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R&D AS AN ENGINE OF REGIONAL ECONOMIC GROWTH IN ROMANIA

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Abstract·

Research and development (R&D) is largely acknowledged as a key factor to promoting economic growth nationally, as well as regionally. The topic of regional development has been receiving special attention in Romania for almost two decades, while regional innovation and competitiveness have only recently begun to attract interest. In this context we aim at exploring the role of R&D, alongside other main production factors, on regional development in Romania. We address this issue in the framework of a panel data model that allows capturing the unobserved regional heterogeneity. The results indicate a significant impact of R&D expenditures on the regional economic growth process in Romania over 1995-2010, thus providing empirical support to large beneficial effects of regional R&D efforts.

Keywords: research and development, economic growth, regions, Romania
JEL Classification: O32, O18.

1. Introduction

R&D is increasingly seen as one of the main drivers of economic growth, not only nationally, but regionally as well (Audretsch, 1998; Goldstein and Renault, 2004; Fischer, 2009). Certain researchers stated that any region that invests sufficient resources and engage effectively in R&D has the potential to achieve economic growth (Cooke and Leydesdorff, 2006; Wang, 2010). Other

authors expressed doubts towards the infallibility of the correlation between R&D and growth, emphasizing that one should also introduce into the equation region's ability to convert knowledge into growth, depending on the existence of a socio-economic environment conducive to innovation and entrepreneurship (Maloney and Rodriquez-Clare, 2007; Sterlacchini, 2008).

Some studies have shown that rich regions are able to take advantage from their R&D activity, while poorer regions would benefit more from imitation. Also, propensity to high R&D intensity is specific to the regions that have exceeded a certain level of development (Braconier, 2000).

There is a two way connection between R&D and economic growth. On one hand, many empirical studies highlight the key place of regional development (measured by regional GDP per capita) among the determinants of regional investments in R&D (Furman et al., 2002; Bhattacharya and Bloch, 2004; Kumar and Aggarwal, 2005; Becker and Pain, 2008; Sterlacchini, 2008; Wang, 2010). On the other hand, knowledge flows from research institutes and universities are often geographically localized and stimulate regional productivity and growth (Lichtenberg and Siegel, 1991; Bilbao-Osorio and Rodríguez-Pose, 2004; Cooke and Leydesdorff, 2006).

In the growth models based on research and development, the propensity to invest in R&D is related to the size of the economy, as larger regions, characterized by wider markets and high resources, are more motivated to carry out R&D activities, which in turn foster more rapid growth (Romer, 1994). Higher incomes in rich regions provide an incentive for buyers to seek top quality and differentiated products that are the result of intensive R&D activities (Markusen, 1986). It all leads to high correlation between R&D expenditures per capita and GDP per inhabitant (Braconier, 2000; Furman et al., 2002; Hu and Mathews, 2005).

An important issue for R&D-driven development is region’s capacity to absorb the results of research and development. The contribution of innovation absorption to the success of regional development policies has been highlighted since the 1950s (Nurske, 1953; Rostow, 1957). From this perspective emerged new concepts such as learning regions (Morgan, 1996), innovative environments (Aydalot, 1986), regional production systems (Camagni 1991; Maillat, 1996), national and regional innovation systems (Morgan, 1996) etc., the authors emphasizing that the coordination and integration of regional production and innovation requires a constant exchange of information and knowledge, which in the end stimulates regional development.

This paper aims to contribute to a better understanding of the role of R&D in promoting regional economic growth in Romania. Previous attempts at assessing the impact of R&D expenditures on the economic growth, usually in the framework of Cobb-Douglas production functions (Sandu and Modoran, 2008; Zaman and Goschin, 2010) were undertaken exclusively at

aggregate (national) level. The paper introduces a regional perspective on R&D inequalities, R&D expenditures and their economic impact, starting from the assumption that region-specific performance in absorbing research results and regional ability to put research and development resources at good use are key factors for economic development. Decision makers could benefit from better knowledge on the determinants of regional R&D disparities and of the mechanisms through which research-development and innovation can contribute to economic growth of the regions. To this end, we try to disentangle the combined impact of R&D and other potential determinants of regional economic growth in the framework of panel data modeling.

2. Inter-regional R&D disparities in Romania

Although relatively low at the beginning of the 1990s, territorial disparities constantly increased in Romania during the transition to market economy. The main feature of regional development in Romania is the dominant position of Bucharest Municipality and Bucharest-Ilfov region. Due to a low level of economic integration, growth potential has not spread significantly in surrounding areas, and the capital is surrounded by some of the poorest counties. A significant development gap also exists between western and eastern Romania (RO INNO, 2008 and 2011; Goschin et al, 2008).

R&D could be among the factors that are accountable for the existing regional disparities, as the territorial distribution of R&D potential and performance is extremely unbalanced (Figure 1). The relative distance between Bucharest-Ilfov region and other regions is much larger in terms of R&D activities and innovation potential compared to GDP/capita (Mitrut et al., 2010).

The conventional analysis of regional intensity of R&D is based on key indicators such as the share of total R&D expenditure (GERD), or the share of companies spending for R&D (BERD) in regional GDP. At EU level, in 2008 regional R&D intensities based on GERD showed large variation in amplitude at NUTS 2 territorial level (regions), ranging from a maximum of 8.7% in the region of Braunschweig, Germany and a minimum of 0.1% in Świętokrzyski region, Poland (Giannitsis and Kager, 2009). Significant regional disparities in terms of R&D intensity exist in Romania as well: the ratio between total investments in R&D and GDP ranged in 2008 between 0.76% in Bucharest-Ilfov region, which concentrates the largest part of Romania's R&D resources, and 0.01% in South-Muntenia.

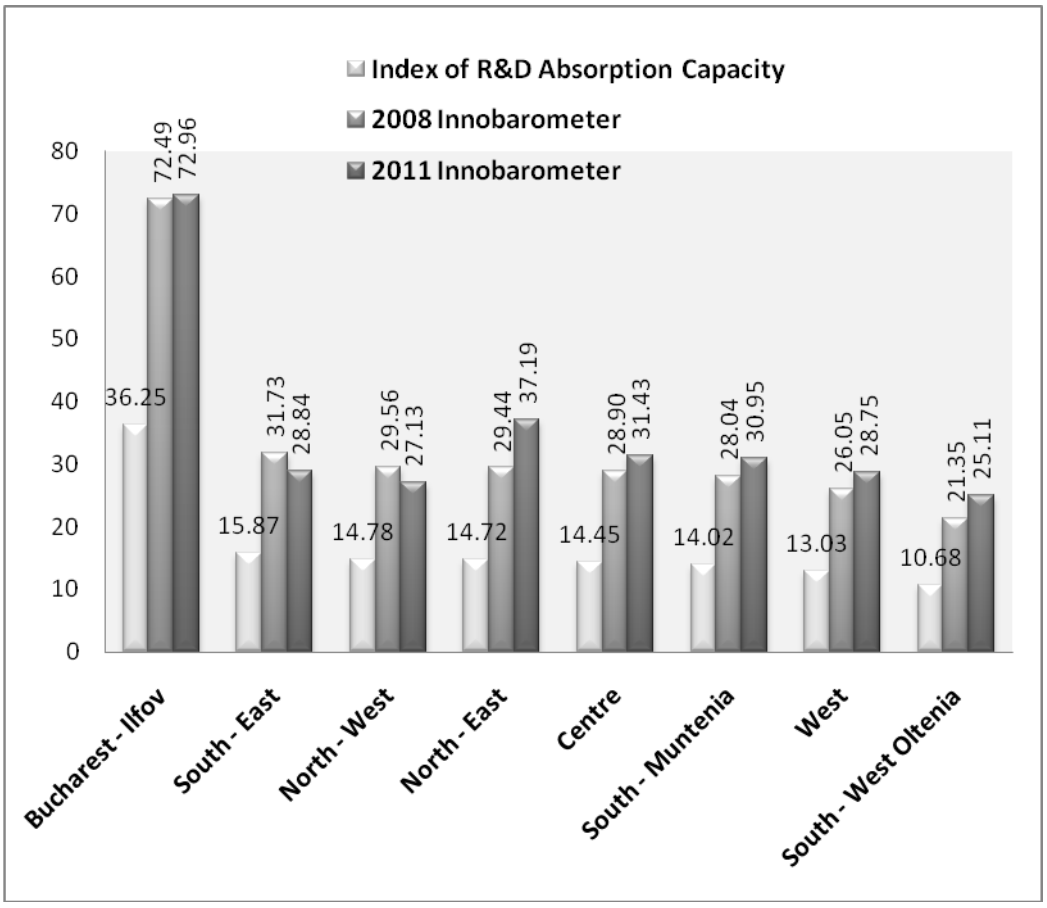

Figure 1. Regional R&D disparities in Romania based on Index of R&D Absorption Capacity[1] and Innobarometer[2]
Source: author's processing based on data from Mitrut et al. (2010) and RO INNO Romania (2008 and 2011)

In spite of small annual variations, the Bucharest-Ilfov region was constantly on top position, the other regions lagging far behind, and sizeable R&D gaps are noticeable for the rest of the country as well (Mitrut et al., 2010). Romania is still lacking a strong R&D policy to address such disparities (Sandu, 2010; Ranga, 2010), although the national innovation strategy states the need to boost development and competitiveness at regional and local level as well.

Romania is currently trying to define a regional strategy for R&D, as well as appropriate policies and priorities for innovation at regional level. The lack of coordination between national and regional policy is one of the main factors limiting the effectiveness of local innovation policy in Romania (Ranga, 2010).

Although the national R&D policy aims to stimulate the regional innovation potential, the territorial component of the national innovation system is still underdeveloped. The National Authority for Scientific Research (NASR) has limited regional competence and the Regional

[1] composite index of the R&D absorption capacity at regional level
[2] synthetic measure of the ability of the Romanian regions to create and develop an environment conducive to innovations

Development Agencies (RDAs), although key players that are best positioned to develop and implement regional policies tailored to the needs of each region, lack expertise in research and development, as well as project management experience, have limited communication with both NASR and local stakeholders and a very low capacity to stimulate regional R&D activities and innovation. A better collaboration between RDAs and other regional authorities, as well as effective communication with NASR, are needed to strengthen their ability to boost regional R&D and innovation, in line with the innovation strategy at national level. Moreover, the RDAs should exercise a greater role in local management of European R&D Funds in order to achieve a higher absorption rate and put these funds to a better use (Ranga, 2010).

3. Models, variables and data

Our empirical approach on the determinants of regional development in Romania starts with a general pooled model that combines cross-sectional and time-series data assuming a common intercept $\boldsymbol{\beta_0}$ for all regions, as in the following specification:

$$\boldsymbol{Y_{it}} = \boldsymbol{\beta_0} + \boldsymbol{\Sigma_j \beta_j X_{itj}} + \boldsymbol{\varepsilon_{it}}, \quad (1)$$

where: $i = 1,...,8$ (development regions), $t = 1995,...,2010$, $\boldsymbol{Y_{it}}$ is the dependent variable GDP/capita, $\boldsymbol{X_{itj}}$ represents the exogenous variables, and ε_{it} is an idiosyncratic error term that varies across time and space and has the usual properties.

Since the previous specification is appropriate only when unobserved effects are unlikely, we further tested specific panel model specifications. The panel data structure enables to account for specific cross section and/or period influence by means of the fixed-effects model. The fixed-effects (FE) model allows for unobserved heterogeneity to be estimated. The FE specification is:

$$\boldsymbol{Y_{it}} = \boldsymbol{\beta_{0i}} + \boldsymbol{\gamma_t} + \boldsymbol{\Sigma_j \beta_j X_{jit}} + \varepsilon_{it}, \quad (2)$$

where $\boldsymbol{\gamma_t}$ represents period fixed effects such as general shifts in business cycle, economic policy, etc. that affect all regions in a similar manner, while β_{0i} reflects cross-section fixed effects (country characteristics that are constant over the period of interest).

The random effects (RE) model captures regional individuality by including region-specific errors $\boldsymbol{e_i}$ alongside $\boldsymbol{\varepsilon_{it}}$ into the general errors $\boldsymbol{u_{it}}$, resulting the following specification:

$$\boldsymbol{Y_{it}} = \boldsymbol{\beta_0} + \boldsymbol{\Sigma_j \beta_j X_{jit}} + \boldsymbol{u_{it}}. \quad (3)$$

The unobserved effect in the RE model must be uncorrelated with the regressors. Such models have to be estimated by generalized least squares (GLS) method due to the composite structure of errors (Wooldridge, 2002).

In order to validate the choice of the fixed effects model instead of POLS, we check for the existence/absence of individual effects by applying an F test. The null hypothesis of the test is H_0: $\beta_{0i} = 0$, $i=1,...,N$, which implies the absence of individual effects and recommends POLS, while the alternative is the fixed effects model. The F test statistic is:

$$F = \frac{(ESS_{POLS} - ESS_{FE})/(N-1)}{ESS_{FE}/((T-1)N-K)} \quad (4)$$

where ESS_{POLS} and ESS_{FE} denote error sum of squares (ESS) in POLS and in FE models, respectively, N is the number of regions, T is the number of years and K the number of regressors in the FE model. If we fail to reject the null hypothesis, regional individual effects are denied, and POLS model is the right one for our dataset; otherwise panel estimation techniques are preferable. If the panel data model is appropriate, we have to choose between fix effects (FE) and random effects (RE) by applying the Hausman test. For the case of panel data the null hypothesis of the test is that the FE and RE estimators do not differ significantly. If the test rejects the null hypothesis, random effects should not be used because they may be correlated with the independent variables in the model. If the test does not reject the null hypothesis it is considered that the estimators of the two models produce similar results.

We are going to estimate the economic impact of R&D regional investments using panel data regression for the eight development regions of Romania, over the period 1995-2010. The choice of the variables and the period under analysis was driven by available territorial statistics, which are fewer, compared to aggregated national statistics. The model analyzes the development level of the regions, measured by regional GDP, depending on total expenditures on R&D and a series of economic characteristics that define the profile of the developing regions of Romania.

In addition to R&D expenditures, the variable of interest in our models, we have also investigated the traditional determinants of economic growth models, namely labor and capital, both in their extensive-quantitative form (number of employees and size of the gross fixed capital formation, respectively) and in their intensive-qualitative form (labor productivity and level of technology). All control variables introduced in the models are factors that can influence the size and development over time for the regional level of GDP, the dependent variable of the models. The variables are described in table 1.

Table 1. The variables

Variables	Description
GDP	Annual regional GDP (million RON, constant 1995 prices)
R&D	Total expenditures for R&D activity, by region (million RON, constant 1995 prices)
EMPL	Employed population by region, annual (persons)
PRODUCTIV	Labour productivity (RON/person in 1995 constant prices)
CAPITAL	Gross fixed capital formation, annually, by region (million RON, constant 1995 prices)
TEHNOL	The technology level is proxied by employment in high-tech industry and knowledge intensive services, as a share of total employed population (%)
INEG	Intra-regional inequality level, measured by the coefficient of variation in regional GDP per capita (%)

Data used for estimating the coefficients of the models (1)-(3) comes from the National Institute of Statistics, Eurostat, as well as own computations.

4. Results and discussion

The modelling attempt started with the pooled OLS regression, followed by fixed-effects and random-effects models, as indicated by equations (1)-(3), all based on the same general economic growth model. The models were estimated for the eight Romanian regions over the period 1995-2010.

Table 2 reports the estimated coefficients only for the first two specifications of the growth model, as the random effects models have failed to provide statistically significant results. Pooled data regression was rejected based on the results from the Redundant fixed effects test and the Hausman test pointed to the fixed-effects as a better choice compared to random-effects model. Therefore, the fixed effects model is the most appropriate for our dataset. The result corresponds to our expectations based on preliminary statistical analysis, given the heterogeneity that exists between regions in Romania. The tests indicated that both cross-section and period fixed effects are statistically significant, cross-section FE being considerably stronger. Cross-section fixed effects reflect specific within-region factors (time-invariant characteristics) that influence regional economic development, while period fixed effects capture time-specific events (e.g. economic crisis) that affect long-term growth.

Since the returns on R&D take time to materialize, the variable of interest –R&D expenditures- was introduced in the equations with various lags to better assess its impact on economic growth. The estimated parameters on R&D variable for the preffered specification -the fixed effects model- indicate a significant influence of research and development on economic

growth across regions and over time (Table 2). The results are consistent with the ones reported by similar studies in the literature.

Table 2. Main results from the regional economic growth models, 1995-2010

Variable	Coefficients		
	Pooled OLS	Cross-section fixed effects	Period fixed effects
R&D	3.864134***	4.171760***	4.115659*
R&D (-1)	4.249992**	5.517368***	4.544355*
R&D (-2)	7.388916***	10.10303***	6.863220**
R&D (-3)	-10.02662	-12.76721	-8.435820
EMPL	0.000774***	0.000636***	0.000771***
PRODUCTIV	0.860982***	0.851234***	0.840972***
CAPITAL	0.006533***	0.004664***	0.007594***
TEHNOL	-19.95137***	-23.00971***	-18.20407***
INEG	-0.561528	-0.295720	-0.632117
Constant	-659.4627***	-523.3447***	-643.1877***
Adjusted R-squared	0.955107	0.956309	0.955062
F-statistic	2328.496	1738.617	989.2964

*** p<0.01; ** p<0.05; * p<0.1.

The regression results suggest that, together with labor and capital, R&D activity is an essential production factor with a significant influence on regional economic growth in Romania. In all models, the coefficients on R&D appear with the expected positive sign and are highly significant, but there is some variability in the estimated coefficients, underlining the importance of model specification.

The results indicate a powerful positive impact of R&D on regional economic growth: for each additional unit of R&D expenditures, regional GDP increases by about 4 units on a time horizon of up to one year, and by 5-6 units for two years lag. In all specifications, the R&D parameter is significant up to three lags, suggesting that the economic effects of R&D expenditures occur quickly, starting from the first year and have a strong impact on GDP growth for another two years, after which the effect dissipates, becoming statistically insignificant. Better understanding of these results would require detailed knowledge of the destination of R&D

funds. A possible explanation for the the rapid economic effects of R&D is the increasing contribution of private research which is more strongly targeted towards achieving immediate results. In this context it would be better to separate private and public R&D spending and include both variables in the model, which could provide a clearer picture of their different effects over time and space. It is common knowledge that public R&D expenditures create basic knowledge with possible "technology spillovers" that generate effects on the long-run, while business-R&D is more oriented towards innovation and immediate implementation in production, generating rapid economic growth effects (Bassanini and Scarpetta, 2001).

The basic factors of economic growth –labour and capital- were also included in the regional growth models, from quantitative, as well as qualitative, perspective. The labor factor exerts a statistically significant positive influence in both forms (regional employment and labour productivity), although productivity has stronger impact on regional development.

The growth impact of capital is also significant and the gross fixed capital formation has the expected positive sign. The qualitative approach on the capital factor in our models is the level of technology. It had been introduced in all equation specifications through a proxy that measures the relative magnitude of employment in high tech sectors, namely the share in total employment of the industrial activities with high technological intensity, and of knowledge-intensive services as well. The estimated coefficient on the technology variable is negative in all specifications (Table 2), suggesting that regional economic growth in Romania is mainly based on low and medium technologies.

We also tested the influence of intra-regional inequalities. Although this variable is not statistically significant, its negative sign suggests that high levels of internal regional disparities hinder regional development.

Statistical tests carried out (Redundant fixed effects test and Hausman test) indicated fixed effects models as the best specification, thus supporting the hypothesis of omitted individual effects influencing regional growth. More specifically, there is some regional (time invariant) individuality in research-development and innovation activity, determined by both quantitative and qualitative factors, such as specificity of regional research and development potential, existence of innovative clusters and technology parks, entrepreneurial culture, ability to assimilate research results in production activities, specific regional policies, etc. Opportunity to highlight these factors is a key advantage of techniques based on panel data (Baltagi, 2005). It should be noted also that the relatively small size of the sample induce a degree of uncertainty about the results.

The coefficient of determination (adjusted R squared) show very good explanatory power for the all three models, 95-96% of the GDP variation being explained by the variables in the model. The final conclusion drawn from the economic growth models that we have tested empirically is the possibility to increase the competitiveness of regional economies by capitalizing on local technological potential which might impact upon businesses. Adequate specialization and performance of local research, development and innovation system turn out to be crucial factors for economic performance of regions, largely explaining the existing regional development disparities in Romania.

5. Conclusions

This paper offered a new perspective on R&D ability to spur innovation and economic growth in Romania, at regional level. Using a panel data approach, the statistical tests indicated the fixed effects model as the best specification of the growth equation, suggesting the existence of stable regional characteristics that influence the economic growth patterns and therefore should be addressed in the assessment of policies for regional development.

The main finding of this paper is that R&D is one of the driving forces of regional economic growth in Romania. The regression models have shown the positive effect of R&D expenditures on regional economic growth over 1995-2010, confirming that the growth strategy based on innovation (as a result of larger investments in research and development) can lead to higher regional growth. Therefore, increased funding of R&D activities and their more balanced territorial distribution should be used as vectors for improving the economic performance of regions, for rising the competitiveness of regional economies and narrowing of the existing disparities. One should keep in mind that final economic and social effects of the R&D are much wider on the long-run.

The results have important policy implications. Post-crisis regional programs for development should target diversification of local economies by boosting private investment in R&D, adequate specialization and performance of local research, development and innovation systems, stimulation of innovative activities and technology transfer from universities and research centers to production sector, according to the business needs of local communities, assistance for the development of innovative SMEs, financial support for companies so that they can acquire advanced technologies and improve their production.

One useful direction for further research could be application of specific spatial econometrics methods in order to address potential autocorrelations (territorial clustering) that affect the accuracy of estimates made with classical regression models. It would also be useful to

increase the length of statistical series by exploiting county level data and by extending the time-span.

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