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Working Paper

Silesian University in Opava
School of Business Administration in Karvina
Institute of Interdisciplinary Research

Working Papers in
Interdisciplinary Economics
and Business Research

Application of ß – Convergence Approach in Visegrad Four Regions

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March 2015

Working Papers in Interdisciplinary Economics and Business Research

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Citation

Nevima, J. and I. Majerová, 2015. *Application of ß-Convergence Approach in Visegrad Four Regions.* Working Paper in Interdisciplinary Economics and Business Research No. 4. Silesian University in Opava, School of Business Administration in Karviná.

Abstract

Jan Nevima, Ingrid Majerová: **Application of ß-Convergence Approach in Visegrad Four Regions.**

The paper focuses on the analysis of real convergence process in the Visegrad Four countries. The aim of the paper is to verify concept of β-convergence at regional level in the case of new Member States of the European Union. The theoretical background of the paper defines the methodological concept of real convergence. It focuses mainly on the concept of β-convergence which is the case of unconditional convergence. This approach is based on the neoclassical growth model. The empirical part of the paper concentrates on the analysis of β-convergence in 35 NUTS 2 regions of the Visegrad Four countries in the period between 1995 and 2012 to a steady state. The steady state is represented by an average of real GDP per capita in EU 28. Used approach assumes that the steady state is changing during the observed period with a nonzero growth. The process of β-convergence is analyzed and evaluated by nonlinear regression econometric model, which is formulated in two variations based on the mathematical concept of deterministic convergence. Gross domestic product per capita in constant prices is used to estimate both models.

Key words

Visegrad Four, NUTS 2 region, ß-convergence, nonlinear regression econometric model, non-linear panel data regression model.

JEL: C01, C15, O11, O47

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Acknowledgement

This paper was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the Institutional Support for Long-term Development of a Research Organization in 2015.

Introduction

Convergence is becoming a more important phenomenon not only in the EU. We can consider convergence as a basic economic assumption for strengthening competitiveness and cohesion in the enlarged EU. Similarly to competitiveness or cohesion, the term convergence has its theoretical background, definition, approaches and possibilities of measurement. The contribution concentrates on real convergence and tests it on the regional level of NUTS II regions of Visegrad Four. The paper aims to verify the hypothesis of β-convergence that poorer countries (countries with a lower income per capita) grow faster than richer countries. The β-convergence concept will be analysed by using a two different nonlinear regression econometric models which assumes a variable steady state during observed period. This is an alternative to traditional approach (Barro and Sala-i-Martin, 1990, 1992). If we evaluate β-convergence, we assume convergence from below – situation when initial economic level of the NUTS II regions of V4 is under the steady state which they converges to.

Methodological foundations of the paper are connected with aspects that influence the model estimation as well as the results of the regional convergence evaluation. These aspects are mainly (1) selection of the territorial level of region, (2) the length of observed period, (3) periodicity of data, (4) selection of convenient indicators for analysis on the basis of available regional data and (5) selection of steady state. Dealing with regional convergence we face the difficulty with short time series of regional economic data. If we evaluate regional convergence in EU, the most convenient unit in nomenclature of territorial statistical units (NUTS) seems to be level of NUTS II. European Commission also targets EU cohesion policy on NUTS II regions in last two programming periods.

The beginnings of empirical testing of real convergence base on Solow model of economic growth (Solow, 1956). The output of each country converges to a steady state which is set by economic conditions (Suchacek and Seda, 2012). Barro and Sala-i-Martin (1995) have developed this idea further and defined β-convergence as a situation where the countries with a lower real income per capita grow faster than the richer countries and also defined σ-convergence which is helpful to investigate lowering logarithm variance of real GDP per capita between economies over time.

The paper tests convergence on regional level. Anyway, this way of testing is not a rather widespread approach; since the national level mostly dominates in the Czech empirical studies (e.g. Slavík, 2005, 2007, Szomolányi et al., 2011, Hančlová, 2010, 2011a). However, some recent studies deal with regional convergence in the EU, e.g. Hančlová (2011b), Tvrdon and Skokan (2011), Petr et al. (2011) or Nevima (2014).

Empirical testing of real convergence in EU on the regional level appears in the foreign literature since the beginning of the 90s of the twentieth century. The frequency of the empirical studies grows proportionally with deepening integration processes in the EU. Several papers deal with regional convergence in EU 15 (e. g. Neven, 1995, Quah, 1996, Martin, 2001, Cuadrado-Roura, 2001, Armstrong, 2002, Castro, 2003, Badinger et al., 2004, or Ertur et al., 2006). Carrington (2006), Paas and Schlitte (2006) or Vojinovic and Oplotnik (2008) deal with empirical analysis of regional convergence in EU 25. The world literature also includes many recent research papers dealing with convergence beyond the EU (Baumol, 1986, Barro and Sala-i-Martin, 1992, 1995, 2004 or Romeo-Avila, 2009) and also with national or regional convergence inside the EU (Sala-i-Martin, 1996, Magrini, 2004, Kutan, 2007 or Dogaru, 2010). Current trends in testing real convergence in the EU also lead to an analysis of harmonization process of economic convergence [9] and convergence processes in European metropolitan macroregions (Smetkowski, 2010). Studies of Vojinovic and Oplotnik (2008), Rodriguez-Pose (1999), Varblane and Vahter (2005) and Bradley et al. (2005) deal with the empirical testing of real convergence in transition economies. Looking at the literature review above presented by following studies concerning real convergence we have to point out the large differences in results between the US economies and Europe and also between national and regional level of convergence.

1. Methodological Foundation of Convergence

Theoretical definition of convergence, form the point of view of economic theories, is a complicated issue, because this term is being used in different modification depending on the type of explored issue. The definition of convergence intuitively says the difference between two or among more variables diminishes in time. It becomes negligible and converges to zero. We generally understand convergence as a process of approaching to a certain level, diminishing the difference between two variables in time (the difference approximates zero).

Necessarily, we highlight the discussion about the relationship between economic growth and convergence which was started by Solow and Myrdal at the end of 50s of the 20th century (Solow, 1956). The 90s of the 20th century were the boom in research concerning convergence after Barro and Sala-i-Martin (1990, 1991, 1992) and Mankiw et al. (1992) published their papers. They come out from the neoclassical theories of growth and developed the concept of convergence on regional level. The boom can be explained by a growing dissatisfaction during the 80s of the 20th century that the regional disparities were not reduced as fast as supposed (Armstrong, 2002). These papers followed immediately after the new growth theories in the 80s of the 20th century (theory of endogenous growth and new economic geography). These theories formed a pile of contradictory theories which challenged a further research (Buček et al., 2008).

1.1. Convergence Typology

Let us briefly outline the basic assumptions of real convergence. Real convergence represents approximating the countries´ economic level to another countries´ economic level (in an integration group). Usually convergence is measured by GDP per capita which excludes the influence of price differences and represents the true value of produced goods in the economy. The Purchasing Power Parity (PPP) or the Purchasing Power Standard (PPS) are used for the international comparison. Real convergence can also be understood as a structural convergence of economies or technologies used Slavík (2005). If we evaluate the relationship of economic level between two economic entities, we can express the convergence definition of economic variables (GDP per capita) for two countries (regions) in time *t* on the base of absolute value of difference. The formula for convergence definition in period *t* and period *t+1* is following Barro and Sala-i-Martin (2004)

$$| y_{1,t} - y_{2,t} | > | y_{1,t+1} - y_{2,t+1} | \qquad (1)$$

where $y_{1,t}$ and $y_{2,t}$ represents relevant economic variables of two countries in time *t.* In case of a negative value we speak about divergence. Divergence is the situation, when the countries go apart. Other formulas appear for evaluation convergence, such as the form of relative differences (Smrčková et al., 2010), as in

$$\frac{y_{1,t}}{y_{2,t}} < \frac{y_{1,t+1}}{y_{2,t+1}} \text{ for } y_{1,t} < y_{2,t} \qquad (2)$$

where *y* is real income per capita and person of unit 1 and 2 in time *t* and *t+1*. This relation shows that the relative differences in economic standard per capita are dwindling in time *t*.

In case of real convergence, often called absolute (unconditioned) convergence (Slavík, 2005), the neoclassical theory of growth is the theoretical background. The theory assumes converging to a steady state which is influenced by other character features of the economy (e.g. savings, population growth, capital depreciation etc.)

The modern theories understand capital in a broader sense (human capita, public capital, technologies). This understanding of capital indicates economies of scale. The result is an ongoing widening of differences in economic performance – either convergence or divergence; and deepening the difference between the countries on the same economic level thanks to the presence of "convenient combination" of various factors.

One steady state for similar economies does not exist because the economies are differently equipped (marginal product of broadly understood capital does not indicate decreasing returns to scale). These models are able to theoretically describe the empirically supported development of economies with a higher production gap in economic standard which grow faster than other (but also can grow faster than other even though they have already reached a higher economic standard) on the other hand others can lag behind.

The empirical testing uses various models of so called conditioned and unconditioned convergence, e.g. β-convergence or σ-convergence.

Unconditioned (absolute) convergence based on neoclassical model means that countries with a lower GDP per capita grow faster even though the growth is not conditioned by other characteristics. This conclusion results from higher growth rates and convergence to steady state for economies which are further. In a simple model, where technology is a constant (e.g. Cobb-Douglass production function $Y(t) = K(t)^{\alpha}.(A(t).L(t)^{1-\alpha}$), the income growth per capita in steady state is zero and is positive if the economic standard is below steady state or negative if the economic standard is higher than the steady state. The unconditioned convergence is a growing function of difference of output and input in steady state. The unconditioned convergence to steady state is a growing function of difference between the output and output in steady state (Slavík, 2005).

In case of conditioned convergence we do not assume the same steady state for different economies. The higher the difference is between the output in steady state and observed output, the faster the economies grow. We can find examples of countries with a higher income per capita which grow faster than countries with a lower income per capita. This means that rich countries diverge in case the country with a higher income is further from steady state than the country with lower income. Convergence is conditioned by a wide row of other explaining variables which cause a different steady state, such as rate of savings, parameters of production function, governmental policies influencing production function due to A variable (influence of technology, flexible labour market, removing the trade barriers, enhancing education, infrastructure etc.).

2. Concept of ß-convergence

Concept of β-convergence is defined as a situation when poorer countries (countries with a lower real income per capita) grow faster than richer countries (Majerová, 2012). The neoclassical models understand convergence as a convergence to steady state. In a neoclassical model, steady state is the situation when the income per capita is constant through time. Under certain circumstances (Toba and Simion, 2011) we can prove that the economy only has one steady state to which it converge regardless the initial conditions. To keep it simple we can quantify the true development of *β*-convergence for time *T* using following regression equation

$$y_{i,T} - y_{i,0} = \alpha_1 - \beta_1 . y_{i,0} + \varepsilon_i \qquad (3)$$

where *i* represent the order number of observation (country, region), *0* and *T* are two different points in time. Concept of *β*-convergence assumes a positive value in parameter β_1. Using the regression equation, we can analyse how systematically the process of convergence continued year by year *t=0,1,2,…T.* If the countries have a stable steady state α_1 and the time is long enough so that the countries can converge to this state, the parameter β_1 = 1 and the real income per capita in time *T* is the same in all observed countries. Anyway, this happens only in the ideal case. Regression coefficient β_1 expresses how much of the difference to the steady state was on average successfully eliminated. This equation assumes steady state with a zero growth per capita.

Studying absolute convergence comes out from neoclassical theory of growth in a closed economy. It can be formalized by following equation, according to Barro and Sala-i-Martin (1990), as in

$$\log \frac{y_{i,t}}{y_{i,t-T}} = a - (1 - e^{-\beta}).\left[\log(y_{i,t-1}) - g(t-1)\right] + u_{i,t} \qquad (4)$$

where $a = g + (1 - e^{-\beta})\log(y^*)$, t is year, i is region, country, $y_{i,t}$ represents GDP per capita in region *i* at the beginning of time *t*, $y_{i,t-T}$ is than GDP per capita in region *i* at the end of time *t* and $u_{i,t}$ is random error.

The model assumes that the random error has a zero mean and is not dependent on (*log* y_{t-1}) and is not autocorrelated. The random variable can be interpreted as an unexpected change in production conditions or preferences. The equation (4) we regard coefficient (*a*) constant. This means the steady state (y^*) (e.g. GDP per capita) is the same for all economies (regions) involved in the model. The time trend *(g-(t-1))* represents exogenous technological change and is the same for all economies (regions). Variable (*g*) represents the growth of selected macroeconomic variable in steady state. Parameter (*β*) can be derived from the slope of regression function and expresses the rate of conversion of state (regions) to steady state. We speak about *β*-convergence if *β > 0*. If the dependence in equation (4) is significantly positive, we confirm absolute convergence. If we have no constant parameter (*a*) and different steady states (y^*) in different economies, we speak about conditioned β-convergence. Barro and Sala-i-Martin (1991) specify it further. The method of condition convergence involves control variables, which show different initial conditions of the economies.

Analysis of *β*-convergence can be derived from the modification of equation (4) to following, as in

$$\frac{1}{T}.\log\left(\frac{y_{i,T}}{y_{i,0}}\right)=\alpha+\beta.\log y_{i0}+\varepsilon_i \qquad (5)$$

The left part of the equation expresses the average growth of *GDP* in constant prices in PPP for the time period *0* to *T*. The average growth depends on the initial economic level ($y_{i,0}$). *T* is the total number of years of the observed period, *α* constant term, *β* is regression coefficient (slope parameter) and ε_f is random error. The direction of *β* line is negative in case of β-convergence. If the direction of *β* line is positive we speak about divergence. The higher slope parameter *β* is in absolute value the faster the convergence.

We can find equation (5) and discussions e.g. in Barro and Sala-i-Martin (1995) or Slavík (2005). We necessarily highlight that the equation (5) implicitly assumes the same steady states in the observed economies. In case we can prove *β*-convergence using this equation we also prove absolute convergence because this equation does not involve the possible existence of different steady states adding other variables (unconditioned convergence).

3. Empirical Analysis ß-convergence in Visegrad Four Regions

For analysis and evaluation of convergence process in Visegrad Four (V4) NUTS 2 regions for NUTS classification (Eurostat, 2011), we come out of a valid neoclassical growth model. GDP negatively depends on initial economic level and economy converges to its steady state in this model. We formulate *two* following *approaches* by econometric models that come out of a *β*-convergence concept in our analysis.

3.1 Methodological Background and Econometric Approach Specification

The first approach is represented by an econometric model, which is based on a non-linear regression model. To estimate the regression model we use the concept of regression equation (5) for testing β-convergence. This was proposed by Barro and Sala-i-Martin (2004) and used in Slavík (2005, 2007). The chosen approach presents the derived econometric model which is estimated by the Ordinary Least Squares (OLS) method.

For the purpose of the paper, we come out from traditional approach to β-convergence, modified especially due to following arguments:

Equation (5) assumes measurement of size of convergence difference of the region (country) to steady state at zero growth. The zero growth is not assumed in our econometric model and, on the contrary, it presents results taking into account development of GDP in all reference period.

We do not provide research of the group of countries and their development to steady state, but we follow the development of each of 35 NUTS 2 regions of V4 to their steady state. The following modify regression equation (6) will come to β-convergence by positive slope of $\beta_{r,t}$ line. In opposite case, by negative slope of $\beta_{r,t}$ line, it will come to divergence. It will be valid by respecting rules of statistical signification.

When evaluating if a region converges, we respect two basic facts:

Positive slope of $\beta_{r,t}$ line is caused by convergence of V4 NUTS 2 regions from below towards average value.

When substituting into following equation (6) we can obtain negative figure on the left side of equation, if the average value is higher than performance of V4 NUTS 2 region.

We will modify econometric model due to above mentioned arguments. We come out of generally valid equation (5) for measurement of β-convergence to following modified regression equation, as in

$$\log\left(\frac{y_{r,t}}{y_{EU,t}}\right) = \hat{\alpha}_{r,t} + \hat{\beta}_{r,t} \log y_{EU,t} + \hat{\varepsilon}_{r,t} \qquad (6)$$

where $y_{r,t}$ is GDP per inhabitant for *r-th* NUTS 2 region, $y_{EU,t}$ represents average level of GDP per inhabitant for all regions of EU 28 in the year t, $\alpha_{r,t}$ is intercept, $\beta_{r,t}$ is slope parameter of regression model, t represents reference period of years 1995 – 2012 and $\varepsilon_{r,t}$ is random error.

Next, we have to set what is steady state. It means level of speed of convergence to defined steady state. By steady state we determine value of economic performance of EU 28 countries approximated by average value of EU 28 GDP per capita. We can assume that the level of performance of evaluated V4 NUTS 2 regions will increase or decrease. However, we come out of a hypothesis that the total performance of the regions increased in each year. By current data accessibility, the regression model deals with calculated average for EU 28 countries. We take this average and its development in time as a level for initial evaluation of real convergence. That is why we compare how each V4 NUTS 2 region converge their economic performance to steady state, i.e. to EU 28 average in reference period 1995 – 2012. We have to specify that value of EU 28 GDP per capita average was always calculated separately for each year of the reference period.

In the second approach the topic of convergence process is solved. The change of EU 28 GDP is determined by the change of GDP of a certain V4 NUTS 2 region applying non-linear panel data regression model with using of dummy variables technique for NUTS 2 regions. The aim of second approach is to show the relative speed of convergence of each V4 NUTS 2 regions to steady state in the reference period 1995 – 2012. Formalized notation of the panel data model is following

$$\ln y_{EU,t} = \hat{\alpha} + \hat{\beta} \ln x_{r,t} + \sum_{r=1}^{35} \hat{\gamma}_r D_{r,t} + \hat{\varepsilon}_{r,t} \qquad (7)$$

where $y_{EU,t}$ is endogenous variable (average of EU28 GDP per inhabitant), $x_{r,t}$ is exogenous variable (GDP per inhabitant for NUTS 2 region), α represents intercept, β is slope parameter of regression model, γ_r is difference parameter of fixed effect of intercept of region, $\varepsilon_{r,t}$ is random error, $D_{r,t}$ represents binary variable for region specification (level of regional GDP per inhabitant, $D_{r,t} = 1$ if it takes data of region *„r“* in time *„t“*, $D_{r,t} = 0$ otherwise), r is it indexes sectional characteristics (in our case V4 NUTS 2 regions; ‘basic region’ is average of EU28, *r =1, 2, 35* (in our case 35 NUTS 2 regions of V4), t is indexes time*; t = 1995, 1996,..., 2012*.

From the legend of the equation of non-linear model of panel data (7) follows that it is necessary, before providing model estimation, to assign dummy variables ($D_{r,t}$) for each NUTS 2 regions of Visegrad Four. Panel data regression model will contain 35 of these dummy variables. Assignment of dummy variables $D_{r,t}$ for each V4 NUTS 2 region is stated in *Table 1* in appendix (see column 'Dummy variable').

3.2 Database for Econometric Analysis and Estimation of Econometric Models

The database for measuring real convergence in V4 NUTS 2 regions is built up by regional GDP data per capita in constant prices. The data is provided by OECD (2011). To compare the data in time we use U.S. dollar constant prices of year 2005 according to Purchasing Power Parity (PPP) recounted particularly by EKS (Elteto-Koves-Szulc) Method. The method is usually used by OECD and Eurostat. Theoretical background of EKS method for setting Purchasing Power Parity for comparing prices in industry is presented in Prasada and Timmer (2003).

Using constant prices and constant parity of the year 2005 we exactly simulate the dynamics of GDP and population. We do not consider the changes in terms of trade and structure. The aim of the empirical research is to analyse 35 NUTS 2 regions in Visegrad Four countries in the reference period 1995 – 2012. We work with a small sample of observations to compare. We are aware of the fact that the limited number of years of available data can influence the results. On the other hand, it is not meaningful to analyse the data for transition economies before 1995 because the countries did not use united methodology for measuring GDP in ESA 95 system.

The problem of a small number of observation and short time series is solved by using the technique of dummy variables in panel data model. The panel model can concentrate more information than the classical regression model. We are better able to monitor the dynamics of variable change. The advantage of this is detection of fixed, respectively stochastic effects, which we were not able to diagnose application only using selected data or time series.

For the purpose of calculation software SPSS for Windows was used. If regional annual data of GDP per inhabitant for V4 NUTS 2 regions are available in reference period 1995-2012, 35 regression equations will arise in the first approach. We can decide according to them, how the NUTS 2 regions (35 of them) gradually converge or diverge to average level of the EU 28. The estimation of $\beta_{r,t}$ parameter will be crucial for the next evaluation of level of convergence process of each region because it shows us which regions converge or diverge to steady state or the situation where we can not clearly decide about convergence or divergence.

The second approach shows the order of regions from the relative *speed* of their convergence to average level of EU 28 point of view. In this case we watch development of γ_r parameter. Final estimation of the panel data model is posted in following equation

$$\begin{aligned} \ln G\hat{D}P_{EU,t} &= 5.657 + 0.496 \ln GDP_{r,t} \\ &- 0.666 D_{1,t} + ... + (-0.036 D_{35,t}) \end{aligned} \tag{8}$$

The overall outputs of both used approaches are concluded in Table 1 for all 35 analysed NUTS 2 regions of V4 countries.

3.3 Interpretation of Results

The first approach identified either β-convergence or (in case of statistical non-significance of $\beta_{r,t}$ parameter) ambiguous conclusion on convergence or divergence of each V4 NUTS 2 region towards EU 28. Therefore we take into consideration statistical significance. A part of every estimation is statistical verification and econometric verification (considering restricted scope of the article we do not state results of econometric verification). We used F-test for testing statistical significance of the model, and t-test for testing of partial regression coefficients. In most estimation they came out of regression coefficients as statistically significant on 5% significance level (see column 'p-value' in Table 1). It means we can objectively assess, based on model formulation (6), if V4 NUTS 2 region convergence takes place or not. Quite high value R^2 (see column 'R^2' in Table 1) of coefficient of determination shows the relevance of results. To conclude the results of the first approach (see column 'Results' in Table 1).

The β-convergence testing prevail (in statistically significant sample of V4 NUTS 2 regions) unambiguous conclusions of tested β-convergence. B-convergence was confirmed in 26 V4 NUTS 2 regions (approx. 74%), statistically significant β-divergence was confirmed in two NUTS 2 regions of V4 countries (approx. 6%). There belong regions in the Czech Republic (CZ01) and Slovakia (SK01). The ambiguous results were found in 7 NUTS 2 regions of V4 countries (20%). There belong 6 NUTS 2 regions in the Czech Republic (CZ03, CZ04, CZ05, CZ06, CZ07 and CZ08) and 1 NUTS 2 region in Hungary (HU33).

We came to a following rule at γ_r parameter after estimation in the second approach. The higher the value of γ_r coefficient, the closer is the NUTS 2 region to the intercept (the region should converge faster to its steady state). The lower the γ_r coefficient, the more distant is the NUTS 2 region from the intercept (the region should converge slower to its steady state). Table 1 shows V4 NUTS 2 regions in the rank of convergence speed towards steady state (see column 'Rank of convergence speed' in Table 1). The relative rank is based on values of parameter γ_r (see column 'Difference parameter of fixed effect' in Table 1).

The second approach does not take into consideration, if the region converges or diverges, but we prefer a general principle that all NUTS 2 regions converge towards EU 28 average level, but each of them in a different speed. Therefore we took into account the value of γ_r parameter which was ordered and according to this order final rank was set due to speed of convergence. In the second approach, the panel data model excluded 5 NUTS 2 regions from the final estimation (see regions HU31, HU32, PL33, PL34, and PL62 with rank 'irrelevant' in Table 1). These NUTS 2 regions where excluded from the model because the volume of p-value in γ_r parameter was statistically non-significant.

The final rank of V4 NUTS 2 regions convergence speed corresponds with the general hypothesis of β-convergence assumptions for the countries at national level. The most developed V4 NUTS 2 regions (e.g. CZ01, SK01, HU10 and PL12, i.e. regions with the capital city agglomeration) converged slower than the least developed V4 NUTS 2 regions (e.g. PL32, PL31, SK04 and PL52) that converged faster.

Tab. 1: Estimation of Econometric Model of β-convergence for Visegrad Four NUTS 2 Regions towards EU 28

Model	Region			Slope para-meter (β_1)	p-value	R^2	Results	Difference parameter of fixed effect (γ_r)	Rank of convergence speed
Regr. Equat.	Code	DV	Name (national)						
1	CZ01	$D_{1,t}$	Prague	1.410	0.000	0.94	β-divergence	-0.666	30.
2	CZ02	$D_{2,t}$	Central Bohemia	0.842	0.000	0.813	β-convergence	-0.286	25.
3	CZ03	$D_{3,t}$	Southwest	0.220	0.237	0.114	*ambiguous*	-0.287	26.
4	CZ04	$D_{4,t}$	Northwest	-0.247	0.295	0.091	*ambiguous*	-0.234	22.
5	CZ05	$D_{5,t}$	Northeast	0.061	0.673	0.015	*ambiguous*	-0.259	23.
6	CZ06	$D_{6,t}$	Southeast	0.382	0.063	0.259	*ambiguous*	-0.277	24.
7	CZ07	$D_{7,t}$	Central Moravia	0.041	0.832	0.004	*ambiguous*	-0.223	19.
8	CZ08	$D_{8,t}$	Moravia Silesia	0.320	0.343	0.075	*ambiguous*	-0.230	20.
9	HU10	$D_{9,t}$	Central Hungary	1.574	0.000	0.955	β-convergence	-0.431	28.
10	HU21	$D_{10,t}$	Central Transdanubia	0.949	0.000	0.878	β-convergence	-0.177	18.
11	HU22	$D_{11,t}$	Western Transdanubia	0.683	0.000	0.696	β-convergence	-0.233	21.
12	HU23	$D_{12,t}$	Southern Transdanubia	0.282	0.000	0.647	β-convergence	-0.060	7.
13	HU31	$D_{13,t}$	Northern Hungary	0.657	0.000	0.678	β-convergence	-	*irrelevant*
14	HU32	$D_{14,t}$	Northern Great Plain	0.504	0.001	0.622	β-convergence	-	*irrelevant*
15	HU33	$D_{15,t}$	Southern Great Plain	0.076	0.415	0.056	*ambiguous*	-0.052	5.
16	PL11	$D_{16,t}$	Łódzkie	1.228	0.000	0.957	β-convergence	-0.079	10.
17	PL12	$D_{17,t}$	Mazowieckie	1.713	0.000	0.939	β-convergence	-0.333	27.
18	PL21	$D_{18,t}$	Malopolskie	0.905	0.000	0.848	β-convergence	-0.057	6.
19	PL22	$D_{19,t}$	Śląskie	0.732	0.000	0.791	β-convergence	-0.174	17.
20	PL31	$D_{20,t}$	Lubelskie	0.492	0.000	0.659	β-convergence	0.039	2.
21	PL32	$D_{21,t}$	Podkarpackie	0.551	0.000	0.728	β-convergence	0.040	1.
22	PL33	$D_{22,t}$	Świętokrzyskie	1.013	0.000	0.919	β-convergence	-	*irrelevant*
23	PL34	$D_{23,t}$	Podlaskie	0.816	0.000	0.842	β-convergence	-	*irrelevant*
24	PL41	$D_{24,t}$	Wielkopolskie	1.211	0.000	0.924	β-convergence	-0.150	15.
25	PL42	$D_{25,t}$	Zachodniopomorskie	0.503	0.000	0.832	β-convergence	-0.111	12.
26	PL43	$D_{26,t}$	Lubuskie	0.775	0.000	0.781	β-convergence	-0.077	8.
27	PL51	$D_{27,t}$	Dolnośląskie	1.145	0.000	0.841	β-convergence	-0.150	14.
28	PL52	$D_{28,t}$	Opolskie	0.488	0.020	0.373	β-convergence	-0.050	4.
29	PL61	$D_{29,t}$	Kujawsko-Pomorskie	0.683	0.000	0.867	β-convergence	-0.078	9.
30	PL62	$D_{30,t}$	Warmiňsko-Mazurskie	0.775	0.000	0.880	β-convergence	-	*irrelevant*
31	PL63	$D_{31,t}$	Pomorskie	0.966	0.000	0.914	β-convergence	-0.124	13.
32	SK01	$D_{32,t}$	Bratislava region	1.623	0.000	0.780	β-divergence	-0.586	29.
33	SK02	$D_{33,t}$	Western Slovakia	1.215	0.001	0.649	β-convergence	-0.162	16.
34	SK03	$D_{34,t}$	Central Slovakia	0.924	0.000	0.691	β-convergence	-0.086	11.
35	SK04	$D_{35,t}$	East Slovakia	0.692	0.000	0.682	β-convergence	-0.036	3.

Source: own

Conclusion

The presented results represent a modification of traditional approaches. The reasons which led to correction are mentioned above.

The aim of the paper was to verify the concept of β-convergence on regional level for 35 NUTS 2 regions in Visegrad Four countries between 1995 and 2012. Our approach bases on a variable steady state with a non-zero growth and the assumption of convergence from below. Β-convergence was statistically confirmed by 26 NUTS 2 regions in V4 countries. Based on parameter β_1 in first approach and on parameter γ_r in second approach, we can state the speed of convergence and verify the hypothesis about β-convergence. The estimate of parameter β_1 shows that the majority of 26 NUTS 2 regions that converge to steady state evince a faster convergence to steady state in case of a lower level of regional GDP per capita and vis-versa. The hypothesis of β-convergence was verified based on the presented estimations of both econometric models.

Two NUTS 2 regions of V4 countries (HU10 Central Hungary and PL12 Mazowieckie) demonstrate β-convergence, but they have very high value of parameter β_1, which actually speak about a high economic level of the regions. These regions are advanced NUTS 2 regions and include the agglomerations of capital cities (Budapest, Warsaw) which converged in the research period to steady state the fastest. In these two cases we cannot verify the concept of β-convergence completely.

NUTS 2 regions CZ01 Prague and SK01 Bratislava region diverged in research period. They did not fulfil the criterion of convergence from below. The GDP per capita exceed significantly the level of steady state. This is why we should speak about convergence from above. The values diverge from above and we verified a statistically significant β-divergence

The econometric models of regional convergence show that the concept of evaluating the level of convergence process directly depends on how the steady state is defined as it unambiguously influences results reached. We have to emphasize that the results are based on a so called unconditional β-convergence otherwise we should include next variables into a regression formula. For example, institutional framework, development of foreign trade, language literacy of inhabitants etc.

By this modification we could analysed so called conditional β-convergence. This means completely different model specification. The second approach used supported theory of real convergence in application of non-linear regression panel data model, using technique of dummy variables. Due to them, we succeeded in convergence speed of NUTS 2 regions by its comparison with average level of GDP per inhabitant of EU 28. In the context the values were ranked and order of regions according to their speed of convergence towards average level was determined.

The results can be a subject of critical analyses. However, the paper showed possibilities which way it is possible to approach towards evaluation of convergence process.

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