Theoretical and Applied Economics
Volume XXII (2015), No. 2(603), Summer, pp. 55-64

Innovation and regional performance in Romania

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Abstract. *Romania occupies a modest innovation position within the European Union. Since 2000 industrial restructuring in the context of economic growth, foreign direct investment and integration in the European research networks led to an increase in the polarization of research and development (R&D) activities between NUTS3 and even NUTS2 regions. The economic crisis which began in 2009 postponed the positive changes in innovative behavior. This paper highlights the growing disparities in R&D and innovation, and how it is influenced by the unequal distribution of income, measured as GDP per capita. To determine the relationship between R&D intensity and economic performance, the paper sets forth an analysis at NUTS3 level using regression analysis and correlation.*

Keywords: research and development, innovation, regional innovation performance, endogenous regional growth, regional inequalities.

JEL Classification: R11, O30.

1. Introduction

The new theory of economic growth brought into discussion the so-called "endogenous factors": creativity, innovation, entrepreneurship, creation and dissemination of knowledge, institutions, leadership and entrepreneurship. Endogenous growth theory emphasizes the link between knowledge accumulation and conventional output, relationship that formed the subject of many important studies. An example is the model for knowledge accumulation developed by Romer (2011, p. 102), which aims to highlight how resources in an economy are allocated between a sector with conventional output and a new, research and development (R&D) sector, as well as how R&D inputs produce new ideas.

The regional dimension proved important in shaping a country's ability to produce knowledge and to use it efficiently. Research on regional development is centered on the spatial dimension of economic activity. Thus emerges the idea that an increase in the volume of knowledge is associated with a concentration of activities that produce knowledge, which in turn facilitates positive externalities of new knowledge. In this context, Audretsch and Aldridge (2009, p. 208) show that both the production of knowledge (and its positive externalities) and entrepreneurship have a spatial determination. The authors also point out that these two form the basis for entrepreneurial clusters.

KIT Report (ESPON, 2013) demonstrates that the geography of innovation in the EU is much more complex than a center-periphery model and generates maps to show the spatial patterns of knowledge generation and innovation in Europe. Illustrated indicators are the degree of technological progress; scientific knowledge; innovations of product, process and organization. It analyzes the impact of innovation on: GDP, total factor productivity and the employment rate. KIT Report also discusses and quantifies the influence of diffusion of knowledge vehicles such as mobility of inventors and connectivity between regions.

The European Union has defined guidelines regarding the actions that should be taken by the central and regional authorities to promote integrative processes and innovation in regions (European Commission, 2007; European Commission, 2010a). Innovation management can be better achieved at regional level. The formation of regional clusters and partnerships between regional actors involved in research, development and innovation enhance the development potential of regions. In a recent analysis, the European Commission (6th Cohesion Report, 2014) shows that economic growth depends on entrepreneurship which is based on individual initiative and appropriate institutional environment. This enhances the message that innovation continues to show a clear spatial concentration.

Several problems were identified in the process of measuring endogenous regional growth. One of them is the lack of available data at a sub-national level; others raise concern regarding the actual method of measuring endogenous growth, in the sense of quantifying. Although there are indicators at regional level, these are limited and may not always quantify the size of endogenous growth. Several authors have successfully used in econometric analyzes labor market indicators (unemployment, employment level) as endogenous variables and as exogenous variables they used complex indicators that illustrate the economic and demographic factors, leadership, institutions and entrepreneurship.

This paper analyzes the innovation potential of Romania within the European Union, using descriptive statistical methods. Research activity is aimed at assessing regional disparities

regarding R&D and innovation in Romania. Using the available statistical data the paper tries to identify a relationship between the potential for innovation and development at regional level in Romania. Considering that a synthetic indicator of innovation effort is given by R&D expenditure, the paper analyzes the link between R&D intensity and economic performance at NUTS3 level using regression analysis and correlation.

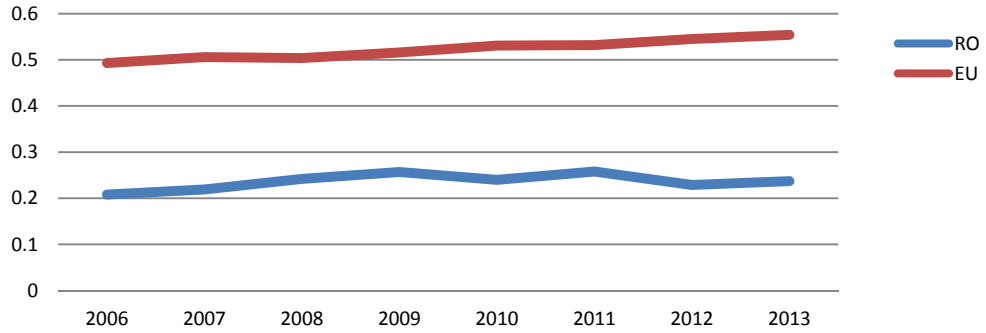
2. The dynamics of innovation in Romania from a European perspective

The European Commission conducted an analysis of the EU innovation potential (IUS, 2014), based on innovation index calculated as a composite index of 25 indicators used to measure innovation performance. On this basis Member States are divided into four groups in terms of performance:

- *Innovation leaders* - includes countries with innovation performance well above the EU average (i.e. more than 120% above the EU average), such as Denmark, Finland, Germany and Sweden;
- *Innovation followers* have a performance close to the EU average (less than 120% but more than 90% of EU). Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, the Netherlands, Slovenia and the UK are the followers in terms of innovation;
- *Moderate innovators* have a performance below the EU average (between 50% and 90% of the EU's performance). Croatia, Czech Republic, Greece, Hungary, Italy, Lithuania, Malta, Portugal, Poland, Slovakia and Spain are moderate innovators.
- *Modest innovators* – have a level of performance well below the EU average (less than 50% of the EU average): Bulgaria, Latvia and Romania.

Differences in innovation performance between EU countries increased in the period 2008-2013. At the same time, the composition of the groups formed according to innovation performance is stable as there is no movements between the groups.

Figure 1. *Innovation index in Romania compared to the EU average*



Source: own representation based on data from Innovation Union Scoreboard 2014, European Commission, p. 92.

In the period 2004-2008 Romania was catching-up in terms of innovation. After the crisis Romania has maintained its status of "modest innovator" but the distance from the EU average increased. Its innovation performance went down from almost 50% of the EU average in 2009 to about 43% in 2013.

The data provided by the European Commission (Table 1) shows that Romania is far below the EU average in almost all innovation performance parameters, with the exception of potential labor resources in R&D. There is a major gap in research expenditure in the business sector and also regarding intellectual assets. Firms engage in innovation activities involving mainly non-R&D expenditure and, especially small and medium enterprises, prefer to introduce new products in the manufacturing process (correlated with process innovations), undertake marketing and organizational innovations in order to increase market resilience. Favorable signals are given by the existence of fast-growing sectors, e.g. IT, which have a high workforce absorption capacity and develop services which form a significant share of total services exports.

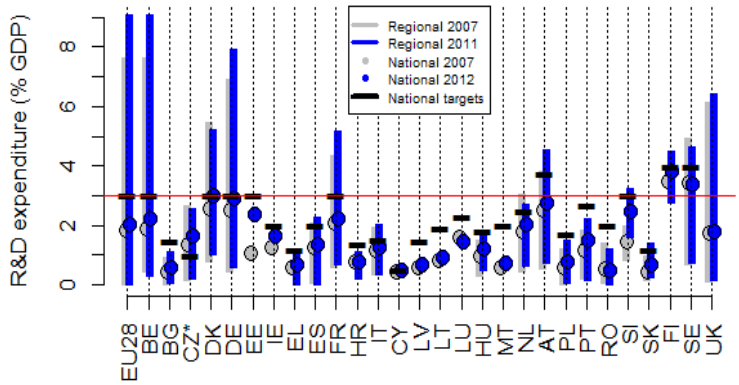
Table 1. *Innovation performance in Romania and European Union**

	UE27	Romania
ENABLERS		
Human resources		
1.1.1 New doctorate graduates per 1000 population aged 25-34	1.7	1.7
1.1.2 Percentage population aged 30-34 having completed tertiary education	35.8	21.8
1.1.3 Percentage youth aged 20-24 having attained at least upper secondary education	80.2	79.6
Open, excellent and attractive research systems		
1.2.1 International scientific co-publications per million population	343	177
1.2.2 Scientific publications among the top-10% most cited publications worldwide as % of total scientific publications of the country	11	3.5
1.2.3 Non-EU doctorate students as a % of all doctorate holders	24.2	2.1
Finance and support		
1.3.1 R&D expenditure in the public sector (% of GDP)	0.75	0.3
1.3.2 Venture capital (% of GDP)	0.277	0.137
FIRM ACTIVITIES		
Firm investments		
2.1.1 R&D expenditure in the business sector (% din GDP)	1.31	0.12
2.1.2 Non-R&D innovation expenditure (% of turnover)	0.56	0.46
Linkages & entrepreneurship		
2.2.1 SMEs innovating in-house (% of SMEs)	31.8	10.8
2.2.2 Innovative SMEs collaborating with others (% of SMEs)	11.7	2.9
2.2.3 Public-private co-publications per million population	7.3	2.9
Intellectual Assets		
2.3.1 PCT patent applications per billion GDP (in PPS€)	1.98	0.41
2.3.2 PCT patent applications in societal challenges per billion GDP (in PPS€)	0.92	0.21
2.3.3 Community trademarks per billion GDP (in PPS€)	5.91	2.33
2.3.4 Community designs per billion GDP (in PPS€)	4.75	0.59
OUTPUTS		
Innovators		
3.1.1 SMEs introducing product or process innovations (% of SMEs)	38.4	13.2
3.1.2 SMEs introducing marketing or organizational innovations (% of SMEs)	40.3	25.5
3.1.3 Employment in fast-growing enterprises in innovative sectors (% of total employment)	16.2	15.2
Economic effects		
3.2.1 Employment in knowledge-intensive activities (% of total employment)	13.9	6.5
3.2.2 Contribution of medium and high-tech products exports to the trade balance	1.27	0.38
3.2.3 Knowledge-intensive services exports as % of total services exports	45.3	45.2
3.2.4 Sales of new-to-market and new-to-firm innovations as % of turnover	14.4	14.3
3.2.5 License and patent revenues from abroad as % of GDP	0.77	0.38

* Innovation Union Scoreboard (IUS) 2014 uses the most recent available data from Eurostat database and other international sources. 11 indicators are from 2012, 4 indicators from 2011 and 1 indicator from 2010.
Source: European Commission, Innovation Union Scoreboard 2014, pg. 85

Investment in research and development holds a key role in the Europe's growth strategy, Europe 2020 (European Commission, 2010b). It argues that innovation is the main actor for competitiveness enhancement. Therefore one of the five targets of EU2020 is the allocation of 3% of GDP to R&D. Figure 2 shows a complex picture of this indicator in the regions and European countries. Vertical bars show the diversity in national and regional innovation performance. These bars show the gap between the best and the worst performing region in terms of expenditure on R&D at NUTS level 2 in the Member States. The figure illustrates wide gaps in terms of R&D spending between countries and within countries. Regions of Romania are among the worst performers in Europe.

Figure 2. *R&D expenditure in EU28 member states in 2007 and 2011*



Source: Eurostat [rd_e_gerdreg]
* The 1% target of the Czech Republic refers only to the public sector.

3. Regional dimension of R&D and innovation in Romania

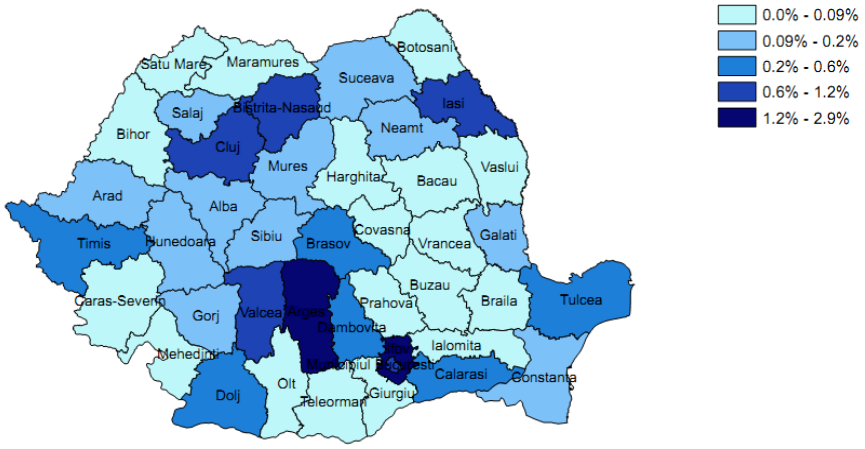
Romania's position within the EU reflects the relative homogeneity of reduced regional innovation performance. Bucharest-Ilfov region has the status of "moderate innovator" in the period 2004-2010, while the remaining regions are classified as "modest innovators". The exception is the South-East region which managed to improve its performance in 2006-2008, but returned during the crisis to its previous modest situation.

One of the most significant indicators for the quantitative evaluation of the innovation efforts is the cost of R&D carried out by the public sector and by companies, even if this doesn't include costs of non-R&D innovation and therefore does not capture all the effort firms make to identify new growth opportunities and economic performance. This is the reason why one of the objectives of Europe 2020 is to achieve a level of 3% of GDP on R&D expenditure.

In Romania the share of expenditure on R&D in GDP was 0.75% in 1995 with a downward trend until 1999. After 2000 industrial restructuring in the context of economic growth, foreign direct investment and integration in European research networks led to major changes in the research and innovation system, and the share of expenditure on R&D to GDP ranged from a minimum of 0.37% in 2000 to a maximum of 0.58% in 2008. At the same time there has been a growing polarization of R&D activity between NUTS3 regions and even at NUTS2 level.

In Romania the R&D resources are concentrated in several counties in association with major university centers or industrial clusters in which specific output is at a technological level above average (Figure 3). Analysis of total R&D spending shows that only Bucharest covers 38% of all the R&D spending in Romania. Adding Ilfov County, the percentage rises to 55% of the total nationwide value. The city of Bucharest, capital of Romania, is the most important pole of development and has a significant influence on Ilfov county which has developed in 2012 a volume of R&D comparable to the North West (includes Cluj and Bistrita Nasaud) and Centre, taken together. Ilfov County is a representative example of a region strongly influenced by commuting population and by expansion of investments to intermediate urban areas or rural areas near the limits of the capital. It is an example of an outlier which distorts the indicators used in the analysis.

Figure 3. *R&D expenditures at NUTS 3 level (% of regional GDP), 2011*



Source: own computation based on data from National Institute of Statistics, Tempo-online database.

The innovation score of NUTS2 regions (Table 2) based on selected indicators from Table 1 indicates some differences that are not related to research and development activities.

Table 2. *Indicators of innovation performance and GDP per capita in Romania, NUTS2 regions, 2011*

NUTS 2 Region	R&D total expenditure (%PIB)	PCT patent applications per billion GDP	SMEs innovating in-house (% of SMEs)	GDP/capita (lei)
Nord-Vest	0,49%	2,2	27%	22469
Centru	0,20%	1,7	23%	24375
Nord-Est	0,30%	4,6	42%	15414
Sud-Est	0,11%	1,4	36%	21196
Sud-Muntenia	0,38%	1,3	31%	21482
București-Ilfov	1,09%	3,9	32%	65363
Sud-Vest Oltenia	0,28%	1,8	30%	19892
Vest	0,23%	1,6	17%	28890

Source: own computation based on data from National Institute of Statistics, Tempo-online database.

The positions occupied by the eight NUTS 2 regions of Romania in a hierarchy established on the basis of innovation performance indicators (Table 3) shows a different innovative orientation. Bucharest-Ilfov region is the first in the R&D expenses, which has a historical determination as the research structure had long been more developed in

Bucharest compared to other cities/regions. Dynamics of non-R&D innovation, however, is higher in other regions, for example the Nord-Est region ranks first at patent applications and the proportion of innovative SMEs, although it is the poorest region. Nord-Est situation is explained by the existence of a concentration of research and technological development activities around the university center (Iași).

Table 3. *Ranks of NUTS2 regions of Romania based on innovative and economic performance indicators, 2011*

NUTS 2 Region	R&D total expenditure (%PIB)	PCT patent applications per billion GDP	SMEs innovating in-house (% of SMEs)	GDP/capita (lei)
Nord-Vest	2	3	6	4
Centru	7	5	7	3
Nord-Est	4	1	1	8
Sud-Est	8	7	2	6
Sud-Muntenia	3	8	4	5
București-Ilfov	1	2	3	1
Sud-Vest Oltenia	5	4	5	7
Vest	6	6	8	2

Source: own computation based on data from Table 2.

Important factors that determine the hierarchy are the existence of industrial clusters that produce average and high-tech goods and services, and foreign direct investment (FDI). The two are highly correlated in Romania last two decades.

Bucharest-Ilfov region held 61.7% of the stock of FDI in 2011, followed by the Centru region (7.6%), Sud-Muntenia (7.4%) and Vest (7.2%), while in other regions the share varies between 2.9% and 5.4%. This concentration of resources makes the Bucharest-Ilfov region not comparable to the others. It is worth noting that the Vest and Centru occupy a modest position in the innovative performance, but have a higher level of development (measured by GDP / capita) based on effective non-innovative activities. Sud Muntenia region benefits from positive economic spillovers generated by the company Dacia-Renault, but involvement of SMEs in the area based on intensive knowledge creation and usage in the production chain is still modest. In these regions branches of multinational companies are developing. These are usually oriented on non-innovative activities in Romania, while the R&D and innovation activities are performed in the parent companies abroad.

The National Strategy for Research, Development and Innovation 2014 - 2020 estimated that public sector R&D "is dispersed, with a high degree of duplication in the institutional missions and with low inter-institutional collaboration. Often it lacks critical mass and the capacity to address interdisciplinary activities". Therefore the strategy aims to defragment the system and to support the concentration of research activities in order to increase the impact of R&D on innovation.

4. Correlation between the level of development and R&D expenditure

The statistical analysis focused on researching the link between R&D spending and economic performance (as measured by GDP or GDP/capita). This approach aims to see whether the two variables are correlated. In case of a favorable outcome, the analysis would be expanded by econometric modeling and identification of causal relations to see

to what extent the innovation effort expressed by R&D spending is a key factor of economic performance in Romania.

The analysis began with the identification of Pearson correlation coefficient of GDP at county level and the level of expenditure on R&D, both expressed in lei (the national currency). As expected, the coefficient values are quite high, over 0.9. These results can be explained by the fact that counties with a high level of production have a higher budget and can afford to spend more (in absolute terms) than other counties. The highest amounts were spent on R&D in 2011 in Bucharest, Ilfov, Cluj, Arges, Iasi and Timis, while in Giurgiu County and Mehedinti there was no spending on R&D.

To reflect more accurately the development level of counties, further in the analysis the GDP per inhabitant is used. Also the level of expenditure on R&D expressed in absolute terms is not a faithful indicator of the financial effort made in this direction. For example, in absolute numbers, Bucharest allocates more than double on R&D than Ilfov County but in relative numbers, R&D expenditure to GDP is 0.89% in Bucharest and 2.88% in Ilfov. Therefore it would be more relevant to use R&D expenditure expressed as a percentage of county GDP.

The current connection between the two variables is not very strong, but in most cases the correlation coefficient is positive, and over 0.5. This means that between the two variables there is a direct link but not strong enough. Due to the fact that the impact of R&D on GDP may not be immediate, the correlation coefficients were also computed between the current values of the GDP / capita and the R&D expenditure from previous years (lags). The coefficient values for lags do not differ significantly from the coefficient values associated to the actual values. This shows that the structure of the two variables doesn't suffer major changes over time.

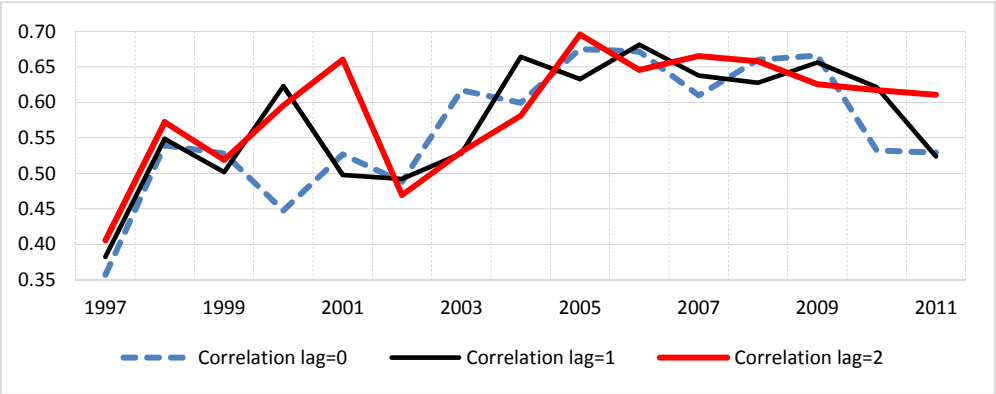
Table 4. *Pearson correlation coefficients between GDP (county level) and R&D expenditure*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
GDP level (lei) ~ R&D expenditure level (lei)																	
	0.89	0.93	0.94	0.95	0.95	0.97	0.96	0.96	0.95	0.95	0.96	0.96	0.97	0.96	0.97	0.97	0.97
GDP/capita level (lei/capita) ~ R&D expenditure level (%GDP)																	
Lag=0	0.54	0.53	0.36	0.54	0.53	0.45	0.53	0.49	0.62	0.60	0.68	0.67	0.61	0.66	0.67	0.53	0.53
Lag=1		0.53	0.38	0.55	0.50	0.62	0.50	0.49	0.53	0.66	0.63	0.68	0.64	0.63	0.66	0.62	0.52
Lag=2			0.41	0.57	0.52	0.60	0.66	0.47	0.53	0.58	0.70	0.65	0.67	0.66	0.63	0.62	0.61
GDP growth rate (t_1/t_0) ~ R&D expenditure level (lei)																	
		0.01	0.02	0.27	0.09	0.31	-0.13	0.07	-0.04	-0.01	0.31	-0.07	0.08	0.16	-0.14	0.00	0.17
GDP/capita level (lei/capita) ~ R&D expenditure level (lei)																	
	0.33	0.30	0.28	0.35	0.36	0.40	0.39	0.37	0.39	0.39	0.41	0.39	0.39	0.44	0.41	0.40	0.41
GDP growth rate (t_1/t_0) ~ R&D growth rate (t1/t0)																	
		-0.13	0.23	0.02	0.07	0.11	0.05	-0.18	-0.12	-0.01	-0.22	0.32	-0.03	0.03	-0.05	-0.17	-0.10
GDP growth rate (t_1/t_0) ~ R&D expenditure level (%GDP)																	
		0.04	-0.26	0.68	-0.03	0.43	0.02	0.07	0.11	0.21	0.54	0.13	-0.01	0.22	-0.04	-0.09	0.25

Source: own computation based on data from National Institute of Statistics, Tempo-online database.

Figure 4 shows the correlation coefficients of GDP/capita and the level of R&D expenditure/GDP, current values, with one year lag (lag = 1) or two-year lag (lag = 2). There aren't notable differences between the three sets of coefficients, but there is a stronger correlation at a lag of two of R&D, i.e. a closer link between the current value of GDP/capita and value two years ago of R&D expenditure.

Figure 4. *Pearson correlation coefficients between GDP/capita (lei) and lags of R&D expenditure (% GDP).*

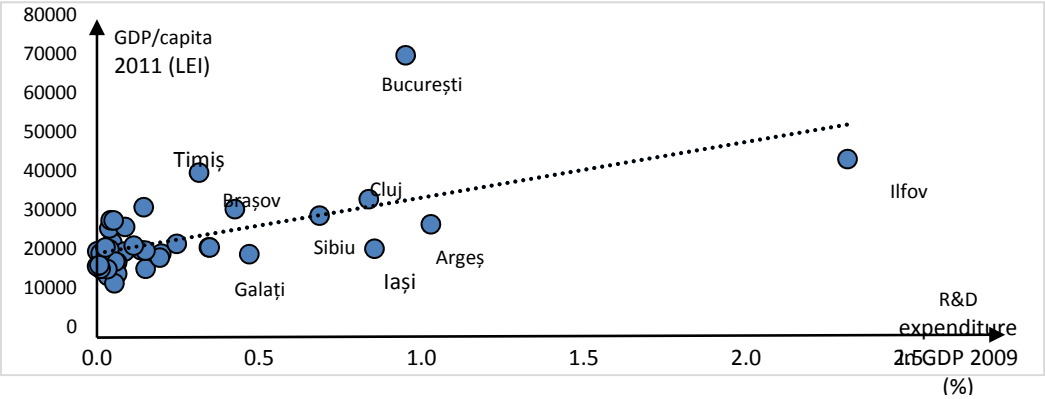


Source: own computation based on data from National Institute of Statistics, Tempo-online database.

For a better illustration of the relationship between the two variables a scatter plot was used. Figure 5 shows that the two data sets tend to follow a linear pattern, emphasized by a regression line. The graph illustrates data on the county level GDP/capita in 2011 and R&D expenditure as a percentage of GDP in 2009. The Pearson correlation coefficient between these two variables is 0.61. Most of the counties are shown on the left side of the graph, having less than 0.4% of GDP devoted to the R&D sector. Above this threshold are 8 counties: Ilfov (2.31%), Arges (1.03%), Bucharest (0.95%), Iaşi (0.85%), Cluj (0.84%), Sibiu (0.68%), Galati (0.47%) and Braşov (0.42%). Regression and correlation coefficient indicate that the developed counties allocate more financial resources to the R&D sector.

The analysis focused on calculating the correlation coefficients for several pairs of data sets and the results are presented in Table 4. The coefficient values indicate a very weak or even nonexistent relationship among different forms (absolute terms / relative terms) of GDP and R&D expenditure at county (NUTS 3) level.

Figure 5. *The relationship between GDP/capita (lei/capita) and the R&D expenditures (% GDP).*



Source: own computation based on data from National Institute of Statistics, Tempo-online database.

Conclusions

Innovation performance gap between Romania and the European Union is very high and the catching up process requires very high efforts. The challenge becomes even greater judging by the fact that the European Union declared that innovation is the main tool to increase competitiveness. In this context Romania has set as target for 2020 to spend the equivalent of 2% of GDP on R&D, significantly higher than the current level.

Large discrepancies exist also within the country, between regions. At NUTS 2 level the share of R&D expenditure in GDP ranges from 0.11% in the Sud-Est region (third worst performance of all 272 EU regions) and 1.09% in the Bucharest Ilfov. At county level, the differences are even greater. In 2012 there were two counties not investing at all in research and development (Ialomita, Bihor). In the opposite situation were the most developed counties, which spent for R&D between 0.5% and 2.9% of GDP.

Innovation still doesn't generate economic development at the regional level. Romania has not yet reached the stage of development sustained through innovation. It failed to reach critical mass of volume and quality of research and development, and technology transfer of R&D results is limited.

Analysis of the correlation between GDP per capita and county expenditures on R&D shows there is a direct link between the two. The most developed regions invest more in R&D than the less developed ones, both in absolute and relative terms.

Acknowledgements

This work was cofinanced from the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013, project number POSDRU/ 159/1.5/S/142115 „Performance and excellence in doctoral and postdoctoral research in Romanian economics science domain"

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