



**IS INTERNAL MIGRATION RELEVANT TO REGIONAL
CONVERGENCE?
COMPARATIVE ANALYSIS ACROSS FIVE EUROPEAN COUNTRIES**

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Biographical Notes

Daniela Bunea has a bachelor degree in Economics and a master degree in European Economy and Finance both from the University of Pitesti in Romania. Currently, she attends a PhD program in Economics at the Bucharest Academy of Economic Studies. Her areas of interest are related to the labour market and mainly during her PhD she was focusing on the internal migration of people in both Romania and Spain. Moreover, this paper is part of her PhD thesis and it was presented at the 9th World Congress of Regional Science Association International “Changing Spatial Patterns in a Globalising World” held in Timisoara, Romania, May 9-12, 2012.

Abstract

This paper carries out a comparative analysis across five European countries of the impact of internal migration on regional income convergence process at NUTS 2 level.

Convergence can be defined as the process by which poorer regions catch up richer regions and, as a consequence, regional disparities decrease. The phenomenon is appreciated using the concepts of sigma- and beta-convergence. Theoretically, human migration is one vital adjustment mechanism of regional disequilibria which contributes to enhancing convergence.

The study uses the methodology of two-way fixed effects panel data model and its main results point out at sigma-divergence in income evolution in Hungary and Romania and at sigma-convergence trends in Austria, Spain and rather constancy in Sweden. Instead, all countries but for Sweden exhibited beta-convergence. Hungary, Sweden and Spain recorded relatively higher gross migration rates. But despite this fact, internal migration's impact on beta-convergence was quite

small (Romania and Spain) or inexistent (Austria, Hungary and Sweden).

JEL Classification: J61, R11, R15, R23

Key-words: convergence, internal migration, fixed-effects panel data, spatial dependence, comparative study

Introduction

According to the Eurostat Nomenclature of Territorial Units of Statistics (NUTS) classification, Austria is divided in 9 states, Hungary in 7 planning and statistical regions, Romania in 8 regions of development, Spain in 17 autonomous communities and 2 autonomous cities, and Sweden in 8 national areas. These are the NUTS 2 territorial units, i.e. the basic units for the application of regional policies or the administrative divisions⁴. The choice for these countries is a consequence of the different timing of EU accession and of their socio-economic diversity.

This paper uses panel data (each region is observed each year) in order to capture the year-by-year changes suffered by the variables employed. The periods under analysis are 1996-2008 for Austria, 1995-2007 for Hungary, 1995-2008 for Romania, 1998-2008 for Spain and 1997-2008 for Sweden. The analysis is carried out at regional (NUTS 2) level and uses indicators such as real GDPs per capita (levels and growth, in prices of the initial year for each country) and migration rates (both net and gross)⁵. These variables are processed in order to determine their time evolution and the existence of sigma- and beta-convergence. Data are taken from the national official institutes of statistics of each country⁶. Also, I need to use the GPS longitude and latitude coordinates of each statistical unit as they are compulsory in computing spatial dependence.

The article is structured as follows: section 2 makes a review of the existing literature and convergence methodology together with some empirical results, including the impact of migration; section 3 carries out an assessment of the time evolution of the internal migration flows within each country; sections 4 and 5 performs tests of sigma- and, respectively, beta-convergence; and finally, section 6 offers some insights on future research.

Literature Review and Convergence Methodology

Main theories of economic growth

Regional convergence is crucial for European Union integration and, in general, for getting political

⁴ They are available at <http://ec.europa.eu/eurostat/ramon/nomenclatures/>.

⁵ In the case of Spain, I also use consumer price indexes per community in computing real GDP.

⁶ Austria- Statistics Austria, Hungary- HCSO Hungarian Central Statistical Office, Romania- INS National Institute of Statistics, Spain- INE National Statistics Institute, and Sweden- SCB Statistics Sweden.

support for any economic integration. As the integration process became deeper and wider, the issue of regional economic disparities both within-country and between-country grew in intensity, especially if we refer to the desire of new Eastern EU members to catch up with the core EU members.

In the economic growth literature there are two main approaches:

- **exogenous or neoclassical growth theory** (optimistic approach): decreasing disparities in income levels because of diminishing returns to capital and constant returns to scale (Solow, 1956);
- **endogenous or new growth theory** (pessimistic approach): persistent and increasing disparities because of positive returns to scale due to the accumulation of factors (Romer, 1990; Lucas Jr., 1988).

Instead, the **new economic geography**, neither optimistic nor pessimistic, claims that the economic situation of a region depends also on its location and neighbours; as a consequence, poor regions should be favoured if they are surrounded by rich neighbours (Krugman, 1991).

Types of convergence

From the perspective of the traditional neoclassical growth theory, convergence takes place when there is a negative relationship between the initial GDP per capita and its growth in time. Convergence implies a long-run process towards the balancing of per capita national product at different scales (Abramovitz, 1986). Thus, the further a region is from its own steady state the faster the region will grow (Solow, 1956).

Convergence should be interpreted in two different ways (Fischer & Stirböck, 2005):

- **convergence in terms of income level:** regions similar in technology, preferences, legal system, etc. tend to reach the same steady-state income level in the long run;
- **convergence in terms of income growth:** all regions will reach the same steady-state growth rate if technology is a public good.

Bernard and Durlauf (1996) define convergence as a process by which each region moves from disequilibrium to equilibrium and distinguishes between global convergence (difficult to reach) and local convergence (more plausible) in a between-country convergence framework.

According to the vast convergence literature, the evolution of regional income can be appreciated by two main types of convergence (Barro & Sala-i-Martin (from now on, BSiM), 1992; Marques & Soukiazis, 1998):

- ♦ **sigma-convergence** (traditional, belongs to Baumol 1986): measures the temporal

dispersion of real output across regions using the standard deviation or the coefficient of variation; when the dispersion falls over time this is a sign of convergence, otherwise there is divergence, and when it shows ups and downs, there is a mix of both⁷;

- ♦ **beta-convergence** (neoclassical, belongs to Barro et al. 1991): measures the relationship between the previous per capita income and income growth rate using the panel regression:

$$\log\left(\frac{gdp_{it}}{gdp_{i,t-1}}\right) / T = \alpha - b * \log(gdp_{i,t-1}) + \delta * X_{it} + \varepsilon_{it} , \quad (1)$$

where gdp_{it} is the per capita income of year t , $gdp_{i,t-1}$ the per capita income at the beginning of each period over which the growth rate is computed, T the time length, α the autonomous or steady-state growth rate (or technological progress rate), b the convergence coefficient, X_{it} a vector of structural exogenous variables influencing income growth, and ε the idiosyncratic error.

The **rate or speed of convergence**, i.e. beta, is computed as $\beta = -\frac{\ln(1+b*T)}{T}$. *If beta turns positive there is convergence, otherwise there is divergence.* One can also compute the **half life**, i.e. the number of years necessary to cover half the distance from the steady state, as $\kappa = -\frac{\ln 2}{\ln(1+b)}$ (Hierro & Maza, 2010). BSiM (1992: 230) estimates β non-linearly because “... as T tends to infinity, the coefficient [b] tends to zero”.

Also, beta-convergence can be:

- ❖ *absolute/ unconditional/ strong*: when homogenous regions (in technology, preferences, institutions, language, etc., or in initial conditions) tend to reach the same steady state in time, i.e. beta is obtained without introducing any structural variable X ;
- ❖ *relative/ conditional/ weak*: when heterogeneous regions (although with similar initial conditions) tend to reach their own steady-state levels, i.e. beta is obtained including some structural variables X ⁸.

Conditional convergence is more appropriate when using between-country data whereas unconditional convergence is more adequate with within-country data (Sala-I-Martin, 1995). Even so, BSiM (2004) recommend using both types of convergence with regional data.

There is also *conditional sigma-convergence* which takes place when the income distribution shrinks over time after controlling for relevant exogenous variables. This implies a decreasing

⁷ Quah (1996) says that sigma-convergence has the shortcoming of offering no information about the intra-distributional dynamics of income.

⁸ Friedman (1992) affirmed that beta-convergence tests may be affected by Galton's fallacy of regression toward the mean. Also, both types may suffer from heterogeneity, endogeneity and measurement problems (Durlauf & Quah, 1999).

variance of predicted income (Pfaffermayr, 2007).

While the sigma-convergence tests for the evolution over time of the distribution of per capita income, beta-convergence tests the mobility of the per capita income within the same distribution. Therefore, **beta-convergence is a necessary but not a sufficient condition for sigma-convergence** (stronger)⁹; thus, these two concepts are more complementary than substitutable (Sala-i-Martin, 1995). Or, the “beta” notion examines how fast poor regions become richer and rich regions become poorer; instead, the “sigma” notion examines whether regional incomes become more similar (Magrini, 2007).

Maurer (1995) explains the statistical relation between the two concepts of convergence in six lemmas based on Cauchy-Schwarz inequality:

1. *sigma-convergence implies necessarily beta-convergence;*
2. *beta-divergence implies necessarily sigma-divergence;*
3. *beta-convergence is compatible with sigma-convergence or sigma-divergence;*
4. *sigma-divergence is compatible with beta-divergence or beta-convergence;*
5. *beta-constancy is compatible with sigma-convergence or sigma-constancy;*
6. *sigma-constancy is compatible with beta-convergence or beta-constancy*¹⁰.

A third type of convergence is **stochastic convergence** which implies that the long-run forecasts of income differences across regions evolve to 0 (Carlino & Mills, 1996, Bernard & Durlauf, 1996). Also, Baumol (1986) introduce a forth concept, **club convergence** which denotes regions with similar structures and initial conditions that converge to one another in the long run. Moreover, Chatterji (1992) bases this concept on the endogenous growth theory which is in favour of multiple and locally stable steady states. If regions differ in saving rates, human capital development and technological innovation or if there are weak interregional spillovers of knowledge, they may not converge to a common steady-state position but there might be convergence only within similar groups (clubs) (Martin, 2001).

Critics of absolute convergence in favour of relative convergence include in the growth regression “control/conditioning variables” to account for regional heterogeneity, while critics in favour of club convergence use “split variables” to account for initial conditions. Differentiating between relative and club convergence is difficult. Absolute convergence implies constant α and β and zero δ , relative convergence implies also non-zero δ whereas club convergence implies varying α and β

⁹ Quah (1993) and Friedman (1992) consider sigma-convergence more important.

¹⁰ Sigma-convergence: decreasing $\text{var}(y_{it})$; Beta-convergence: $\text{cov}(y_{it}, y_{i,t-1}) < \text{var}(y_{it})$; Sigma-constancy: steady $\text{var}(y_{it})$ over time; Beta-constancy: $\text{cov}(y_{it}, y_{i,t-1}) = \text{var}(y_{it})$.

and non-zero δ (Johnson & Takeyama, 2003). In practice, club convergence is considered mainly when referring to cross-country convergence, while the others are more suitable when testing within-country convergence.

Convergence and migration

Empirical convergence across countries and regions has started with the work of Barro et al. in 1991. Afterwards, an extensive number of studies flourished. The majority of them are based on the neoclassical growth theory. According to this, in time, poorer regions (with a lower capital intensity or ratio capital/labour) catch up richer regions (higher capital intensity) in their GDP/capita level due to decreasing returns to capital. Moreover, allowing for mobility (people/labour) across regions would speed the rate of convergence only if migrants are homogenous¹¹. Unless controlling for migration, the speed of convergence would be overestimated. Migration is expected to have a negative effect on convergence (BSiM, 2004).

The existing literature predicts that within developed countries, migration is expected to have a rather small impact on income convergence (BSiM, 2004), whereas within developing countries its impact is expected to be higher as migrants are in general low skilled and move from poor agricultural regions to wealthier urban ones (Kirdar & Saracoğlu, 2007).

The impact of migration should be assessed considering both net and gross migration. Using gross (arrivals and departures) and net migration (balances) could yield different results because in- and out-migration may not work symmetrically in the growth rate equation and, therefore, should not be treated as such. It is possible that even when net migration is null, gross migration streams may conduct to important regional redistributions of human capital and, in turn, regional characteristics may reflect differently on gross migration flows. Another way put, a subtle variation in net migration rate can be accompanied by large variations in both in- and out- migration rates. Therefore, using only net migration instead of both net and gross migration could be misleading. According to the neoclassical approach, in-migration should negatively impact on convergence while out-migration positively (Østbye & Westerlund, 2007; Etzo, 2008).

Econometric methods of convergence estimation

In assessing convergence, either across European regions or within-country regions, various researchers employed the following econometric methods of estimation:

- cross-sectional data using OLS or NLS: it is affected by omitted variables and by the

¹¹ The issue of heterogeneous migrants will be investigated in a future paper.

assumption of regional homogeneity in parameters (Arbia et al., 2005);

- panel data with fixed effects (Islam, 1995; Evans, 1997; Etzo, 2008): allow for unobserved regional heterogeneity or time invariant characteristics, present more variability and less collinearity, allow for more degrees of freedom, provide more efficient estimates and are more informative; such studies found higher beta rates;
- dynamic panel data using GMM in first differences (Caselli et al., 1996; Tondl, 2001) to treat endogeneity or system GMM to overcome the problem of weak instruments (Blundell & Bond, 1998);
- cross-sectional spatial data models using OLS or ML: take advantage of the spatial dependence existing between the growth rates of neighbouring regions (Rey & Montouri, 1999; Niebuhr, 2001; Carrington, 2002);
- spatial fixed-effects panel data: help separating the spatial heterogeneity (region-specific characteristics) across regions from spatial dependence (Arbia et al., 2005);
- spatial dynamic panel data (Badinger et al., 2002).

Spatial econometrics is a branch of econometrics which deals with spatial dependence and spatial heterogeneity in cross-sectional and panel data regression models. The necessity to use spatial econometrics in convergence testing is because regional data cannot be independently generated given similarities among adjacent regions (Arbia et al., 2005). ***Spatial dependence*** can be split in nuisance dependence and substantive dependence. The existence of *nuisance (error) dependence* (or spatial autocorrelation) violates the OLS hypothesis of independent residuals thus generating unbiased but inefficient OLS estimates¹². This form of spatial dependence is due to poor matching between observations and spatial patterns, to measurement problems or to omitted variables spatially autocorrelated. *Substantive dependence* is due to spatial spillover effects (externalities) across regional boundaries and ignoring it would produce biased estimates (Anselin & Rey, 1991). ***Spatial heterogeneity*** refers to structural instability, i.e. varying error variances (heteroskedasticity) or variable coefficients. Spatial heterogeneity is related to the notion of *convergence club*. The existence of convergence clubs requires estimating one growth equation per club. Spatial dependence is more expected in internal regional convergence studies because factors of production are quite mobile across regions of one country (Aldan, 2005). This phenomenon can be annihilated by introducing regional dummies in OLS estimations (Paas et al., 2006).

¹² In the absence of relevant exogenous variables, spatial autocorrelation proxies for these omitted variables taking over their effects. Also, R² would be misleading and *t* and *F* statistics would be biased.

Moran's I statistic, the most common statistic in detecting global spatial dependence¹³, works under the null hypothesis of no spatial autocorrelation and takes values within the range [-1, 1] with -1 indicating perfect dispersion, +1 perfect correlation/clustering, and 0 random spatial pattern (Moran, 1950). **Geary's C statistic**, more sensitive to local spatial autocorrelation, is in the range [0, 2] with values < 1 indicating positive spatial autocorrelation, values > 1 negative autocorrelation, and values ≈ 1 no spatial dependence (Geary, 1954).

The models largely employed in testing spatial dependence are the spatial error model which tests for nuisance dependence, the spatial lag/autoregressive model and the spatial cross-regressive model both testing for substantive spatial dependence. The **spatial error model (SEM)** replaces the error term ε_{it} by $(1 - \lambda W)^{-1} \mu_{it}$, where W is the row-standardized weight matrix and λ is a nuisance parameter. This model should be estimated using ML since OLS returns unbiased but inefficient estimates¹⁴. Further, the **spatial lag model (SAR)** implies adding the *spatial lag of the dependent variable* in the right-hand side of the growth equation, i.e. $W * \log(gdp_{it}/gdp_{i,t-1})$; because this spatial lag is endogenous, SAR should be estimated via maximum likelihood (ML) because OLS estimates would be biased and inconsistent¹⁵. Next, the **spatial cross-regressive model (SCR)** is estimated adding the *spatial lag of the independent variable* in the right-hand side of the equation growth, i.e. $W * (\log gdp_{i,t-1})$; because this spatial lag is exogenous, the model can be estimated via OLS (Anselin, 1999).

SAR and SCR are both suitable to filter out spatial spillovers, but when spatial dependence is caused by measurements problems (mismatch between economic activity and regions) only SAR is suitable (Aldan, 2005; Anselin, 1999). Combining these two models in one single is also possible, thus forming the **spatial Durbin model** (Viton, 2010).

Within-country beta-convergence: previous empirical results

Rey and Montouri (1999) employed a spatial econometric perspective in analysing the dynamics of regional income convergence patterns in the US over the period 1929-1994. They used cross-

¹³ $I = \frac{N}{S_0} * \left[\frac{\sum_i \sum_j w_{ij} (y_i - \bar{y})(y_j - \bar{y})}{\sum_i (y_i - \bar{y})^2} \right]$, where N is the number of regions, S₀ the sum of the elements in the spatial weight matrix W which summarizes the spatial effects between regions, w_{ij} are the elements/weights (i, j) of the matrix W, $w_{ij} = c_{ij} / \sum_{j=1}^N c_{ij}$, where $c_{ij} = 1$ when i and j share a common border and 0 otherwise.

¹⁴ The only difference is that ML estimators do not correct for the degree of freedom.

¹⁵ LMLAG (Lagrange multiplier test based on spatial lag model) is used to test for spatial autocorrelation in spatial lag models estimated with ML.

sectional data. Their results revealed the existence of spatial correlation in growth rates. Because regions cannot be treated as “isolated islands” (Quah, 1996), convergence studies should consider the spatial dependence of regional growth, i.e. one region is also dependent of other regions growth due to various interactions (trade, labour markets, information, knowledge, etc.).

Johnson and Takeyama (2003) studied absolute, conditional and club convergence hypotheses in US states in 1950 and 1993. Their results confirmed the existence of both conditional and club convergence, although club convergence seems to have been stronger.

BSiM (2004) estimated convergence in per capita personal income across 48 states of USA over 1990-1990 (divided in 8 sub-periods) using cross-sectional data and found significant but different conditional convergence rates for each decade. They used as control variables the population density (and its square value) and the heating degree days. Also, they estimated convergence for Japanese prefectures over 1955-1990 (7 sub-periods) and also found significant but different rates of conditional convergence. The conditioning variables used were the extreme temperature, each prefecture’s own population density and of its neighbours’. They employed a Two-Stage Least Square (2SLS) method of estimation.

Arbia et al. (2005) used spatial fixed-effects panel data in modelling regional convergence and growth within Italian provinces over 1951-2000. The motivation for using both fixed-effects panel data and spatial econometrics is to separate the individual effects of spatial dependence and spatial heterogeneity (i.e. omitted variables)¹⁶. When testing for conditional convergence using cross-sectional data they obtained convergence for the whole period and both sub-periods (1951-1970, 1970-2000). When estimating a fixed-effects spatial lag model, all beta coefficients fall although remain robust, adjusted R² rose, the spatially lagged term of growth rate turned positive and significant, thus confirming the positive effect of technology spillovers, factor mobility and trade on provincial convergence. Afterwards, when estimating a fixed-effects spatial error model, the authors obtained significant spatial autocorrelation coefficients and similar beta coefficients as those obtained using the standard fixed-effects model. Hence, spatial lag model was more suitable.

Kirdar and Saracoğlu (2007) analysed internal convergence across 67 Turkish provinces for the 1975-2000 period. They used panel data, employed also 2SLS method and controlled for provincial fixed effects. The variables used were real gross provincial product per capita, net internal migration rates, provincial population densities and state of emergency status. Their results showed a strong negative impact of migration on provincial convergence because of two main reasons: first, most Turkish migrants were low skilled workers leaving rural areas for urban ones and, secondly,

¹⁶ Fixed effects (i.e. regional dummies) control for omitted, time-invariant variables.

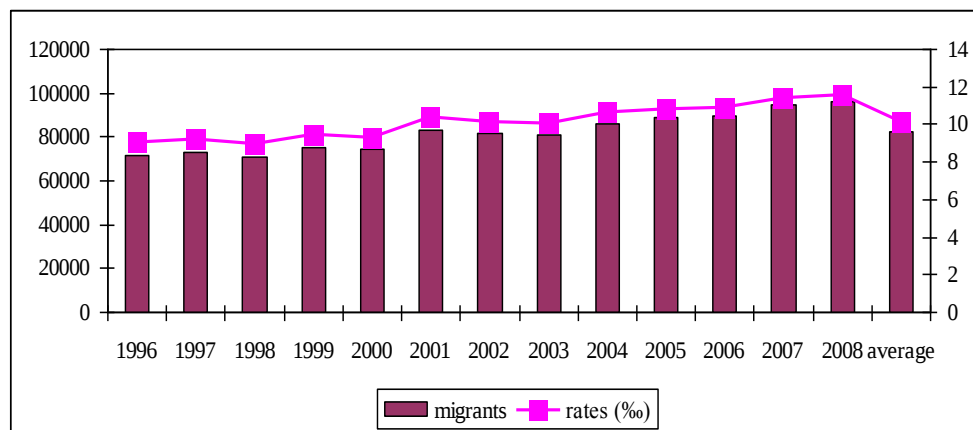
migration within Turkey reached very high levels.

Etzo (2008) assessed the impact of domestic migration on provincial growth rates for Italy over the interval 1983-2002 (divided in two sub-intervals 1983-1992 and 1993-2002). After including conditioning variables (to control for different steady states or structural differences) such as population growth rate and saving rate, and using panel data with fixed effects, the author found conditional convergence during the whole period and the two sub-periods. Afterwards, when adding net migration (with 2 lags), the results showed positive and statistically significant coefficients of migration for 1983-2002 and 1993-2002. Onward, when replacing with gross migration (2 lags), in-migration did affect income growth negatively during the first sub-period, whilst out-migration turned negative and statistically significant for the whole period and the second sub-period. Because both in- and out-migration turned negative and affected growth in the same direction during the first decade, this means that net migration was a bad measure in studying the impact of migration on convergence and that is why proved insignificant earlier.

Evolution of Internal Migration within the Five European Countries

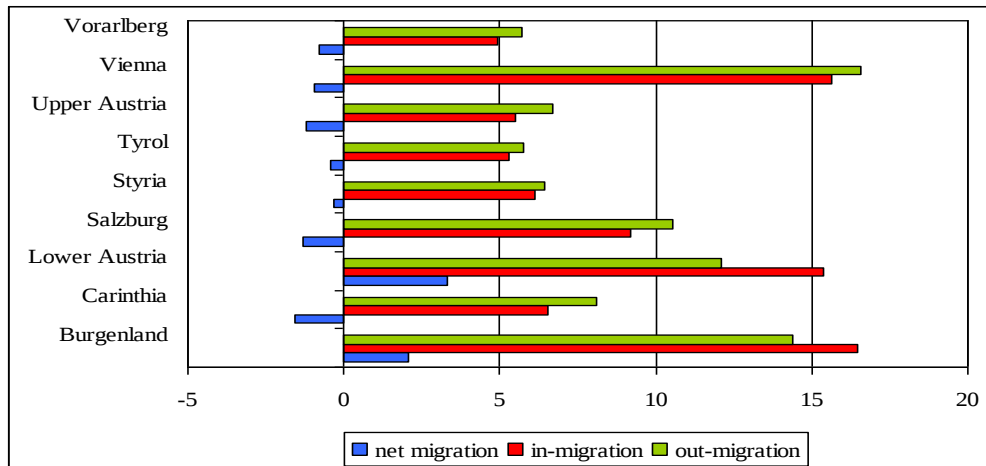
Austria 1996-2008. The annual average rate of gross migration was of 10.1‰ (82,055 migrants). The annual rates went from 8.9‰ in 1998 to 11.5‰ in 2008. On the other hand, average net migration rates by state were within the range ± 2 ‰ with 2 exceptions, Burgenland (2.1‰) and Lower Austria (3.3‰). Two states turned positive balances while the other 7 turned negative balances, Lower Austria and Carinthia registering the highest rates.

Figure 1. Gross migration in Austria (absolute and relative values)



Source: Personal processing based on Austria Statistics data

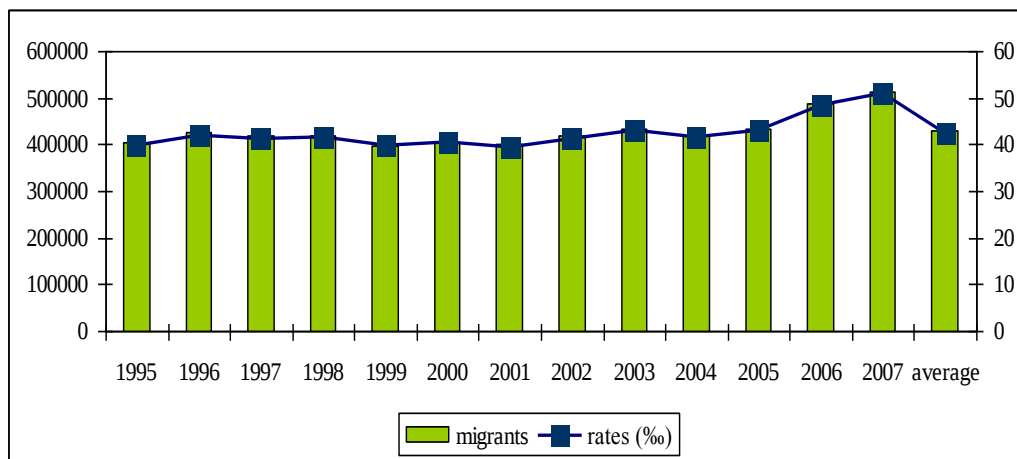
Figure 2. Average migration rates by state in Austria



Source: Personal processing based on Austria Statistics data

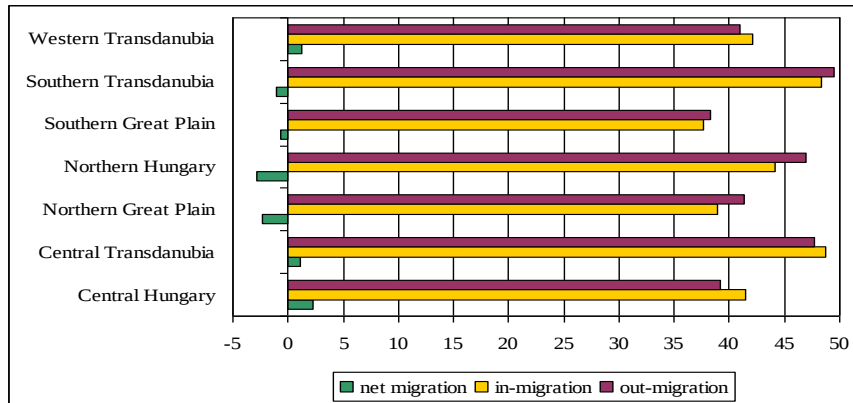
Hungary 1995-2007. In Hungary, the annual average gross rate of migration was 42.5‰ (429,700 migrants) with a minimum value in 2001 (39.3‰) and a maximum one in 2007 (51.1‰). Net migration rates by region were in the range ± 3 ‰, three provinces having net inflows and four having net outflows. Northern Hungary and Central Hungary recorded the highest negative and, respectively, positive rates. Figures 3 and 4 are illustrative.

Figure 3. Gross migration in Hungary (absolute and relative values)



Source: Personal processing based on HCSO data

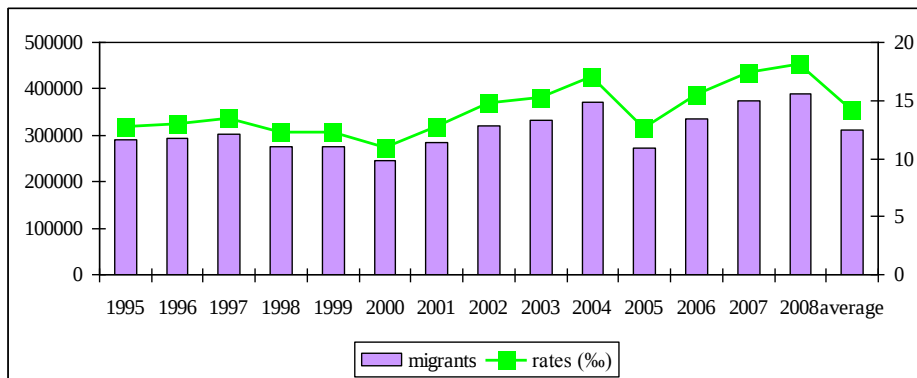
Figure 4. Average migration rates by region in Hungary



Source: Personal processing based on HCSO data

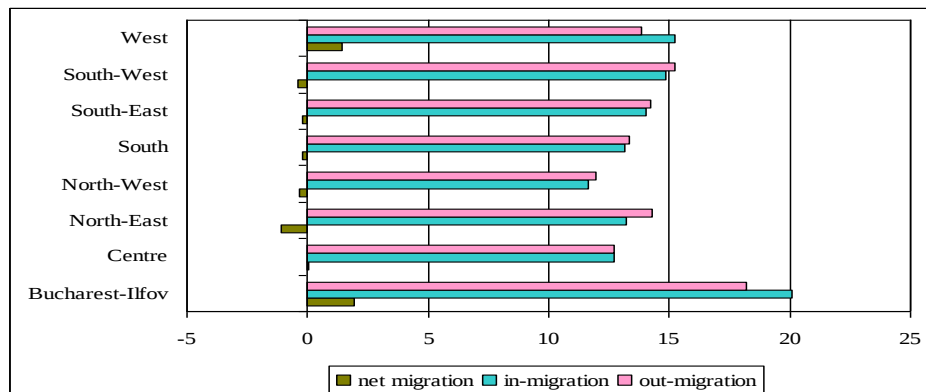
Romania 1995-2008. Romania recorded an annual average gross migration rate of 14.1‰ (311,300 migrants). Annual rates went from 10.9‰ in 2000 to 18.1‰ in 2008. By region, net migration rates were within $\pm 2\%$ with three regions registering positive balances and five negative balances. North-East had the highest net outflow rates while Bucharest-Ilfov had the highest net inflow rates. Figures 5 and 6 are available.

Figure 5. Gross migration in Romania (absolute and relative values)



Source: Personal processing based on INS data

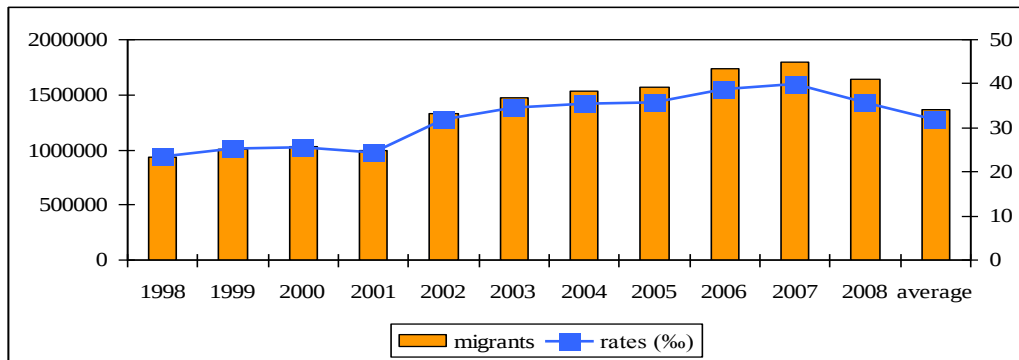
Figure 6. Average migration rates by region in Romania



Source: Personal processing based on INS data

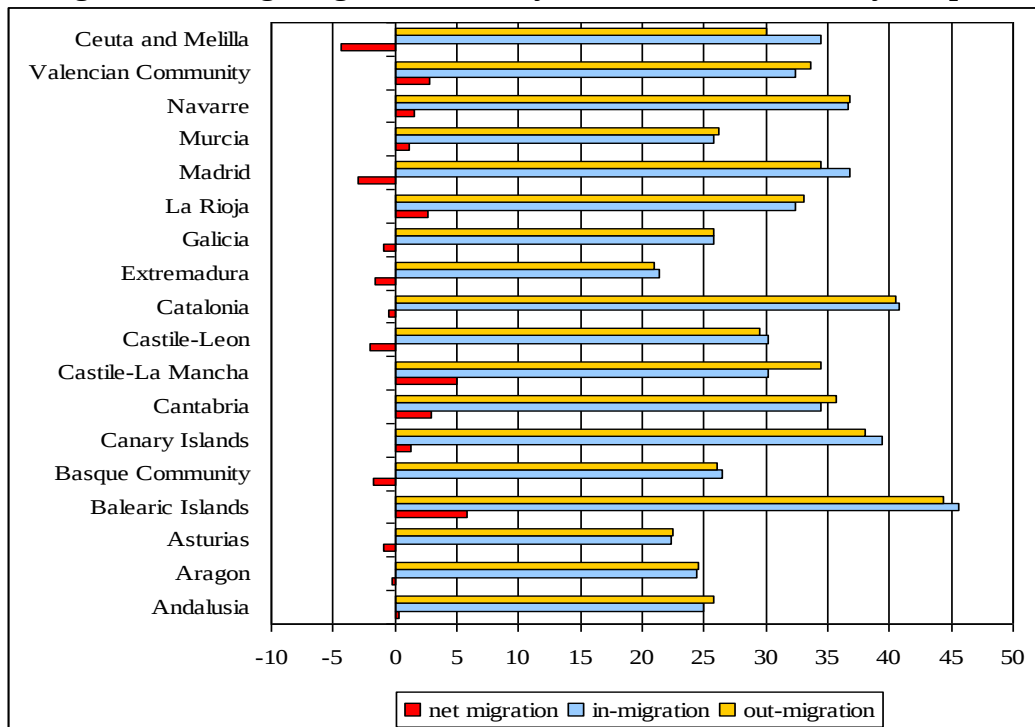
Spain 1998-2008. Spain recorded an annual average rate of migration of 31.7‰ (1,366,050 migrants), a minimum rate of 23.4‰ in 1998 and a maximum rate of 39.7‰ in 2007. Community rates were within $\pm 5\%$, with one exception for the Balearic Islands (5.8‰). Balearic Islands and Ceuta & Melilla recorded the highest rates. Communities divided equally their negative and positive balances. See figures 7 and 8.

Figure 7. Gross migration in Spain (absolute and relative values)



Source: Personal processing based on INE data

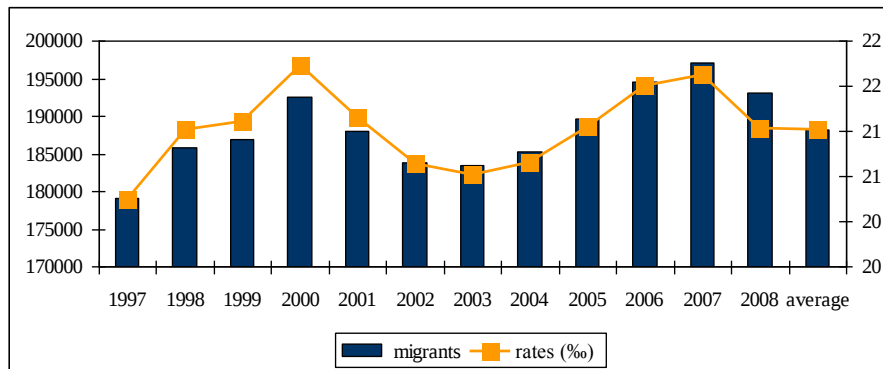
Figure 8. Average migration rates by autonomous community in Spain



Source: Personal processing based on INE data

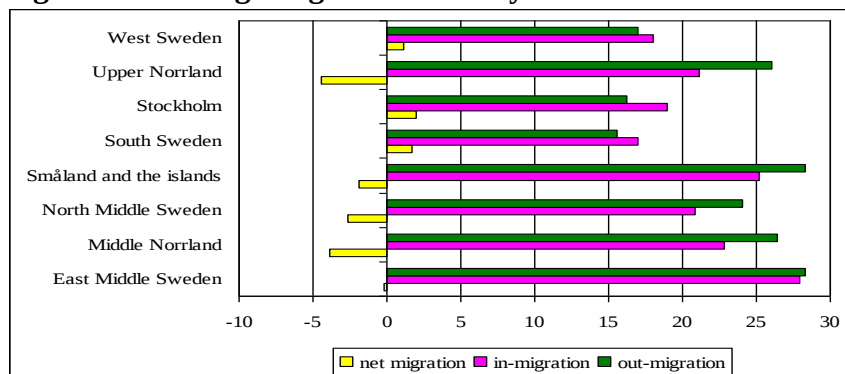
Sweden 1997-2008. Sweden registered an annual average rate of 21‰ (188,260 migrants) with a low in 1997 (20.2‰) and a peak in 2000 (21.7‰). Net migration rates by area were within the range $\pm 5\%$, with 3 areas positive (Stockholm the highest) and five negative (Norrland the highest) (figs. 9 and 10).

Figure 9. Gross migration in Sweden (absolute and relative values)



Source: Personal processing based on SCB data

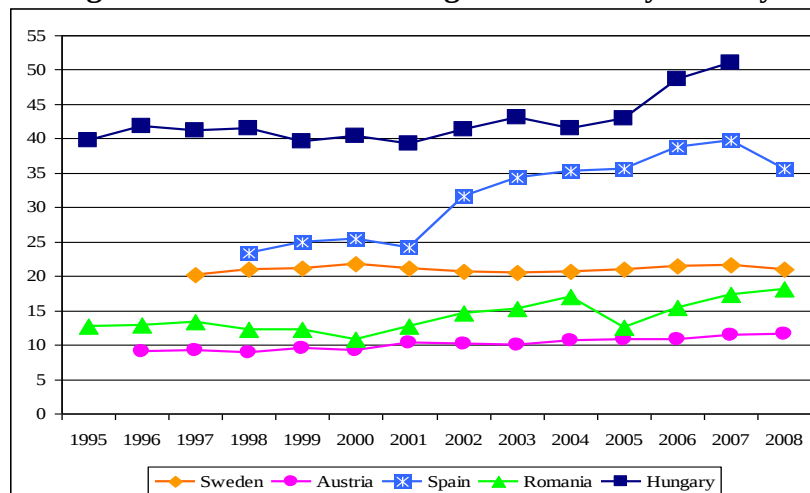
Figure 10. Average migration rates by national area in Sweden



Source: Personal processing based on SCB data

Making a comparison based on previous graphs, figure 11 displays strong fluctuations of gross migration rates in Spain, moderate fluctuations in Hungary and Romania and very small ones in Austria and Sweden. Moreover, the ranking of migration by country followed the hierarchy: Hungary, Spain, Sweden, Romania and Austria, i.e. the Hungarians were the most mobile whilst the Austrians the least mobile.

Figure 11. Gross internal migration rates by country



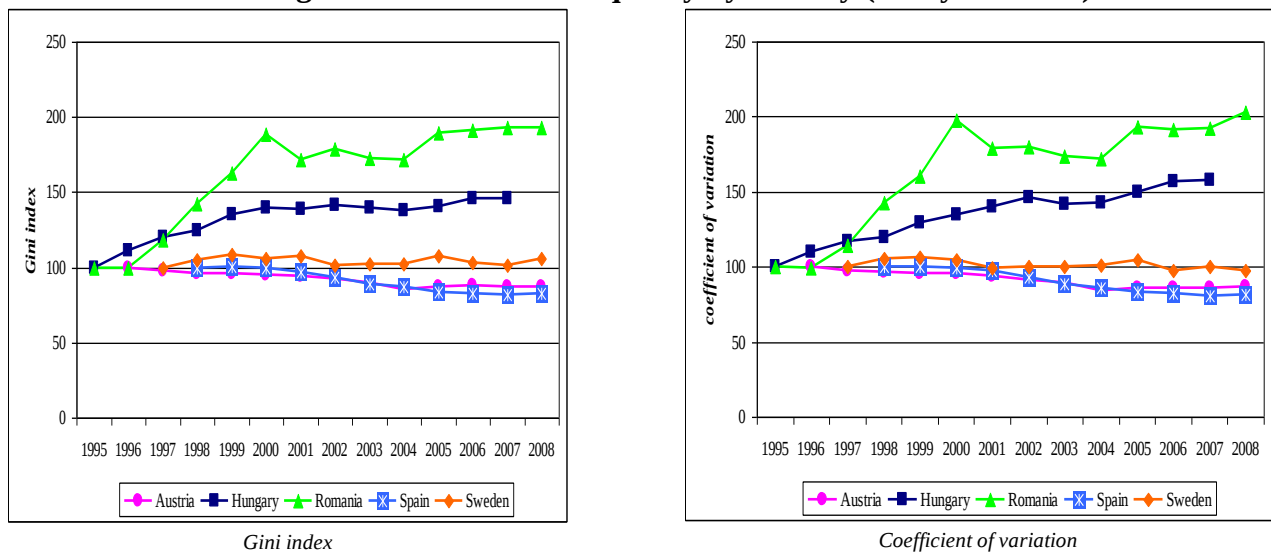
Source: Personal processing

Sigma-Convergence Trends in Regional Income

Before starting, I need to make a short (average) income ranking of regions for each country. In Austria, the ratio between Vienna (the richest state) and Burgenland (the poorest) was 2.11; four states had higher incomes than the average. Hungary registered a ratio of 2.38 between Central Hungary (max) and Northern Hungary (min); two regions of seven were relatively richer than the average. Romania had three regions with above average incomes and a ratio of 2.88 between Bucharest-Ilfov (max) and North-East (min). Spain recorded an average ratio of 1.95 (Madrid vs. Extremadura); seven communities (from 18) were richer than the national average. And finally, in Sweden, the average ratio between the highest regional income (Stockholm) and the lowest one (East Middle Sweden) was 1.62; moreover, Stockholm was the only area with a higher income than the average. Therefore, it seems that the Eastern countries experienced bigger income gaps between leading and follower regions.

The following two charts of figure 12 illustrate the two most representative indexes of inequality used in the literature to assess sigma-convergence: the coefficient of variation and the Gini index. Both indexes are computed using real GDP/capita in logs. So, it seems that Austria and Spain witnessed income sigma-convergence processes while Hungary and Romania witnessed income sigma-divergence. The highest variations belonged to the newest members of the EU, Romania and Hungary. The only uncertainty regards Sweden because, according to the Gini index, it recorded a slight divergence, but as for the C.V., it was subjected to a slight convergence trend. One possibility to solve this is to compute the ratios between the maximum area income and the minimum area income in both 1997 and 2008. The result, a decrease in ratios from 1.63 to 1.61 indicates a weak sigma-convergence.

Figure 12. Indexes of inequality by country (first year = 100)



Source: Personal processing

Beta-Convergence Testing

This study is performed on long panel data (small N/T ratio or asymptotic in T) except for Spain (asymptotic in N)¹⁷. In order to obtain the best linear unbiased estimates (BLUE), I need to test for unit root in the dependent variable, spatial dependence, heteroskedasticity, serial autocorrelation, fixed or random effects (regional and/or time), normally distributed errors, and poolability¹⁸. Table 1 display the main measures of spatial dependence for per capita GDPs (level and growth) and reveals the existence of no spatial dependence¹⁹.

Table 1. Moran's I and Geary's C spatial dependence measures

	<i>Austria</i>		<i>Hungary</i>		<i>Romania</i>		<i>Spain</i>		<i>Sweden</i>	
	Z-val	p-val	Z-val	p-val	Z-val	p-val	Z-val	p-val	Z-val	p-val
Independent variable (log(GDP-1))										
<i>I</i>	-25.38	0.00	-1.47	0.07	-13.23	0.00	15.23	0.00	-14.33	0.00
<i>C</i>	16.48	0.00	3.22	0.00	6.88	0.00	-2.94	0.00	7.63	0.00
Dependent variable (log(GDP/GDP-1))										
<i>I</i>	-0.01	0.49	0.50	0.30	0.44	0.32	2.27	0.01	0.73	0.23
<i>C</i>	0.86	0.19	0.58	0.28	-0.10	0.45	-1.45	0.07	-1.21	0.11

Source: Personal processing

In consequence, the method of estimation is **fixed-effects panel data model via OLS** because data is limited to a precise group of entities and not randomly drawn from a larger population (Baltagi, 2005). In the case of Austria, I use only time fixed effects because the incremental F test rejected the robustness of regional dummies. Instead, in the other four cases, I control for both regional and time effects. Concretely, the econometric regression has the following general form:

$$\log\left(\frac{gdp_{it}}{gdp_{i,t-1}}\right) \Big/ T = \eta_i + \nu_t - b * \log gdp_{i,t-1} + \delta * mri_{i,t-2} + \varepsilon_{it}, \quad (2)$$

where η_i is the region-specific effect (time invariant) and ν_t is the time-specific effect (common to all regions); $mri_{i,t}$ is the migration rate computed as the ratio between the difference of in-migrants and out-migrants at the end of year t, and the region's population at the beginning of year t (or, end of year t-1)²⁰.

The next two tables show the results of the investigation, table 2 when migration is not considered and table 3 when migration is added.

¹⁷ Because of this fact, Roodman (2006) considers that a regional shock, reflected in the error term, will decline over time. Also, the correlation of the lagged dependent variable with the error term will be insignificant. Therefore, in such case using the Arrelano-Bond difference GMM estimation is not necessarily.

¹⁸ All tests and regressions have been carried out in STATA (version 9.2/SE).

¹⁹ In computing the weights matrix (W), I used the following GPS coordinates (longitude and latitude): Austria, Romania and Spain – regions', Hungary – regional capitals', and Sweden – regional largest cities' coordinates.

²⁰ Migration is considered with two lags to avoid simultaneity.

Table 2. Results of regressions with no migration

<i>Migration excluded</i>	Austria	Hungary	Romania	Spain	Sweden
<i>Beta (%)</i>	0.09**	1.92**	1.54**	-0.22	5.18
<i>Half time</i>	770	36	45	-	-
<i>Adj. R2</i>	0.62	0.56	0.82	0.80	0.50
<i>Overall F test</i>	6.40**	23.83***	94.48***	407.5***	339.89***
<i>Regional dummies</i>	No	Yes (7)	Yes (8)	Yes (18)	Yes (8)
<i>Time dummies</i>	Yes (12)	Yes (12)	Yes (13)	Yes (10)	Yes (11)
<i>Dummy F test</i>	16.46***	3.64***	2.86**	6.38***	2.62**
<i>Observations</i>	108	84	104	180	88
<i>Beta-convergence</i>	Yes	Yes	Yes	No	No

Significant at: ** 5% threshold; *** 1% threshold

NB: Two-way fixed-effects regressions include the option *cluster (dummy)* to control for both heteroskedasticity and AR(1) serial correlation. Akaike and Schwartz information criteria confirm that using this option I get better results.

Source: Personal processing

Table 3. Results of regressions with migration

<i>Migration included</i>	Austria	Hungary	Romania	Spain1	Spain2	Sweden
<i>Beta (%)</i>	0.15***	2.09**	2.87***	-0.33	0.95***	5.67
<i>Half time</i>	462	33	24	-	73	-
<i>Net migration (%)</i>	-	-	0.10*	0.009***	-	+
<i>In-migration (%)</i>	-	+	+		-0.0056**	+
<i>Out-migration (%)</i>	+	+	-		-0.012***	+
<i>Adj. R2</i>	0.71	0.51	0.84	0.86	0.88	0.51
<i>Overall F test</i>	5.59***	37.14***	624.15***	198.91***	351.27***	61.52***
<i>Regional dummies</i>	No	Yes	Yes	Yes	Yes	Yes
<i>Time dummies</i>	Yes	Yes	Yes	Yes	Yes	Yes
<i>Dummy F test</i>	18.78***	3.17***	4.63***	6.46***	6.90***	2.71**
<i>Observations</i>	84	77	96	162	162	80
<i>Beta-convergence</i>	Yes	Yes	Yes	No	Yes	No

Significant at: * 10% threshold; ** 5% threshold; *** 1% threshold

NB: 1. Net migration and gross migration rates have been separately included in the regressions.

2. Values in the table correspond to the equation which holds steady the net migration, less for Spain2.

Source: Personal processing

Interpretation:

1. All countries, except for Spain (see also 3.) and Sweden recorded conditional beta-convergence and very slight effects (Romania and Spain) or none of net migration. Moreover, after controlling for net migration which turned a positive coefficient, Romania increased its beta-convergence value. I could suppose that this combination of increasing beta rate and positive migration for Romania is due to a brain gain effect. In turn, this could imply that migrants were heterogeneous in their human capital content.

2. Gross migration, in the form of in- and out-migration rates, in spite of not being significant, proved to work symmetrically in Austria and Romania.
3. Very interesting in the regressions presented above is the fact that, in the case of Spain, beta-convergence estimate turned positive and significant only after controlling for the effects of gross migration. Both in- and out-migration estimates turned negative meaning that gross migration lowered the income growth rate with a stronger impact of out-migration. This last fact explains the positive value of net migration estimate. Moreover, if I consider the values of adjusted R² and overall F test, I can conclude that this model is the best of all.
4. The highest convergence rate belonged to Romania (2.87% /year after including net migration) while the lowest belonged to Austria (0.15% /year with net migration added).
5. Considering the six lemmas of Maurer (1995) stated earlier and the best models for each country, I can conclude that Hungary and Romania confirm the 3rd lemma (beta-convergence is compatible with sigma-divergence), Austria and Spain confirm the 1st lemma (sigma-convergence implies beta-convergence), while the 5th lemma (beta-constancy is compatible with sigma-consistency or sigma-convergence) is suitable for Sweden¹⁸.

Final Remarks

In a future article I intend to extend the analysis at NUTS 3 level in order to get a clearer view on the issue and to include an education indicator to control for human capital endowment and, thus, to establish the existence of a brain drain or brain gain effect. Furthermore, the irrelevance of spatial dependence may be overcome by deepening the analysis at a more disaggregated level. Also, I plan to perform a convergence analysis through the distribution dynamics approach to overcome the shortcomings of the static approach.

Acknowledgement

This article is a result of the project POSDRU/88/1.5./S/55287 “Doctoral Programme in Economics at European Knowledge Standards (DOESEC)”. This project is co-funded by the European Social Fund through The Sectorial Operational Programme for Human Resources Development 2007-2013, coordinated by The Bucharest Academy of Economic Studies in partnership with West University of Timisoara.

¹⁸ Young et al. (2007) also found for US counties (1970-1998) that sigma-divergence may accompany beta-convergence.

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