

Paas, T.; Vahi, Triin

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## Regional Disparities And Innovations In Europe

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# Regional Disparities and Innovations in Europe

Tiiu Paas, Triin Vahi

University of Tartu, Estonia, Faculty of Economics and Business Administration

[tiiu.paas@ut.ee](mailto:tiiu.paas@ut.ee); [vahi.triin@gmail.com](mailto:vahi.triin@gmail.com)

## Abstract

The paper focuses on quantitative assessment of the innovation's role in explaining regional disparities and convergence in Europe. The empirical part of the study bases on the regional GDP per capita and innovation indicators on the EU-27 NUTS2 level regions. Based on the selected set of initial innovation indicators for the 262 EU NUTS2 level regions and using the principal components factor analysis method, three composite indicators of regional innovation capacity are extracted. The preliminary research results show that around 60% of variability of regional GDP per capita is explained by composite indicators of regional innovation performance. Estimating convergence equations, we noticed that regional innovations tend to increase inter-regional differences, at least during the short-run period. Thus, if regional income convergence is a policy target, additional policy measures beside innovation activities should be effectively implemented.

*Keywords:* regional disparities, convergence, innovation, policy implications

*JEL classification codes:* R11, O11, C21

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## 1. Introduction

The issue of regional income disparities, growth and convergence has been the subject of a large body of empirical research since the beginning of the 1990s. Numerous studies on regional growth and convergence have been conducted during the recent decades which rely on neoclassical and endogenous growth models (e.g. Barro and Sala-i-Martin, 1995; Romer, 1986, 1990; Lucas, 1988; Armstrong, 1995) as well as on the NEG – New Economic Geography models (e.g. Krugman 1991). Despite of great interest in this matter, there is continually lot of discussable problems related to regional development and policy measures supporting economic growth and development of countries and regions. For instance there is still a research gap in exploring the role of innovations in regional economic growth and income convergence. Innovation activities as well as economic growth vary in countries and

regions worldwide but the reasons for these different developments have not been satisfactorily identified and analysed so far.

The paper focuses on examining the relationship between regional innovation and economic development in the EU countries and their NUTS-2 level regions<sup>1</sup> looking for the answers to the research questions about the role of innovations in variability of regional GDP pc and in regional income convergence. We consider GDP pc as the indicator of the regions' economic development level. The overwhelming aim of the study is to get additional information for elaborating policy proposals that may support regional development as well as income convergence if that will be a policy target.

The empirical part of the paper bases on the Eurostat data of GDP pc in the EU-27 countries and their respective NUTS-2 and NUTS-3 level regions. Additionally, we use Eurostat and Regional Innovation Scoreboard (RIS) data that are related to several aspects of the NUTS-2 regions' innovation performance. We implement principal component factor analysis in order to elaborate composite indicators of regional innovation performance. These indicators allow us to quantitatively examine the role of innovations in regional development and convergence. Relying on composite indicators of regional innovation performance, we specify and estimate regression models in order to, first, to examine the relationships between the regional GDP pc and composite indicators of regional innovation performance, and second, to test conditional convergence hypothesis.

Due to data restrictions on innovation performance it is not feasible to conduct a long-run convergence analysis. We can rely on regional innovation information only of the period 2000-2007. However, although the explanatory capacity for long-run developments is limited, we believe that analysing data of shorter periods may yield important insights into recent tendencies in regional income disparities and convergence taking into account different innovation performance of the EU regions.

The paper consists of five main sections. The next section introduces some theoretical and empirical considerations, which are relevant to our analysis. Section 3 gives a short overview of regional innovation performance indicators and presents the results of principal component factor analysis implemented for elaborating composite indicators of regional innovation performance of the EU NUTS-2 regions. The results of empirical analysis examining the relationship between the level of economic development and innovation performance as well as the results of testing conditional convergence hypothesis are presented in section 4. Finally, discussions and conclusions are presented in section 5.

## **2. Regional income disparities and convergence: some theoretical considerations and empirical evidence**

Explanatory approaches of economic growth and development are based on differences in capital accumulation (Solow 1956 and 1957), technological development (Kaldor 1961, Romer 1990), human capital and productivity (Lucas 1988, Rebelo, 1991), and innovations

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<sup>1</sup> NUTS (Nomenclature of Statistical Territorial Units) are spatial units used by EUROSTAT. While spatial units in NUTS-0 are countries, the level of spatial aggregation decreases with the levels 1, 2 and 3.

(Rodriguez-Pose and Crescenzi 2008; Lundvall, 1992 and 2007). The theories touching most directly on regional disparities and convergence are trade and growth theories, considering also the persistence of regional disparities (e.g. Cuadrado-Roura and Parellada, 2002; Fingleton, 2003; Harris, 2008). The most well-known arguments for examining regional disparities come from the neoclassical approach. According to this approach, regional disparities as a rule should vanish over time. The neoclassical arguments for vanishing disparities between nations or regions have also been the basis for the convergence literature (e.g. Barro, 1991). The full equalisation of regional income is captured by the concept of absolute convergence. The arguments for absolute convergence rely usually on the Solow growth model (Solow, 1956), which predicts the long run growth to approach the long run rate of technological progress. If regions are characterised by differences in technological level or other factors (e.g. innovations) that influence production factors, the disparities may also be persistent. In case of technological differences and innovations each region or country converges towards its own steady state, denoted by conditional convergence (see also Barro and Sala-i-Martin, 1995). Conditional convergence is consistent with endogenous growth models in which technological progress is modelled as depending on the concept of  $\beta$ -contributions to the research and development (Romer, 1986, 1990; Lucas, 1988).

Absolute convergence hypothesis relies on the traditional neoclassical growth model and postulates that relatively poor economies grow faster than relatively rich ones. If regions differ only in their initial income levels and capital endowment per worker, they converge towards an identical level of per capita income. This is referred to as absolute  $\beta$ -convergence. By contrast, conditional convergence exhibits heterogeneity in growth factors which gives rise to different growth paths. In the case of conditional convergence, where regions are marked, for example, by differences in technology, innovation performance, institutions and economic structure, regions converge towards different steady-state income levels. A specific problem associated with  $\beta$ -convergence is that it does not necessarily imply a reduction in the variation of regional income levels over time (see Barro and Sala-i-Martin, 1995). Hence, a negative correlation between initial income levels and subsequent growth rates does not always prove of declining regional disparities. The results of several studies observing regional convergence over a couple of decades show varying rates of convergence over time, showing also that the speed of convergence over shorter periods may deviate significantly from the long-run average (e.g. Barro and Sala-i-Martin, 1995; Armstrong, 1995; Cuadrado-Roura, 2001).

In order to examine income disparities and their dynamics in EU-27 countries and their regions, we rely on the Eurostat GDP pc data of the period 1995-2007. First, we apply Theil's index of inequality (Theil, 1967) in order to decompose overall regional disparities into within-country and between-country components<sup>2</sup>. Theil's inequality measure is derived from

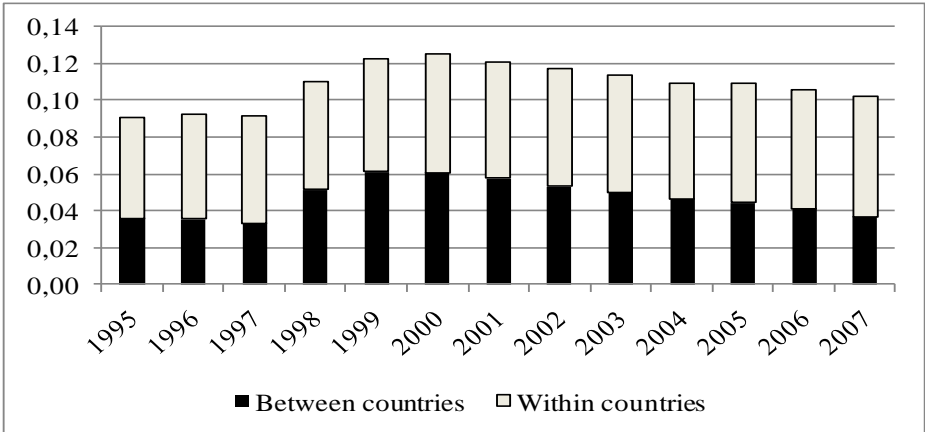
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$$^2 T_{total} = \sum_i \left( \frac{N_i}{N} \right) \ln \left( \frac{N_i/N}{Y_i/Y} \right) \quad (1), \text{ where } N - \text{population in all regions, } N_i - \text{population in region } i, Y -$$

total GDP in all regions,  $Y_i$  – total GDP in region  $i$ .

information theory and can be associated with the strand of literature dealing with inequality (see Cowell, 1995). This index allows us to analyse development of regional within-country disparities in the context of the general catching-up process taking place in the EU. Figure 1 presents information about decomposition of regional disparities between the EU countries and within the countries' NUTS-3 level regions during the period 1995-2007.

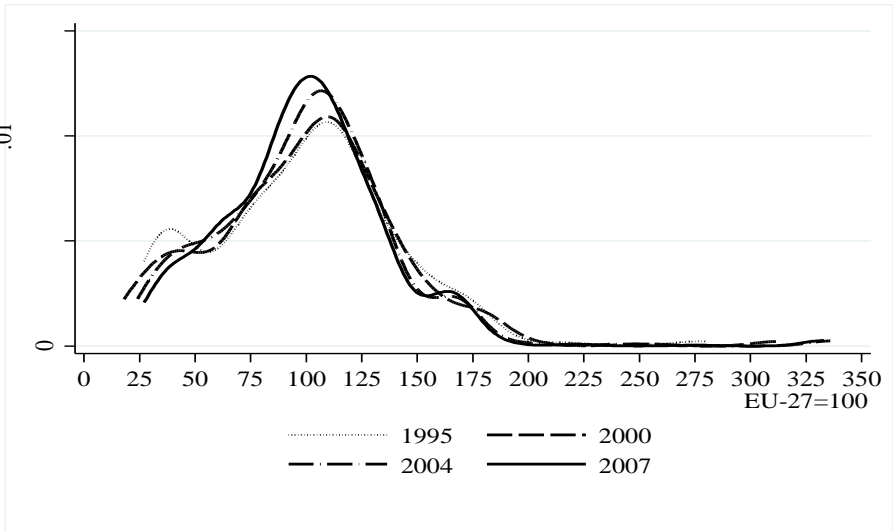
**Figure 1.** Theil index based decomposition of income disparities within and between EU countries



Source: Authors' calculations based on Eurostat data

Second, we apply a non-parametric approach based on Kernel function for examining the external distribution of regional income disparities of the NUTS-2 level regions (figure 2).

**Figure 2.** Density functions of regional income distribution in EU (EU-27=100), NUTS-2 regions, 1995-2007



Source: Authors' calculations based on Eurostat data

We can see that overall inequality is starting to decrease since 2000 but this decrease is mainly due to declining disparities in GDP pc between the EU countries (including also the countries that started to join since 2004). The share of within countries inequality (income disparities between the regions of a country) is slightly increasing since that time. Over time the share of within countries inequality component has increased to 69,4% in 2007.

In conclusion, regional income disparities are still persistent in the EU and do not have a clear tendency to decline. Overall inequality is starting to decrease since 2000 but this decrease is mainly due to declining disparities in GDP pc between the EU countries (including also the countries that started to join since 2004). The share of within countries' inequality is slightly increasing since that time. Over time the share of within countries inequality component has increased to around 70% in 2007. Despite the fact that the number of regions which have income below 50% of the EU average is somewhat declining, there is remarkable polarisation of regions according to their GDP pc.

### **3. Regional innovation and composite indicators of regional innovation performance**

In recent years, the concept of regional innovation systems has evolved into a widely used analytical framework generating empirical foundation for policy making. It is a widespread belief that innovation system creates a framework for innovation performance of a region. At the same time, the concept of regional innovation systems does not have commonly accepted definitions yet; usually it is understood as a set of interacting private and public interests, formal institutions and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use and dissemination of knowledge (see also Doloreux, 2003; Doloreux and Parto, 2005).

Regional innovation performances are quantitatively examined by several indicators integrated within the European Regional Innovation Scoreboard (RIS) providing statistical facts on regions' innovation performance. The RIS methodology and innovation indicators are in conformity with the European Innovation Scoreboard (EIS) methodology and indicators (see Hollanders and van Cruysen, 2008; Hollanders et al., 2009). Both scoreboards consider innovation as a process consisting of three main components: innovation input, activities and output establishing three groups of innovation indicators. These are: 1) "Enablers" capturing the main drivers of innovation that are external to the firm; 2) "Firm activities" capturing innovation efforts that firms undertake; 3) "Outputs" capturing implementation of innovations into the market and within the organisations, e.g. economic effects.

However, the use of some data at regional level presents certain limitations regarding data availability and reliability; therefore RIS captures somewhat less information compared to EIS (for details see Hollanders et al., 2009). Due to these limitations, the RIS does not provide an absolute ranking of individual regions, but only ranks groups of regions at broadly similar levels of innovation performance. Regions are ranked into groups from high to low innovation performance for overall performance (Hollanders et al., 2009).

We elaborate composite indicators of NUTS-2 level regions implementing method of principal component factor analysis (FA). This method aims to describe a set of initial  $k$  variables  $X_1, X_2, \dots, X_k$  in terms of a smaller number of  $m$  factors that highlight the relationship between these variables. It assumes that the data is based on underlying factors of the model, and that data variance can be decomposed into common and unique factors (for more see Nardo et al., 2005; OECD, 2008). The factor model is as follows:

$$X_i = \sum_{j=1}^m a_{ij}F_j + e_i \quad (2),$$

where

$X_1, X_2, \dots, X_k$  – initial set of variables (standardised with zero mean and unit variance);  $i = 1, 2, \dots, k$ ;  $k$  is the number of the initial variables;

$F_1, F_2, \dots, F_m$  – aggregated indicators – common factors (uncorrelated, each has a zero mean and unit variance);  $j = 1, 2, \dots, m$ ;  $m$  is the number of factors;

$a_{ij}$  – factor loadings related to the variable  $X_i$ , measured as a correlation between the initial variable  $i$  and factor  $j$ ;

$e_i$  – the specific factor supposed independently and identically distributed with zero mean.

The interpretation of the essence of factors bases on the matrix of the factor loadings ( $a_{ij}$ ). In order to support the interpretation of the factor loadings, the rotated matrix of the loadings is calculated to obtain a clearer pattern of factor loadings. The most common rotation method is the “varimax rotation”, which is used also in our case.

As a rule, the choice of initial indicators bases on theoretical and methodological considerations and on the checking of the robustness of the extraction results (e.g. Cronbach coefficients, several statistical tests, correlation matrix). Based on these considerations and the test results, the indicators were chosen so that they reflect the internal consistency of the initial items and describe innovation performance from different angles.

In our analysis, we rely on the RIS methodological framework and composition of indicators by choosing the initial nine innovation indicators of the EU-27 NUTS-2 regions. The chosen set of initial variables for elaborating composite indicators of regional innovation performance is presented in the table 1. We include three groups of indicators that may explain innovation capability of a region: 1) human capital related indicators; 2) expenditure to R&D and patents, 3) employment in knowledge intensive sectors. We are aware, that by choosing the initial indicators we had to take into account limitations of data availability, reliability as well as comparability.

The chosen indicators capture both input to innovation (human capital, investments) as well as possible outcomes (e.g. employment in knowledge and technology intensive sectors) of innovation activities

We are aware that these indicators as well as the activities behind them are closely interrelated. The high correlation of the initial innovation indicators (called multicollinearity) is one of the problems related to the measurement of innovation that was also stressed by

Schibany and Streicher (2008). That creates complications for specification and estimation of models regressing level of economic development (GDP pc) as an independent variable and innovation indicators as dependent variables. The implementation of factor analysis enables us to avoid multicollinearity problem in the regression model.

**Table 1.** Regional innovation indicators

Variable	Definition	Source (Eurostat)
HRST	Human resources in science and technology (percentage of economically active population)	Regional S&T statistics
TERTIARY	Population with tertiary education (ISCED 5-6) (1000 between 25 and 64 years)	Regional labour market statistics
LIFELONG	Participation in life-long learning (1000 between 25 and 64 years)	Regional labour market statistics
R&D_PUBLIC	Public R&D expenditures (R&D expenditures in the government sector and the higher education sector) (percentage of GDP)	Regional S&T statistics
R&D_BUS	R&D expenditures in the business sector (percentage of GDP)	Regional S&T statistics
PATENT	Patent applications to the EPO (per million of inhabitants)	Regional S&T statistics
KNOWL_SERV	Employment in knowledge-intensive services (percentage of total employment)	Regional S&T statistics
TECH_SECTORS	Employment in high-tech sectors (high-tech manufacturing and knowledge-intensive high-technology services) (percentage of total employment)	Regional S&T statistics
TECH_MANUF	Employment in high and medium high-technology manufacturing (percentage of total employment)	Regional S&T statistics

Source: Eurostat 2010, 2011

Based on the selected set of initial innovation indicators (table 1) for the 262 NUTS-2 regions of the year 2007 and implementing the principal components factor analysis method we extracted three principal components – factors  $F_j$  ( $j=1,2,3$ ) that explain 80.8% of the variation of the initial innovation indicators. The first factor (F1) explains 38.7%, the second (F2) 22.0% and the third (F3) 20.1% of the total variation. Table 2 presents the rotated factor loadings for the factors and the explained variance (*Varimax* method is used for rotation).

First composite indicator or factor has the strongest loadings (correlations) with the indicator “employment in knowledge intensive services” (0.91). Other strong factor loadings are with the variables (HRST, TECH\_SECTORS, R&D\_PUBLIC, R&D\_BUS and PATENT) that are related to the employment in knowledge intensive services capturing both private and public sectors (e.g. education, medicine). We name this factor as the factor of knowledge based service sector (F1). Second factor has the strongest loadings with the education variables (TERTIARY, LIFELONG); we name this factor as the factor of human capital (F2). The last composite indicator – factor has the strongest loadings with the initial variable that characterises employment in high-tech manufacturing sectors (TECH\_MANUF) having also statistically significant and strong factor loadings with variables PATENT and R&D\_BUS. This factor (F3) we consider as the factor of high-tech manufacturing.



**Table 2.** Rotated factor loadings

Initial indicators	Factor 1	Factor 2	Factor 3
HRST	<b>0,86</b>	0,27	0,15
TERTIARY	0,18	<b>0,95</b>	0,09
LIFELONG	0,39	<b>0,86</b>	0,13
R&D_PUBLIC	<b>0,64</b>	0,32	-0,08
R&D_BUS	<b>0,60</b>	0,22	<b>0,60</b>
PATENT	<b>0,69</b>	0,11	<b>0,55</b>
KNOWL_SERV	<b>0,91</b>	0,19	0,00
TECH_SECTORS	<b>0,70</b>	0,25	0,44
TECH_MANUF	-0,05	0,04	<b>0,95</b>
Explained variance (%)	38,65	22,00	20,14
Cumulative variance (%)	38,65	60,65	80,79

Note: factor loadings  $\geq 0,6$  are in bold.

Source: authors' calculations based on Eurostat data

The level of composite indicators – factors F1, F2 and F3 in every region are characterised by the factor scores that exhibit the level of the composite indicator for a region in comparison with other regions. If the value of the score is 0, that means that according to the factor this region has the average level, and respectively a negative and positive score reflects the regions' position below or above the average. In order to summarize the scores of the regions' innovation performance factors F1, F2 and F3 to obtain a synthesized innovation indicator – the aggregated innovation indicator – we use the weights that represent the explanatory power of these factors (respectively 0,387 for F1; 0,220 for F2 and 0,201 for F3; see table 2).

Table 3 presents information about distribution of the regions according to their innovation capability and the level of the GDP pc relative to the EU-27 GDP pc. Majority of EU NUTS2 regions (31.7%) belong to the group where the level of per capita GDP forms 100-125% of the EU average level. The factor scores of all three factors F1, F2 and F3 – the composite indicators as well as the aggregated innovation indicator of regions' innovation performance are as a rule above the average in the regions with high GDP pc.

**Table 3.** Composite innovation indicators of the EU-27 regions (measured by factor scores)

	GDP pc <75%	GDP pc 75-100%	GDP pc 100-125%	GDP pc $\geq 125\%$
Aggregated innovation indicator	-0,55	-0,13	0,23	0,46
F1. Knowledge based service	-1,19	-0,05	0,38	0,87
F2. Human capital	-0,09	-0,23	0,07	0,32
F3. High-tech manufacturing	-0,33	-0,31	0,32	0,29
n	60	69	83	50

Source: authors' calculations based on Eurostat data

In conclusion, the preliminary results of empirical analysis of innovation capability of the EU NUTS-2 level regions, which can be explained by three composite innovation indicators and measured by the factor scores, show that distribution of the regions according to their level of economic development (measured by GDP pc) is strongly related to innovations.

#### 4. The role of innovation in regional economic development and convergence

In this part of our paper we examine more profoundly the relation between the level of economic development and innovation performance of the EU regions implementing regression analysis and estimating several regression models. We also test the hypothesis of conditional convergence controlling for the regional innovation performance indicators.

The role of innovation capability in regional economic development and convergence processes is considered from two angles putting emphasis on testing of following research hypothesis:

1) the variability of the level of economic development measured by the GDP pc as a proxy of regional income is statistically significantly explained by the regional innovation performance described by the factor scores of the composite indicators F1, F2 and F3;

2) there is an evidence of conditional  $\beta$ -convergence of regional income if controlling for innovation performance (measured by the factor scores of composite indicators) and country-specific effects (measured by dummy variables for countries).  $\beta$ -convergence is defined as a negative relationship between initial income levels and subsequent growth rates.

In order to test these hypotheses two basic regression equations will be estimated based on the data for 262 EU NUTS-2 level regions.

First, regression equation examining the role of innovation factors in explaining variability of regional income:

$$\ln(Y_{2007}) = \alpha + \beta_1 F_{1,2007} + \beta_2 F_{2,2007} + \beta_3 F_{3,2007} + \beta_4 D_{EU} + D_{country} + u_{2007} \quad (3),$$

where  $Y_{2007}$  – GDP pc (PPS) in 2007;

$F_{1,2007}$  – knowledge based service factor in 2007;

$F_{2,2007}$  – human capital factor in 2007;

$F_{3,2007}$  – high-tech manufacturing factor in 2007;

$D_{EU} = 1$  if EU-12 and 0 if EU-15;

$D_{country}$  – country dummies;

$u_{2007}$  – error term;  $\alpha$  – constant;  $\beta_1, \beta_2, \beta_3, \beta_4$  – parameters.

Second, regression equation of conditional  $\beta$ -convergence of regional income:

$$\ln\left(\frac{Y_{2007}}{Y_{2000}}\right) = \delta + \gamma_1 \ln(Y_{2000}) + \gamma_2 F_{1,2000} + \gamma_3 F_{2,2000} + \gamma_4 F_{3,2000} + \gamma_5 D_{EU} + D_{country} + \omega_{2007} \quad (4),$$

where  $Y_{2007}, Y_{2000}$  – GDP pc (PPS) in 2007 and 2000;

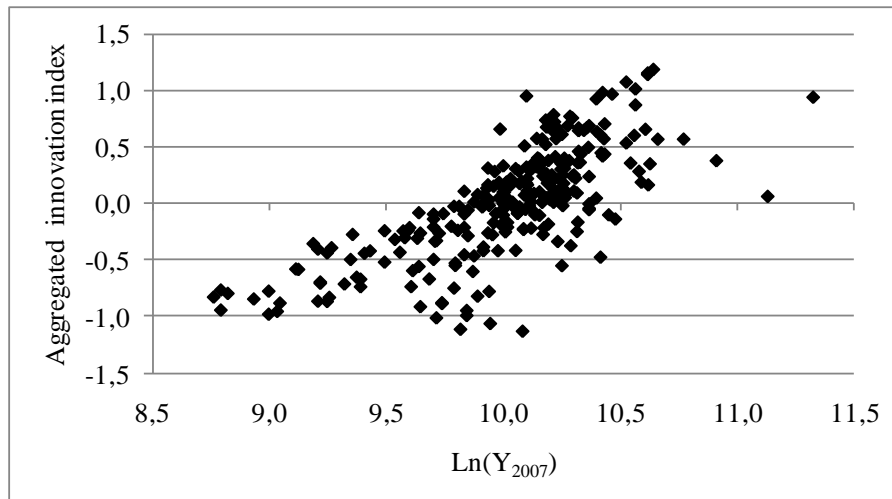
$F_{1,2000}$  – knowledge based factor in 2000;

$F_{2,2000}$  – human capital factor in 2000;  
 $F_{3,2000}$  – high-tech manufacturing factor in 2000;  
 $D_{EU} = 1$  if EU-12 and 0 if EU-15;  
 $D_{country}$  – country dummies;  
 $\omega_{2007}$  – error term;  $\delta$  – constant;  $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5$  – parameters.

We implement the common cross-sectional OLS approach for testing hypotheses and estimating the regression equations (3) and (4) controlling also for heteroskedasticity and using robust estimators in the case of necessity.

Figure 3 examines the relationship between regional GDP pc and the aggregated indicator of regional innovation performance as a weighted average of the factor scores of the innovation factors F1, F2 and F3. The figure confirms our opinion that the variability of regional income might be remarkably explained by the variability of regional innovation performance.

**Figure 3.** Regional income ( $\ln(Y_{2007})$ ) and aggregated innovation index



Source: authors' calculations based on Eurostat data

For testing the hypothesis 1 about the statistically significant relationship between the level of regional income and innovation performance we estimate several variants (models 1, 2 and 3) of the basic regression equation (3). The estimated models differ depending on the inclusion or not of the country-specific ( $D_{country}$ ) and country-group (EU-15 or EU-12) dummies into the model.

Table 4 presents the modelling results of testing the hypothesis 1. The estimation results show that the variability of regional income is statistically significantly related to regional innovation performance and this relationship is statistically significant in both cases when country-specific factors are taken into account (model 3) as well as in the case they are not taken into account (model 1). All indicators of regional innovation performance (factors 1, 2 and 3) are positively related to the regional income. The level of regional income is as a rule lower in the EU new member states (model 2).

**Table 4.** Cross-sectional OLS between regional income ( $\ln(Y_{2007})$ ) and innovation factors

	Model 1	Model 2	Model 3
$F_{1,2007}$ – Knowledge based service	<b>0,309</b> <sup>***</sup> (0,019)	<b>0,227</b> <sup>***</sup> (0,022)	<b>0,281</b> <sup>***</sup> (0,026)
$F_{2,2007}$ – Human Capital	<b>0,055</b> <sup>***</sup> (0,017)	<b>0,049</b> <sup>***</sup> (0,015)	<b>0,052</b> <sup>***</sup> (0,013)
$F_{3,2007}$ – High-tech manufacturing	<b>0,075</b> <sup>***</sup> (0,014)	<b>0,071</b> <sup>***</sup> (0,012)	<b>0,114</b> <sup>***</sup> (0,015)
$D_{EU}$		<b>-0,373</b> <sup>***</sup> (0,049)	
$D_{country}$	No	No	Yes
$\alpha$	<b>10,019</b> <sup>***</sup> (0,015)	<b>10,098</b> <sup>***</sup> (0,013)	<b>10,022</b> <sup>***</sup> (0,025)
R <sup>2</sup>	0,634	0,737	0,846
Adjusted R <sup>2</sup>	0,630	0,732	0,827
n	262	262	262

Note: Robust standard errors in parentheses. Significant at \*\*\* 1%, \*\* 5%, \* 10% level

Source: authors' calculations

Table 5 presents the testing results of the conditional  $\beta$ -convergence hypothesis (hypothesis 2).

**Table 5.** Cross-sectional OLS: conditional  $\beta$ -convergence ( $\ln(Y_{2007}/Y_{2000})$ )

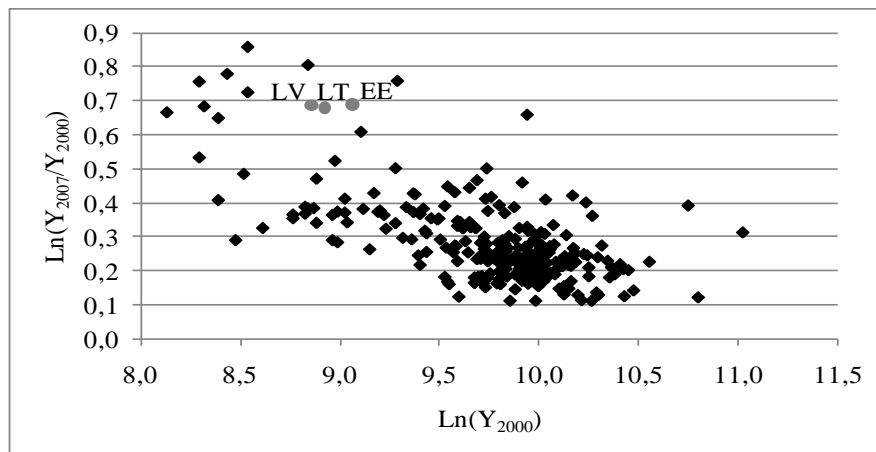
	Model 4	Model 5	Model 6
$\ln(Y_{2000})$	<b>-0,215</b> <sup>***</sup> (0,027)	<b>-0,117</b> <sup>***</sup> (0,033)	<b>-0,063</b> <sup>***</sup> (0,022)
$F_{1,2000}$ – Knowledge based service	<b>0,018</b> <sup>*</sup> (0,09)	<b>0,010</b> (0,008)	<b>0,030</b> <sup>***</sup> (0,009)
$F_{2,2000}$ – Human capital	<b>0,015</b> <sup>***</sup> (0,006)	<b>0,013</b> <sup>**</sup> (0,006)	<b>0,004</b> (0,004)
$F_{3,2000}$ – High-tech manufacturing	<b>0,003</b> (0,006)	<b>-0,003</b> (0,006)	<b>0,004</b> (0,005)
$D_{EU}$		<b>0,127</b> <sup>***</sup> (0,029)	
$D_{country}$	No	No	Yes
$\delta$	<b>2,376</b> <sup>***</sup> (0,263)	<b>1,395</b> <sup>***</sup> (0,322)	<b>0,852</b> <sup>**</sup> (0,215)
R <sup>2</sup>	0,472	0,533	0,861
Adjusted R <sup>2</sup>	0,464	0,524	0,843
n	262	262	262

Note: Robust standard errors in parentheses. Significant at \*\*\* 1%, \*\* 5%, \* 10% level

Source: authors' calculations

When the estimated coefficient of logarithm of the initial income variable ( $\ln(Y_{2000})$ ) is statistically significant and negative, we confirm the hypothesis that poor economies tend to grow faster than rich ones (see models 4, 5 and 6 table 5; see also figure 4).

**Figure 4.** Initial income ( $\ln(Y_{2000})$ ) and economic growth ( $\ln(Y_{2007}/Y_{2000})$ )



*Source:* authors' calculations based on Eurostat data

Since the convergence patterns are supposed to differ between the EU-15 and the NMS (EU-12), the country-group dummy is included in the equation (model 5). The parameter of this variable is statistically significant confirming the view that regional convergence/divergence processes are different in these groups of countries. According to the model 5, only the parameter of innovation performance composite indicator F2 (human capital) is statistically significant. The sign of this parameter is positive indicating that human capital as a composite indicator of regional innovation performance is in favour of income divergence, at least in the short run time horizon.

When country specific dummies are included in the regression equation (model 6), the estimation results show that only factor 1 (composite factor of knowledge-based service) has statistically significant relation to economic growth. Positive sign of the relevant parameter indicates that this innovation performance factor is not in favour of supporting convergence; it even indicates favouring divergence. Thus, the regions where the initial level of knowledge based services is higher grew faster. When country-specific conditions are taken into account, other two factors (F2 – human capital, F3 – high-tech manufacturing) do not have statistically significant relation to regional convergence in the short-run perspective (2000-2007). Evidently, the effects of human capital and high-tech manufacturing have also time-lag being transformed into regional economic growth.

In conclusion, we got confirmation to the hypothesis 1 that regional innovation performance is playing a significant role in explaining regional income disparities between the EU NUTS2 regions. At the same time, regional income convergence, which has been rather weak during the investigated short run period (2000-2007), is not supported by the innovation performance of regions.

## 5. Conclusion

Regional income (measured by GDP pc) shows considerable and persisting variability in EU. Although over time, regional income disparities have decreased between member states, they

have been rather stable or even increased within countries themselves. This suggests that persistent economic disparities continue to pose a challenge for EU, its member states and regions. Innovation is aimed at increasing productivity and gaining competitive advantage, thereby leading to an increase in the level of economic development of countries and regions. Therefore regional innovation has become an important political target in EU regional policy.

In order to empirically assess the role of innovation in regional economic development and convergence process, regional income level and convergence models were estimated based on the EU NUTS-2 regions data having composite indicators of regional innovation performance (factors F1, F2 and F3) as explanatory variables. The composite indicators of regional innovation performance were elaborated using the method of principal components factor analysis for the 262 EU NUTS-2 regions of the years 2000 and 2007. The extracted three factors explain 80.8% of the variation of the regions' initial innovation indicators. The first factor (F1 – knowledge based service) explains 38.7%, the second (F2 – human capital) 22.0% and the third (F3 – high-technology manufacturing) 20.1% of the total variation of regional innovation performance.

The most important role in regional variability of GDP pc is played by knowledge based services. Knowledge based services are typically above average in high-income old member states regions, which are known for investing heavily in R&D in public and private sector, supporting scientific and technological fields, knowledge-intensive service and high-technology sectors and encouraging patenting activity. The statistically significant relationship between economic development and human capital factor also found support. Investments in human capital, especially in higher education and life-long learning, create favourable conditions for knowledge development and innovative activities in a region. Lastly, statistically significant relation between economic development and medium and high technology manufacturing factor got confirmation, referring to the need to continue investments in the field. In high-income old member states regions' high-technology manufacturing is supported by private sector R&D investments and patenting activity. In mostly low-income new member states regions last two activities remain at considerably lower level affecting the potential of high-technology manufacturing. In addition, high-technology potential needs labour force with specific skills which are not always present in a region.

The results of conducted regression analysis show that almost 63.4% of variability in regional GDP pc can be explained by factors of regional innovation performance (Model 1). If country specific dummies were included in the model (see Model 3), the explanatory power of the model increased till 84.6%. The opinion that regions' innovation performance plays an important role in explaining regional income inequality got support during our empirical study. Thus, the results allow once again concluding that innovative efforts of regions are supportive to their economic development measured by the GDP pc. The empirical results of our study also show that innovation factors explain around 47.2% of short run (2000-2007)

economic growth in the EU-27 NUTS-2 regions. Additionally, around 40% of regional growth is explained by the country specific factors explain.

Estimators of conditional convergence model confirms that regional inequalities are decreasing in the EU, but innovative activities even tend to increase regional GDP pc differences, at least in the short run perspective (2007-2000). High-income regions, where knowledge based services play an important role, are evolving rapidly and thus income convergence process is not supported. Innovative regions tend to have higher productivity and income levels, which leads to differences in regional levels of economic development. In conclusion it can be said that regional development and convergence process depends on innovation, but it also depends on other factors like institutions, infrastructure, political stability etc., which affect the potential to absorb, use and assimilate innovations in a region. If regional income convergence is a policy target, additional policy measures beside innovation activities should be effectively implemented.

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