

SPATIAL RELATIONS OF THE CONVERGENCE IN THE CENTRAL AND EASTERN EUROPEAN REGIONS

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Abstract: *Convergence among regions is one of the political objectives of the European Union. In our study we have studied the territorial features of this phenomenon in the Central and Eastern European macroregion by regional approach (NUTS2). Our basic goal is to explore the general and spatial correlations of social and economic convergence. The methodology of our analysis is the absolute convergence test complemented by the spatial features (contiguity relations). The main question of research focuses on whether the convergence is predominant in the examined region? How do spatial interactions contribute to the convergence process?*

Key words: *β convergence, σ convergence, regional growth, social and economic inequalities*

INTRODUCTION

In our study we describe the territorial features and chances of the convergence in an abstract space (Central and Eastern Europe, exactly EU) defined by us. The convergence among regions is one of the main political objectives of the European Union. Article 130a of the Single European Act clearly stated that “in order to promote its overall harmonious development, the Community shall develop and pursue its actions leading to the strengthening of its economic and social cohesion. In particular the Community shall aim at reducing disparities between the various regions and the backwardness of the least-favoured regions” [1]. Later the Treaty on European Union [2] involved next to the economical and social marker the territorial too, highlighting the spatial importance of the convergence.

There are two kinds of interpretations, which can be read above: on the one hand, the intention to reach a reference point, on the other hand, as the approaching to each other, as the reducing of the inequalities [3], [4]. Kotosz [5] and Paas et al. [6] applied three categories for the typing of the convergence-processes. In the *absolute convergence* hypothesis, the per capita incomes of countries or regions converge with one another in the long-term regardless of the initial conditions. Poorer countries and regions grow faster than richer ones and there is a negative relationship between average growth rates and initial income levels even if no other variables are included in the regression models as explanatory factors. It is assumed that all economies converge to the same unique and globally stable steady-state equilibrium. According to the conditional convergence hypothesis, the per capita incomes of countries or regions converge with one another in the long-term provided that their structural characteristics (e.g. technologies, human capital, institutions, population growth rates, infant mortality rates, etc.) are identical. In the case of conditional convergence, equilibrium differs by economy, and each particular economy approaches its own but unique equilibrium. The club convergence means that, the territorial units belong to group or club-specified balance condition. The convergence-processes are specified by the initial conditions concerning certain groups. The club convergence hypothesis allows multiple and only locally stable steady-state equilibriums.

The convergence analyzes can be considered diverse both the involved territorial units, the method and the dependent variables, see for example [7], [4], [8], [5], [9].

In our study the absolute convergence was tested in the CEE region, according to the standard neoclassical growth model of Solow [10]. Convergence occurs because of lower and diminishing returns to investment in more developed and capital abundant countries and sectors. Capital investment spreads to new, less-capital abundant countries and sectors, where returns to investment are higher; likewise, labour migrates to the more developed countries where wages are higher. Nevertheless, capital accumulation merely cannot sustain growth in the long term, while growth in total factor productivity can. The Solow model does not predict absolute convergence, but it does predict that per capita income in an economy converges to its steady-state value. It also predicts convergence in factor prices and the standard of living [11]. The theory got several critics and modifications [12], [13], still it can be applied as a spread examination frame in the analyzes of the territorial convergence [7], [8], [11], [14], [15], [8]. Besides this, the role of the spatiality is clearly appreciating in the convergence analyzes [7], [16], [17].

In our study we are looking for answers to the following research questions:

- Can we observe economic and social convergence at regional level in Central and Eastern Europe?
- What kinds of differences can be found in the cases of the economic and social convergence?
- How can the spatial interactions contribute to the convergences of the economic and social growth and development?

MATERIALS AND METHODS

According to [7] the examination of the absolute (β -) convergence hypothesis based the cross-section data, we estimate regression equation in the following form:

$$\frac{1}{T} \log \frac{y_{i,T}}{y_{i,0}} = \beta_0 + \beta_1 \log y_{i,0} + \varepsilon_i$$

where $\log y_T$ and $\log y_0$ are the natural logarithms of development variables in region i in the last and the first year of the period under analysis, respectively β_0 coefficient is a constant, β_1 is the slope of the regression line, ε is the error term, T indicates the duration of the period. With the help of the following formula (below) we can measure the β coefficient, which shows the speed of convergence. β on the right side of the formula, comes from the above mentioned regression equation, this is the β_1 parameter signing the slope of the regression line.

$$\beta = -\frac{1}{T} \ln (1 + \beta T)$$

With the speed of convergence the half-life convergence can be calculat, that is how much time takes it to reach the half-way to the direction of the full-convergence in the examined region while the speed doesn't change (half-life convergence = $\ln 2/\beta$) [4].

The β -convergence analysis can be completed with the examinations of the inequalities of the development variables. Sigma (σ) convergence occurs when income (or any other development indicator) differentiation between the regional units decreases over time [7]. According to [18] and [4] the beta and sigma convergence are in connection with each other, the existence of beta-convergence is necessary, but it's not sufficient condition of the sigma-convergence. Sigma-convergence can be realized without beta-convergence as well [19]. The measurement of the sigma-convergence is calculated with the indicator of the coefficient of variation. (CV=standard deviation/mean)

Traditionally the β -convergence examinations doesn't take into consideration the spatiality [5]. That's why besides the method of the ordinary least squares (OLS) regression we apply in favour of the inconsistent estimation the maximum likelihood spatial error (ML SEM), maximum likelihood spatial lag (SLM) and the spatially weighted least squares models (SWLS) [20], [21], [22].

The global spatial autocorrelation test (Moran's I) is applied for the spatial dependence. The average spatial pattern of the growth variables is explored by the global approach. The formula of Moran's I:

$$I = \frac{n}{2A} \frac{\sum_{i=1}^n \sum_{j=1}^n \delta_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^n (y_i - \bar{y})^2}$$

where n is the number of the spatial units indexed by i and j , y is the variable of interest, \bar{y} is the mean of y , A means the numbers of the neighborhood relations, the value of δ_{ij} coefficient is 1, if the i and j are neighbors, anyway it is 0 [23].

The required database was provided by the Eurostat. In addition to the economic development (GDP per capita, purchasing power parity) the Human Development Index (HDI) was also included into our analyzes. The HDI, which express the regional well-being is created by four indicators: the per capita income of households, the rate of those who completed less than primary and primary and lower secondary education, the rate of those who graduated in the tertiary education and the life expectation at birth [24]. The methodological particularity of the index editing is published by Bubbico-Dijkstra [24], for the purpose of the temporal comparison we completed it defined the minimum and maximum values [25]. We made our examinations for the period of 2004-2014. The observation area is Central and Eastern Europe, which contains the NUTS2 regions of Poland, Czech Republic, Slovakia, Hungary, Slovenia, Romania, Bulgaria, Germany and Austria. The involvement of the last two countries was important, because these counties means the gravity centres for the new member states, they are the main economical and financial partners [26].

RESEARCH RESULTS

First of all, we explored the pairwise correlation relationships of the development variables using the Pearson's correlation coefficient. By comparison we run the coefficients of the HDI components, too. The table 1 figures the correlation matrix. The matrix shows the extent of the correlation separated for the initial conditions and separated for the growth rates. The correlation coefficients of the static (initial) variables (above the diagonal) describe clear, one-way and significant relations between the economic and the social development and between its components respectively. So the examined social and economical features strengthen each other, excepting one (between the GDP per capita and the education index) there are close correlations. The direction of the dynamic interactions (growth rates) is similar, (synergising correlations exist), but regarding the strength of the relationships are more diverse (below the diagonal).

Table 1.

Correlational relationships (Initial level of development/Growth rates)

	HDI	Household income	Life expectation	Education	GDP per cap
HDI	-	.939**	.935**	.880**	.895**
Household income	.876**	-	.947**	.705**	.948**
Life expectation	.826**	.740**	-	.734**	.884**
Education	.705**	.431**	.587**	-	.691**
GDP per cap	.739**	.895**	.651**	.382**	-

*Note: above the diagonal the pairwise correlation coefficients of the static variables can be seen, below the diagonal the correlational relationships of growth rates are shown. The ** means significance at .01 level. Source: own editing, 2017*

Most of the pairwise correlations are strong, but between the dynamics of educational level and the income indicators there are only medium weak relation. In addition, we highlight the connections between the increase of the income indicators and

the life expectancy at birth, in the case of the per capita income of the household there is a stronger correlation, than in the case of the GDP per capita.

In the following tables (2., 3.) are the results of the absolute β -convergence. In order to get the correlations we use the ordinary least square method to run the regression, than after the test of the spatial dependence of the error terms (Moran I), the regressions will be completed by the spatial features having appropriate specification. Than the main indicators of the convergence will be calculated. (The convergence rate, the half-life convergence.)

We have to definate the spatial structure of the examined space: we have to give, which are the regions who are neighbors to our region [27]. The choice of the appropriate spatial weight matrix was achieved as it follows. In the case of the dependent variables (growth rates) the Moran I index was running more kinds of distance matrices. The first and second order queen and rook-, the 4, 5, 6 nearest neighbors-, and the 175, 200, 225 km distance-based weight matrices were applied. During our analyzes we experienced that the queen weight matrix (with first order of contiguity) seizes the spatiality the best. The Moran's I value is here the highest: in the case of the HDI growth 0,830, while in the case of the GDP per capita growth is 0,694.

The high and significant Moran I values show the strong importance of the spatial autocorrelation, so the regions having similar growth are in the same cluster in CEE. During the following analyzes we worked with the usage of this weight matrice. We made the regression analyzes with more other matrices, but they had no meaningful changes in the main parameters.

Table 2.

Absolute convergence of the HDI by different regression models

	OLS	ML SEM	SWLS (HET)
intercept	.201*** (35.336)	.185*** (21.354)	.187*** (12.831)
HDI (ln, 2004)	-.044*** (-30.,447)	-.040*** (-18.415)	-.040*** (-11.186)
lambda	-	.735*** (9.821)	.741*** (7.986)
R-squared	.905	.947	0.906
Log likelihood	370.069	390.575	-
Akaike info criterion	-736.137	-777.15	-
Breusch-Pagan test	4.002**	23.837***	-
Likelihood Ratio Test	-	41.013***	-
Lagrange Multiplier (error)	45.151***	-	-
Lagrange Multiplier (lag)	23.628***	-	-
Moran I (res.)	.455***	.018	-
Speed of convergence (%)	5.83	5.08	5.16
Half-life convergence (ys)	11.89	13.64	13.43

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.10. The spatial weight matrix is based on first order queen contiguity. See the t- (OLS) and z-score (ML, SWLS) values in parentheses. Source: own editing, 2017

According to our results, in the table 2 and 3 we show that in the examined period in the CEE region the absolute convergence has prevailed. The regression β -coefficient – indicating the convergence – has negative sign. So the regions with lower development levels have higher growth rates and vice versa. The strengths of the coefficients of determination are significant different in the OLS regressions (0.489 and 0.905). In the case of the HDI the slope of the regression line is more powerful, that’s why we can

observe the major phenomenon of the convergence. According to the global autocorrelation test run on the error terms (Moran I), significant information left in the models. The Lagrange multiplier gives the information to choose the regression completing with spatial characteristics. The regressions were completed in the case of the change of the HDI with the OLS regression's spatial lagged error terms, in the case of the GDP per capita growth with the neighbor values of the dependent variable. So in the first case we used the spatial error model (SEM), in the other case the spatial lag model (SLM) was used.

Table 2.
Absolute β -convergence of GDP per capita by OLS and ML regressions

	OLS	ML SLM
intercept	.206*** (11.503)	.059*** (3.253)
GDP per capita (ln, 2004)	-.018*** (-9.586)	-.005*** (-2.995)
W	-	.729*** (10.248)
R-squared	.489	.704
Log likelihood	313.561	333.163
Akaike info criterion	-623.121	-660.326
Breusch-Pagan test	5.073*	6.068
Likelihood Ratio Test	-	39.205***
Lagrange Multiplier (lag)	28.108***	-
Lagrange Multiplier (error)	9.230***	-
Moran I (res.)	0.207***	-.021
Speed of convergence (%)	1.95	.52
Half-life convergence (ys)	35.62	132.79

Note: *** significant at .01, ** significant at .05, * significant at .10. The spatial weight matrix is based on first order queen contiguity. See the t- (OLS) and z-score (ML, SWLS) values in parentheses. Source: own editing, 2017

About the fit of the models in the maximum likelihood regression give information not only the R-squared values, but also the Log likelihood and the Akaike information criterion, too. In the first case the higher, in the last case the lower value is more favourable. In the case of both variables, the involvement of the spatially lagged values optimizes the explanatory power. The spatial dependence is tested by the likelihood ratio test (the applied weight matrix), according to this, the processes taking place in the neighbor regions have a significant influence on the increase of both HDI and GDP per capita. In the case of the HDI convergence the residuals has not constant variance (heteroskedasticity can be seen), so here the robust estimation of covariance matrix was used (SWLS HET, [21], [23]). The models completed with spatiality, give a more balanced figure about the determination. So it can be state that the regional convergence depends not only on the initial levels, but also the activities in the neighbor regions have obviously influence (spill-over effects). Kocziszky [28] leads back the interactions between the subnational territorial units to the producing-, service- and infrastructural processes involving more regions, and the movement of the human capital-, purchasing power- and capital among the different developed regions. These phenomena touch not only the economic convergence, but also have an influence on the growth of the social development. The tables 2 and 3 show the yearly rates of the convergence speed and the half-life convergences calculated by the regression betas. Although the regression betas have negative signs, but the speed of the convergence and the half-life convergence show different patterns. In case of HDI the yearly speed of convergence rate is over 5% in all cases, the half-life convergence doesn't exceed the 14 years. The regional economic

performance has much lower speed of convergence (about 2 %), taking the spatiality into consideration it falls back to its quarter level. (It is similar as the half-life convergence increases). In both cases the spatial effects lower the regression betas of the original OLS models (and the calculated indicators, too). Examining the economic development the ongoing processes in the neighbor regions are more considerable. During a more deeper examination we suppose that convergence clubs can be found in the examined space.

Last but not least, the territorial income and HDI differentiation between the regions decreased over the examined 10 years. So, the β -convergence met the σ -convergence between 2004 and 2014. We can see higher variability in case of GDP per capita, while the HDI has lower regional inequality in the CEE region. On figure a powerful decrease of the coefficient of variation can be seen until 2008, later the slope of the curves relapse significantly. This phenomenon is because of the economic recession probably.

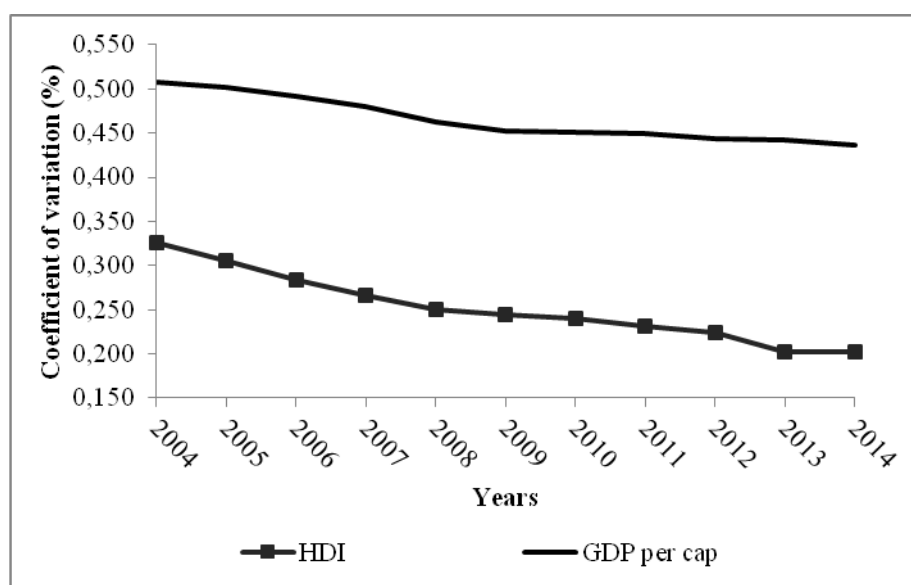


Figure 1. Sigma-convergence of HDI and GDP per capita

Source: own editing, 2017

CONCLUSIONS

In our study, the convergence of the GDP per capita and the Human Development Index was examined in the Central and Eastern European NUTS2 regions, from 2004 to 2014. Both traditional and spatial analyzes strengthen the absolute convergence hypothesis, which means that the less developed regions grow faster than the well developed regions, independent on any other explanatory factors.

The spatiality contributes as an active factor to the growth in the case of both development indicators. For the economic performance (growth of GDP per capita) the spatial effects have more powerful influence on the convergence than the initial level, in case of the human development index the faster speed of convergence can be highlighted. We have to draw the attention, though the mathematical-statistical analyzes resulted significant outcomes, the deeper analysis of the real spill-over effects is suggested in the relation of the examined phenomenon.

As a further research direction the statement of convergence and of the local features of the catch-up is justified. Although, our study highlights the role of the spatiality, but basically the convergence analyzes are evaluated by the global indicators

(Global Moran's I, regressions completed with spatial features). So kind of examination can be for example the geographically weighted regression or the calculation of the unique paths of the certain regions (speed of convergence, half-life convergence). Whereas the period of the examination is quite short, but it's expedient to share the observation-period with the consideration of the beginning of the economic recession.

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