

## EXAMINING THE ECONOMIC CONVERGENCE IN CENTRAL AND EASTERN EUROPE BY USING THE MARKOV CHAIN METHOD

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**Abstract:** Promoting convergence among regions is one of the European Union's (EU) political goals. In our study we analyse this phenomenon on the level of NUTS3 in the post-socialist Central and Eastern Europe. One of the methods used to analyse the change in economic inequalities is the Markov chain model.

Using the model, we describe contexts related to regional convergence, responding to the existence and speed of the phenomenon, including its spatial characteristics. Based on the results, convergence in Central and Eastern Europe exists and takes a very long period of time. When analysing convergence, it is necessary to take into account the country effects (institutions) and the effective participation of metropolitan areas.

**Key words:** Central Eastern Europe, convergence, Markov chain model, mobility, GDP

### INTRODUCTION

Convergence and catching up of Central and Eastern Europe has become a highlighted topic during the past one or two decades from both scientific and sectoral policy aspects. The majority of these countries joined the EU. This fact gave a large momentum to the subject, in particular to the subsidy policies involving lagging behind areas.

Numerous researchers studied this field in this period. They tested the main economic growth theories with regional scope, from neoclassic approach to the new economic geography integrating spatial dimensions [6], [12], [17], [5], [7], [1]. The justification of the convergence has been influenced by several factors, such as the examined territorial level, the time of observation and the applied assessment methods. Convergence analyses showed the importance of country specific factors (policies and institutions), the existence of spatial (spill-over) and agglomeration effects, clubbing of regions with similar development level and growth potential as well as the connections between territorial differences and peripherality.

In our study we examined how convergence changed following the year 2000 in six post-socialist countries characterised by analogous history and socio-economic structure. During the analysis we describe the mobility related to these areas pointing out the phenomena of catching up and marginalisation.

### MATERIALS AND METHODS

NUTS3 level regions were the meso-level observation units in our study, while at macro level we examined the post-communist Central and Eastern Europe, i.e. Poland, the Czech Republic, Slovakia, Hungary, Romania and Bulgaria. In case of NUTS3 regions we delineated functional (nodal) metropolitan areas. Important cities were united with their agglomerations. Data were provided by Eurostat. Per capita GDP has been estimated, derived from national data, on 2010 prices. The observed period of the examination was 2000 to 2015.

According to Quah [14], [15] sigma convergence cannot adequately describe the mobility of regions, thus we followed the methodology recommended by him: the Markov chain model. This approach makes it possible to evince the movements of regions regarding the different time periods by applying so-called stochastic transition probability

matrices. Incomes shall be discretionalised for this method; establishing the given bins requires great attention. In case the probability of transition from one class to another is high, then the mobility is also high. If the probability of staying in the same class is high, it means that the mobility is low. Mobility and/or stability indices are available for measuring movement, while the so-called ergodic distribution expects a state in which the distribution does not change any longer, thus it can be interpreted as a future stable point. It is also possible to calculate the so-called convergence index that measures the convergence toward the medium class (average). If this value is low, then the distribution is multimodal and convergence clubs have come into existence. The speed of transition – i.e. the time needed for reaching one state from another – can also be determined. In the Markov terminology it is called the average mean first passage time. The half-life of the chain can be determined, too. This value shows how much time is needed for reaching the halfway point towards the steady-state. Detailed context of the model is discussed by numerous other authors [13], [8], [11], [9].

### RESEARCH RESULTS

For discretising the examined area we used selection by observations of an equal number; the regions was divided into five equal parts (quintiles). Five categories were created: the first, second, third, fourth categories include those reaching 54%; 82 %; 101% and 133% of the regional average, respectively. The fifth category contains those areas exceeding 133%. This so-called regional number method provided the basis for our calculations. Furthermore, examinations were also made by population belonging to the given categories and states.

According to the regional number based one step transition matrix the proportion of stable regions (that do not change category) is high: 112 regions remained in the same category during the examined period (Table 1). Most developed regions showed the highest level of stability (91%), followed by categories 2, 1 and 4 with considerably lower percentage. Regions belonging to the middle category are characterised by the lowest stability and the highest mobility. Only 54% of those areas falling into this quintile remained here until the end of the period. As regards of mobility upward movement is more probable in the first three categories. Based on these results convergence can clearly be detected. In case of the group with the lowest economic performance the probability of changing into one quintile higher is 33%. As for the second and third categories the same values are 21% and 30%, respectively. Two regions moved not one but two categories during the examination period: one jumped up from category 3, while the other went down from category 4.

Altogether the probability of downgrade is higher in case of the fourth and fifth categories (the latter can of course move only to this direction). Provided that we complete the analysis based on the population the above-mentioned relations appear in a more sophisticated form. Values connected to both stability and mobility change: the probability of catching up is higher, that of exclusion is lower in each case. Population of upward moving regions is significantly higher (examined by Kruskal-Wallis H test); indicators of stability and mobility alter accordingly from region number based calculations (Table 2). Results have been compared to the urban-rural typology including larger city proximity [2]. We revealed that upward change of category is more frequent in urban and peri-urban regions than in predominantly rural areas. On the contrary, downward mobility is more probable in these latter regions. Directions, strength and reliability of the relations were justified by cross-tabulation analysis.

**Table 1.**

**One step transition probability matrix for per capita GDP in Central and Eastern Europe (2000-2015)**

	1	2	3	4	5		1	2	3	4	5
1	0.67	0.33				1	0.58	0.42			
2	0.12	0.68	0.21			2	0.07	0.71	0.23		
3		0.18	0.52	0.27	0.03	3		0.14	0.44	0.33	0.10
4		0.03	0.24	0.62	0.12	4		0.02	0.16	0.66	0.16
5				0.09	0.91	5				0.04	0.96

Note. Table on the left: examination results based on region numbers, table on the right: examination results based on population.

Source: own calculation, 2018

Steady-state distribution proved to be very uneven. Results calculated by region numbers are slightly more balanced than in case of population-based examinations (Table 2). As for the latter, the extent of concentration is remarkable in quintiles 4 and 5 which indicates that economic catching up can clearly be connected to demographic processes (i.e. migration toward cities and urban areas). The convergence index also underlined this tendency and the phenomenon of club-forming as well. Convergence directing toward steady-state distribution can be considered very slow in both cases with half-lives of 7.35 and 6.82 periods. Mean first passage times palpably show the convergence process: upward category changes are definitely quicker in lower development levels (Table 3). During these examinations the advantage of more urbanised areas regarding convergence could be again observed. It shall be noted that the rate of transition in more developed regions is systematically higher in both cases.

**Table 2.**

**Summarising statistics on Central and Eastern European convergence**

	1	2	3	4	5	1	2	3	4	5
Initial distribution (%)	19.0	21.0	20.0	21.0	19.0	12.0	16.0	19.0	18.0	35.0
Steady-state (%)	7.0	20.0	19.0	22.0	33.0	1.0	5.0	6.0	15.0	73.0
Half-life	7.35 periods					6.82 periods				
Stability	0.68					0.67				
Mobility	0.40					0.42				
Convergence index	0.28					0.26				

Note. Table on the left: examination results based on region numbers, table on the right: examination results based on population.

Source: own calculation, 2018

In order to answer the question about where convergence occurred, we indicated the states of the involved regions in a map (Figure 1). The Czech Republic has the highest number of stable regions and population: 92% of the areas and 97% of the population belong to the most advanced category. In Poland over 80% of the population is characterised by stability. In some sense it reflect historical division [4]. Western and metropolitan areas are characterised by more favourable states, while the central and eastern parts of the country have average and below-average values, respectively. Beside the capital, other metropolitan areas (the so-called “second-tier cities”, [3]) belong to the most improved category. One of them (Łódź+) enters this group by 2015, while Szczecin+ has fallen out of this category by the end of the examination period. Further catching up can be attributed to other “smaller metro” type towns (e.g. Ostrołęka, Rzeszów, Kalisz). Based on the proportion of non-transition regions Bulgaria, Hungary, Romania and Slovakia fell into the same group. However, these countries show great differences regarding the direction of mobility. Hungary can be displayed in this respect. With the exception of the central region, Fejér, Győr-Moson-Sopron, Zala, Bács-Kiskun, Csongrád,

Borsod-Abaúj-Zemplén and Komárom-Esztergom counties (the last being the only upward-moving) all the other areas level downward. Their cumulated population reaches approximately 40%. In case of Hungary Békés county shall be mentioned, too. It is the only region among those participating in the examination that deteriorated by two categories in 15 years. In case of all the other above-mentioned countries the process of catching up is dominant.

**Table 3.**

**Average mean first passage times in regions of Central and Eastern Europe**

	1	2	3	4	5		1	2	3	4	5
1	14.2	3.0	9.6	17.9	36.2	1	147.9	2.4	7.3	17.0	18.0
2	40.5	5.1	6.6	14.9	33.2	2	349.7	21.1	5.0	14.6	15.6
3	58.7	18.2	5.3	8.3	26.6	3	436.6	86.9	16.3	9.6	10.6
4	65.2	24.7	9.3	4.6	21.5	4	454.7	105.0	28.3	6.8	8.9
5	75.8	35.3	19.9	10.6	3.0	5	479.7	130.0	53.3	25.0	1.4

*Note. Table on the left: examination results based on region numbers, table on the right: examination results based on population.*

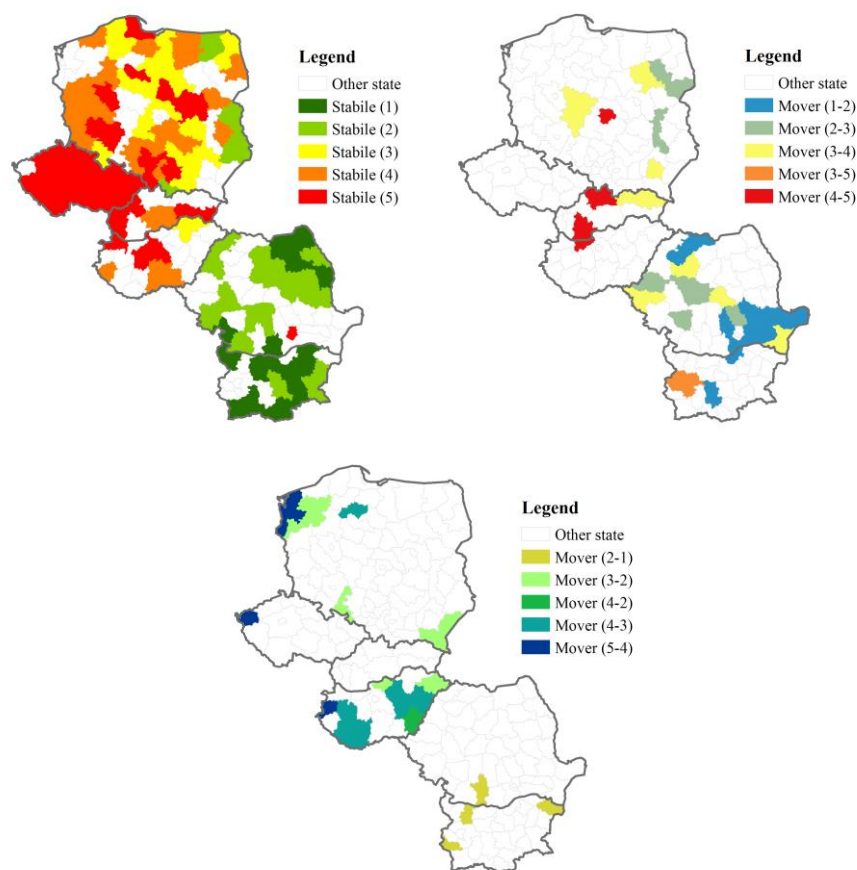
*Source: own calculation, 2018*

In Romania convergence cannot be dissociated from the settlement network. Counties with large, second-tier cities and important towns (Timis, Cluj, Brasov, Arad, Sibiu, Constanta) show more emphasised improvement. In Bulgaria we can find the only region (Sofia+) that was able to change two categories upward within the examined period. Plovdiv (another second-tier city) and Ruse province with its high population potential show considerable catching up. The proportion of those stalling in the lowest two categories is high in both countries: 47% and 57% in Romania and Bulgaria, respectively. The entire area of Slovakia is involved in catching up processes. Two of the Slovakian regions (Banská Bystrica and Prešov) converged into category 4 by 2015, while all the other regions belonged to the most advanced category in the last year of the research.

**CONCLUSIONS**

In our study we examined the convergence of the regions found in six post-socialist countries by the changes of per capita GDP values between 2000 and 2015. Based on the results it can be concluded that catching up was an existing phenomenon in this period, but achieving full convergence requires a much longer time frame. This process is due to the driving force of metropolitan areas (since rural regions far from large cities represent only one-tenth of the upward-moving areas). It emphasises the positive effects of agglomeration externalities in economic growth [10]. Within the framework of this article the role of spatial dimensions is suitable for confirming the phenomenon of national level differentiation. Among the countries involved Hungary shall be pointed out where marginalisation affected considerable area and population between 2000 and 2015. Assessment of spatial dimensions is still a field to be studied in Central and Eastern Europe by e.g. testing the impact of regional environment on growth [8] or estimating the transition of spatial autocorrelation patterns [16].

At last, but not at least we reckon that the Markov chain model is able to reveal diverse and valuable results. Its application is highly recommended as a supplement for “classical” analysing methods.



**Figure 1. States of economic performances in the regions of Central and Eastern Europe (2000-2015)**

*Source: own calculation, 2018*

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