EFFECTS OF KNOWLEDGE DISSEMINATION ON REGIONAL EUROPEAN ECONOMIC PERFORMANCE

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Abstract

The aim of the paper is to assess the impact of the innovation activity on the economic performance în the European NUTS 2 regions, in the period 2000 – 2014, based on a production function of an aggregate output (GDP per capita) which include patent activity as a factor of influence. To this end, the first part presents an overview of developments in macroeconomic indicators, levels of performance and their correlation with applications for patents relative to the population during the period between 2000 and 2014 at NUTS 2 European regional level. In part two, we assessed the econometric effects of the output of innovation or of patent applications on growth with data coming from 265 regions grouped by their inovatinvness capacity (leaders, important, moderate, modest).

The results achieved reflect the particular importance of patenting growth and patenting aplications as a whole and, in particular, of patented technologies and knowledge not only regionally but internationally. Meanwhile, a weak innovation activity, as reflected by the small number of patent applications, is a factor that can hamper economic growth. This is highlighted in a separate analysis on groups of innovators, where we obtained very good economic results in case of a sustained innovation activity reflected by requests filed under International Procedure (PCT).

Key words: regions, innovation, economic growth

JEL: O31, O40, R11

1. Correlative developments of innovation activity and regional economic performance

The performance of the regional economy is measured by gross domestic product (GDP) million. Population - measured by the number of residents on 1 January - is included to take into account the relative size of each region. The labor factor is represented by the number of employees over 15 years. R&D effort is measured by the total intramural expenditures for R&D (millions of euro). Human capital is represented by the number of economically active individuals with secondary and/or tertiary education.

Figure no.1a: **Regional distribution of PCT patents per thousand inhabitants (2013)**

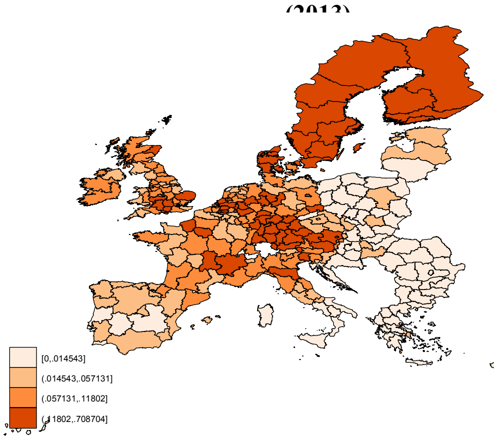
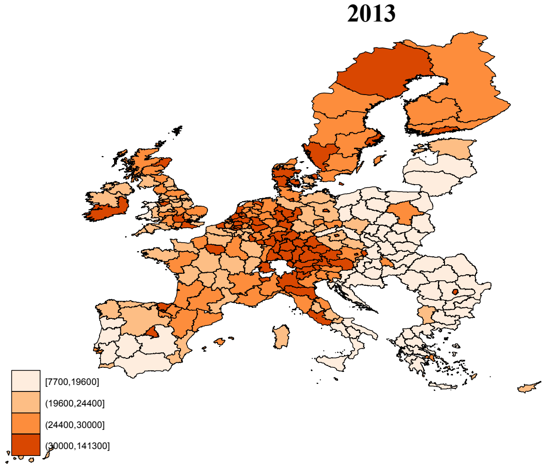


Figure no. 1b: **GDP per capita 2013**



Source: own preparation in STATA 14.0, based on Eurostat and OECD data, 2016

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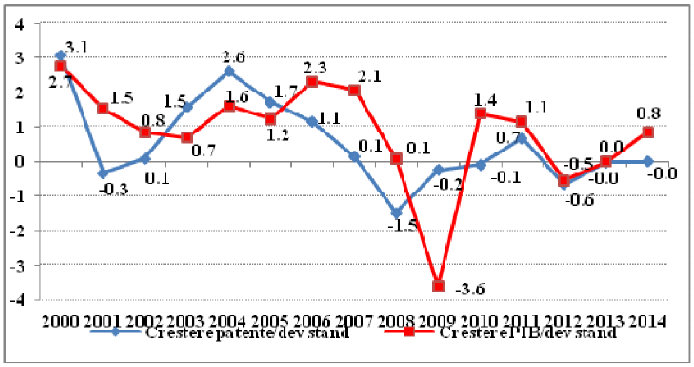
Relative to the number of inhabitants, the map distribution of patent deposits overlaps very well over the regional distribution of GDP per capita. Data for 2013 included in the figure below suggests a possible association between the two indicators.

The financial crisis in the first decade of the 2000s visibly affected the innovation economy. By virtue of the decrease in revenues and funds allocated to this task, the situations of increased risk made the pace of applications for patents to slow down. The following figure captures a comparison between the growth rate of real GDP and the patent applications throughout the European Union, since 2000. Growth rates in GDP and patents are reported to deviations of their standard values.

Figura nr. 2: **GDP and filing of patent applications growth rate in the UE-28 2000 – 2014 (%)**



Source: own preparation in STATA 14.0, based on Eurostat and OECD data, 2016

We note that innovation activity (measured in this way) had an annual growth rate somewhat steady, at least until the crisis in the sense that there was a continuous increase from 2001 to 2004, followed by a steady decrease until 2008 and a slight recovery until 2011; the lingering effect of the crisis has led to further cuts of patent applications filed. However, the decline was not as deep in terms of patent applications, but their subsequent rates remain negative to slightly positive rates of economic growth for the EU economy as a whole. Yet, the crisis has affected less innovative regions with less intense activity, but which have been in a period of economic growth..

Table no. 1 **Real GDP and Patent applications growth rate 2000 – 2014 (%)**

	2000	2001	2002	2003	2004	2005	2006	2007
Patent applications growth rate	5.51	-0.60	0.16	2.81	4.69	3.08	2.07	0.25
Real GDP growth rate	3.6	2	1.1	0.9	2.1	1.6	3	2.7
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
Patent applications growth rate	-2.66	-0.44	-0.15	1.21	-1.19	-0.05	-0.02	
Real GDP growth rate	0.1	-4.7	1.8	1.5	-0.7	0	1.1	

Source: Eurostat, 2016

Moreover, even as a trend, the two developments are very similar. However, even if GDP has a similar evolution, it is further, with a lag period following the innovation until 2012 after that, the annual GDP growth there no longer seems to be in line with patenting. Analysis of the EU and subsequently of the member States highlights the great diversity of situations encountered, making it difficult for a forward-looking view of the relationship evaluated within European regions. Thus, during the 14 years considered, it was revealed the need for evaluation of a factorial complex and the use of estimation techniques by which we can make a better possible control of the validity of variables and specifications of models (endogeneity, the omission of important determinants, error assessment, etc.).

The correlation between patent applications and GDP per capita for 2014 is strong. This is true for the correlation between the annual average of the two indicators for the period 2000 – 2014 as well, suggesting a possible association between their variations:

Figure no. 3a: **The relationship between patent applications and GDP per capita in 2014**

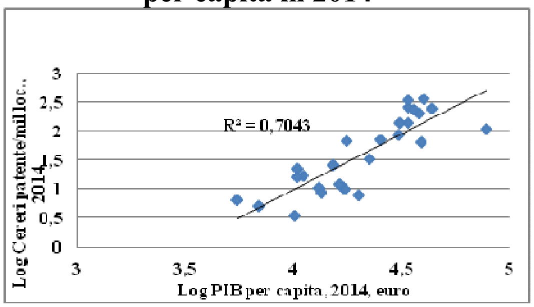
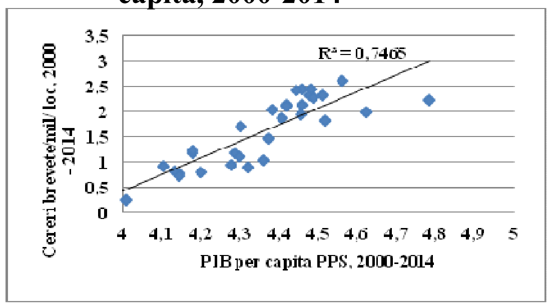


Figure no. 3b: **Patent applications and GDP per capita, 2000-2014**



Source: own preparation based on OECD data, 2016

Territorial units included in the analysis are at the national level, the Member States of the European Union, to which we added depending on data availability, Norway and Switzerland. The study, however, was focused on assessing the relationship outlined at regional level and the spatial analysis comprised 265 territorial units, of which 258 NUTS 2 and 7 NUTS 1 for countries where there is no such a level of administration (Cyprus, Estonia, Latvia, Lithuania, Malta and Luxemburg). The time period considered for all regions and variables 2000 - 2015, nationally, and differentiated 2000-2015 / 2012, for analyzes conducted at the regional level.

Analyses are performed in all regions, and separately on four groups of innovative regions. Thus, we used a grouping of regions according to regional innovation performance (knowledge resources endowment and innovative capacity), according to the latest *Regional Innovation Scoreboard* (European Commission, RIS, 2016) and *European Innovation Scoreboard* (European Commission, EIS, 2016) issued by the European Commission. Europe's regions (regions 214 different units) were classified into four different groups depending on innovation performance: regional *leaders* in innovation (*LEADER,* 36 regions), strong regional innovators (*STRONG*, 65 regions), moderate regional innovators (*MODERATE*, 83 regions) and *modest* regional innovators (*MODEST*, 30 regions).

The four groups of regions delineated according to the latest assessment by the European Commission (European Commission, 2016) are characterized as follows:

- *leaders* (*Leaders Innovators*) are those regions with a relative performance measured by regional performance index of 20% or more above the EU average; all 36 regional innovation leaders in the EU are located in only seven EU Member States: Denmark, Finland, France, Germany, the Netherlands, Sweden and the UK; whole countries included in this group are: Denmark, Finland, Germany and Sweden;

- *important regional innovators* (*Strong Innovators/(Innovation followers*), 65 units, are performing regions between 90% and 120% of the EU average. The group of countries includes Austria, Belgium, France, Ireland, Luxembourg, the Netherlands, Slovenia and the UK;

- *regional moderate innovators* (*Moderate Innovators*) are performing regions between 50% and 90% of the EU average, the largest group (83 regions), comprising Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Italy, Lithuania, Malta, Poland, Portugal, Slovakia and Spain;

- *modest* regional innovators (*Modest Innovators*) 30 regions which are performed under 50% of the EU average. All regions in Bulgaria, Latvia and Romania and thus at the national level these countries are modest innovators. In most countries there is limited variation between regional performance groups, suggesting that innovation performance at the regional level is linked to the national level. However, the fact that in some countries there is a greater variation (especially in larger countries) highlights also regional particular features and the existence of " regional areas of excellence".

In Austria, Belgium, Bulgaria, Czech Republic, Hungary, Ireland and Romania, all regions are in the same performance group, on the other hand in 12 countries there are two different regional performance groups. Only four larger Member States (France, Germany, Italy and Spain) present three different regional performance groups. In addition, Cyprus, Estonia, Latvia, Lithuania, Luxembourg and Malta are included nationally, as in these countries there is no regional administrative level, in such manner the composition of the group's performance is identical to the ratio 2016 of the Scoreboard European Innovation (European Commission, RIS, 2016).

2. Effects of dissemination of knowledge on regional economic performance

Griliches (1979, 1986) studied the role of knowledge in economic growth externalities. He believes that the productivity of a company depends not only on its efforts in R&D, but also the stock of knowledge available in its area. Subsequently, Griliches (1992; 1994) concluded that spillovers of R&D are an important determinant of endogenous growth. Its conclusions are strongly confirmed by specialists as a starting point in establishing policies that support innovative work. However, the current situation shows big differences in performance in spatial innovation or organization. Despite technological developments, there are organizations, sectors or regions where these activities are proving difficult to implement, given the costs takeover.

2.1. Research hypotheses and models of analysis

The subsequent analysis shows, under these terms, unequivocal role of innovation in growth and regional development. To this end, we sought to evaluate whether the output of innovation activity plays a role in the performance of regional economic on a sample of 265 European regions over the period 2000-2014, based on a production function for the entire sample and then assessing the output effects on economic performance of regional innovation on four groups of regions, according to the 2016 European Commission Report (European Commission, RIS, 2016).

The analysis is based on a logarithmic Cobb-Douglas function where the dependent variable is expressed by GDP per capita, and the explanatory variables are based on the standard factors like the accumulation of physical capital and human capital, technical progress and integration into the labor market, then we added the measures listed on innovation activity. The general formula used is as:

$$\log GDP\ p.c. = \alpha_0 + \alpha_1 \log gfcf + \alpha_2 \log educworkforce + \alpha_3 \log population + \alpha_4 \log emprate + \alpha_5 \log R\&D + \alpha_6 \log patentapp + \varepsilon$$

Thus, we have tested the following hypotheses:

I.1: Physical capital (***I.1.1***) and human capital accumulation (***I.1.2***) positively influence GDP growth.

I.2: Regional population size is a factor of economic development.

1.3: There is a direct and positive correlation between regional the economic size and the degree of insertion of the labor force in economic activities.

1.4: A broad and intense activity of research - supported by financial efforts and highly skilled workforce is a basic input in production.

***1.5*: ** The output of innovation, regardless of the action taken in combination with other potential determinants is essential in any process of growth.

Basically, we estimated externality effects of innovation on a production function which includes innovation's dimension as a determinant of regional growth, using a Cobb-Douglas function. In the estimated models, we regressed GDP per capita in relation to innovation indicators, along with those specific to an equation of economic growth.

The results presented in Table 2 are obtained as follows: the first five models have as independent variables: accumulation of fixed capital and human capital, population size, expenditure on research and development and the patent applications submitted to the EPO. The last three models have substituted applications to the EPO with the international recorded ones, both being instrumented by the number of requests after the inventor's country of origin and priority year.

Table no. 2

The impact of innovation performance on regional economic performance

	m1 b/se	m2 b/se	m3 b/se	m4 b/se	m5 b/se	m6 b/se	m7 b/se	m8 b/se
log_pat_epo_nr	0.060*** (0.00)	0.025*** (0.00)	0.028*** (0.00)	0.025*** (0.00)	0.029*** (0.00)			
log_pat_pct_nr						0.031*** (0.00)	0.032*** (0.00)	0.030*** (0.00)
log_fbkf	0.411*** (0.01)	0.327*** (0.01)	0.303*** (0.01)	0.301*** (0.01)	0.315*** (0.01)	0.310*** (0.01)	0.309*** (0.01)	0.296*** (0.01)
log_edu_sec	0.295*** (0.02)	0.185*** (0.02)	0.195*** (0.02)	0.180*** (0.02)	0.087*** (0.02)	0.036 (0.02)		
log_edu_tert		0.354*** (0.01)	0.347*** (0.01)	0.350*** (0.01)	0.325*** (0.01)	0.365*** (0.01)	0.367*** (0.01)	0.379*** (0.01)
log_ocup			0.375*** (0.03)	0.349*** (0.03)	0.193*** (0.04)	0.153*** (0.03)	0.144*** (0.03)	0.253*** (0.04)
log_chel_cd					0.005 (0.01)	0.009 (0.01)	0.011 (0.01)	0.011 (0.01)
log_pop	1.028*** (0.06)	0.289*** (0.06)	-0.032 (0.06)					
log_dens_pop								-0.419*** (0.07)
Constanta	-4.003*** (0.37)	0.658 (0.34)	1.660*** (0.35)	1.568*** (0.09)	2.151*** (0.11)	2.309*** (0.10)	2.395*** (0.09)	3.052*** (0.13)
R-squared	0.705	0.791	0.800	0.796	0.823	0.823	0.823	0.815
F	1520.519	1934.944	1662.258	2014.074	1338.949	1526.182	1829.336	1414.600
N observat	2790.000	2790.000	2730.000	2839.000	1981.000	2217.000	2217.000	2173.000

* p<0.05, ** p<0.01, *** p<0.001

Source: own preparation using STATA 14.0

The later models (Table 3) are performed on the sample segments, in order to identify differences, if any, in terms of influence and importance of the innovation on regional development. The LEADER group comprises of 36 regions from 7 countries, the group STRONG consists of 65 regions from 8 countries, the group MODERATE consists of 83 regions in 13 countries, and group MODEST innovation includes 30 regions from only 3 countries.

We took into account the specifications run as the output measure of innovation, both the number of patent applications filed with the EPO and those who followed the international path.

Table no. 3

The role of innovation in economic growth of the European regions

	leader1 b/se	leader2 b/se	strong1 b/se	strong2 b/se	moderate1 b/se	moderate2 b/se	modest1 b/se	modest2 b/se
log_pat_pct_nr	0.074***		0.035***		0.031***		0.018***	
	(0.01)		(0.01)		(0.01)		(0.01)	
log_pat_epo_nr		0.035**		0.036**		0.037***		0.011
		(0.01)		(0.01)		(0.00)		(0.01)
log_fbkf	0.292***	0.368***	0.240***	0.294***	0.335***	0.309***	0.330***	0.316***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
log_edu_sec		0.516***		0.434***		0.052		0.047
		(0.03)		(0.04)		(0.03)		(0.018)
log_edu_tert	0.204***	0.522***	0.252***	0.416***	0.290***	0.296***	0.546***	0.462***
	(0.03)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.04)	(0.05)
log_pop		-0.383***		-0.593		-1.361***		-1.959
		(0.10)		(0.09)		(0.11)		(0.26)
log_ocup	0.673***		-0.602***		-0.156***		0.403***	
	(0.08)		(0.05)		(0.06)		(0.08)	
Constanta	0.844***	3.654***	1.394***	5.505***	3.077***	11.086***	3.44***	14.602***
	(0.21)	(0.57)	(0.13)	(0.52)	(0.15)	(0.68)	(0.23)	(1.80)
R-squared	0.694	0.765	0.660	0.652	0.789	0.844	0.883	0.899
F	308.538	319.609	569.617	399.911	774.265	821.550	522.961	383.467
N observations	597.000	544.000	1275.000	1171.000	906.000	830.000	308.000	245.000

* p<0.05, ** p<0.01, *** p<0.001

Sursa: own preparation using STATA 14.0

Overall, it appears that this activity (innovation) proves to be very necessary for regional economic development. Whatever the extent considered, namely applications through PCT respectively EPO, the estimated elasticities have maximum statistical significance coefficients, are positive and robust in terms of economic magnitude. However, the size of the economic impact is significantly higher in models 1, 3, 5 and 7 which relate to applications filed under the international procedure, the economic effect when filed with the EPO is significantly lower.

Contrary to expectations, expenditures on research and development are not in a direct, positive relation with GDP per capita, an effect that could be distorted because of the measure used in the models, namely, their expression in unit value and not by referring to the production value. Physical capital, human capital, with secondary and higher education and labor market integration (both in terms of absolute values and expressed as the employment rate) are instead elements that contribute to a better regional economic performance. Population size can be, however, an obstacle in this process of growth, given its contradictory developments in recent years.

For lower-performing regions in innovation (MODEST group), there are large differences from the other three groups of regional innovators. Overall, we estimate that sustained international innovation activities, are in a positive relationship with the economic performance of the region, but the narrowing of the range of spread of patenting only to the European level can not be regarded as an important influencing factor of GDP. This reflects, on the one hand, the need to increase the absolute level of patent applications - as an expression of the importance given to innovation activity – and, on the other hand, the need to overcome the limitation of regional or even European patenting, by directing the activities to international recognition.

These results can be combined with the significantly reduced labor pool in MODEST group of regions, insufficient financial support of innovative activity, along with the importance of increasing education, workforce qualification and increase the accumulation of physical capital.

The conclusions we can deduce from these results are:

In a very clear statistically and economically significant manner innovation output appears to be crucial for regional economic growth. Overall, patent applications would support an increase in GDP per capita of 0.025% to 0.060%, regardless of the indicators considered in the specifications and measuring methods thereof. Somehow, the procedure registered international patents are constant in terms of the magnitude of the economic impact, ranging between 0.030% and 0.032%.

The other major determinants in relation analyzed are bound by the accumulation of physical and human capital, whose relevance is even higher as the population with higher education increases.

Similarly, the performance of the labor market has a strong significance in the economic growth process, which results in positive estimated coefficients on the related variable and also supporting other factor combinations of GDP growth.

Contrary to expectations, expenditure on research - development does not indicate a clear support to GDP, even though its estimated coefficient is of positive sign, but the fact there is no statistical significance suggests that this measure should be considered carefully in such models. One possible explanation is that in a considerable number of regions considered, these costs are very low and have been declining since 2008. Perhaps the same explanation can be brought for the effect sometimes positive and sometimes negative of demographic size, revealing not so much importance to the population, but especially to the people with university engaged in the labor market.

Conclusions

Succeeding the performed analysis, the following conclusions can be drawn:

1. As a result of enhancing competitiveness, innovation performance is a first class determinant of economic growth

2. The more, the innovation activity is sustainable and broader protected by intellectual property rights, which highlights the recognition and the importance of this process, the effects on growth are more significant.

3. The lower patenting is in terms of absolute size applications, but also in terms of worldwide recognition, the more regions are less important innovators and the less their innovation activity can support regional economic performance. A possible solution to this problem is a greater degree of international openness

Bibliography

1. Audretsch, David and Feldman, Maryan (1996), "R&D spillovers and the geography of innovation and production". *American Economic Review*, June 1996, 86(3), pp. 630-640.
2. Boschma, R. A. (2005) "Proximity and innovation: a critical assessment". *Regional Studies*, 39: pp. 61–74.
3. European Commission (2016) "Regional Innovation Scoreboard, RIS 2016.
4. European Commission (2016) "European Innovation Scoreboard, EIS, 2016.
5. Eurostat (2016). Science, Technology and digital Society.
6. European Patent Office (2016), PATSTAT Database.
7. Fagerberg Jan, Feldman Maryann P. and Srholec Martin (2012) "Technological Dynamics and Social Capability: US States and European Nations CERGE-EI Prague, WP. 455.
8. Foddi, M., Marrocu, E., Paci, R., Usai, S. (2012) "Knowledge, human capital and regional performance". KIT- ESPON Final Report
9. Griliches Zwi (1979), "Issues in assessing the contribution of research and development to productivity Growth". *Bell Journal of Economics* Spring, 10(1), pp. 92-116.
10. Griliches, Zwi (1986), "Productivity, R&D, and basic research at the firm level in the 1970's". *American Economic Review,* 76(1), pp. 141-154.

11. Griliches, Z. (1990) “Patent statistics as economic indicators: a survey”. *Journal of Economic Literature*, 28: pp. 1661–1707.
12. Griliches, Z. (1992) “The search for R&D spillovers”. Scandinavian Journal of Economics, 94: S29–47.
13. Marrocu, E., Paci, R., Usai, S. (2011) “Proximity, Networks and Knowledge Production in Europe. CRENOS Working Paper 2011/09.
14. OECD (2002) “Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development”, OECD Publishing
15. OECD (2009) “Patents as Statistical Indicators of Science and Technology”, in *OECD Patent Statistics Manual*, OECD Publishing.
16. OECD (2014) “Science, Technology and Industry Outlook”, OECD Publishing.
17. OECD (2016) REGPAT Database.
18. Paci, R., Marrocu, E. (2013) “Knowledge assets and regional performance”. Growth and Change, 44: pp. 228–257.
19. Rodríguez-Pose, A. and Crescenzi, R. (2008) “R&D, spillovers, innovation systems and the genesis of regional growth in Europe”. *Regional Studies*, 42, 1, pp. 51-67.