INNOVATION VERSUS INCOME CONVERGENCE IN CENTRAL AND EASTERN EUROPE. IS THERE A CORRELATION?*

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The heterogeneity of response of the different economies facing the world economic crisis has brought into attention once again the issue of convergence inside the European Union. The high growth rates experienced by CEEC during the last decade created an optimistic view of rapid convergence towards Western Europe. But the crisis showed that the sources of economic growth in the region were not appropriate for a long run growth. Innovation is a key source of competitiveness and a contributor to a sustainable growth path. Even though CEEC lag behind other European countries in terms of R&D investment, a certain progress can be observed. The objective of the present paper is to establish if there is a correlation between the convergence in terms of GDP and the convergence in terms of innovation for the CEEC. Based on yearly Eurostat data for the period 1998-2008, we quantify the progress of each of the 10 CEEC both in closing the income gap and the innovation gap. We then rank the countries according to their speed of convergence and perform a Spearman rank correlation analysis. The results show that, on average, convergence in R&D is not correlated with convergence in GDP. The Czech Republic is the only country with a positive correlation between R&D intensity and GDP growth. Bulgaria, Hungary and Slovakia show a negative relationship between investment in R&D and economic growth. This implies that for most of the countries in Central and Eastern Europe, economic growth during the period 1998-2008 was mostly driven by non-innovation factors.

Key words: convergence, growth, innovation, R&D
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1. Introduction

All central and eastern European countries have faced a recession period after the fall of the socialist regime, followed by a return to positive growth rates in the mid and late nineties. Some countries have found the growth path relatively fast, during the early nineties, while others (like Romania, Bulgaria) have experienced long recession periods and reached a dynamic growth only starting from 1997-1998.

Economic growth during the transition period had a particular pattern in CEEC. Capital has provided a certain positive contribution to growth, while labor had a small or even negative contribution (IMF, 2006). In this respect, CEEC stand out among other emerging countries, where labor input has typically contributed substantially to growth. Most of the growth during the transition period was actually accounted by the increase in total factor productivity (TFP). Even though the classical source of TFP growth is technical progress and innovation, growth during transition was mostly explained by efficiency improvements in the use of capital and labor (Havrylyshyn, 2001).

Starting in the late nineties, CEEC experienced a return to the classical factors determining growth, with an increase importance for innovation and technical progress. Once the transition period completed, the growth process in CEEC should be sustained by factors like capital intensity, innovation, human capital and competition (OECD, 2003). Since the main source of productivity growth during transition was actually the decrease in employment and only to a

small extend the faster increase in output (Van Ark and Piatkowski, 2004), the post-transition period calls for new and sustainable sources of long term productivity increase.
In this context, investment in research and development (R&D) becomes an important component of the competitiveness of CEEC, not only in terms of creation of new technology, but mostly as a determinant of the absorptive capacity. Local innovation and creation of new technologies becomes complementary to the transfer of innovation created abroad (Mitra, 2008). Since CEEC are rather technology using rather than technology generating (Radosevic 2005, Arnold et al. 2000), this second aspect may become the most important feature of the role of R&D as a factor of economic growth in Central and Eastern Europe.
The inclusion of innovation and research and development as determinants for economic growth is supported both by theoretical growth models and empirical research. Neoclassical theory Solow (1957) puts technical progress in the heart of long term growth, but states its exogenous nature. Endogenous growth models like Romer (1990), Grossman and Helpman (1991) are searching for the sources of technical progress and find innovation to be a solution to diminishing returns of classical factors. The "new growth theory" argues that R&D investment can foster long run economic growth. The interest of policy makers in the role of R&D is all the more important when considering the social rate of return, which surpasses the private rate of return of companies undergoing innovation activities (Griliches 1992).
The objective of this paper is establish if there is a correlation between the convergence process of CEEC towards the knowledge based economy and the income convergence of GDP/capita. We would normally expect a positive relationship between the two evolutions, since R&D investment is considered to be a determinant factor of economic growth. We first construct two rankings and compute a rank correlation coefficient, which turns out to be statistically insignificant, due to the heterogeneity of the countries in the sample. We then proceed with an individual analysis, which confirms the different patterns exhibited by the CEEC in the R&D-economic growth relationship. The Czech Republic is the only country where R&D intensity is correlated with economic growth, while most of the countries show in inconclusive relationship.
The structure of the paper is as follows. Section 2 presents a descriptive analysis of the convergence process in CEEC, with emphasis on research and development. This allows us to identify specific patterns in the relationship R&D – economic growth. Section 3 presents the methodology and the data being used, as well as the results obtained. Section 4 outlines the policy implications and the main conclusions of the paper.

2. GDP and R&D convergence in CEEC

There has been little research on the determinants of growth for the Central and Eastern European countries in the post-transition period, even less including research and development or human capital. One important reason for little research at macroeconomic level is poor data quality and availability for these countries, which makes econometric applications very sensitive and often leads to inconclusive results. Another reason might be the fact that the low volume of R&D investment seemed insufficient to generate a significant effect on economic growth. Indeed, during the nineties, the increase in productivity was actually accompanied by a decrease in R&D investment, so growth was generated by non-R&D factors (Radosevic, 2005).
The process of income convergence between CEEC and the European Union is clearly taking place, but with various speeds and different enhancing factors (Daianu, 2002). On average, CEEC reduced their income gap from 52% to 36% during the period 1998-2008 (see Table 1). The evolutions seem to follow a β convergence pattern, meaning that countries that were the least developed experienced a rapid growth (the Baltic states), while more advanced countries like Slovenia or the Czech Republic were progressing more slower (Veugelers and Mrak 2009).
It is well known that CEEC do not yet produce fundamental innovation, but rather adapt existing technologies transferred from abroad (Verspagen, 2001). Both human capital and effort in R&D

can substantially facilitate the effectiveness of this transfer and the capacity of the receiving economy to implement such innovation created abroad (Griffith *et al*., 2004; Aghion and Howitt, 2005). At a first glance, CEEC seem to have an advantage in this matter, having inherited solid R&D and education systems from their socialist past. Unfortunately, R&D is still oriented towards fundamental rather than applied research, making cooperation between universities and enterprises rather rare. Therefore, the R&D process has a relatively low efficiency due to the difficulty in transposing the R&D effort into an increase in productivity (Radosevic, 2005).
If convergence of CEEC towards EU27 in terms of GDP/capita is progressively taking place, catching-up in terms of knowledge economy is much more slow (Aralica et al. 2009). There are even opinions stating that a convergence towards a given target, as it was the case with the Lisbon agenda, is not suitable for all member states (van Pottelsberghe de la Potterie 2008). Even though a certain increase in R&D intensity can be observed, the differences compared to the European average remain significant. Table 1 presents these differences in R&D intensity and calculates the gap between CEEC and EU27, both in terms of R&D and GDP/capita.

Table 1. R&D intensity in CEEC and the catching up process, 1998-2008

		1998	**2000**	**2004**	**2005**	**2006**	**2007**	**2008**
EU27	R&D intensity	**1.79**	**1.86**	**1.83**	**1.82**	**1.85**	**1.85**	**1.92**
	St. dev.	60%	63%	67%	65%	63%	62%	61%
CEEC	R&D intensity	**0.72**	**0.72**	**0.75**	**0.80**	**0.87**	**0.85**	**0.89**
	St dev.	42%	46%	47%	47%	49%	48%	49%
Gap in R&D intensity		**60%**	**61%**	**59%**	**56%**	**53%**	**54%**	**53%**
Gap in GDP/capita		**52%**	**52%**	**45%**	**43%**	**41%**	**38%**	**36%**

Source: Own calculations based on Eurostat data. The gap represents the difference in R&D intensity, as a percentage of EU27. We define R&D intensity as the share of total R&D expenditure in GDP.

With an average share of R&D expenditures in GDP well below 1%, CEEC obviously lag behind the other members of the EU, having an R&D intensity below what might be expected given their income level (Radosevic, 2005). The gap in R&D intensity is decreasing over time, but the speed of convergence is fairly small. From a gap of 60% in 1998, CEEC have only managed to reduce the gap to 53% by 2008, so the difference remains remarkably high.
Both the level of R&D intensity and its dynamics present considerable variation between EU countries, and this variation seems to have increased over time. Table 2 presents the convergence status of R&D intensity for each of the 10 CEEC, depicting a heterogeneous behavior among these economies.

Table 2. The gap in R&D intensity between CEEC and EU27

	1998	**2008**	Average yearly evolution of R&D gap	Convergence status towards EU27
Bulgaria	68%	76%	0.7%	No convergence
Czech Republic	36%	23%	-1.2%	Convergence
Estonia	68%	33%	-3.5%	High convergence
Latvia	78%	68%	-0.9%	Low Convergence
Lithuania	70%	58%	-1.1%	Convergence
Hungary	63%	48%	-1.5%	Convergence
Poland	63%	69%	0.6%	No convergence
Romania	73%	70%	-0.3%	Low convergence
Slovenia	25%	14%	-1.1%	Convergence

	1998	2008	Average yearly evolution of R&D gap	Convergence status towards EU27
Slovakia	56%	76%	1.9%	No convergence

Note: The gap represents the difference in R&D intensity between each of the countries and EU27, as a percentage of EU27.

Inside the CEE group, several patterns emerge. A sub-group of countries present no-convergence in terms of R&D during the period 1998-2008: (Bulgaria, Poland and Slovakia), with a clear divergence in the case of Slovakia. The second sub-group presents a decrease of their gap towards EU average (Estonia, Czech Republic, the Baltic States, Hungary, Romania and Slovenia). Romania and Slovenia present a low, but positive, speed of convergence. The difficulty in R&D intensity convergence could be explained by the fact that for countries with high rates of GDP growth, as CEEC, R&D expenditure as % of GDP needs to grow at very high rates in order to close the gap (Veugelers and Mrak 2009).

3. Research methodology, data and results

We have established in the previous section that both income and R&D convergence is taking place in CEEC, but at fairly different speeds. The research question we address is the existence of a correlation between the two convergence processes. If such a correlation is to exist, then R&D can be considered an enhancing factor for economic growth.

We construct two raking of the 10 CEEC according to their speed in closing the GDP gap and the R&D intensity gap. We then test the correlation between the two rakings by using the Spearman rank correlation coefficient. The formula used to compute the coefficient is the following:

$$\rho = 1 - \frac{6\sum_{i=1}^{n}(x_i - y_i)^2}{n(n^2 - 1)}$$

Where:

- x_i and y_i are the ranks occupied by country i in GDP convergence ranking and R&D convergence ranking respectively.
-n represents the total number of countries, in our case 10.

The Spearman correlation coefficient is a non-parametric measure similar to a Pearson correlation coefficient between ranked variables, without making the assumption that the variables are extracted from a normal distribution. The advantage over the Pearson coefficient is that it does not require a linear relationship between the two variables. A coefficient equal to zero shows no correlation between the two rakings. A coefficient equal to 1 implies that an increase in R&D intensity is always accompanied by an increase in GDP. A positive, but less than 1, coefficient would imply that GDP tends to increase when R&D intensity increases. Equally as important as the value of the coefficient is its significance level. Since the Spearman coefficient does not assume a specific distribution, the significance value is obtained based on a table of critical values, provided by Best and Roberts (1975). After running an overall analysis based on the sample of 10 CEEC, we proceed by depicting individual correlation analysis between growth and R&D intensity for each of the countries.

The data we used comes from Eurostat, has a yearly frequency and is available for the period 1998-2008. For the construction of the rankings, we used GDP/capita expressed in purchasing power standards and R&D intensity computed as the share of total R&D expenditures in GDP. We then calculated the gaps in GDP/capita and R&D intensity as a percentage of EU27. The same series were used to compute the individual correlation coefficients.

Based on the analysis presented in section 2, we constructed a ranking of the countries according to their speed in reducing the R&D intensity gap. Data is presented in column (1) of Table 3.

Estonia, Hungary and the Czech Republic present the fastest convergence of R&D intensity towards European average. Poland, Bulgaria and Slovakia occupy the last ranks, presenting, as described above, a divergence process in R&D investment.
We added a raking in terms of income convergence in order to see whether there is a correlation between the two rankings (column 2 of Table 3). In terms of increase in GDP/capita, the Baltic countries are the top runners. They have started with relatively high income gap, but manage to reduce it by more than 20 percentage points in 10 years. Countries that occupy the last ranks are actually those who had a smaller gap from the beginning (i.e. Slovenia and the Czech Republic had only 20-30% gap in 1998). So this is a confirmation of the hypothesis of β convergence, according to which countries with larger gaps converge faster than countries with smaller gaps.

Table 3. Correlation analysis between GDP/capita and R&D convergence

Countries	Ranking by R&D convergence	Ranking by GDP convergence	Individual correlation between GDP growth and R&D intensity
	(1)	(2)	(3)
Estonia	1	1	-0.34 (0.2989)
Hungary	2	9	-0.56** (0.0722)
Czech Republic	3	8	0.77*** (0.0059)
Lithuania	4	2	0.50 (0.1209)
Slovenia	5	7	0.18 (0.6016)
Latvia	6	3	0.15 (0.6521)
Romania	7	4	0.12 (0.7356)
Poland	8	10	-0.03 (0.9338)
Bulgaria	9	6	-0.61** (0.0476)
Slovakia	10	5	-0.70** (0.0174)
Spearman rank correlation		0.163	
Significance (p-value)		0.65	

Source : Authors' calculations based on Eurostat data, using the STATA software. The first two columns contain rankings of the 10 CEEC according to the reduction in their income and R&D gap, for the period 1998-2008. Column (3) presents the individual correlation coefficients between GDP growth and R&D intensity, with the corresponding p-values in brackets. The symbols *, ** and *** indicate significance levels of 10%, 5% and 1% respectively.

The Spearman rank coefficient has a value of 0.163, showing a low positive correlation, which in turn is not statistically significant (p-value = 0.65). We cannot therefore establish a significant correlation between the two rakings, meaning that an increase in R&D intensity is not systematically accompanied by an increase in GDP. Even though on the long run both convergence processes are taking place, GDP convergence does not seem to be correlated with R&D convergence. This lack of correlation is due to other factors determining growth, which generate the observed differences in the speed of convergence. The result does not imply that

R&D does not have a positive contribution to growth, but it states that, on average, investment in R&D does not speed up the process of income convergence. The present levels of R&D intensity are not sufficient to generate a visible increase in GDP, so its relative importance seems to be much lower than for other determinants of growth.

We proceeded with an individual analysis of economic growth versus R&D intensity for the 10 countries, during the period 1998-2008. We performed an individual correlation analysis, in order to identify if the countries follow a similar path. Results are presented in column (3) of Table 3. We found that the average evolution depicted earlier hides heterogeneous patterns.

Hungary, Bulgaria and Slovakia show a negative correlation between economic growth and R&D intensity. While they were progressing in economic growth, they allocated less of their income to R&D expenditure. So growth seems to have been decoupled from R&D expenditure in these countries. One possible explanation resides in the sources of innovation. Some countries might create it locally by investment in R&D, while others might import it by foreign trade or foreign direct investment (Perugini et al. 2008, Narula 2009). Slovakia actually experienced a severe drop in all R&D components during this period and is a particular case of growth without R&D investment.

The Czech Republic is the only one of the ten countries presenting a highly significant positive correlation. Being one of the more advanced CEEC, the Czech economy has settled on the more classical factors of long term economic growth, like innovation and human capital investment. (Perugini et al., 2008). Its constant increase in R&D expenditure was accompanied by sustained GDP growth.

The other six countries show a rather insignificant correlation between GDP growth and R&D intensity, given by high p-values associated with their coefficients. Though the R&D intensity in these countries has continuously increased during this period, they have not yet reached the point of transforming this effort into an increase of output. They still suffer from week R&D systems, which make cooperation between academia and industry sectors difficult (Radosevic 2004, 2005). Estonia stands out being on the first position in both rankings and showing a considerable progress along the convergence path. Slovenia also visibly increased its R&D expenditure, so a positive and significant contribution to growth is expected in the future. The Baltic States, although not presenting yet a significant correlation, have a high potential in innovation driven growth, because of their constant increase in R&D expenditure.

Our research has several limitations. First, the Pearson correlation coefficient assumes a linear relationship between the two variables. The lack of linear correlation does not exclude non-linear forms of correlation, like an exponential one, which may account for continuous R&D investment with a later effect on growth. Second, a correlation between two variables does not mean a causality relationship, even though theory suggests that R&D should act as a cause in economic growth. For the case of CEEC, a hypothesis that higher income levels lead to an increase of R&D investment may very well be plausible. These limitations open the field for future research: including R&D in a cross-country growth regression and testing the nature of the causal relationship.

4. Conclusion

As a general conclusion, CEEC present a heterogeneous pattern in the path towards the knowledge based economy, though a small but positive trend in R&D intensity can be identified. Bulgaria, Poland and Slovakia seem to make an exception to the rule, reducing their share of R&D and therefore magnifying their gap with the European Union. On the other hand, Estonia shows a remarkable progress both in innovation and income levels, being the top runner among CEEC.

In the post-transition period, CEEC are in search of sustainable factors to increase productivity and foster long-term growth. The crisis has particularly affected these catching-up economies, and the recovery path is likely to be more knowledge-based. Innovation and research and

development could be important contributors to sustain the competitiveness of these countries and the re-adjustment of the catching-up process. The aim of this paper was to test whether the income convergence in Central and Eastern Europe was correlated with the increase in R&D intensity. We constructed two rankings of the 10 countries according to the status of convergence (income and innovation) and computed a Spearman rank correlation coefficient. The result shows a slightly positive, but insignificant correlation between the two evolutions. Suspecting high heterogeneity among the sample, we proceed with an individual analysis. The Czech Republic is the only country where the two evolutions are positively and significantly related. Hungary, Bulgaria and Slovakia show a negative relationship between economic growth and R&D intensity, which is consistent with the view that growth was mostly generated by non-R&D factors. The other six countries in the sample do not present a significant correlation between the two variables. The results indicate that for the majority of the new member states, the income convergence is not supported by innovation-convergence.

These differences in the innovation capacity point out to two different factors: differences in the stocks of capital, labour and knowledge, but mostly different efficiency of the innovation systems. This means that besides the effort put into R&D, the economies should also have the capacity to transform knowledge into growth. This is thought to be one of the weak points of CEEC. The structure of their research systems in favor of government and education sectors renders business applications difficult. R&D activities also need a certain maturation time to generate an increase in productivity, which CEEC have probably not reached yet.

As policy recommendations, countries with large gaps in terms of innovation (Bulgaria, Slovakia, Romania, Latvia, Poland, Lithuania) should focus on improving their absorptive capacity rather than investing high shares in fundamental research trough government and academic systems. The challenge they are facing is to create an innovation demand from private companies, who do not find profitable opportunities for innovative activities. They should also improve their educational systems, which struggle with low efficiency. Despite high enrollment rates, there is a lack of correlation with the needs of the private sector.

Countries with smaller gaps, like the Czech Republic, Slovenia and Estonia, should concentrate on local innovations to sustain productivity growth and stimulate applied business research. Even though they are investing in R&D, they have difficulties in leveraging this effort into an increase of output. Government policies should facilitate cooperation between academia and private sector and increased government R&D spending should have a stimulating role on business innovation activities.

References

1.Aghion, Philippe and Peter Howitt, 2005, Growth with Quality-Improving Innovations: An Integrated Framework, *Handbook of Economic Growth*, Volume 1A, edited by Philippe Aghion and Steven N. Durlauf. Amsterdam, North-Holland, pp. 67-110

2.Aralica Zoran, Racic Domagoj, Redzepagic Denis, 2009, R&D activity as a growth factor of foreign owned SMEs in selected CEEC, *Croatian economic survey*, Vol. 11 (11) 73-93.

3.Best D. J., Roberts D. E., 1975 „Algorithm AS 89: The Upper Tail Probabilities of Spearman's rho*" Applied Statistics*, Vol. 24, No. 3, 377-379

4.Daianu, Daniel, 2002, Is catching-up possible in Europe?, *Romanian Journal of European Affairs*, vol. 2, no. 1, pp. 50-64

5.European Commission, 2006, *Strategic Evaluation on Innovation and the knowledge based economy in relation to the Structural and Cohesion Funds, for the programming period 2007-2013*, Czech Republic country report

6.Griffith, R., Redding, S., Reenen, J.V., 2004. Mapping the two faces of R&D: Productivity growth in a panel of OECD industries, *Review of Economics and Statistics* 86, 883-895;

7.Griliches, Z., 1992, The search for R&D Spillovers, *Scandinavian Journal of Economics*, Vol. 94, pp. 29-47.

8.Grossman, G. and E. Helpman, 1991, *Innovation and Growth in the Global Economy*, Cambridge: MIT Press, chapters 1-5.
9.Havrylyshyn Oleh, 2001, *Recovery and Growth in Transition. A decade of Evidence*, IMF Staff papers, Vol. 48, Transition Economies: How Much Progress?, pp. 53-87
10.IMF, 2006, *Growth in the Central and Eastern European countries of the European Union/* Susan Schadler, Ashoka Mody, Abdul Abiad, and Daniel Leigh—Washington D.C. International Monetary Fund
11.Mitra Pradeep, 2008, "*Innovation, Inclusion and Integration. From Transition to Convergence in Eastern Europe and the former Soviet Union*", The World Bank, Washington
12.Narula, Rajneesh, 2009, "*Attracting and embedding R&D by multinational firms: policy recommendations for EU new member states*," UNU-MERIT Working Paper Series 033, United Nations University, Maastricht Economic centre on Innovation and Technology
13.OECD, 2003, *Science Technology and Industry Outlook*, OECD Publishing, Paris
14.Perugini, C, Pompei F., Signorelli M, 2008, "FDI, R&D and Human Capital in Central and Eastern Europe", *Post-Communist Economies*, Taylor and Francis Journals, vol. 20(3), pp. 317-345
15.Radosevic Slavo, 2004. "A Two-Tier or Multi-Tier Europe? Assessing the Innovation Capacities of Central and East European Countries in the Enlarged EU," J*ournal of Common Market Studies*, Blackwell Publishing, vol. 42(3), pages 641-666, 09
16.Radošević, S. (2005) *Are systems of innovation in Central and Eastern Europe inefficient*? Presented at: The DRUID Tenth Conference 2005: Dynamics of Industry and Innovation of Industry and Innovation: Organizations, Networks and Systems, Copenhagen, Denmark
17.Romer, P. M., 1990, Endogenous technological change, *Journal of Political Economy*, no. 98, pp. 71-101
18.Van Ark Bart, Piatkowski Marcin, 2004, "Productivity, innovation and ICT in Old and New Europe," I*nternational Economics and Economic Policy*, Springer, vol. 1(2), pages 215-246
19.Van Pottelsberghe de la Potterie, Bruno, 2008, **Europe's R&D: Missing the Wrong Targets?** *Intereconomics***,** Volume 43, Number 4**, pp. 220-225**
20.Verspagen Bart, 2001. "*Economic Growth and Technological Change: An Evolutionary Interpretation*," OECD Science, Technology and Industry Working Papers 2001/1, OECD Publishing
21.Veugelers R, Mrak M, 2009, *The knowledge economy and catching up member states of the EU*, Knowledge Economists Policy Brief - N°5, European Commission