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INCOME ABSOLUTE BETA-CONVERGENCE OF NUTS 3 LEVEL REGIONS IN NEW EU MEMBER STATES BEFORE AND DURING A CRISIS*

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Abstract

This paper is aimed at answering the question of whether absolute income (GDP *per capita*) beta-convergence exists in the case of regions in new EU Member States before the period of 2000–2008 and during the 2008–2011 crisis. The sample consists of 211 regions (NUTS 3-level) of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia.

The research is based on econometric models, namely on the spatial lagged model (SLM), the spatial error model (SEM) and the Durbin spatial model which contrary to the ordinary least squares the (OLS) model include possible spatial dependencies. The SLM and SEM models as well as the Durbin spatial model detect the absolute income beta-convergence on the level of about 1% during the years 2000–2008. Additionally, models do not confirm the existence of absolute income beta-convergence during the crisis of 2008–2011. SLM models (which offer the most reliable findings) find a spatial correlation (measured by the rho-parameter) at a level of 0.75 during 2000–2008 and 0.35 during 2008–2011. Thus, absolute income beta-convergence in the case of NUTS 3 regions in 10 new EU Member States existed only in the pre-crisis period and this period is characterized by much stronger spatial dependencies than the period of 2008–2011.

Keywords: income convergence, NUTS 3 regions, new EU Member States, crisis, spatial dependencies

JEL classification: F15

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Introduction

Convergence is one of the fundamental issues of European integration. This paper is aimed at answering the question of whether absolute income (GDP *per capita*) beta-convergence exists in the case of regions in new EU Member States before the period of 2000–2008 and during the 2008–201 crisis. A separate analysis of convergence for the crisis period appears to be the main value added of the paper. The sample consists of 211 regions (NUTS 3-level) of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia.

The research is based on econometric models, namely on the spatial lagged model (SLM), the spatial error model (SEM) and the Durbin spatial model which contrary to the ordinary least squares the (OLS) model include possible spatial dependencies. The paper includes three major sections: (1) literature review, (2) methodological considerations concerning convergence equation and estimation techniques and finally (3) an empirical study on absolute income beta-convergence among the NUTS 3 regions of the selected 10 new EU Member States.

1. Literature review

Convergence is one of the fundamental topics of economic integration. Consequently, there are a lot of studies, both theoretical and empirical, concerning the processes of convergence. This literature review includes examples of research focusing on income (GDP per capita) convergence among relatively poorer regions of the European Union – namely regions in Greece, Portugal and Spain, and obviously regions in the new EU Member States. Therefore, it is possible to compare (up to a point) results stemming from research and from my empirical study.

Firstly, Soukiazis and Antunes (2004) scrutinize convergence process among the thirty NUTS 3 Portuguese regions studying the evolution of per capita income and productivity during the period 1991–2000. Their results show that convergence among the 30 regions in Portugal is rather conditional than absolute. Labour shares in the main economic sectors are important in explaining convergence in per capita income and productivity. Output growth, reflecting demand conditions and labour composition by sectors are shown to be relevant conditioning factors in explaining the convergence process in productivity. Moreover, their evidence shows a more significant shift of labour from the primary to the tertiary sector and when this element is introduced into the convergence equations, convergence is shown to be higher. Also Braga (2003) examines income sigma- and beta-convergence among the NUTS 3 Portuguese regions during the period 1970–2001. He proves that in the Portuguese case, the clustering phenomenon leads to growth and convergence within regions and between regions. He claims

clusters generate mechanisms of equal growth and living conditions. Additionally, Cardoso and Pentecost (2011) detected that human capital had a positive impact on regional growth and convergence in Portugal during period 1991–2008. They confirmed the convergence among NUTS 3 Portuguese regions and proved that both secondary and higher levels of education have a significant positive effect on regional growth rates which may be regarded as supportive of the Portuguese education policy, which over the last three decades has attempted to raise the regional human capital by locating higher education institutions across the country.

Secondly, Tsionas et. al (2014) investigated regional convergence in Greece during the period 1995–2005. According to his study there is an absence of convergence across NUTS 2 Greek regions while there is evidence of convergence at the prefectural level (NUTS 3).

Thirdly, Viegas and Antunes (2013) empirically analysed convergence among NUTS 3 regions of the Iberian Peninsula between 1995 and 2008. The results reveal divergent national trends and indicate no evidence of catching-up effects among the poorest regions, confirming the existence of economic clusters.

After a review of studies on regions in Greece, Portugal and Spain, I will focus on papers concerning the new EU Member States. Paas et al. (2007) conducted an analysis for 1214 NUTS 3 regions of EU-25 countries during the period 1995–2002. The authors detected absolute convergence in the EU-25 regions but the speed of regional income convergence was higher for the EU-15 than for the 10 new Member States which joined the EU in 2004. They also discovered that although there was an overall regional income convergence in the EU-25 countries, there was on average no convergence within the countries. Moreover, Artelaris et al. (2010) examined the convergence of NUTS 3 regions in all apart from Cyprus and Malta which were new Member States which joined the EU in 2004 and 2007. They identified the existence of regional convergence clubs in many of the new EU Member States. In their opinion the identification of regional convergence clubs, irrespective of the pattern that emerges in each, highlights the heterogeneous spatial impact of the EU economic integration process. Their results question the ability of markets to generate self-correcting mechanisms for regional imbalances.

Additionally, Nevima and Melecky (2011) examined the process of real convergence in the Visegrad countries at regional NUTS 2 level. Their study confirmed the existence of beta-convergence among 35 NUTS 2 regions of the Visegrad Four countries in the period 1995–2008. Herz and Vogel (2003) focused on regional growth and convergence in a sample of 31 Central and Eastern European regions (31 NUTS 2 regions from Poland, Hungary and the Czech Republic) over the period 1990–2002. They found out that the regional disparity decreased in the first half of the 1990s. Thereafter it has remained stable. Almost all of the reduced disparity

seems to be attributable to income convergence between countries. At the country level, on the other hand, they find no evidence for sigma-convergence. Their econometric analysis finds evidence for conditional beta convergence.

The two next papers are concentrated on the case of Romania. Namely, Benedek and Veress (2013) who investigated economic convergence between regions in Romania and between the NUTS 2 and NUTS 3 Romanian regions and EU in the period 2000–2010.Their main results confirmed that while there was an evident convergence between the country as a whole and EU, the inter-regional disparities in Romania has widened. Moreover, Mikulić et al. (2013) provide an analysis of regional convergence in the EU-27 and Croatia during the period 2001–2008 at the NUTS 2 and NUTS 3 level. According to their model, absolute beta-convergence can be found on the national level for EU countries. Convergence can also be found for new Member States regions, but convergence speed on the regional level is lower in comparison to the national level and the estimated beta-convergence parameter is less significant. No evidence on regional convergence (on the country level) can be found in Croatia, and the disparities have been highly persistent throughout the period of 2000–2008. More precisely, aside from Latvia and Portugal, Croatia recorded the smallest change in regional dispersion between 2000–2008 when compared to new Member States.

The Literature review ends with three examples of Polish studies concerning regional convergence. Firstly, Rosiek and Włodarczyk (2012) conducted a study on the labour market's convergence, thus they focus on unemployment rate instead on GDP per capita (as the unemployment rate is an important factor affecting the wealth of citizens, I include their research in the literature review). The empirical research conducted by these authors demonstrate that the speed of sigma-convergence is low. In 1999–2007 they found sigma-convergence in unemployment rates between the EU NUTS 2 regions, but in the 2008–2009 data they indicated a divergence in regional unemployment rates in the EU-27. In the conducted analysis only the beta-convergence of regional unemployment rates is significant and negative. This shows a convergence process where NUTS 2 regions in the EU-27 with higher unemployment rates catch-up with the other ones with lower unemployment rates. An analysis of beta-convergence indicates that within the period 1999–2009 the dispersion of labour productivity, labour force participation rates, and employment rates between NUTS 2 regions in the EU-27 was reduced. However, this relationship was not statistically significant. Secondly, Supińska (2013) detected unconditional and conditional income beta-convergence among the 211 NUTS 3 regions of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, and Slovakia during the period 1999–2008. According to her study the process of regional growth

is also determined by the level and changes in human capital, as well as by the location of the region, i.e. the regions which are located in dynamically developing areas may benefit from their location and grow faster. An article prepared by Misiak and Jabłoński (2013) presents the results of the statistical calculations of sigma- and beta-convergence among the EU regions in the period of 1995–2008. Their calculation was conducted on the basis of GDP per capita data for 189 NUTS 2 regions of the EU area and generally confirm both types of convergence.

To sum up, generally studies confirm regional convergence in the European Union; however convergence does not always occur unconditionally, among all regions and during all periods. Consequently, the processes of European integration do not guarantee the existence of convergence as it also depends on the country- and period-specific factors.

2. Methodology and data

As this paper investigates absolute income beta-convergence[1] among NUTS 3 regions, I have used the following equation proposed by Baumol (1986):

$$\frac{1}{n} ln \frac{y_{i,1}}{y_{i,0}} = \alpha + \beta ln\, y_{i,0} + \varepsilon_i \tag{1}$$

where $y_{i,0}$ and $y_{i,1}$ correspond to the GDP per capita[2] of region i at the initial and final year respectively and n is the number of years in the analysed period. Whenever a negative and statistically significant relation is found between the initial GDP per capita level and the corresponding growth rate, we can assume the presence of absolute income beta-convergence (variable $y_{i,0}$ is statistically significant and the parameter β is negative, thus the annual speed of convergence[3] equals $-\frac{\ln(1+n\beta)}{n}$). The equation proposed by Baumol describes a static model, but it is enough to detect the existence (lack) of absolute beta-convergence (see a definition of absolute beta-convergence in the footnote).

Convergence equations can be estimated by ordinary or non-linear last squares (OLS or NLS) methods; however they do not include the possible spatial dependencies between regions. Consequently, I use spatial estimation techniques, namely the spatial lagged model (SLM) and

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[1] Absolute income beta-convergence means that lower initial GDP per capita will lead to a higher average growth rate of GDP per capita.

[2] Naturally, GDP per capita has a number of drawbacks but still can be treated as a measure of a citizens income (wealth).

[3] The process of convergence is usually characterised by the speed of convergence (in %) and time to overcome the half of distance (equals ln(2) divided by the speed of convergence) that separates the economy of the country (region) from its steady state.

the spatial error model (SEM). I implement the following estimation procedure. First, I estimate the OLS model. Using the estimation results of the OLS model I check the existence of spatial dependencies by a statistical test (e.g. the Moran test, and the Lagrange multiplier test). Secondly if tests show spatial dependencies, I introduce a special spatial component to the equation – row-standardized matrix ***W***, which reflects the spatial relations between the analysed regions. More precisely, it shows how pairs of regions relate to each other. In this paper I apply the common border matrix (it is a binary matrix with values equalling 1 when the regions are neighbours and 0 otherwise). Before putting into a model, a common border matrix is undertaken into the process of row-standardization (the sum of each row in a row-standardized matrix equals 1). The same matrix ***W*** was used earlier in the mentioned statistical tests identifying spatial dependencies. Thirdly, I estimate the SLM and SEM and compare their quality using information criteria and the results of previous statistical tests (Kopczewska, 2006, pp. 123–142).

The spatial lagged model includes external spill overs resulting from the economic growth of other regions (namely neighbouring regions). In SLM spatial dependence is introduced to the equation through a spatially lagged dependent variable. Matrix ***W*** in this type of model is included together with the spatial lag of the dependent variable:

$$y_i = \beta_i \boldsymbol{X_i} + \rho \boldsymbol{W} y_j + u_i; \;\; u \sim IIDN(0,1) \tag{2}$$

where y_i and y_j correspond to the dependent variable in region i and in neighbouring regions j respectively and $\boldsymbol{X}$ is the set of independent variables. The Rho-parameter (ρ) is the spatial coefficient, which is used to assess the existence and strength of spatial relations. If it is significant, a dependent variable is explained not only by the domestic determinants, but also by factors coming from external (neighbouring) regions. However, spill overs may result from many other factors, which are not captured by the SLM model. To incorporate the effect of unknown sources of spill overs, the spatial error model can be used. In this model spill overs become a part of the error term component, and spatial dependency is revealed in the error terms, i.e. the error terms are correlated and show spatial covariance. In spatial error models, matrix ***W*** is introduced to the error term equation:

$$y_i = \beta_i \boldsymbol{X_i} + u_i \quad \text{where} \quad u_i = \lambda \boldsymbol{W} u_j + \varepsilon_i \varepsilon_i \sim IIDN(0,1) \tag{3}$$

where $\boldsymbol{W}u_i$ is the spatial lagged error term, ε_i is the random error term of the model, and the λ is a coefficient that is introduced to the model to satisfy the assumption about random error terms. It shows to what extent shocks in neighbouring regions are transferred to the analysed region (Kopczewska, 2006, pp. 132–133).

In this paper the research is a cross-section analysis, covering 211 NUTS 3 regions of 10 out of 13 new EU Member States: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, and Slovakia (Cyprus and Malta are excluded from the sample because they did not belong to the former communist block and Croatia is also excluded as it joined the EU much later than other countries). The initial year of analysis is 2000 because during the period 2000–2004 (2007) 10 new EU Member States were intensively supported by EU pre-accession funds aimed also at improving the convergence. The year 2008 was chosen as a symbolic beginning of the global economic crisis as (in 2008 there was a peak in the GDP and GDP per capita before their sharp falls in 2009). Data concerning GDP per capita of the 211 NUTS 3 regions are extracted from the Eurostat statistical database.

3. Estimation results

Estimated models are aimed at answering the question of whether absolute income beta-convergence exists in the case of regions in the new EU Member States before the period of 2000–2008 and during the 2008–2011crisis. I first start with models for 2000–2008. The OLS estimation detects absolute income beta-convergence on the level of 3%[4] (Table 1).

Table 1. Results of the OLS models of absolute convergence

Period	2000–2008	2008–2011	2000–2011
Intercept	0.304799***	0.032933	0.228228***
ln y_0	–0.026166***	–0.003958	–0.019672***
R^2	0.3393	0.008602	0.3422
Adjusted R^2	0.3361	0.003859	0.3391
F-statistic	107.3***	1.814	108.7***
AIC	–989.71	–1003.2	–1112.8

*** Denotes statistical significance at level 0.001.

Source: own study based on the estimation in R CRAN (commend lm()).

However, the goodness of the fit of the model (R^2 and Adj R^2) is low (about 34%). Such low values of R^2 point out that some important factors might have not been included in the regression. Consequently, using the OLS estimation results and row-standardized matrix $\boldsymbol{W}$, the model is tested for the existence of spatial dependencies (see Table 2). The Moran and LM tests suggest a replacement of the OLS model by spatial models – SLM appears to be better than SEM (higher value of statistics in the LM test for the SLM test than for the SEM test; robust

[4] The half distance that separates from a steady state is about 23 years.

LM tests also suggest the choice of SLM). Additionally, the map of residuals in the OLS model (see the first map in Figure 1) illustrates the spatial correlation. Positive and negative rests are not distributed randomly, which suggests the existence of spatial dependencies between regions.

Table 2. Results of tests for spatial dependencies

Period	2000–2008	2008–2011	2000–2011
Moran I test	0.577736268***	0.219875147***	0.487082859***
LM test for SLM	164.3559***	22.6774***	128.7748***
LM test for SEM	151.835***	21.992***	107.924***
Robust LM test for SLM	15.002***	1.546	20.8793***
Robust LM test for SEM	2.481	0.8607	0.0285

*** Denotes statistical significance at level 0.001.

Source: own study based on an estimation in R CRAN (commends lm.morantest() and lm.LMtests()).

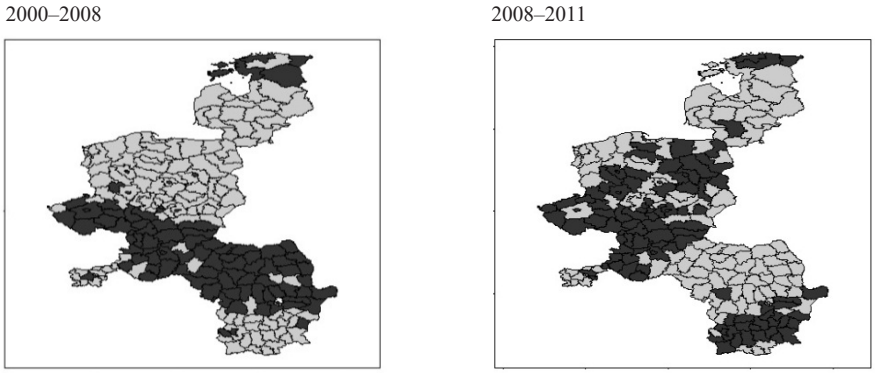

Figure 1. The Rests of the OLS models (positive rests in black, negative rests in grey)

Source: own study based on an estimation in R CRAN (commend residuals()).

According to the SLM there is an absolute income beta-convergence at the level of 0.9%[5] among the NUTS 3 regions of the 10 new EU Member States during the period of 2000–2008 (see Table 3). Moreover, SEM confirms the absolute convergence at the level of 1.3%[6] (see Table 4). However, the information criteria (lower value of AIC and higher value of LogLik[7]) together with the earlier mentioned values of the LM test statistics[8] (see Table 1 – in the case of the SEM statistics in the LM robust test is not even statistically significant) confirm that SLM is a better specification than SEM. The value of the rho-parameter illustrating spatial

[5] The half of a distance that separates from a steady state is about 77 years.
[6] The half of a distance that separates from a steady state is about 53 years.
[7] Higher absolute value of information criterion means better model specification.
[8] Statistically significant and the higher value of statistics means better model specification.

dependencies is almost 0.75 and is statistically significant (see Table 3). During the period of 2000–2008 a 1% increase in GDP per capita growth rates of neighbouring regions increased the rate growth of the investigated region by about 0.75 p.p. In other words growth in one region is explained in about 56% by the growth of surrounding areas.

The OLS estimation of the model for the period of 2008–2011 does not detect absolute income beta-convergence (see Table 1). The goodness of fit of the model (R^2 and Adj R^2) is extremely low (less than 1%). Such low values of the R^2 point out that some important factors for sure have not been included in the regression. Consequently, the model is tested for the existence of spatial dependencies (see Table 2). The Moran and LM tests suggest the replacement of the OLS model by spatial models – this time SLM seems to be slightly better than SEM (slightly higher value of the statistics in the LM test for the SLM test than for the SEM test; robust LM do not suggest anything). The map of residuals in the OLS model (see the second map in the Figure 1) illustrates the existence of a spatial correlation, however much weaker than for the years 2000–2008.

Table 3. Results of the SLM of absolute convergence

Period	2000–2008	2008–2011	2000–2011
Intercept	0.0934338***	0.0172670	0.0712349***
ln y_0	–0.0086731***	–0.0021222	–0.0064719***
ρ	0.74581***	0.34914***	0.72158***
Wald-statistic	267.48***	16.83***	216.8***
AIC	–1138.3	–1018.7	–1232.8
LogLik	573.1456	513.3493	620.4146

*** Denotes statistical significance at the level of 0.001.

Source: own study based on an estimation in the R CRAN(commend lagsarlm()).

According to the SLM and SEM there is no absolute income beta-convergence among the NUTS 3 regions of the 10 new EU Member States during the period of 2008–2011 (see Tables 3 and 4). Information criteria (with a slightly lower value of AIC and slightly higher value of LogLik) confirm that SLM has a slightly better specification than SEM. The value of the rho-parameter illustrating spatial dependencies is almost 0.35 (more than two times lower than in the model for the years 2000–2008) and is statistically significant (see Table 3).

Weaker spatial dependencies between regions and the lack of convergence during the period of 2008–2011 could have been be caused by the global economic crisis. Firstly, during a crisis regions could focus on themselves rather than on neighbouring regions. Secondly, the economic growth in one region together with stagnation or even recession in neighbouring regions could disturb the processes of convergence.

Table 4. Results of the SEM of absolute convergence

Period	2000–2008	2008–2011	2000–2011
Intercept	0.191282***	0.0156406	0.1280882***
ln y_0	–0.012057***	–0.0020324	–0.0073013***
λ	0.79423***	0.34997***	0.77611***
Wald-statistic	347.21***	16.897***	296.31***
AIC	–1130.4	–1018.4	–1222.6
LogLik	569.187	513.2241	615.2827

*** Denotes statistical significance at level 0.001.

Source: own study based on an estimation in R CRAN(commend errorsarlm()).

The SLM and SEM models detect the absolute income beta-convergence on the level of about 1%[9] during 2000–2008. Additionally, models do not confirm the existence of absolute income beta-convergence during the crisis of 2008–2011. Models for the whole period (2000–2011) inform about the absolute income beta-convergence at the level of 0.7%[10] (SLM – see table 3) and 0.8%[11] (SEM-see Table 4). The strength of interregional dependencies measured by the rho-parameter is about 0.72 (see Table 3).

Table 5. Results of the Durbin spatial model of absolute convergence

Period	2000–2008	2008–2011	2000–2011
Intercept	0.09114221***	0.03098644	0.0810483 ***
ln y_0	–0.00917807**	0.00077299	–0.0044428
lag ln y_0	0.00075642	–0.00445413	–0.0030997
ρ	0.74892***	0.34187***	0.70307***
Wald-statistic	240.72***	15.953***	171.74***
AIC	–1136.3	–1017.3	–1231.7
LogLik	573.1633	513.6546	620.8641

***/** Denotes statistical significance at level 0.001/0.01.

Source: own study based on an estimation in R CRAN (commend lagsarlm()).

Additionally, I estimated the Durbin spatial model which combines both the SLM and SEM models. The Durbin spatial model detects convergence during the period before the crisis (and also in the whole period of 2000–2011) and does not confirm convergence during the crisis (see Table 5). The speed of convergence during 2000–2008 is about 1%[12] and during 2000–2011 about 0.5%.[13] Generally, the Durbin spatial model confirms the previous estimation results of

[9] The half of a distance that separates from a steady state is about 69 years.
[10] The half of a distance that separates from its steady state is about 99 years.
[11] The half of a distance that separates from its steady state is about 87 years.
[12] The half of a distance that separates it from a steady state is about 69 years.
[13] The half of a distance that separates from a steady state is about 139 years.

the SLM and SEM models. Thus, the strength of spatial dependencies before the crisis was much stronger than during the crisis.

Conclusions

The SLM and SEM models as well as the Durbin spatial model detect the absolute income beta-convergence on the level of about 1% during 2000–2008. Additionally, the models do not confirm the existence of absolute income beta-convergence during the crisis years of 2008–2011. The SLM models (which offer the most reliable findings) find a spatial correlation (measured by the rho-parameter) at a level of 0.75 during 2000–2008 and 0.35 during 2008–2011. Thus, the absolute income beta-convergence in the case of the NUTS 3 regions in the 10 new EU Member States existed only in the pre-crisis period and this period is characterized by much stronger spatial dependencies than the period of 2008–2011.

My results correspond with study of Nevima and Melecky (2011) who examined the process of real convergence in the Visegrad countries at the regional NUTS 2 level. Their study confirms the existence of absolute beta-convergence among the 35 NUTS 2 regions of the Visegrad Four countries in the period 1995–2008,[14] so the period before the crisis. Also Mikulić et al. (2013) confirmed absolute beta-convergence before the crisis (namely during the period of 2001–2008) at a level of 4.5 % for the whole European Union and at a level of 2.3% for the new EU Member States (NUTS 2 level and OLS estimation). Finally, Supińska (2013) detected absolute beta-convergence for the 211 NUTS 3 regions (the same sample as in my study) in the period of 1999–2008 at a level of about 1% (SLM and SEM). To sum up, before the crisis absolute income beta-convergence among the regions of the new EU Member States existed but during the crisis probably it did not. However, further studies are needed as soon as data for the upcoming years of (2012, 2013 and so on) are available.

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