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The more the merrier?

Migration and Convergence among European Regions

Lorenz Benedikt Fischer* and Michael Pfaffermayr†

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Abstract

Using a spatial systems estimator to incorporate spatial interactions and endogeneity of income levels and migration, this paper finds a positive effect of migration on cohesion within the European Union on the NUTS 2 level. As migration can generally be observed from low to high income regions, growth rates of income per worker tend to decrease in regions experiencing net immigration, while lagging regions experience higher speeds of income convergence. As a result, migration increases σ-convergence. Results show an increase of more than one third. Free movement of persons also proves to increase efficiency, displayed by higher average convergence speeds.

Keywords: Conditional spatial β- and σ-convergence; Migration; Spatial Solow model; European regions
JEL: R11; C21; O47

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Introduction

To uncover the effect of migration on regional income growth and further on cohesion, one needs to account for the interdependency of income levels and migration. Acknowledging spatial interaction between regions due to endogenous migration of workers calls for a re-assessment of European regional convergence. Indeed, the spatial system estimates presented here support neoclassical models predicting that, in absence of brain drain, migration promotes convergence in income per capita, caused by increasing capital-labour ratios in lagging regions due to emigration of workers to richer regions (Barro and Sala-i-Martin, 1991, 1992, 2004).

There is no general concurrence on the relationship between economic growth, migration, and convergence. As Barro and Sala-i Martin (2004, p.492) write: "We found... that the migration of workers with low human capital from poor to rich economies tended to speed up the convergence of per capita income and product." This finding implies that, inter alia, migration changes the (relative) productivity of countries or regions. If migration transfers workers with low human capital to richer regions, convergence gains momentum. Conversely, if the migration process were to transfer workers with high human capital to richer countries, divergence would be elevated. These phenomena are labelled brain gain and brain drain[1].

For migration to speed up cohesion, migrants should not possess much higher human capital than natives. If they did, a substantial surplus to compensate the negative effect of migration on capital intensity would be necessary. Without self-selecting to migrate, the assumption of lower average human capital may hold if two regions encounter substantial differences regarding the level of human capital per capita of their respective natives, where the net receiving region enjoys higher human capital per capita (see, for example, Dolado, Goria, and Ichino (1994); Faini (1996); Barro and Sala-i Martin (2004); Sun, Hong, and Li (2010)). From a European perspective, around 85% of all interregional movements take place within a country (Dijkstra and Gáková, 2008). Thus, in a regional context, it is arguably hard to hold on to such differences. It appears that the assumption of migrants bearing lower human capital is traditionally linked to migration flows between countries. On this issue, Pekkala and Tervo (2002), investigating Finnish census data, report two important findings. Firstly, migration is subject to self-selection, and secondly, migrants appear more "employable" than natives. Borjas, Bronars, and Trejo (1992) find that within the US, migrants in 1986 had a three percent higher educational attainment on average than non-movers, similar to Shioji (2001). Dolado et al. (1994) report that international migrants only bear around 80% of human capital compared to natives.

The aim of this paper is to investigate the effect of migration in the context of regional convergence across Europe. While this subject is not new, we offer some new perspectives suggesting a system approach to identify the impact of migration on regional income convergence.

A number of studies on regional development that include migration do not tackle endogeneity, like Rodríguez-Pose and Vilalta-Bufí (2005) or Soto and Torche (2004)[2]. In the same manner as, for example, Barro, Sala-i Martin, Blanchard, and Hall (1991), Barro and Sala-i Martin (1992), or Kırdar and Saracoğlu (2008), we account for this problem via including a migration function.

However, as is shown in section 2, migration already enters in the model, rather than being treated as endogenous at the econometric stage. Through migration, the model allows for interaction between neighbours. We employ a feasible generalized spatial 3 stage least squares (FGS3SLS) estimator, as developed in Kelejian and Prucha (2004), based on a complete dataset of 270 adjacent European NUTS 2 regions from 2004 to 2010. Understanding the mechanism of migration and its effect on growth appears as a cornerstone of migration policies and economic development.

The structure of this investigation is as follows. In next section 2, the theoretical foundations are built up using a spatial Solow model. Section 3 shortly covers the estimation technique that is applied to the data, and the subsequent sections 4 and 5 deal with the estimation results, the interpretation thereof and convergence, and some robustness checks. Finally, the main conclusions are presented.

Spatial net migration in a Solow model

The spatial Solow growth model is based on a constant returns to scale production function with labour, physical and human capital as inputs (Dolado et al., 1994). Formally, the production function of region i writes

$$Y_i = K_i^{\varphi} L_i A_i \tag{1}$$

with Y_i as output, K_i as aggregate capital and L_i as labour. A_i denotes the state of labour augmenting technological progress that, similar to McQuinn and Whelan (2007), exhibits a common deterministic growth rate x. Following Dolado et al. (1994), we introduce K_i as broad composite of human (H) and physical capital (C) with Cobb-Douglas form

$$K_i = C_i^{\alpha} H_i^{\beta}. \tag{2}$$

Additionally, we also assume that $\alpha + \beta = 1$. Initial differences in technology across regions are captured by initial conditions A_{i0}.

Defining y_i as the log of regional GDP per efficiency unit of labour as well as c_i and h_i as the logs physical and human capital per efficiency unit of labour allow rewriting the regional production function in intensive form.

$$y_i := \varphi k_i, \tag{3}$$

To derive an empirical specification of spatial income convergence that accounts for labour mobility among regions, Barro and Sala-i-Martin (1992, 2004), Braun (1993), Dolado et al. (1994) and Sun et al. (2010) augment the Solow model and postulate a net migration function. Population growth in a specific region is composed of the natural population growth rate n and the net migration rate. In reduced form, a region's net migration rate depends positively on the difference between a region's own income per worker and the (spatially) weighted average income per worker of the other regions. However, at a given income differential between any two regions, the migration flows are smaller the larger the costs of migration. The distance between two regions is used as the main indicator of these costs.

In microeconomic models, the migration decision is typically modelled to depend on differences in wage and employment outlooks. Molho (2001) presents an intuitive model, where emigration and immigration are allowed to occur simultaneously within regions due to random wage offers. The binary decision of an agent to emigrate is affirmative if the expected utility of moving is larger than the utility of not moving net of some migration cost. Migration functions may also be based on a 2 region overlapping generations framework, where the share of people born in one region and moving to another is proportional to the wage or income differential (Faini, Galli, Gennari, and Rossi, 1997). Thus, the propensity to emigrate is modelled to be dependent on differences in the wage level, migration costs, and other determinants of utility such as amenities (Piras, 2010). Since the migration decision is based on the comparison of locations, relative values may be more relevant than absolute values.

Formally, the net migration rate is given as $\dot{\mu} = \frac{M}{L}$m with M defined as the account of emigrating and immigrating workers as a share of the labour force. Denoting L_H as the number of natives in a region, the total labour force in a region is given as $L = L_H + L_M$. Assuming that the share of migrants, $\frac{L_M}{L}$, is small (≈ 0) and that the natural population growth rate[3] is constant and given as $n = \frac{\dot{L}_H}{L_H}$, the population growth in a region can approximately be written as (Appendix 1):

$$\frac{d\log(L_H + L_M)}{dt} \approx \frac{\dot{L}_H}{L_H}(1 - \frac{L_M}{L}) + \frac{\dot{M}}{L} := n + \dot{\mu}. \tag{4}$$

Applicable to many regions, the income differential in region i may be specified as $\sum_{j=1}^{N}(w_{ij}(y_i - y_i^*) - (y_j - y_j^*))$, where w_{ij} represents the spatial weight attributed to region j. As Molho (2001) lays out, any steady state (denoted by $*$) requires a constant share of new migrants and, therefore, zero *net* movement of people among regions. Thus, the steady state net migration, $\dot{\mu}^*$, is assumed to be zero, implying a constant steady state population growth rate n. Away from the steady state, a region's net migration rate is hypothesized to increase with higher income per worker (y_i) and larger supply of amenities (u_i), which both might be measured relative to the corresponding spatial average. To summarize, the net migration function writes

$$\dot{\mu}_i - \dot{\mu}_i^* = \sum_{j=1}^{N} w_{ij} \left(\kappa \left[(y_i - y_i^*) - (y_j - y_j^*) \right] + \psi \left[(u_i - u_i^*) - (u_j - u_j^*) \right] \right). \tag{5}$$

Equation (5) demands the use of a symmetric spatial weight matrix in order to guarantee that the sum of net migration flows is zero at any point in time. Formally, the term

$$\begin{aligned} \sum_i \dot{\mu}_i &= \sum_i \sum_j w_{ij} \left(\kappa(y_i - y_j) + \psi(u_i - u_j) \right) \\ &= \sum_j \sum_i w_{ij} \left(\kappa y_i + \psi u_i \right) - \sum_i \sum_j w_{ji} \left(\kappa y_j + \psi u_j \right) \end{aligned}$$

is only zero if $w_{ij} = w_{ji}$, so that $\mathbf{W}$ is symmetric.

To establish the law of motion of income per efficient worker, the spatial Solow model assumes that net investment is proportional to output due to the constant savings rate s_i. Thus, in terms of composite capital per efficiency unit of labour, $\widehat{k}_i$, and accounting for human capital brought by migrants, net investment at time t equals (Appendix 2)

$$\dot{\widehat{k}}_i = s_i \widehat{k}_i^{\varphi} - \left(d + \delta \dot{\mu}_i\right) \widehat{k}_i, \tag{6}$$

where d denotes the generalized depreciation rate $x + n + \vartheta$, with x as technological progress, n fertility net of mortality, and ϑ the depreciation rate of the composite capital. Dolado et al. (1994) refer to the parameter $\delta = (1 - \beta\varepsilon_h)$ as the "weighted immigrants' human capital" or "the aggregate immigrants' capital" relative to natives. Thereby, ε_h is the amount of human capital brought to a region by an immigrant relative to the human capital of a native representative agent. This formulation implies that both a high share of human capital in production, β, and a large amount of human capital brought in by migrants relative to natives, ε_h, dampen the impact of net migration on growth in GDP per capita that is induced by its contribution to population growth.

Since net migration is zero in the steady state, we establish the log steady state value of output per efficient worker using (3) and (6):

$$\mathbf{y}^* = \frac{\varphi}{1-\varphi} \boldsymbol{\theta} \tag{7}$$

where $\boldsymbol{\theta}$ is a vector with typical element $ln(d/s_i)$.

To obtain a convergence equation that can be estimated empirically, we approximate the law of motion linearly around the steady state. In matrix form one gets

$$\dot{\mathbf{y}} - \dot{\mathbf{y}}^* = -(\varphi - 1)d\,(\mathbf{y} - \mathbf{y}^*) - \delta\varphi\left(\dot{\boldsymbol{\mu}} - \dot{\boldsymbol{\mu}}^*\right) \tag{8}$$

$$\dot{\boldsymbol{\mu}} - \dot{\boldsymbol{\mu}}^* = (diag(\mathbf{W} \cdot \boldsymbol{\iota}) - \mathbf{W})\left[\kappa(\mathbf{y} - \mathbf{y}^*) + \gamma(\mathbf{u} - \mathbf{u}^*)\right] \tag{9}$$

where $\boldsymbol{\iota}$ is a vector of ones of size n.

Appendix 3 shows that convergence will occur as long as $\varphi\left(1 + \frac{\delta\kappa}{d}\right) < 1$; then the (social) marginal return of capital is decreasing and the neoclassical convergence property dominates despite the spatial externalities. The inequality also implies that a combination of high sensitivity to migrate and high 'weighted immigrants' human capital' can cause the system to be unstable, whereas a high depreciation rate naturally counters such a tendency. In other words, cases in which high human-capital agents can migrate at too low cost might lead to divergence and corner solutions.

Following Lee, Pesaran, and Smith (1997), initial income per capita $\mathbf{y}_0$ enters endogenously, adding a third equation to the system. Hence, the final structure of the model requires the estimation of a triangular system of three equations. In the convergence equation, referring to the evolution of real income per worker, there are two endogenous variables, net migration and initial income; the second equation explains net migration rates by initial income per capita and a set of exogenous variables; lastly, initial income is estimated by purely exogenous variables.

Econometric Specification

Lahiri and Schmidt (1978) recommend applying FIML or 3SLS for the estimation of a triangular system with cross-equation correlation, manifesting itself in the form of a non-diagonal variance-covariance matrix $\mathbf{\Sigma}$ of the disturbances of the system. For the estimation of systems such as the one outlined above, Kelejian and Prucha (2004) propose a *feasible generalized spatial three stage least squares* (FGS3SLS) estimator, which can additionally correct for spatial correlation.

In its general form, the system to be estimated may be written as (in concordance with Kelejian and Prucha (2004))

$$\mathbf{M} = \mathbf{M}\mathbf{B} + \mathbf{X}\mathbf{\Gamma} + \overline{\mathbf{M}}\mathbf{\Lambda} + \mathbf{U} \tag{10}$$

$$\mathbf{U} = \mathbf{W}_U\mathbf{U}\mathbf{R} + \mathbf{E} \tag{11}$$

where $\mathbf{M}$ and $\mathbf{U}$ are the $n \times 3$ matrices containing the endogenous variables and the disturbances with elements $m_{q,i}$ and $u_{q,i}$, where column $q = [1, 2, 3]$ refers to the corresponding equation, respectively. $\mathbf{X}$ denotes the $n \times K$ matrix comprising blocks of all exogenous variables. The $n \times 3$ matrix $\overline{\mathbf{M}}$ contains spatially lagged endogenous variables, and in the present case is given as $[\mathbf{0}, \mathbf{0}, \mathbf{W}\mathbf{y}_0]$. $\mathbf{B}$, $\mathbf{\Gamma}$, and $\mathbf{\Lambda}$ are the corresponding coefficient matrices. Spatial and equation-wise error correlations are captured in $\mathbf{U}$ and $\mathbf{E}$. The 3×3 diagonal matrix, $\mathbf{R}$, includes the spatial correlation parameters of the disturbances, while $\mathbf{\Sigma}$ denotes the observation-wise error correlation so that $E[\mathbf{EE}'] = (\mathbf{\Sigma} \otimes \mathbf{I}_n)$. Equations (10) and (11) indicate that is not necessary to constrain endogenous variables and error terms to the same spatial processes.

In the inverse distance matrix $\mathbf{W}$, weights are defined as

$$w_{ij} = \frac{r_{ij}^{-\tau}}{\varsigma} \qquad \forall \quad i \neq j \quad \& \quad r_{ij} < r^*, \tag{12}$$

and zero else, where r_{ij} is the distance between the centroids of two regions measured in km and r^* is some threshold distance. As shown above in equation (9), row-normalizing is not feasible, as it perturbs the symmetry of a matrix.

The decay parameter τ determines the pace at which weights decline. Let the distance of two regions to a third region be r_1 and $r_2 = kr_1$. Then, the weight of the second region is given as k^τ times the weight of the first. Imputing a threshold implies that regions further away from region i than r^* do not directly interact with each other, from which we refrain in the estimation.

At the NUTS 2 level, some relatively small regions, for example Brussels, have very close neighbouring regions. Thus, $\mathbf{W}$ might exhibit potentially very large row sums, which may distort the maximum row sum normalized weights, especially at large values of τ, in turn indicating a fast spatial decay. For example, at $\tau = 1.1$, the mean row sum is approximately 0.5, while at $\tau \approx 2$ it is only one tenth. Therefore τ is restricted to values around unity.[4] To get the optimal value of the decay parameter, a grid search finds the best-fitting specification using McElroy's system R^2 (McElroy, 1977).

In the queen-contiguity case, $\tau = 0$ and $r_{ij} = 1$ if two regions share a common border and zero otherwise. In order not to induce serial correlation, the errors are assumed to correlate spatially only via contiguity. Kelejian and Prucha (2010) show that the parameter spaces for $\mathbf{\Lambda}$ and similarly $\mathbf{R}$ depend on the eigenvalues of $\mathbf{W}$, $\mathbf{W}_U$, and the sample size. Maximum-row normalization constrains the parameter space of the eigenvalues to the interval $(-1, 1)$.

The inclusion of the exogenous variables in each of the equations is based on the theoretical model of income convergence and net migration laid out above and a summary is given in Table 1. Identification of the model is assured by fulfilling conditions 1 and 2 in Greene (2003, ch. 15).

Table 1: Exogenous variables in the system

Equation	Exogenous Variables
income growth:	share of secondary education, share of tertiary education, city/capital region
migration:	spatial relative output density, remoteness, spatial relative heating-degree days, flood affinity, wildfire affinity, city/capital region, country fixed effects
initial income:	initial population density, heating-degree days, city/capital region, latitude, longitude, country fixed effects

The suggested FGS3SLS estimator proceeds in three stages. The first stage estimates the coefficients of each of the $q = 3$ equations in the system separately using 2SLS. Thereby, the matrix of instruments contains all linearly independent exogenous variables in the system as well as the spatial lags thereof. The second stage estimates the spatial parameters, ρ_q using a generalized method of moments estimator proposed by Kelejian and Prucha (1999, 2004). The third stage first applies the Cochrane-Orcutt transformation using the estimates of ρ_q from the second stage. The last step is the re-estimation of the parameters of the model with these transformed data applying 3SLS. Thus, this estimator also accounts for error correlation across system equations.

Data and Estimation Results

The data comprise 270 European regions at the NUTS II level covering the period 2004 to 2010 (Source: Eurostat and Cambridge Econometrics). In order to establish a cross-section, all variables are averaged over that period.

Initial income and its growth rate are measured in terms of real gross regional product per worker. In the robustness section results for real income per employee are also presented, since, at the regional level, using the number of employees as denominator prevents possible mismeasurement caused by commuting. Lastly, net-immigration is defined as the difference of immigrants minus emigration per one thousand natives.

In the convergence equation, secondary and tertiary education enter as exogenous variables, which are measured as the share of the population aged 25-64 with a corresponding degree. In the migration equation, initial income is calculated as

Figure 1: Density plots of log-income per worker for the years 2004, 2005, and 2010.

spatial difference as defined in equation (9). The exogenous variables of the migration equation include proxies for (dis)amenities including heating-degree days[5], output density (defined as real GRP per square kilometre), and flood- and fire affinity. The latter two variables are categorical variables ranging from 0 to 5, where 5 is the highest affinity towards floods/wildfires. As mentioned in section 2, distance is used as the main indicator of immigration costs, which are approximated by remoteness defined as a region's average distance to all other regions. Similar to initial income, the heating-degree days and output density enter as spatial differences. The reason for that is that agents are concerned with comparative rather than absolute values of income when deciding to migrate. Lastly, the initial level of real income per worker is exogenously determined by initial population density and its spatial lag, heating degree days and its spatial lag, a dummy for city regions, and country dummies.

With regard to the geographical structure, about 86% of the NUTS II region in our sample have at least three neighbours according to the queen-contiguity scheme. On average, each region has 4.7 common-border neighbours. Summary statistics of all variables are given in Appendix 4.

Given the time frame 2004 − 2010, due the Great Recession in 2009, one would expect rather slow average growth rates of income and small estimates of convergence speeds.The average growth rate of real income per worker in the sample is at 0.61% with standard deviation 1.83%. Nonetheless, it appears central to investigate convergence also in times of *economic distress*. Lastly, average net migration rates amount to 0.32% on average with a standard deviation of 0.43%., while average population growth rates are almost of the same magnitude at 0.35% and with a standard deviation of 0.61%.

Table 2 shows the FGS3SLS estimation results of the baseline systems for both exogenous (model I) and endogenous (model II) initial real income per worker and suggests the following interpretation. Focusing first on the convergence equation, we conclude that, at least in the observation period, migration is an important channel through which spillovers among regions manifest themselves in the European Union. For reasons of comparability, we also present results for a model including knowledge spillovers in the production function. As the coefficient of spatially lagged real income per worker in the convergence equation in Table 5 in Appendix (6) is insignificant, there is no indication of such spillovers besides those induced by migration. However, in the migration equation, the positive coefficient of spatial-relative initial income per worker suggests that, on net, migration is observed from low- to high-income regions. In combination with the negative effect of migration on average growth of real income per worker, this implies that migration indeed, on average, speeds up income convergence in Europe.

Previous results suggesting conditional convergence or positive effects of investment in human capital are also supported. Two opposing results in contrast to the vast number of similar findings on convergence are Rodríguez-Pose and Vilalta-Bufí (2005), who find divergence among 49 NUTS 1 regions, and Deller, Lledo, and Marcouiller (2008), who report a positive effect of initial income in two out of three estimated models, focusing on growth effects of amenities in US counties. Further, city regions or ones that contain a capital city prove to show higher growth rates, which serves as an indicator of positive agglomeration forces.

The estimates for the migration function are in line with theory in that higher expected wages promote, whereas disamenities hinder immigration. It is also visible that both relative and absolute variables have explanatory power when it comes to migration rates. From an agent-based view, it appears natural that income and amenities are considered relative to other regions. Considering amenities, cities can be interpreted as regions with a relatively high supply thereof. As such, they can also expect higher immigration rates, as Table 2 implies.

The negative impact of output density can be interpreted as increasing propensity to commuting or, at least, increasing possibilities for workers to commute. As the neighbours' $j \neq i$ output density increases, there are more attractive possibilities in surrounding areas for workers in region i, making commuting more profitable. On the other hand, if region i*'s* output density rises, it may become more affordable to move to close-by regions.

Lastly, the estimation of initial values using country fixed effects and mostly purely exogenous variables proves to be accurate. Similarly, Badinger, Müller, and Tondl (2004) using a panel of European regions, argue that region specific effects allow to account for differences in initial technology level. In the present case, the cross-section is able to capture such differences at the country level.

Table 2: FGS3SLS estimation.

	growth I	migration I	growth II	migration II	initial income II
migration	-0.590		-0.688		
	(-1.704)		(-2.490)		
initial income	-0.013		-0.015		
	(-5.943)		(-6.705)		
share secondary education / 100	0.038		0.034		
	(3.578)		(3.211)		
share tertiary education / 100	0.064		0.060		
	(4.316)		(4.061)		
spatial-relative initial income		0.689		0.774	
		(4.626)		(4.357)	
spatial-relative output density		-0.131		-0.133	
		(-3.814)		(-3.847)	
spatial-relative heating-degree days		-1.050		-0.912	
		(-4.749)		(-4.606)	
remoteness		-0.608		-0.562	
		(-2.479)		(-2.271)	
floods		-0.002		-0.001	
		(-0.071)		(-0.036)	
fires		-0.069		-0.061	
		(-1.989)		(-1.752)	
latitude					0.009
					(1.287)
longitude					-0.015
					(-3.351)
initial density					0.361
					(7.744)
heating-degree days					-0.134
					(-1.678)
spatially lagged initial density					-0.308
					(-1.955)
spatially lagged heating-degree days					0.299
					(2.459)
city or capital region	0.005	0.233	0.006	0.220	0.025
	(1.650)	(2.743)	(2.013)	(2.511)	(1.570)
constant	0.106	4.486	0.129	4.125	11.126
	(4.591)	(2.593)	(5.454)	(2.359)	(21.632)
ρ_ε	0.484	0.363	0.488	0.352	0.086
R^2 (non-transformed model)	0.543	0.642	0.540	0.640	0.957
R^2_z system	0.3735			0.8798	

Notes: Dependent variables are the average growth in GRP per worker between 2004 and 2010, net migration rates, and initial GRP per worker. t-values are given in parentheses below each coefficient. For the initial value and migration equation, country fixed effects are not reported. The sample comprises 270 regions. Coefficients in the migration columns are multiplied by 100. τ_2^* is 0.59 in model I, 0.48 in model II.

β-convergence

In a spatial system with feedbacks, each entity has a unique speed of convergence, depending on its spatial and relative position towards its neighbours. Thus, the estimated coefficient of real income per worker yields only an approximation to the mean convergence speed. To acquire correct estimates for the speed of convergence and grasp the effect of migration on convergence, we measure the average direct effect of migration by $n^{-1}tr(\mathbf{B})$, where $\mathbf{B}$ is interpreted as the partial derivative of migration in the reduced form of the system given in Appendix 3 (LeSage and Pace, 2008). Thus, $\mathbf{B}$ measures the effect of initial income both directly and indirectly through the migration channel:

$$\mathbf{B} = (\varphi - 1)\, d\mathbf{I} - \delta\kappa\varphi\, (diag(\mathbf{W} \cdot \boldsymbol{\iota} - \mathbf{W}) \tag{13}$$

At heterogeneous initial gaps[6], which we assume here, the effect of region j on region i depends on the relative proximity to the steady state. In this case, one region's effect on the convergence speed of another region is positive if (i) both regions are below the steady state with the former one further away, (ii) both regions are above the steady state with the former one closer, or (iii) the former region is below the steady state and the latter one above. Thus, the composition of neighbouring regions might have significant effects on convergence rates.

As expected, the results show mean convergence speeds lower than the meta-analytic 2.7% (see Ozgen et al., 2010).[7] Maria Abreu, de Groot, and Florax (2005), conducting a meta-analysis on a large-scale dataset and without explicitly considering studies dealing with migration, find support for the 'legendary' 2%, though with sizeable heterogeneity. On average, the direct effect of the full model amounts to a speed of convergence of 1.58%. Without migration, where the second term in equation (13) is set nil, the average direct effect is at 1.27%. Thus, migration increases the average speed of convergence by almost one quarter.

A similar way to measure the speed of convergence, similar to Pfaffermayr (2012), may be defined as

$$\Psi = \frac{1}{t} \cdot Diag\left[\mathbf{y_0^*} - \mathbf{y_0}\right]^{-1} \left[\left(\mathbf{I} - e^{\beta \mathbf{B} t}\right)\left(\mathbf{y_0^*} - \mathbf{y_0}\right)\right]. \tag{14}$$

Migration might cause regions to drift off the steady state in the short term. For example, regions Limburg (NL42) and Syddanmark (DK03) in Figure 2 show negative convergence speeds at $t = 1$, indicating off-drifting. At $t = 50$, however, they show positive average rates.[8] Therefore, mean convergence speeds should be interpreted carefully when using equation (14). Additionally, some regions may start relatively close to the steady state, further impeding the calculation of exact summary measures. For example, region Bremen (DE50) shows an initial gap of almost zero (0.0204), which increases after one year to 0.0224, a rise of almost 10%. However, it appears valuable to demonstrate the heterogeneous effects of migration on regions as in Figure 2.

σ-convergence

To look at the effects of migration on σ-convergence, one needs to investigate the evolution of the distribution of income per worker across regions. In reduced form, income per worker may be written as

$$\mathbf{y}_t = \mathbf{B}_1 \cdot \mathbf{y}_0 + \boldsymbol{\epsilon}_t \tag{15}$$

$$\mathbf{B}_1 = [1 + (1 - \varphi)d]\,\mathbf{I} + \delta\kappa\varphi \cdot diag(\mathbf{W} \cdot \boldsymbol{\iota} - \mathbf{W}), \tag{16}$$

where $\mathbf{B}_1$ quantifies the direct and indirect effect of initial income and $\boldsymbol{\epsilon}_t$ denotes the combined shocks of $\mathbf{y}_t$ and $\boldsymbol{\mu}_t$. In a spatial setting, due to heterogeneous convergence

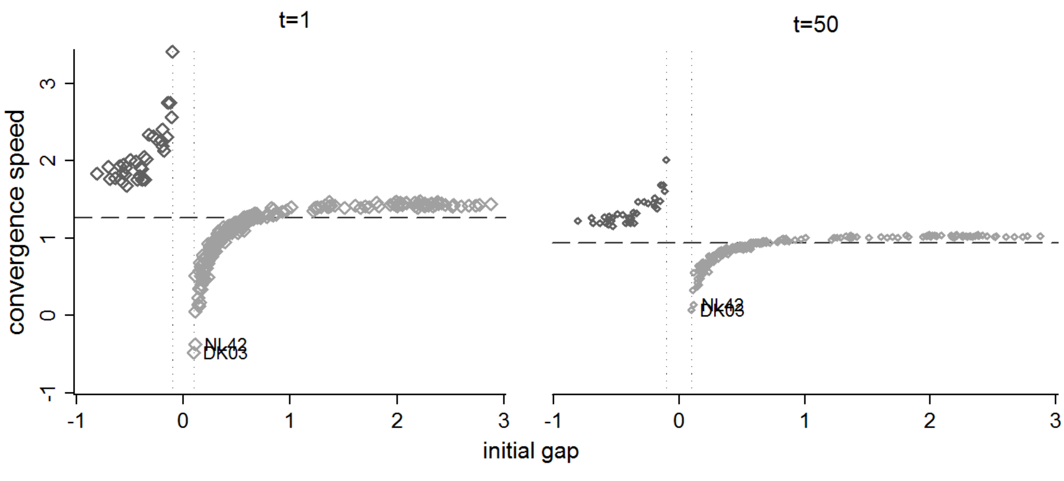

Figure 2: Convergence speeds vs. Initial gaps at $t = 1$ and $t = 50$ years. Regions closer than 10 percentage points to the steady state excluded. Dashed horizontal lines show calculated homogenous convergence speeds without migration.

speeds, every region has a specific variance. Therefore, a natural approach is to look at the average variance of income per worker at time t. Denoting the corresponding variance-covariance matrix $\mathbf{V}_{.}$, we get:

$$\mathbf{V}_{\mathbf{y}_t} = \mathbf{B}\mathbf{V}_{\mathbf{y}_0}\mathbf{B}' + \mathbf{V}_{\boldsymbol{\epsilon}_t}, \tag{17}$$

where

$$\begin{aligned}
\mathbf{V}_{\mathbf{y}_0} &= \sigma^2_{\varepsilon_{y0}} \left[(\mathbf{I} - \rho_{y_0}\mathbf{Q})'(\mathbf{I} - \rho_{y_0}\mathbf{Q})\right]^{-1} \\
\mathbf{V}_{\boldsymbol{\epsilon}_t} &= \sigma^2_{\varepsilon_{y_t}} \left[(\mathbf{I} - \rho_{y_t}\mathbf{Q})'(\mathbf{I} - \rho_{y_t}\mathbf{Q})\right]^{-1} + (\delta\varphi)^2\sigma^2_{\varepsilon_\mu} \left[(\mathbf{I} - \rho_\mu\mathbf{Q})'(\mathbf{I} - \rho_\mu\mathbf{Q})\right]^{-1}.
\end{aligned}$$

σ-convergence occurs if $\mathbf{V}_{\mathbf{y}_0} < \mathbf{V}_{\mathbf{y}_t}$. Inserting the estimates of the FGS3SLS estimator, σ-convergence is evident with and without migration; in the latter case, the variation of income per worker on average decreases by 1.66% per year. When allowing for migration, the decrease amounts to 2.25%, which is more than one third higher.[9] This indicates that migration indeed contributes to the convergence process of European regions.

Robustness

To check for possible mismeasurement caused by commuting, Table 4 in the Appendix 6 presents estimation results for (initial) income per employee. Most coefficients remain in signs and coefficients, though with slight absolute decreases. Changing the denominator from the labour force to only employed persons is mainly downscaling thereof. As a comparison of Tables 2 and 4 shows, there are only some control variables that changed significance, for example the coefficients of the share of secondary education, or flood affinity. However, the main conclusion remains.

Traditionally, the channel through which knowledge spillovers are assumed to occur is via wealth levels. Therefore, we include a spatially lagged income variable in the convergence equation. In fact, in the convergence equation, the spatial lag of initial income per worker is found insignificant, as shown in Table 5 in Appendix 6. In view of the spatial Solow model discussed above this finding implies that knowledge-spillovers without migration tend to be small and cannot be identified separately.

Changing spatial correlation might be a source of biased results. Nearby neighbours may be positively, while distant ones may be negatively spatially correlated (Fischer and Getis, 2009, p.205). Therefore, positive spillovers may be detected only at rather small radii, and appear insignificant when taking all neighbours into account. However, different cut-off radii appear to have no effect worth mentioning. As an example, Table 6 reports the system results for a cut-off radius of 1000 km.[10] Similarly, the speed of convergence is essentially independent of the exact specification of the weight matrix. Lastly, also the influence of the decay parameter proves to be minor. Table 7 shows that coefficients and t-values are practically resistant to changes in $\tau \in [0.4, 1.4]$. With steps of 0.01, the system is re-estimated 101 times.

To conclude, the estimation results prove to be stable against changes in the spatial weight matrix, the measurement of the dependent variable, and the inclusion of spatially lagged real income per worker.

Conclusion

This paper examines the impact of migration on income growth among European NUTS 2 regions and finds a positive effect on cohesion within the European Union. As the results of this empirical investigation show, migrants, not initial income/technology levels appear as the main channel through which spillovers manifest themselves, even when controlling for knowledge spillovers in the production function in the form of initial income per worker. Considering the time frame of the data (2004-2010), the slow convergence rates of about 1.6% do not appear contradictory to earlier results that show higher estimates. Rather, they show that convergence is also prevalent in periods of economic distress.

Due to endogeneity of migration rates and initial income levels, and the spatial interdependence between regions, a feasible generalized spatial three stage least squares estimator is applied. Instead of a priori assuming a specific weight matrix, theoretical foundations define the structure, and a grid search finds parameters of spatial weight matrices that fit the data best. The optimal decay parameter for migration proves to be smaller than one, indicating decreasing costs to distance. The results also suggest an increasing propensity to commute to dense regions in terms of output, indicating the trend towards suburbanization.

Migration benefits cohesion in terms of reduced variation of steady state gaps by elevating growth rates of poorer regions relative to richer ones. Such movements may also empower efficiency gains due to an increased capital-labour ratio in lagging regions, which translates in higher mean convergence speeds in a free movement scenario. Thus, migration has an important role to play in cohesion policies, in that enabling workers to move freely levels the playing field of per-worker income. Migration effectively increases σ-convergence by more than one third compared to a no-migration scenario.

Notes

[1]See Commander, Kangasniemi, and Winters (2004) for a review on this topic.

[2]See Ozgen, Nijkamp, and Poot (2010) for a concise review on empirical research on (internal) migration and convergence.

[3]Immigration from outside of Europe remains unobserved and is taken as a part of natural population growth.

[4]τ is bounded away from 0, since a decay parameter close to zero degenerates $\mathbf{W}$ to a matrix of off-diagonal constants $w_{ij} = \frac{1}{n-1}$. This implies complete insensitivity with respect to distance, as $lim_{\tau \to 0, n \to \infty}(W \cdot x) = \overline{x}$ for some variable x, (Kelejian, Prucha, and Yuzefovich, 2006).

[5]Heating-degree days are defined as "$(18 - T_{min}) \cdot days$ if T_{min} is lower than or equal to 15 degrees" (Eurostat).

[6]Initial gaps are calculated using each region's (conditional) steady state: Shortly,

$$u_{0i} = \frac{\mathbf{x}_{i,1}\gamma_1}{1 - \beta_{1,y_0}} - y_{0i}, \tag{18}$$

where $\mathbf{x}_{i,1}\gamma_1$ is the predicted per worker income growth rate using only (exogenous) conditioning variables, and β_{1,y_0} is the coefficient of initial income per worker.('1' denotes the first equation of the system - the convergence equation) Note that in this specification, a positive gap indicates that a region is below its steady state.

[7]Note that Ozgen et al. (2010) only look at studies investigating net-internal migration.

[8]16 Regions exhibited such behaviour, of which each starts relatively close to the steady state. All regions make way for the steady state at approximately $t = 60$.

[9]Similar to the calculation of convergence speeds, the case without migration is simply achieved by setting the coefficient of migration, $\delta\varphi$, nil.

[10]The robustness checks included all possible distance bands.

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Appendix

1 Population growth

$$\frac{d\log(L_H+M)}{dt} = \tfrac{1}{L_H+M}\left(\dot{L}_H+\dot{M}\right) := n+\dot{\mu}$$

2 Law of motion

Capital is interpreted in a broad sense as $\widehat{k}_i = \widehat{c}_i^{\alpha}\widehat{h}_i^{\beta}$. Equal marginal returns allow expressing human and physical capital as shares of aggregate capital:

$$\frac{\partial\widehat{y}_i}{\partial\widehat{c}_i} = \frac{\partial\widehat{y}_i}{\partial\widehat{h}_i} \rightarrow \widehat{h}_i = \tfrac{\beta}{\alpha}\widehat{c}_i$$

The laws of motion of $\widehat{h}_i$ and $\widehat{c}_i$ may thus be formulated as

$$\begin{aligned}\dot{\widehat{h}}_i &= s_h\widehat{k}_i^{\varphi} - [d+\dot{\mu}_i(1-\varepsilon_h)]\widehat{h}_i \\ \dot{\widehat{c}}_i &= s_c\widehat{k}_i^{\varphi} - [d+\dot{\mu}_i]\widehat{c}_i\end{aligned}$$

where d denotes the generalized depretiation rate $x+n+\vartheta$. In terms of broad capital, one gets

$$\dot{\widehat{k}}_i \quad : \quad = s\widehat{k}_i^{\varphi} - \left(d+\dot{\mu}_i(1-\beta\varepsilon_h)\right)\widehat{k}_i$$

where $s = \alpha^{1-\beta}\beta^{\beta}\left(s_h+s_c\right)$. The linear approximation around the steady state is given in matrix form as

$$\dot{\tilde{\mathbf{k}}} \approx \frac{d}{\varphi-1}(\mathbf{k}-\mathbf{k}^*) - \delta\dot{\boldsymbol{\mu}}$$

3 System calculations

The system describing equations (8) and (9) may be compactly written as

$$\begin{bmatrix} \mathbf{I} & -\mathbf{A} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{bmatrix} \dot{\mathbf{y}} \\ \dot{\mu} \end{bmatrix} = \begin{bmatrix} \mathbf{B}_{11} & \mathbf{0} \\ \mathbf{B}_{21} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{y} \\ \mu \end{bmatrix}$$

Observe that

$$\begin{bmatrix} \mathbf{I} & \mathbf{A} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{bmatrix} \mathbf{I} & -\mathbf{A} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} = \begin{bmatrix} \mathbf{I} & \mathbf{0} \\ \mathbf{0} & \mathbf{I} \end{bmatrix}$$

so that

$$\begin{bmatrix} \dot{\mathbf{y}} \\ \dot{\mu} \end{bmatrix} = \begin{bmatrix} \overbrace{\mathbf{B}_{11} + \mathbf{A}\mathbf{B}_{21}}^{\mathbf{B}} & \mathbf{0} \\ \mathbf{B}_{21} & \mathbf{0} \end{bmatrix} \begin{bmatrix} \mathbf{y} \\ \mu \end{bmatrix}$$

Note that the solution implies that the two equations of the system can be interpreted separately. From the model, apply

$$\begin{aligned} \mathbf{A} &= -\delta\varphi\mathbf{I} \\ \mathbf{B}_{11} &= (\varphi - 1)d\mathbf{I} \\ \mathbf{B}_{21} &= \kappa\left(diag(\mathbf{W}\cdot\boldsymbol{\iota}) - \mathbf{W}\right) \end{aligned}$$

The solution of the first row writes

$$\begin{aligned} \mathbf{y}_t - \mathbf{y}_t^* &= e^{\mathbf{B}t}\left(\mathbf{y}_0 - \mathbf{y}_0^*\right) \\ e^{\mathbf{B}t} &= \mathbf{I} + \mathbf{B}t + \mathbf{B}^2\frac{t^2}{2!} + ... \end{aligned}$$

Lyapunov stability is assured by negative eigenvalues of $\mathbf{B}$(Tu, 1994). The Gershgorin circle theorem allows an approximation of the eigenvalues of a square matrix by building a disc around the diagonal value with a radius equal to the absolute row or column sum of the corresponding non-diagonal entries. For the spatial weight matrix $\mathbf{W}$, the maximal eigenvalue is equal to the 1-norm. Due to maximum row normalization, all eigenvalues of $\mathbf{W}$ are less than or equal to 1. Further, note that the Gershgorin theorem implies positive definiteness of $(diag(\mathbf{W}\cdot\boldsymbol{\iota}) - \mathbf{W})$, i.e. strictly positive eigenvalues in the range $(0, 2)$. Note that $\mathbf{W}$ is indefinite. Lastly, rewrite $diag(\mathbf{W} \cdot \boldsymbol{\iota}) - \mathbf{W} = \boldsymbol{\Sigma} - \mathbf{W}$

$$\mathbf{B} = \mathbf{B}_{11} + \mathbf{A}\mathbf{B}_{21} = (\varphi - 1)\, d\,(\mathbf{I}) - \delta\kappa\varphi\,(\boldsymbol{\Sigma} - \mathbf{W})$$

Since the weight matrix is symmetric and $\boldsymbol{\Sigma}$ is diagonal, we can use $\mathbf{W} = \mathbf{P}\boldsymbol{\Lambda}\mathbf{P}^{-1}$ and $\boldsymbol{\Sigma} = \mathbf{I}\boldsymbol{\Lambda}_{\Sigma}\mathbf{I}$.

$$\mathbf{B}_{11} + \mathbf{A}\mathbf{B}_{21} = \mathbf{P} \cdot diag\,[(\varphi - 1)d - \delta\kappa\varphi(\lambda_{i,W} - \lambda_{i,\Sigma})] \cdot \mathbf{P}^{-1}$$

The theoretical maximum eigenvalue of $\mathbf{B}$ is achieved at $\lambda_{i,W} = 1$ and $\lambda_{i,\Sigma} = 0$. Consequently, stability is assured by:

$$(\varphi - 1)d + \delta\kappa\varphi < 0$$
$$\varphi \cdot \left(1 + \frac{\delta\kappa}{d}\right) < 1$$

4 Summary Statistics

Table 3: Summary statistics - average values for the period 2004-2010.

Variable	Mean	Std. Dev.	Min	Max
average growth in real grp per worker	0.0061	0.0183	−0.0464	0.0856
average growth in real grp per employee	0.0077	0.0162	−0.0752	0.1268
net migration per 100 natives	0.319	0.430	−0.593	1.800
log initial real grp per worker	10.4797	0.7206	8.1293	11.7758
log initial real grp per employee	17.4663	0.6974	15.0744	18.3749
share secondary education	48.0904	13.8859	13.3000	78.5000
share tertiary education	26.0507	8.7373	9.0000	53.1000
log heating-degree days	7.8762	0.3562	6.5098	9.1638
log output per square km	14.6538	1.5748	11.2400	20.4446
log remoteness	7.0184	0.2572	6.6951	7.8018
flood affinity	2.8866	1.2489	1	5
fire affinity	1.6431	1.1254	1	5
latitude	48.9432	5.8606	35.1734	69.5890
longitude	9.3807	9.1377	−8.8648	27.4982
log initial population density	4.9608	1.1877	1.1939	9.1202
city/capital region dummy	0.0815	0.2741	0	1

5 Graphs

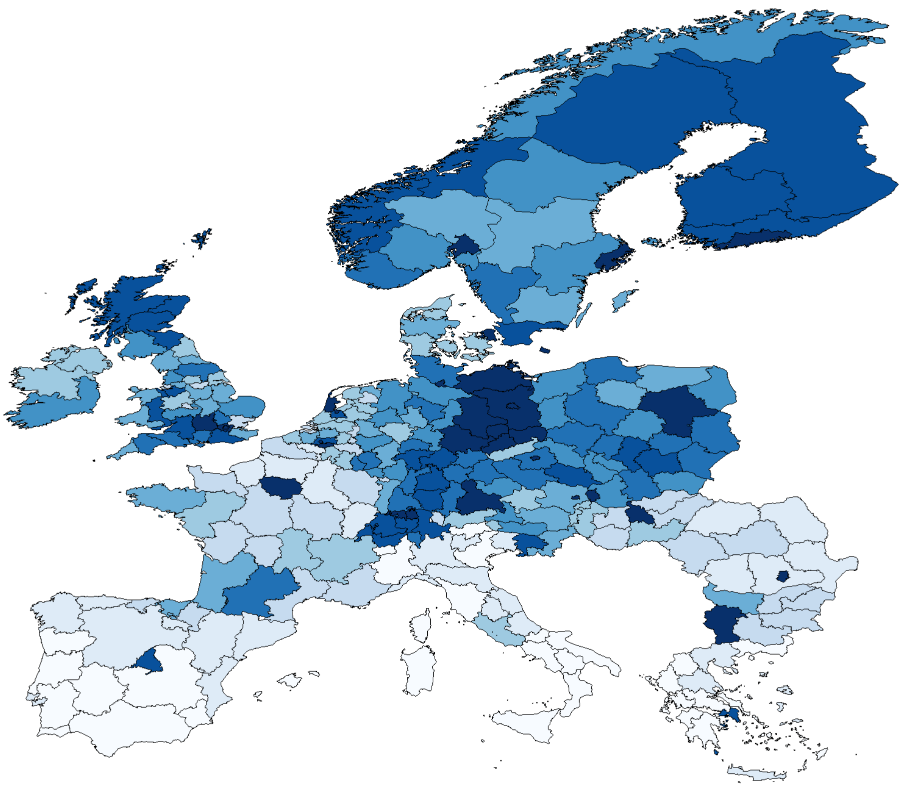

Figure 3: Implied steady states.

6 Robustness

Table 4: Income and Initial Income per Employee

	growth	migration	initial income
migration	-0.429		
	(-1.731)		
initial income	-0.013		
	(-7.873)		
share secondary education / 100	0.001		
	(0.127)		
share tertiary education / 100	0.041		
	(3.097)		
spatial-relative initial income		1.348	
		(3.862)	
spatial-relative output density		-0.149	
		(-3.644)	
spatial-relative heating- degree days		-1.268	
		(-4.290)	
remoteness		-0.640	
		(-2.558)	
floods		-0.008	
		(-0.249)	
fires		-0.041	
		(-1.149)	
latitude			0.008
			(1.682)
longitude			-0.009
			(-2.839)
initial density			0.253
			(7.410)
heating-degree days			-0.106
			(-1.849)
spatially lagged initial density			-0.333
			(-0.886)
spatially lagged heating-degree days			0.326
			(1.248)
city	0.004	0.207	0.022
	(1.055)	(2.388)	(2.020)
constant	0.229	4.575	17.418
	(7.844)	(2.586)	(49.845)
ρ_ε	0.116	0.391	0.050
R^2 (nontrans.)	0.262	0.626	0.976
R^2_z system		0.9312	

Notes: Dependent variables are the average growth in GRP/employee between 2004 and 2010, net migration rates, and initial GRP/employee. t-values are given below the corresponding coefficient. For the initial value equation, country fixed effects are not reported. The sample comprises 270 regions. Coefficients in the 'migration' column are multiplied by 100.

Table 5: FGS3SLS results

	growth I	migration I	growth II	migration II	growth III	migration III	initial income III
migration	-0.635		-0.713		-0.638		
	(-1.816)		(-2.044)		(-2.304)		
initial income	-0.013		-0.011		-0.014		
	(-5.917)		(-4.795)		(-6.089)		
spatially lagged initial income			-0.001		-0.000		
			(-1.082)		(-0.353)		
share secondary education / 100	0.038		0.044		0.036		
	(3.530)		(3.679)		(3.262)		
share tertiary education / 100	0.064		0.066		0.062		
	(4.322)		(4.429)		(4.121)		
spatial-relative initial income		0.702		0.701		0.773	
		(4.586)		(4.579)		(2.215)	
spatial-relative output density		-0.136		-0.137		-0.259	
		(-3.865)		(-3.872)		(-3.413)	
spatial-relative heating- degree days		-1.118		-1.117		-2.728	
		(-4.806)		(-4.803)		(-3.498)	
remoteness		-0.614		-0.606		-0.576	
		(-2.511)		(-2.476)		(-2.341)	
floods		-0.003		-0.002		-0.018	
		(-0.083)		(-0.074)		(-0.572)	
fires		-0.069		-0.069		-0.037	
		(-2.010)		(-2.003)		(-1.078)	
latitude							0.011
							(1.707)
longitude							-0.014
							(-3.193)
initial density							0.362
							(7.787)
heating-degree days							-0.140
							(-1.764)
spatially lagged initial density							-0.278
							(-1.789)
spatially lagged heating-degree days							0.280
							(2.334)
city	0.005	0.236	0.005	0.237	0.006	0.330	0.024
	(1.660)	(2.806)	(1.571)	(2.813)	(2.001)	(4.443)	(1.529)
constant	0.105	4.534	0.101	4.475	0.125	4.372	11.041
	(4.581)	(2.628)	(4.379)	(2.593)	(5.068)	(2.525)	(21.517)
ρ_ε	0.483	0.363	0.471	0.363	0.483	0.367	0.085
R^2 (nontrans.)	0.542	0.642	0.540	0.642	0.541	0.619	0.957
R_z^2 system	0.3746		0.3787			0.8790	

Notes: Dependent variables are the average growth in GRP/LF between 2004 and 2010, net migration rates, and initial GRP/LF. t-values are given below the corresponding coefficient. For the initial value equation, country fixed effects are not reported. The sample comprises 270 regions. Coefficients in the 'migration' columns are multiplied by 100.

Table 6: Income and Initial Income per worker, 1000km radius.

	growth	migration	initial income
migration	-0.674		
	(-2.445)		
initial income	-0.014		
	(-5.870)		
spatially lagged initial income	-0.000		
	(-0.293)		
share secondary education / 100	0.000		
	(3.151)		
share tertiary education / 100	0.001		
	(4.156)		
spatial-relative initial income		0.726	
		(2.339)	
spatial-relative output density		-0.231	
		(-3.467)	
spatial-relative heating- degree days		-2.123	
		(-3.318)	
remoteness		-0.563	
		(-2.248)	
floods		-0.022	
		(-0.682)	
fires		-0.022	
		(-0.644)	
latitude			0.010
			(1.468)
longitude			-0.013
			(-3.067)
initial density			0.360
			(7.761)
heating-degree days			-0.137
			(-1.757)
spatially lagged initial density			-0.309
			(-1.725)
spatially lagged heating-degree days			0.281
			(2.156)
city	0.006	0.325	0.027
	(1.994)	(4.381)	(1.780)
constant	0.125	4.246	11.096
	(4.809)	(2.413)	(21.602)
ρ_ε	0.481	0.396	0.095
R^2 (nontrans.)	0.540	0.621	0.958
R_z^2 system		0.8781	

Notes: Dependent variables are the average growth in GRP/employee between 2004 and 2010, net migration rates, and initial GRP/worker. t-values are given below the corresponding coefficient. For the initial value equation, country fixed effects are not reported. The sample comprises 270 regions. Coefficients in the 'migration' column are multiplied by 100.

	coefficients				t-values			
	mean	min	max	sd	mean	min	max	sd
growth								
migration	-0.678	-0.710	-0.619	0.019	-2.458	-2.575	-2.240	0.069
initial income	-0.015	-0.015	-0.014	0.000	-6.735	-6.791	-6.611	0.032
share sec. education / 100	0.034	0.034	0.036	0.000	3.233	3.198	3.339	0.026
share tert. education /100	0.061	0.060	0.061	0.000	4.085	4.049	4.116	0.018
city	0.006	0.006	0.007	0.000	2.055	2.005	2.105	0.021
constant	0.129	0.126	0.131	0.001	5.475	5.329	5.532	0.032
migration								
spatial-relative initial income	0.009	0.006	0.010	0.001	3.823	1.857	5.186	0.816
spatial-relative output density	-0.002	-0.003	-0.001	0.000	-4.016	-4.428	-3.182	0.245
spatial-relative heating-degree days	-0.016	-0.027	-0.008	0.005	-4.487	-4.794	-3.551	0.284
remoteness	-0.006	-0.006	-0.005	0.000	-2.430	-2.612	-2.040	0.136
floods	-0.000	-0.000	0.000	0.000	-0.264	-0.561	0.024	0.171
fires	-0.001	-0.001	-0.000	0.000	-1.578	-1.769	-1.138	0.188
city	0.003	0.002	0.003	0.000	3.263	2.046	4.482	0.678
constant	0.044	0.037	0.047	0.003	2.551	2.109	2.760	0.162
initial income								
latitude	0.010	0.008	0.012	0.001	1.413	1.129	1.739	0.146
longitude	-0.014	-0.016	-0.013	0.001	-3.169	-3.552	-2.780	0.166
initial density	0.359	0.355	0.363	0.002	7.701	7.552	7.803	0.064
city	0.026	0.023	0.030	0.002	1.694	1.492	1.996	0.147
heating-degree days	-0.136	-0.152	-0.105	0.010	-1.704	-1.882	-1.346	0.114
spatially lagged initial density	-0.372	-0.626	-0.225	0.090	-1.640	-1.957	-0.704	0.294
spatially lagged heatin-degree days	0.353	0.239	0.562	0.073	2.104	1.074	2.463	0.347
constant	10.885	10.173	11.138	0.258	21.638	20.671	21.912	0.244

Table 7: Summary of estimated coefficients and t-values over the search window of the decay parameter.

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The more the merrier? Migration and convergence among European regions

Abstract
Using a spatial systems estimator to incorporate spatial interactions and endogeneity of income levels and migration, this paper finds a positive effect of migration on cohesion within the European Union on the NUTS 2 level. As migration can generally be observed from low to high income regions, growth rates of income per worker tend to decrease in regions experiencing net immigration, while lagging regions experience higher speeds of income convergence. As a result, migration increases sigma-convergence. Results show an increase of more than one third. Free movement of persons also proves to increase efficiency, displayed by higher average convergence speeds.

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