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The impact of economic crisis on R&D convergence in Romania

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The Impact of Economic Crisis on R&D Convergence in Romania

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Abstract

All national development strategies designed in the last two decades in Romania acknowledged R&D as a priority sector, but its funding is still insufficient and the territorial component of the national innovation system is still underdeveloped. The existence of major technological disparities among Romanian regions and counties has been recognized as a constraint in building an efficient national innovation system, but it is still lacking a strong regional R&D policy to address such disparities. The recent economic crisis brought about new hardships on the Romanian innovation system. R&D intensity declined from 0.58 % in 2008 to 0.38 % in 2014, placing Romania at the bottom of European Union hierarchy. In this context our paper explored the convergence patterns of R&D in Romania over 1995-2014 and several subperiods, with a focus on the recent economic crisis, applying the “sigma” and “beta” convergence methods. We found a discontinuous sigma convergence trend, with many periods of divergence that disrupted the convergence process, and conditional beta convergence over 1995-2014. When exploring the relevant subperiods of the overall time span, the results indicated absolute (unconditional) beta convergence until 2008, and no significant evidence of either convergence or divergence afterwards. Sigma convergence has been also reversed during the crisis, but seems to have resumed in the last couple of years. Our findings clearly show the disruptive impact of the economic crisis on the convergence path, from the perspective of both sigma and beta technique.

Key words: research and development, sigma and beta convergence, spatial model, Romania

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1. Introduction

Research and development (R&D) activity is central to leading discovery and driving innovation, therefore being an important driver of productivity, competitiveness and economic growth, both nationally and regionally. All national development strategies designed in the last two decades in Romania acknowledged R&D as a priority sector, but its funding is still insufficient and the territorial component of the national innovation system is still underdeveloped.

Not only there is low convergence of the Romanian R&D system with the European one up to now, but the internal gaps persisted in the last two decades. Moreover, research and development activity might be among the factors accountable for the increasing regional economic disparities, as the territorial distribution of the technological capabilities and innovation performance is extremely unbalanced, the capital region (Bucharest-Ilfov) concentrating over half of the national R&D endowment. The relative distance between Bucharest-Ilfov and other regions is much larger in terms of R&D activities and innovation potential compared to GDP/capita. The existence of major technological disparities among Romanian regions and counties has been recognized as a constraint in building an efficient national innovation system, but Romania is still lacking a strong regional R&D policy to address such disparities.

The recent economic crisis brought about new hardships on the Romanian innovation system. Following a significant rise in research and development funding prior to the crisis, R&D intensity declined from 0.58 % in 2008 to 0.38 % in 2014, placing Romania at the bottom of European Union hierarchy. The increased vulnerabilities of the lagging regions following the crisis hamper Romania's economic development and its position on the global economic map. Economic convergence of Romania's counties relies, at a great extent, on the convergence in their technological capabilities and innovation performance.

The convergence of the regional R&D and innovation system is an essential component of successful regional development because, on the one hand, it provides a key asset to improve local economic competitiveness and, on the other hand, facilitates cohesion in the social sector. Although decision makers could benefit from better knowledge on regional R&D inequalities

and of the convergence process, the topic was so far rarely addressed in Romanian literature. In this context our paper fills a gap in the literature by exploring the regional convergence patterns of R&D in Romania over 1995-2014 and several subperiods, with a focus on the recent economic crisis. To this aim we apply the traditional “sigma” and “beta” convergence methods, as introduced by Barro and Sala-i-Martin (1995).

In the reminder of this paper, Section 2 briefly reviews the relevant literature, when Section 3 describes our research framework. The research findings are reported and discussed in Section 4, concentrating on the post-crisis developments in regional R&D catching-up. Finally, Section 5 concludes by offering a short summary of the main results and their policy implications.

2. Literature review

The mainstream literature has already proven that R&D, innovation and technology diffusion are important driving forces for the European economic growth and productivity convergence (Jungmittag, 2004, Fagerberg et al, 1997). Enlarged integration processes increased both the heterogeneity and the polarisation of knowledge creation, of technological capabilities and innovation performance within the EU (Archibugi and Filippetti, 2011). Divergence in the capabilities of generating and absorbing cutting edge technologies and innovations represents a generally acknowledged determinant of differences in economic growth pace. Moreover, the gaps between member states in terms of innovation and technological capacity and performance weaken the EU position against the global competitors, such as the USA but also emerging economies (Veugelers, 2016).

In the last decade, in the context of the efforts to design and consolidate the European System of Innovation, among EU countries there has been a gradual and systematic process of convergence in terms of national R&D strategies and policies, as well as in terms of R&D expenditures (Reding, 2005; Altuzarra, 2016). Unfortunately the recent crisis added supplementary strains to the challenges already confronting this process – globalisation, accelerated technological progress, important divides between the more advanced countries and the new member states –,

disrupting the slow but steady convergence trend in innovation capabilities and performance within the EU (Archibugi and Filippetti, 2011; Stanisic, 2012).

The convergence in research, development and innovation has been systematically approached and monitored, both at national and regional levels, having in view trends, causalities, contextual and institutional particularities at country level, regional socio-economic disparities, etc. (Leonardi, 1995; Funke and Niebuhr, 2000; Boldrin et al, 2001; Jungmittag, 2006; Lundvall and Tomlinson, 2007; Pfaffermayr, 2009; Kim, 2012, etc.). Empirical studies indicated that opposite and even divergent forces have simultaneously worked in favor and against R&D and innovation convergence. The differences between innovation performance and capabilities among countries or regions might be explained not only by the intensity of R&D expenditure, but also by other particularities, such as the level of capital accumulation and innovation infrastructure, the quality of human capital and the level of investment in education, by the coherence and linkages within the innovation system (Abramowitz, 1986; Fagerberg, 1994). The speed of convergence tends to be higher for public R&D expenditures compared to those of companies and higher education institutions (Altuzarra, 2016).

The R&D divide within EU is accompanied by even higher internal inequalities in most member countries. Regional particularities are due to various historical, institutional, cultural and contextual factors, such as human capital, education system, financial infrastructure, labour markets, political and economic institutions, external linkages, etc. These dimensions influence the national capacity to absorb new and improved technology and management techniques and, further on, the catching up pace. Various studies targeting the issue of innovation convergence at regional level warned that intensification of international cooperation and linkages may actually deepen the interregional disparities within national borders, given the proximity and agglomeration effects (Moreno et al, 2005; Rodriguez-Pose and Crescenzi, 2008; Guerreiro and Guerreiro, 2015; Altuzarra, 2016).

The recent economic crisis has drawn attention to its aftermath on the innovation performance map of the EU member states at national and regional levels. (Filippetti and Archibugi, 2011; ECa, 2013; Sandu and Anghel, 2011; Goschin et al, 2015). As expected, the crisis hit most of the national RDI sectors, but the magnitude varied within EU, given different political responses,

different budgetary constraints, different socio-economic context. What seemed to be a slow catching-up process at the level of lagging EU countries came to a halt. Moreover, some authors argue that divergence superseded convergence (ECb, 2013, Filippetti and Archibugi, 2011).

In Romania the capital region – Bucharest-Ilfov concentrates most of the R&D potential, while the other regions lag well behind in terms of business expenditure on research and innovation, as well as in the linkages between the public and business sectors. So far, these gaps have proven to be persistent and difficult to close (Sandu, 2010 and 2014; Sandu and Anghel, 2011; Antonescu, 2015; Goschin et al, 2015). The R&D catching-up of the lagging counties is nevertheless important as it would foster the economic development of Romania (Zaman and Goschin, 2007; Sandu and Modoran, 2008; Goschin, 2014 and 2015) and its convergence within the EU (Sandu and Paun, 2009; Goschin et al., 2015). The Romanian research system has to cope with low demand for its results, in the context of deindustrialization and domination of foreign capital (which relies on R&D performed in the origin countries), inadequate research infrastructure that does not stimulate high performance, unbalanced distribution of researchers among research fields and regions, ineffective networking of researchers from different R&D institutions and/or universities, as well as weak interconnection between public and private research, which impede the rapid flow of knowledge between the two sectors (Sandu, 2010 and 2014). Lack of regional public policies targeting these problems led to persistent disequilibrium, with negative impact on the Romanian R&D performance. Adding to previous challenges, the severe downside of the GDP during the recent economic crisis had a serious impact on the Romanian R&D system, which is largely dependent on public funding.

3. Method, variables and data

In order to investigate the R&D convergence process among the Romanian counties we will apply the traditional sigma and beta methods (Barro and Sala-i-Martin, 1995), as well as spatial models.

We will calculate firstly the annual coefficient of variation (σ_t) for R&D:

$$\sigma_i = \frac{\sqrt{\frac{\sum_{i=1}^n (R_i - \bar{R})^2}{n}}}{\bar{R}} \quad (1)$$

where \mathbf{R} is a measure for R&D activity (the number of R&D employees or total R&D expenditures), i represents the county and t , the year. A declining trend for this indicator suggests the reduction of R&D dispersion among counties, i.e. sigma convergence. The statistical significance of the convergence process will be further validated using the Augmented Dickey - Fuller (ADF) test (Dickey and Fuller, 1981).

Beta convergence is defined as a catching-up process in which laggards run faster. We will apply the following model of *absolute beta convergence* for R&D:

$$\frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right) = a + b \log(R_{t_0}) + \varepsilon, \quad (2)$$

where \mathbf{R} represents the number of R&D employees (full time equivalent), a is a constant, T represents the timespan of the analysis, and ε is the error term. If the regression coefficient b is negative it means that the counties with higher initial R&D had a slower growth in this activity, while the ones with lower initial R&D are catching up by growing faster, i.e. there is beta convergence among counties.

The absolute beta convergence model in (2) is based on a hypothesis of structural homogeneity. The *conditional beta convergence* model adds control variables to account for differences among countries, as follows:

$$\begin{aligned} \frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right) = & a + b \log(R_{t_0}) + \log(GDP_{t_0}) + \log(IND_{t_0}) + \log(EDU_{t_0}) + \\ & + \log(URB_{t_0}) + \log(FDI_{t_0}) + \varepsilon \end{aligned} \quad (3)$$

where the additional variables included in the beta convergence models are GDP - Gross Domestic Product per inhabitant, FDI - foreign direct investments stock from 1991 to the year of reference, EDU – annual number of graduates from tertiary education, URB – the urbanization

rate, IND – the industrialization rate. The new b coefficient in equation (3) reflects the different county equilibrium levels depending on local conditions.

Considering the potential spatial autocorrelation, we will also use spatial models of conditional beta convergence, starting with an autoregressive model, as follows:

$$\begin{aligned} \frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right) = & a + b \log(R_{t_0}) + \rho \cdot W \frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right) + \log(GDP_{t_0}) + \\ & + \log(IND_{t_0}) + \log(EDU_{t_0}) + \log(URB_{t_0}) + \log(FDI_{t_0}) + \varepsilon \end{aligned} \quad (4)$$

where W is the spatial weight matrix (the neighborhood structure) and $\rho \cdot W \frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right)$ is the spatial lag of the dependent variable.

Secondly we will estimate a spatial error model that includes the spatial dependence in the error term:

$$\begin{aligned} \frac{1}{T} \log \left(\frac{R_{t_0+T}}{R_{t_0}} \right) = & a + b \log(R_{t_0}) + \log(GDP_{t_0}) + \log(IND_{t_0}) + \log(EDU_{t_0}) + \\ & + \log(URB_{t_0}) + \log(FDI_{t_0}) + (\lambda W \varepsilon + v) \end{aligned} \quad (5)$$

The existence of spatial dependence will be tested using Moran's I statistic (and the permutation test (Anselin and Rey, 1991). The choice of the best model for our data is based mainly on Lagrange multiplier tests for spatial error and lag.

Data for our analysis come mainly from the Institute of National Statistics database, while foreign direct investments stock data are from The National Trade Register Office. In order to highlight the different effects of the periods of growth and decline, we divided the overall interval under consideration into several time intervals to be analyzed separately: 1995-2000, 2000-2008 and 2008-2014.

4. Results and discussion

We firstly tested sigma convergence in R&D among Romanian counties over the period 1995-2014. The annual values of the sigma convergence indicator seem to indicate a declining trend (Figure 1) suggesting regional R&D convergence, although this trend was frequently reversed.

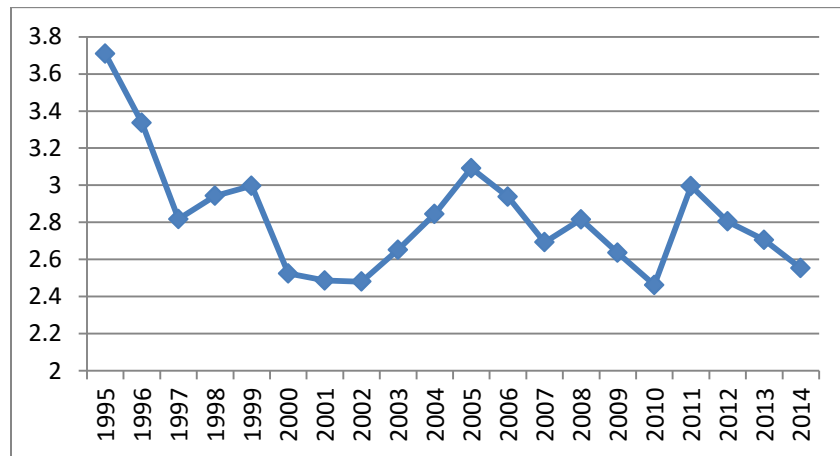


Figure 1. Sigma convergence in R&D

New policy initiatives and the increase in the public funding for research and innovation activities during the years before the recent economic crisis (largely due to government commitment to meet the objective of Lisbon Strategy and Barcelona target), contributed to the partial recovery of the R&D system and to the narrowing of the regional gaps. The temporary divergence periods (1998-1999, 2003-2005, 2011) that disrupted the convergence process are largely associated with crises and GDP decline that entailed lower funding of research and development. Under-financing of R&D activity has negative long-term structural effects, leading to a rise of the brain-drain phenomenon and decreasing the performance in this sector.

We tested the statistic significance of the trend in R&D regional dispersion by performing several standard unit root tests on sigma series: Augmented Dickey-Fuller, Elliott-Lothman-Stock DF-GLS and Phillips-Perron. All these tests failed to reject the null hypothesis that SIGMA has a unit root and the test equations indicated a negative trend in sigma values (i.e.

sigma convergence), but the coefficient of the trend variable is not statistically significant, therefore sigma convergence is not confirmed on the long run.

Moving on with the analysis, we tested beta convergence in R&D among Romanian counties, using the spatial software developed at The Center for Geospatial Analysis and Computation (GeoDa, 2015). We first estimated the classic absolute and conditional beta convergence models in (2) and (3) for the entire period (1995-2014) and on subperiods. The results (Table 1) indicate absolute beta convergence for the period 1995 to 2008, as the estimated coefficients for logarithm of initial R&D are highly significant and bear negative sign. The annual average speed of convergence was very high (6.97%) during the first subperiod 1995-2000 and declined to 2.65% over 2000-2008.

Table 1. Estimation results for classic absolute and conditional beta convergence models

Period	Absolute convergence model	Conditional convergence model	
	Beta Coefficient (Std.Error)	Beta Coefficient (Std.Error)	Significant covariates
1995-2014	-0.08542 (0.12352)	-0.32216** (0.14746)	EDU
1995-2000	-0.05881 * (0.01249)	-0.09304* (0.01428)	EDU, IND
2000-2008	- 0.02385** (0.01197)	inconclusive	
2008-2010	inconclusive	inconclusive	
2010-2014	0.00781 (0.06683)	inconclusive	

* significant at < 1%; ** significant at < 5%

From the perspective of the conditional convergence model the overall period under investigation might also indicate regional R&D convergence (Table 1), but when investigating the relevant subperiods we found that since the start of the recent economic crisis the results from the classic convergence models became inconclusive. The most significant additional regressor in the conditional beta convergence model is education, captured by the regional number of tertiary educated persons. This is in line with the previous literature indicating that quality and availability of human resources (an output of the educational system) is a crucial

factor for the absorptive capacity (Krammer, 2009; Archibugi and Filippetti, 2011). Another significant factor in the conditional beta models is the industrialization rate, a proxy for development level, but all the other additional variables are statistically insignificant.

The diagnostics for spatial dependence have been performed on all intervals, but Moran's I test for errors couldn't reject spatial randomness, except for the interval 2010-2014, therefore the classic OLS model seems to be the best fit for our data up to 2010. Moran's I statistic and the permutation test confirmed the existence of significant spatial autocorrelation in the dependent variable "R&D average growth" for the post-crisis interval – 2010 to 2014 (Appendix). Consequently, the spatial beta convergence models, in absolute and conditional form, have been estimated for this period (Table 2).

Table 2. Estimation results for absolute and conditional beta convergence models, 2010-2014 (dependent variable – R&D annual growth rate)

ABSOLUTE BETA CONVERGENCE MODELS				
Variables	Spatial lag model		Spatial error model	
	Coeff.	Prob.	Coeff.	Prob.
W_R&D_Growth	-0.93489	0.0000		
CONSTANT	-0.35959	0.0185	-0.27190	0.0287
Ln_R&D_initial	0.02695	0.3061	0.03027	0.1525
LAMBDA			-0.94852	0.0000
Statistics				
R-squared	0.35848		0.3638	
Log likelihood	-47.7359		-47.6733	
AIK	101.472		99.3467	
Spatial dependence: Likelihood Ratio Test (prob.)	11.3220 (0.0008)		11.4482 (0.0007)	
CONDITIONAL BETA CONVERGENCE MODELS				
Variables	Spatial lag model		Spatial error model	
	Coeff.	Prob.	Coeff.	Prob.
W_R&D_Growth	-0.99848	0.0000		
CONSTANT	0.85676	0.0200	1.1692	0.0298
Ln_R&D_initial	0.03461	0.2429	0.0541	0.1468
Ln_URB	0.9069	0.0310	0.9455	0.0487
Ln_EDU	0.09203	0.1415	0.1279	0.1158
LAMBDA			-0.9082	0.0000
Statistics				
R-squared	0.4065		0.4573	

Log likelihood	-46.651	-44.693
AIK	103.306	97.278
Spatial dependence: Likelihood Ratio Test (prob.)	12.8191 (0.000)	14.8467 (0.0001)

Although Ln_R&D_initial is statistically insignificant both in the spatial lag and spatial error model, its positive sign suggest a reversal of the beta convergence trend in previous subperiod. The statistic criteria point to the spatial error model as the best fit for the data, while the Likelihood ratio test reveals that both spatial models surpass the classic one.

In sum, the results from the beta convergence analysis indicate that the conditions for R&D catching-up were met for the period up to the recent crisis, but the situation dramatically changed afterwards. In Romania the economic crisis brought forth massive cuts in the R&D expenditures both in the public and private sectors. The hardest hit by the recent economic crisis were the counties with the highest gap to the best performers. As the innovation leaders responded better to the crisis than the followers or the lagging behind counties, this reversed the catching-up trend observed prior to the crisis.

The persistence of high R&D regional inequalities and weak convergence enablers calls for adequate policies, able to stimulate the regional innovation potential and underpin faster development of the Romanian regional research and innovation system. The absorptive capacity for knowledge and technology should also be stimulated, as it is a critical driver for the innovation performance in the case of catching up counties, enhancing the local ability to take advantage of the technological advancements achieved elsewhere.

Conclusions

Beyond contextual economic determinants, the current heterogeneity among the Romanian counties regarding R&D and innovation systems configuration and performances is the outcome of a complex and intricate network of causalities and determinants. After a relatively sustained process of slow improvement in R&D activity and partial convergence among Romanian

counties, there is currently a significant divide in innovation performance and technological capabilities, jeopardizing the goal of sustainable development and socio-economic convergence.

We found a discontinuous sigma convergence trend in R&D, with temporary periods of divergence that disrupted the convergence process, and conditional beta convergence over 1995-2014. When exploring the relevant subperiods of this time span, the results indicated absolute (unconditional) beta convergence until 2008, and no significant evidence of either convergence or divergence afterwards. Sigma convergence has been also reversed during the crisis, but seems to have resumed in the last couple of years.

Our findings clearly show the disruptive impact of the economic crisis on the convergence path, from the perspective of both sigma and beta technique. As far as Romania is concerned, the economic crisis brought forth massive cuts in the R&D expenditures, both in the public and private sectors. Many other drawbacks hamper the convergence process both with EU and within national boundaries: prevalence of low and medium technology industrial sectors, immature innovation culture, lowest R&D intensity within EU, lack of political continuity and coordination regarding the RDI sector, outflows of qualified RDI personnel, underperforming higher education institutions, peripheral position to the international knowledge flows, weak linkages between private and public sectors, very low number of patent applications.

Romanian counties have been unevenly hit by the shock of the economic crisis, leaving the R&D and innovation activities underfinanced and de-stabilized. The already weak and poorly financed research systems faced further budgetary constraints while the business sector withdrew, as well, financial support for research and innovation activities. Moreover, the foreign investment attracted by Romanian counties has been mostly medium and low-technological level and showing little or no interest in performing R&D activities in Romania. Therefore FDIs did not stimulate technological advancement or the capacity to absorb technology and to transform innovation into economic benefits.

The persistence of high R&D regional inequalities and low convergence calls for adequate policies, able to stimulate the regional innovation potential and underpin faster development

of the Romanian regional research and innovation system. To this end, adequate and coordinated programmes, innovation infrastructure and policy tools at regional and national levels are further needed to foster cooperation and transfer of best practice. Public financial resources for R&D need to follow a coherent and consistent prioritization scheme. Based on fruitful dialogue with industrial actors, with business sector, with other stakeholder and in line with the strategic priorities set in the broader European R&D programmes, the public funds for research and innovation need to be directed towards the most important areas for the national and regional development.

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Appendix

