called type I error). The data come from a normal distribution, and for that reason a parametric version of the ANOVA will be used. The individual sets of data (models in terms of typology of socio-economic characteristics) have identical data scattering. The results are summarized in the following Table 2.

Table 2. ANOVA of GERD and EPO

	GERD			EPO	
Year	F-Ratio	P-Value	Years	F-Ratio	P-Value
2005	23.82	0.0000	2005	34.87	0.0000
2006	21.20	0.0000	2006	32.72	0.0000
2007	20.45	0.0000	2007	30.56	0.0000
2008	17.68	0.0000	2008	34.66	0.0000
2009	17.11	0.0000	2009	29.77	0.0000
2010	13.72	0.0000	2010	32.92	0.0000
2011	9.90	0.0000	2011	34.11	0.0000
2012	9.34	0.0000	2012	33.21	0.0000
2013	10.38	0.0000	2013	33.69	0.0000
2014	11.35	0.0000	2014	27.48	0.0000

Source: Own computations based on EUROSTAT (2017)

It is remarkable that the Barttlet's P-Value (or the value of the test statistic) decreases over time (increases), hence the authors can assert that the scattering in individual macro-regions is different, although this is not statistically compelling at the level of significance selected by the authors. As a result, the individual states begin to noticeably differ in terms of the intensity of support for science and research, and this does not bring about unification, but rather greater differences.

Nonetheless, the basic thesis will be verified by the Analysis of variance itself. The results show clearly that there is a decline in the F-Ratio in individual years, although with a slight fluctuation, especially towards the end of the pursued period. In fact, this means that the ratio of intergroup and intragroup variability changes and, furthermore, the differences within groups are growing. However, there is still a statistically significant dependence of the GERD on the socio-economic model of the state, and thus there are significant differences in the level of this characteristic within the group of countries.

Regarding the patent applications, the situation is contrasting. Although the data also originate from the normal distribution, there are different pop variances within each group. Within the Bartlett test, homoscedasticity[3] cannot be found at the 5% level of significance. For example, in 2014 the Bartlett's statistic is approximately 20.2099, thus P-Value is extremely low, about 0.0025. This situation is observed during the whole period examined.

Nevertheless, the results seem to be rather compelling in terms of the analytical purposes of differences between the macro-regions. In detail, an unequal development of the F criterion over the period pursued is obtained. The differences between the models and within the models as well, therefore, fluctuate; only the last period records a slight statistical approximation, but this approximation is not regarded as a trendy issue. Out of all individual models, both Scandinavian and Continental models are significantly different in terms of statistics.

Table 3. Multiple Range Tests of EPO in 2014

Macroregion	Count	Mean	Homogeneous Groups
Balcan	3	5.0300	X
Baltic	3	17.5150	X
Central European	5	26.9000	X
Mediterranean	6	32.4375	X
Anglo-Saxon	2	77.6750	X
Conservative	6	180.238	X
Scandinavian	3	312.4170	X

Source: Own computations based on EUROSTAT (2017)

Interestingly, internal differences are greater for developed models, while the Balkan model is the most homogeneous model. Consequently, it can be concluded that there are significant differences in the number of patent applications between macro-regions dominated by continental and Scandinavian countries. Within groups there is a heterogeneity, where the advanced states are more heterogeneous compared to the less developed models. These facts are summarized in Table 3, which is based on the multiple range test.

[3] This has also been verified by other variances compliance tests. The Levene´s test is the only exception as this test is significant only when selecting the 10% of lower significance level.

Conclusion

The importance of the R&D investment for the economic growth of developed economies is growing steadily, including all the EU Member States. Since the new millennium, the European Union is highly aware of the importance of this type of investment. At the European Council in Barcelona in 2002 the EU stipulated that the Member States should invest 3% of their GDP in this area in order to maintain its competitiveness and long-term economic stability. The targets were also incorporated into the follow-up Europe 2020 Strategy in 2010. Nevertheless, the attitude of the EU Member States towards this area is rather heterogeneous and a number of the EU Member States invest significantly less means in this area.

At the same time, the internationalization as well as intensity of international trade in goods grew significantly. Therefore, the international IP protection, which guarantees a temporary monopoly position in the foreign markets and increases the financial return on R&D investments on the business level, also influences more notably the economic growth of the developed economies, including the EU Member States.

The authors of the article tested the hypothesis of whether the volume of R&D investment had a positive impact on the number of the EPO patent applications. Based on the calculations in part two, this hypothesis can be confirmed. For a two-year delay, the correlation coefficient reaches 0.869, while reaching the value of 0.875 for the delay of three years. The reliability of this test is very high. The level of significance on which the hypothesis of independence can be rejected is less than 0.1 per mile. It also follows from the conclusions that one percentage point of R&D expenditure generates approximately 100 EPO applications.

At the same time, the number of international patent applications drops from the Scandinavian model (average of 312.417) towards the Balkan model (average of 5.030). The homogeneity of the individual macro-regions rises in the same direction; the Balkan macro-region reaches a variance of 1.562, however, the Scandinavian model shows a variance of 58.442.

Regarding the differences between the macro-regions, the growing disparity in the EU's economic development has been confirmed. The macro-regions are starting to differ more remarkably in the intensity of support for R&D. The results show that the more economically advanced macro-regions are, the more they differ. Apart from the impact on the number of the international patent applications, the position of the individual EU Member States on investment in research and development has an increasing influence on the deepening of the economic disparities within the EU as well. In our future research, we would like to focus on the growing heterogeneities within the particular macro-regions and gain more detailed identification of the factors causing these differences to better understand the causes of the divergent intra-regional development within the EU. Also, there is the possibility of weighing the spatial autocorrelation tools to influence the dependencies of the occurrences of the given indicators across the evaluated countries.

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