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Interregional migration within the European Union in the aftermath of the Eastern enlargements: a spatial approach

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Abstract This paper investigates interregional migration on a pan-EU level for the era immediately following the accession of new member states with relatively low income levels. It is shown that it is possible to account for spatial effects of interregional migration despite the lack of data on region-to-region migration flows. In the paper, a spatial model framework of interregional migration is developed that corresponds to a spatial lag of X model or, by inclusion of a spatial autocorrelation term, a spatial Durbin error model. The framework shows that within a system, a linear model of migration inevitably results in a function of net-migration which is based on a column-standardised weight matrix. A region's migration level is assumed to be simultaneously affected by determinants at home as well as in other regions, where the latter's influences decrease with distance. The specifications are subsequently applied to data on net-migration rates in 250 European NUTS2 regions over the period 2006–2008. The empirical results reveal a robust association between a region's net-migration rate and its relative location in space. Moreover, migration is driven by income opportunities, labour market conditions, economic growth, human capital endowments as well as temporarily imposed restrictions on the freedom of movement of workers.

Keywords Interregional migration · Enlarged EU · Spatial econometrics · Column-standardised weight matrix

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Interregionale Migration innerhalb der Europäischen Union in den Folgejahren der Osterweiterungen – Ein räumlicher Ansatz

Zusammenfassung Im vorliegenden Artikel werden interregionale Migrationsflüsse innerhalb der gesamten Europäischen Union für die unmittelbar auf den Beitritt von Staaten mit relativ niedrigen Einkommensniveaus folgende Zeit untersucht. Trotz der Nichtverfügbarkeit direkter Migrationsflussdaten können räumliche Effekte interregionaler Migration gemessen und interpretiert werden. Zu diesem Zweck wird ein räumliches Modell interregionaler Migration entwickelt, das als räumlich-ökonometrische Spezifikation dem Spatial-Lag-Of-X-Modell, bzw. – bei Inklusion eines räumlichen Autokorrelationsterms – dem Spatial-Durbin-Error-Modell entspricht. Es wird gezeigt, dass ein lineares Migrationsmodell zwangsläufig zu einer Nettomigrationsfunktion führt, die auf einer spaltenstandardisierten Gewichtsmatrix basiert. Die Spezifikationen werden in weiterer Folge für 250 europäische NUTS2-Regionen für den Beobachtungszeitraum 2006–2008 geschätzt, wobei die empirischen Ergebnisse eine robuste Beziehung zwischen der Nettomigrationsquote und der relativen räumlichen Lage einer Region anzeigen. Darüber hinaus zeigen die Ergebnisse signifikante Effekte der Einkommenshöhen, der Arbeitsmarktbedingungen, des Wirtschaftswachstums, der Humankapitalausstattungen sowie temporärer Einschränkungen der Arbeitnehmerfreizügigkeit.

Schlüsselwörter interregionale Migration · EU-Erweiterungen · räumliche Ökonometrie · spaltenstandardisierte Gewichtsmatrix

1 Introduction

Over the past quarter century, Europe has experienced three important events which eased migration within the continent. Firstly, the dissolution of the Council for Mutual Economic Assistance (Comecon) in 1991 facilitated cross-border movements for the respective residents. Secondly, the Treaty on European Union (Maastricht Treaty) came into force in 1993, seeking to guarantee the free movement of people within the EU. Thirdly, the EU accession of 13 new member states since 2004—of which nine had been part of the Comecon—enlarged the territory of the EU considerably. Economic theory stresses that employment and income opportunities are among the main drivers of migration (e.g. Todaro 1969; Greenwood 1975). Nevertheless, previous studies based on migration within and between Western European countries often report weak migration sensitivities with respect to interregional (and international) changes in labour market conditions (see Decressin and Fatás 1995; Bentivogli and Pagano 1999; Puga 2002; Fidrmuc 2004).

Recently, however, the topic of migration has re-gained considerable attention in European public debates in the context of the EU accessions of 12 new member states in 2004 and 2007, whose average income levels were and remain considerably lower than those of the already established 15 member states (EU15). In view of the generally weak intentions expressed by Europeans of moving to another country or to another region within their own country (Eurofound 2006) and given the persistence in regional unemployment disparities, it comes as no surprise that the European Commission emphasises the benefits of interregional migration and underlines the need of mobilising the EU's existing human resources in its *Europe 2020* strategy. Indeed, within a common monetary area, labour mobility is widely considered to be one of the most important adjustment mechanisms to asymmetric shocks and imbalances not least because the exchange rate instrument is not available to countries and regions. However, in 2006, only around 2 per cent of Europeans in working age lived in an EU country other than their country of origin—a figure that remained largely unchanged in the previous 30 years (European Commission 2006) and is reported to stand at 3.2 per cent in 2010 (Vasileva 2011).

Against the background of these developments, the present paper is set out to explore the drivers of interregional migration within the EU for the time immediately following the enlargements of 2004 and 2007. To this aim, a model of migration within an economic system of interrelated regions is developed which demonstrates how factors that influence out- and in-migration critically depend on the ties between regions. Specifically, spatial weights are constructed to account for such mutual connectivities. As a result, the relative location in space of each region (i.e. the spatial location in relation to all other regions) together with the variables in both source and destination regions are the ingredients used to explain interregional net-migration rates. The model is directly transferred to spatial econometric model specifications and applied to data on realised net-migration in 250 European NUTS2[1] regions over the period 2006–2008, including all continental new member states (NMS) that accessed in 2004 and 2007 except the Baltic states.

In addition to potential region-specific labour market determinants of migration, the paper considers the impact of labour market conditions in spatially related regions. A further factor of relevance concerns migration policy. While most EU15 countries implemented at least some form of temporary restriction to immigration from the NMS, Austria and Germany were the only member states which applied such restrictions for each sector and stretched their duration to the agreed maximum of 7 years. Due to their geographical proximity, these countries were concerned about a potential disproportionately high share of immigration from the NMS (Slavu 2008).[2] Furthermore, the role of human capital in influencing migration is also discussed in this paper. This is motivated by the results of recent *Eurobarometer* surveys carried out by the European Commission, which reveal that a large share of respondents expressing an intention to migrate consists of persons still studying. Moreover, respondents are more likely to consider working in another country the longer their respective duration of education, and a number of micro-econometric studies finds that higher levels of education have a significant positive effect on the individual probabilities of migration (e.g. Bover and Arellano 2002). So far, however, it is less clear whether

[1] NUTS is short for *Nomenclature des Unités Territoriales Statistiques*.

[2] Specifically, their proximity to relatively lower wage countries and the expectation of detrimental effects of immigration on domestic unemployment and wages were used as arguments to justify these temporary repeals of the EU's four freedoms.

such a link carries through to the macro level. Under the assumption that relatively highly educated migrants are more likely to benefit from migrating to regions where their education is demanded, that is, under the premise of a spatial concentration of human capital, one would expect higher net-migration rates in regions with a higher (initial) concentration of educational attainment among the population.

It should be noted that as of now, the European Union provides no data on interregional migration flows. In this sense, methodological advancements such as the spatial econometric modelling of origin-destination flows (see LeSage and Pace 2008; Fischer and Griffith 2008) or tests of new economic geography models in the spirit of Crozet (2004) cannot be realised due to a lack of pan-EU data. This means that any attempt of studying interregional migration within the EU after the eastern enlargements is unavoidably limited to the use of *net-migration* data, which is defined as the difference between total in-migration and total out-migration.[3] Therefore, the aim of this paper lies in providing a framework for the study of migration between a large number of European regions based on available data. The research question relates to the estimation of variables that account for spatial separation of origins from destinations that constrains or impedes the interaction of interregional migration within the enlarged European Union.

The first contribution of the paper is methodological. As discussed by Arbia and Fingleton (2008) and LeSage and Pace (2014), the arbitrariness of choosing a spatial weight matrix is often seen as a weak point of spatial econometrics by its critics. For this reason, we set up a spatial model framework of interregional migration that shows that within a system, a linear model of migration inevitably results in a function of net-migration which is based on a column-standardised weight matrix. The model framework demonstrates that the usually applied row-standardised weight matrix is by no means a self-evident or in any way obvious choice. In addition, our proposed method of column-standardisation gives more weight to centrally located regions, which is an aspect that we also discuss.

Secondly, we apply the model framework as the basis for our spatial econometric model specifications. These specifications, namely a *spatial lag of X model* and a *spatial Durbin error model*, correspond to direct transformations of the spatial model framework and provide an exemplifying case of deducing spatial econometric model specifications from theoretical reasoning. The empirical results identify the drivers of interregional migration in an economic area that is characterised by vast disparities with respect to socio-economic variables such as income and unemployment. Our results, which underline the impact of distance on migration, are then compared with the existing literature. To the best of our knowledge, the present econometric study is the first that considers interregional migration for the period immediately following the EU's enlargements which includes the NMS regions.

The paper is structured as follows. In the next section, relevant literature on the drivers of migration is briefly reviewed. After that, the model framework and the spatial econometric model specifications are introduced. The subsequent two sections describe the data and present the results. The final section concludes. It should be

[3] Net-migration as dependent variable has also recently been used by Ederveen et al. (2007) and Rodríguez-Pose and Ketterer (2012) in EU15 migration studies.

noted that in what follows, the frequently used terms "in-migration" and "out-migration" refer to interregional migration that may or may not involve the crossing of a national border, while "immigration" and "emigration" involve international migration, and "migration" without further specification refers to any kind of mobility of persons.

2 Literature Review

There exist several theories to explain migration. Models of new economic geography focus on the role of agglomeration effects which stem from increasing returns. As modelled by Myrdal (1957), the core of an economy may benefit from such forces and become more attractive for mobile factors when its endowments are high in comparison to the periphery. The idea of increasing returns in connection with a regional core-periphery structure within a superordinate economy has been taken up by Krugman (1991), who develops an influential model that shows how both capital and skilled labour may be attracted to the central region, leaving the peripheral region relatively underdeveloped.[4] These models help to explain how human capital tends to migrate to regions where human capital endowments are already relatively high.

In Krugman's (1991) model, workers maximise utility by reacting to the ratios of nominal wages to regional price levels. Although a non-dynamic model, this assumption reflects neoclassical economic theory, which typically assumes that the decision to migrate is guided by the objective of maximising lifetime expected utility. Accordingly, whether or not a person migrates depends on the comparison between the current and future expected costs and benefits associated with such a move. Within a model of migration from rural to urban areas, Todaro (1969) emphasises that a simple comparison of real income levels in the source and destination regions falls short of explaining migration, and that the probability of finding a job in the destination region is a further essential determinant of mobility.

Over the past years, numerous empirical papers have tested these predictions. Studies based on European data yielded mixed empirical results, though. Bentolila and Dolado (1991), for example, report that migration within Spain did not respond to interregional wage differentials in the time period 1962–1986. Controlling for fixed country and time effects, Bentivogli and Pagano (1999) state that regional net-migration is sensitive to changes in income disparities, but unresponsive to changes in the relative unemployment rates. Their data comprise annual NUTS1 data of 11 EU member states over the time period 1981–1994. Faini et al. (1997) contend that the simultaneous occurrence of an increase in the dispersion of regional unemployment rates and a decrease in interregional migration rates within Italy can be explained in terms of the growing financial constraints involved in moving across borders: Higher unemployment is associated with a lower disposable household income which in turn aggravates the household's ability to cover the expenses of migration of family

[4] Krugman (1991, pp. 484) refers to mobile "workers with industry-specific skills" and distinguishes them from immobile peasants. In this sense, industry workers represent human capital as defined by "the total contribution of workers of different skill levels to production" (Romer 2005, pp. 134).

members. The estimation results show that households in Italy with an unemployed head or a low level of income are less likely to move.

Decressin and Fatás (1995) point to the advantage of using regional data when analysing migration in Europe, as the aggregation of highly different regional units within a country obscures the fact that regions in different countries may react more similarly to changes in the economic environment than regional markets within a country. One of their findings is that it takes considerably more time for an economic shock to be accommodated by migration in Europe than in the US. The magnitude of migration in Europe three years after a shock occurs is equivalent to the magnitude of migration observed only one year after a similar shock occurs, in the US. This finding is corroborated in Ederveen et al. (2007) who estimate both static and dynamic panel data models using NUTS2 net-migration data of 83 regions of seven EU member states spanning the period 1983–2000. The estimations show that regions with higher female labour participation rates exhibit lower regional net-migration rates, whereas no such relation is found regarding male labour participation rates. The authors interpret this result as evidence that the labour supply of men is close to being inelastic, while the elasticity of female participation is such that it supersedes migration as a labour-market adjustment mechanism.

Fidrmuc (2004) and Huber (2004) analyse labour market adjustment within transition economies before the EU's eastern enlargements and find that interregional mobility was no more responsive to asymmetric shocks in EU accession countries than in the EU15. The studies conclude that migration is ineffective in narrowing regional disparities in the formerly centrally planned economies. The data used are in-migration and out-migration per region recorded by national statistical offices. Employing data based on records from municipal population registers, Stark et al. (2009) provide evidence that migration within Poland during the period 1999–2005 was not driven by changes in average per-capita disposable income levels, but rather by the dispersion of income in the regional population. The authors conclude that an increase in relative rather than absolute poverty induces individuals to emigrate. Zaiceva and Zimmermann (2008) use the information of *Eurobarometers* conducted before and after the EU enlargement and find that after 2004, the determinants of migration intentions do not differ between the respondents in the NMS and those in the EU15. In particular, migration intentions tend to increase with the years of schooling and are higher for young, male, urban individuals who have already moved abroad in the past and are unsatisfied with their salary. The role of the employment status appears to be less clear in determining migration intentions. Rodríguez-Pose and Ketterer (2012) use net-migration rate data for 133 European regions of 12 EU15 countries from 1990–2006 and show that—beyond economic and human capital related factors—local amenities such as average temperature and recreation and tourism services significantly affect migration.

Finally, a strand of the literature points to the growing importance of student migration and the fact that the intention of studying abroad for a temporary period may end in a permanent stay (Tremblay 2002). In this context, Dreher and Poutvaara (2011) show that in the US the stock of foreign students is an important predictor for subsequent migration flows. In the European context, the process of harmonisation of university education and student exchange programs has led to rapidly increasing student flows that are geographically unevenly distributed (Tremblay 2002).[5] Parey and Waldinger (2011) use information on the European ERASMUS student exchange program and find that studying abroad significantly increases an individual's probability of subsequently working in a foreign country.

To summarise, studies on interregional migration within the EU so far consider the EU15 area while ignoring the NMS, or they consider migration from the NMS to the EU15 while lacking a pan-EU perspective. The literature considers income levels and unemployment rates as the most important determinants, but not all empirical studies identify them as decisive. Although empirical evidence is scarce, the role of human capital is nevertheless considered as critical by theory. Furthermore, migration occurs with a time lag with respect to individual decision-making and actual migration, i.e. changes in economic conditions do not occur simultaneously but rather before corresponding changes in migration patterns.

3 The model framework

This section's purpose is to transform a set of linear equations describing in-migration and out-migration to a spatial econometric model specification that can be applied to the available data. The model framework developed in this section can be considered as a spatial augmentation of Greenwood's (1978) linear model of migration. Two critical assumptions that lead to the subsequent section's spatial econometric model specification are discussed and formalised. These assumptions relate to Lee's (1966; see also Stillwell 2008) conceptualisation of migration as being influenced by gravity variables: origins, destinations and the links between them. Regional characteristics that attract migrants are regarded as "pull factors", while those that drive people out are regarded as "push factors". Since the act of migrating imposes costs, distance is seen as impeding migration.

The first assumption relates to the nature of decision-making based on economic variables. If a variable is considered to be decisive, then this can only be the case if it has a preferable value in one region relative to another: If, for example, wages in one region are high enough to represent a pull factor that attracts migrants, then it must be that they are low enough in at least one other region to represent a push factor there. The same reasoning holds for each variable that potentially affects migration. Hence, we argue that within a system, if a potential migrant decides to take action because the value of a particular variable within the destination region is expected to increase his or her utility, then it must be that he or she prefers that value *relative* to the value in other regions, including his or her origin.[6]

[5] Recently, the research investigating the role of migrant networks as drivers of international migration has received considerable attention (e.g. Pedersen et al. 2008; Mayda 2007; Nowotny and Pennerstorfer 2011). Such data are not available for the sample underlying the present study.

[6] Greenwood (1978) considers two separate equations for in-migration and out-migration which consist of the same variables but one, namely the percentage of urban population, which appears in his in-migration equation only. Considering our first assumption, we may ask why the percentage of urban population is expected to have no effect on out-migration, if it is expected to affect in-migration. In our perception, if

The second assumption relates to the impact of distance between regions on the interaction between regions. Distance is widely accepted in the literature as having an impact on migration, as it increases (i) the direct costs of moving as such, (ii) opportunity costs, (iii) information costs, (iv) psychic costs and, furthermore, (v) migrants often follow past migrants, who may have moved to near destinations (Greenwood 1997; Borjas 2010). In this sense, distance-weighted variables represent spatial spillovers: The closer a favourable regional characteristic is located, the higher its effect on actual migration.

Consider a system of n regional economies with unrestricted migration within the superordinate system. In such a system, one unit of out-migration from a particular region is necessarily equal to one unit of in-migration to a different region, and vice versa. It follows that those variables that determine a region's out-migration are the same that determine another region's in-migration. Individuals are assumed to base their migration decisions upon observed conditions and expectations. Therefore, realised migration depends on temporally lagged determinants. By assuming a linear relationship, the equations for in-migration I and out-migration Ω at period t for any region $i=1,2,\ldots,n$ amount to

$$\mathrm{I}_{i,t} = \gamma_1 X_{1,i,t-1} + \gamma_2 X_{2,i,t-1} + \ldots \quad (1)$$

$$\Omega_{i,t} = \beta_1 X_{1,i,t-1} + \beta_2 X_{2,i,t-1} + \ldots \quad (2)$$

Where the Xs represent the variables that explain migration. By definition, net-migration M equals the difference between in-migration and out-migration and therefore at any t the following relation applies for any region i:

$$\mathrm{M}_{i,t} = \mathrm{I}_{i,t} - \Omega_{i,t} \quad (3)$$

From Eqs. (1), (2) and (3) it can be seen that variables that have an impact on in-migration and out-migration may not be captured by net-migration, as the effects may outweigh each other. However, estimations that are exclusively based on in-migration may also overestimate some variables' effects on population-change, as the same variables may also induce out-migration. In this sense, net-migration is—in contrast to pure measures on in-migration and out-migration—the appropriate determinant for migration-induced population-change. Nevertheless, the interpretation of net-migration is different from in-migration and should not be equated.

In order to capture the connectivity of region j to region i, a weight-variable w_{ij} with the following properties is defined: A region j is directly connected to i if $w_{ij}>0$, which in the present context means that those variables that stimulate or hinder out-migration in j will simultaneously influence in-migration in i. Consider an $n\times n$ matrix **W** where a neighbourhood relation between any two regions i and j is captured by the corresponding element in row i and column j. By defining $w_{ij} \geq 0 \wedge w_{ii} = 0 \ \forall i$,

one migrant chooses to migrate from region i to region j because j is more urban, then it follows that he or she chooses to migrate from region i to region j because i is less urban.

in-migration to region i can be expressed as the weighted sum of out-migration from all other regions, or formally

$$\mathrm{I}_{i,t} = \sum_{j=1}^{n} w_{ij}\Omega_{j,t} \quad (4)$$

It is convenient to express this relation in matrix-form as $\mathbf{I}=\mathbf{W}\boldsymbol{\Omega}$, where $\mathbf{I}$ and $\boldsymbol{\Omega}$ are $n\times 1$ vectors that consist of the respective values of in-migration to and out-migration from the n regions at period t. Note that the total number of out-migration from any region is split across all other regions, so that at any t a certain share of any region i's out-migration has a particular region $j \neq i$ as destination. In mathematical terms this means that the sum of weights that each particular element of the vector $\boldsymbol{\Omega}$ is being multiplied with must equal one, i.e. $\Sigma_{i=1}^{n} w_{ij} = 1 \forall j$. This condition is fulfilled if $\mathbf{W}$ is a column-standardised matrix. Consequently, this condition ensures that the sum of out-migration equals the sum of in-migration, i.e. $\Sigma_{i=1}^{n}\mathrm{I}_{i,t} = \Sigma_{i=1}^{n}\mathrm{O}_{i,t}$.

From $\mathbf{I}=\mathbf{W}\boldsymbol{\Omega}$ it follows that $\boldsymbol{\Omega}=\mathbf{W}^{-1}\mathbf{I}$. In accordance with Eq. (3), $\mathbf{M}=\mathbf{I}-\boldsymbol{\Omega}$, where $\mathbf{M}$ is an $n\times 1$ vector that captures the regions' values of net-migration. Consequently, at any t the following relation applies for the system:

$$\mathbf{M} = \mathbf{W}\boldsymbol{\Omega} - \boldsymbol{\Omega} \quad (5)$$

Note that within a system, the sum of net-migration values $\Sigma_{i=1}^{n}\mathrm{M}_{i,t} = 0$. This zero-sum relation prevails if and only if the above defined condition $\Sigma_{i=1}^{n} w_{ij} = 1\ \forall j$ is fulfilled, that is, if all outflows of a region are absorbed by the other regions within the system. Put differently, from a column-standardised $\mathbf{W}$ as applied in Eq. (5) it follows that total net-migration equals zero.

For any region i, Eq. (5) may also be expressed in non-matrix form as

$$\mathrm{M}_{i,t} = \beta_1 \sum_{j=1}^{n} w_{ij} X_{1,j,t-1} + \beta_2 \sum_{j=1}^{n} w_{ij} X_{2,j,t-1} + \ldots - \beta_1 X_{1,i,t-1} - \beta_2 X_{2,i,t-1} - \ldots \quad (6)$$

Equation (6) states that within the system of n regions, a variable that determines out-migration from one region i must have an influence on net-migration in at least one region $j \neq i$, which is captured by the opposite signs of the coefficients of the weighted and unweighted explanatory variables, respectively. If region i is influenced by more than one region of the system, the relative influence of each particular region j is weighted by its individual proximity to region i.

Note that the model framework can easily be extended to include third-country migration. In analogy to an internal migrant, an external migrant who enters or leaves the system must base his or her decision in which region he or she will settle on variables that determine his or her utility. There is no a priori reason to assume that these variables differ with respect to external and internal migration. By considering that these variables are the same, Eqs. (1) and (2) also hold for immigrants and emigrants, respectively. However, if external migrants are included in the specification, then in general $\Sigma_{i=1}^{n}\mathrm{M}_{i,t} \neq 0$.

Despite the assumption of identical utility functions, it may be that migrants have nevertheless preferences for particular regions (e.g. as a matter of preferred languages or cultures), or that external migration differs due to varying third-country migration laws across the EU's member states. Furthermore, since external migrants do not move within the system but rather enter or leave the system from beyond, the impact of distance may vary. The net-migration Eq. (6) may therefore be augmented by a variable ε that captures these exogenous impacts, where the impact of space can be captured by a spatial autocorrelation coefficient ρ, so that $\varepsilon_{i,t-1} = \rho\Sigma_{i=1}^{n} w_{ij}\varepsilon_{j,t-1} + \varphi_{i,t-1}$, with φ capturing the remaining non-spatial effects.

4 Spatial econometric model specification

To estimate net-migration, Eq. (6) can be re-formulated in matrix-form as

$$\mathbf{y} = \mathbf{X}\hat{\boldsymbol{\beta}} + \mathbf{W}\mathbf{X}\hat{\boldsymbol{\beta}}' + \boldsymbol{\varepsilon} \tag{7}$$

where $\mathbf{y}$ is an $n \times 1$ vector of observations on net-migration for the n regions at period t, $\mathbf{X}$ is an $n \times p$ matrix containing the values of explanatory variables at period $t-1$, $\mathbf{W}$ is an $n \times n$ matrix as defined in the preceding section, and $\hat{\boldsymbol{\beta}}$ as well as $\hat{\boldsymbol{\beta}}'$ are $p \times 1$ vectors of coefficients that correspond to the β s in Eq. (6) with negative and positive signs, respectively. The $n \times 1$ vector $\boldsymbol{\varepsilon}$ captures the variables' potentially differing impact on international migration as discussed above. If these impacts have spatial effects, they can be expressed as

$$\boldsymbol{\varepsilon} = \rho\mathbf{W}\boldsymbol{\varepsilon} + \boldsymbol{\varphi} \tag{8}$$

Where ρ is a spatial autocorrelation coefficient of error terms and $\boldsymbol{\varphi}$ is a vector of i.i.d. errors with variance σ^2. Equation (8) can be re-expressed as $\boldsymbol{\varepsilon} = (\mathbf{I_n} - \rho\mathbf{W})^{-1}\boldsymbol{\varphi}$, with $\mathbf{I_n}$ being an $n \times n$ identity matrix.

W may be interpreted as representing a spatial weight matrix that captures the connectivities w_{ij} between all pairs of regions. A specification which allows for spatial lags of the explanatory variables as represented by Eq. (7) is referred to by LeSage and Pace (2009, pp. 30) as a spatial lag of X model (SLXM), since the model contains spatial lags of neighbouring home characteristics as explanatory variables. If the specification additionally allows for spatially dependent errors as represented by Eq. (8), then it is referred to as a spatial Durbin error model (SDEM). In contrast to spatial autoregressive models such as the spatial Durbin model (SDM), the SLXM and SDEM do not include a spatially lagged dependent variable, which greatly simplifies the interpretation of the results: The partial derivatives of the dependent variable with respect to any independent variable are identical to the respective coefficients. Hence, the interpretation is straightforward (see LeSage and Pace (2009) for a discussion).

The larger the value of one particular element w_{ij}, the closer region j is considered to lie to region i. Note that for each region i, some regions lie closer than others, so that the specific connectivities of any two regions j and j' may take on different values, with either $w_{ij} > w_{ij'}$, or $w_{ij} = w_{ij'}$, or $w_{ij} < w_{ij'}$. Note also that if a region j lies relatively close to region i this does not necessarily mean that region i lies relatively closely to region j, i.e. it may be that $w_{ij} \neq w_{ji}$. If $\Sigma_{i=1}^{n} w_{ij} = 1 \; \forall j$, then $\mathbf{W}$ corresponds to a column-standardised weight matrix as required by the model framework.

In contrast to row-standardised matrices, column-standardised matrices are only seldom used in applied spatial econometrics. There is, however, no a priori reason to expect one type of weight specification to yield superior results. Applications of a column-standardised matrix based on theoretical reasoning are found in Ponds et al. (2010) and Vinciguerra et al. (2011), who find a column-standardised matrix suitable in capturing knowledge flows. Although the aforementioned papers examine a different issue, they are related to the present paper as the choice of the appropriate weight matrix is based on theoretical reasoning. In this context it should be mentioned that the absence of theoretical foundations regarding the spatial weight matrix has been subject to criticism (Corrado and Fingleton 2012; Gibbons and Overman 2012). The present paper contributes to this discussion insofar as it argues and shows that a row-standardised spatial weight matrix is not necessarily an appropriate approach. On the one hand, row-standardised weight matrices are acknowledged to facilitate the computation and interpretation of the spatial autocorrelation coefficient, because the maximum eigenvalue of such a matrix equals one and for this reason the coefficient has a maximum value of one (Anselin 2006). These advantages, however, also hold for column-standardised matrices: Since the Perron Frobenius theorem ensures that every stochastic matrix has a largest absolute value of an eigenvalue of one (Pasinetti 1981, pp. 297), the spatial autocorrelation coefficient has a maximum value of one in the case of a column-standardised weight matrix, too.

The elements w_{ij} for $j=1,2,\ldots,n$ are assumed to be non-negative and non-stochastic, with $w_{ij}=0$ if $i=j$. In principle, the elements w_{ij} and the resulting weight matrix $\mathbf{W}$ may be developed from any concept of distance. Considering that migration by its very nature depends on some kind of transport, this study's weight matrices are based on road travel times by car between NUTS2 regions as calculated by Schürmann and Talaat (2000).[7] The original matrix contains the respective time it takes to travel from region i to j in its rows, and therefore the columns contain the travel times from j to i.

Any distance-based approach can be used with different functional forms where $w_{ij} = f(\delta_{ij})$, δ_{ij} denoting the distance from region i to j. In what follows, inverse distance weights based on a predefined constant number k of neighbours are applied, which means that closer neighbours are given relatively more weight. This concept is often referred to as the concept of k-nearest neighbours and represents one of the most common methods of constructing a weight matrix. Next, two methods of column-standardisation are described, of which the first one (labelled "method 1" henceforth) is straightforward as each region is assigned those k regions as neighbours that are closest column-wise. Formally,

$$\begin{cases} w_{ij} = \delta_{ij}^{-r} \Big/ \sum_{i=1}^{n} \delta_{ij}^{-r} & \text{if} \quad \delta_{ij} \leq \delta_j^{*}(k) \forall i, j = 1, 2, \ldots, n; i \neq j \\ w_{ij} = 0 \quad \text{if} \quad \delta_{ij} > \delta_j^{*}(k) \vee i = j \end{cases} \tag{9}$$

[7] The distances are originally calculated by travel times between the central cities of NUTS3 regions. Based on these results, Schürmann and Talaat (2000) estimate the distances between the corresponding NUTS2 regions.

and where $\delta_j^*(k)$ is a defined critical cut-off distance for each region, and r is an arbitrary exponent. The result is an $n \times n$ matrix where each column has the same number of nonzero elements, and where each column-sum equals one. An alternative method (labelled "method 2" henceforth) to construct an appropriate column-standardised matrix is to simply transpose a conventional row-standardised nearest-neighbours matrix, formally expressed as

$$\begin{cases} w_{ji} = \delta_{ij}^{-r} / \sum_{j=1}^{n} \delta_{ij}^{-r} \text{ if } \delta_{ij} \le \delta_i^*(k) \forall i, j = 1, 2, \ldots, n; i \neq j \\ w_{ji} = 0 \text{ if } \delta_{ij} > \delta_i^*(k) \vee i = j \end{cases} \tag{10}$$

The result is a column-standardised matrix that is identical to the one above if $w_{ij} = w_{ji}$ $\forall$ i, j, i.e. if the weight matrix is symmetric. However, the applied car travel times are asymmetric and hence in this paper $w_{ij} \neq w_{ji}$. The associated distances are nevertheless fairly similar, therefore the weight matrices constructed by method 1 and method 2 differ only slightly from each other.

Note that with both methods, while the column-sums of each matrix equal one, the row-sums are not identical across regions. This is important as it follows from matrix algebra that any weighted variable $\Sigma_{j=1}^{n} w_{ij} X_j$ will ceteris paribus have higher values the higher the corresponding row-sum $\Sigma_{j=1}^{n} w_{ij}$. Expressed verbally, more centrally located regions will display higher row-sums, peripheral regions will display lower row-sums. Also note that since the sum of column-sums equals n, it must be that the sum of row-sums also equals n, from which it follows that the average row-sum equals $n/n = 1$. Put differently, the column-standardised nearest neighbour matrix is able to capture the relative centrality/peripherality of a region: A row-sum higher than one corresponds to relative centrality, while a row-sum smaller than one corresponds to relative peripherality. Hence, there exists a striking difference to the commonly applied concept of row-standardised weight matrices: Whereas a row-standardised weight matrix implicitly assumes that the impact of other regions is identical for each region under consideration, a column-standardised matrix regards those regions which lie relatively closely to other regions as being influenced more strongly.

5 Variables and data

The estimations in this paper are based on the NUTS2 regions as classified by Eurostat.[8] Of all NUTS2 regions, those 250 regions that geographically lie in Europe and for which sufficient data for the considered time period exist are included in the study. For a list of the included regions see Appendix A. The source of all data is Eurostat, summary statistics and correlation coefficients of the employed variables are reported in Tables 5 and Table 6 in Appendix B, respectively.

It should be noted that in what follows, all regions are treated alike although it may be argued that intra-national migration may differ from international migration

[8] The classification is primarily based on institutional divisions, where the threshold levels for the number of NUTS2 regions' inhabitants are 800,000 and 3,000,000.

for various reasons, the most important of which are institutional, cultural, historical and linguistic variations between countries, which are not or to a lesser extent relevant with respect to interregional migration within a member state. Although data on region-to-region migration flows are not available, greater similarity within countries or other spatial areas is accounted for indirectly via two channels. Firstly, it is a safe assumption that the applied spatial weight matrices, which are based on travel time distances, are more correlated to national ties than pure great circle distances would be. With closer regions given more weight as a consequence of the application of inverse distances, this correlation is accounted for. Secondly, since many if not all considered regional variables are also influenced by policies of the respective national authorities, similarity between regions within a member state is captured through similar values of income, growth etc.

5.1 The dependent variable

The dependent variable in Eq. (7) is the net-migration at regional level normalised by the respective regional population size, which yields a measure of net-migration per inhabitant and region, averaged over the years 2006, 2007 and 2008.[9] The net-migration data are based on records from municipal population registers and correspond to the definition of migration that is identical to the act of crossing an administrative border (i.e. actually migrating).[10] Using this strict definition avoids many of the problems encountered in attempting to identify a migrant (see, for example, Pedersen et al. (2008) for a discussion). Especially in regional studies, attempts to categorise migrants on the base of an attribute such as the country of birth, citizenship or the parents' countries of birth seem inappropriate.

Figure 1 visualises the respective net-migration rates in the EU, which are very heterogeneous across regions and by no means always positive. Figure 2 accompanies the map of Fig. 1 by displaying how net-migration rates vary across the member states' regions. Some regions in Bulgaria, France, Germany and Hungary are among those with the lowest (i.e. negative) net-migration rates. These cases, however, are not necessarily representative for the countries' overall net-migration rates which may be relatively high—as in the case of France. At the other end of the spectrum, some regions in the Czech Republic, Italy and Spain exhibit the highest net-migration rates.

[9] For some regions, data on net-migration is not available for all of the observation period's three years, and the average has been taken of the respective available periods. This is the case for all Danish, Finnish, Greek, and Irish (Republic of Ireland) regions as well as Sardinia (Sardegna) for 2006, for all Belgian, English and Welsh regions for 2008, and for all four Scottish regions as well as for Northern Ireland for 2006 and 2008, which amounts to a total of 67 estimated values out of 750.

[10] As in most studies (see Decressin and Fatás 1995), the data include external migration. The analyses would possibly benefit from data that capture migration flows between each pair of regions in the sample. As of today, however, such data are available only for particular countries, and where it exists, the data are limited to intra-country flows.

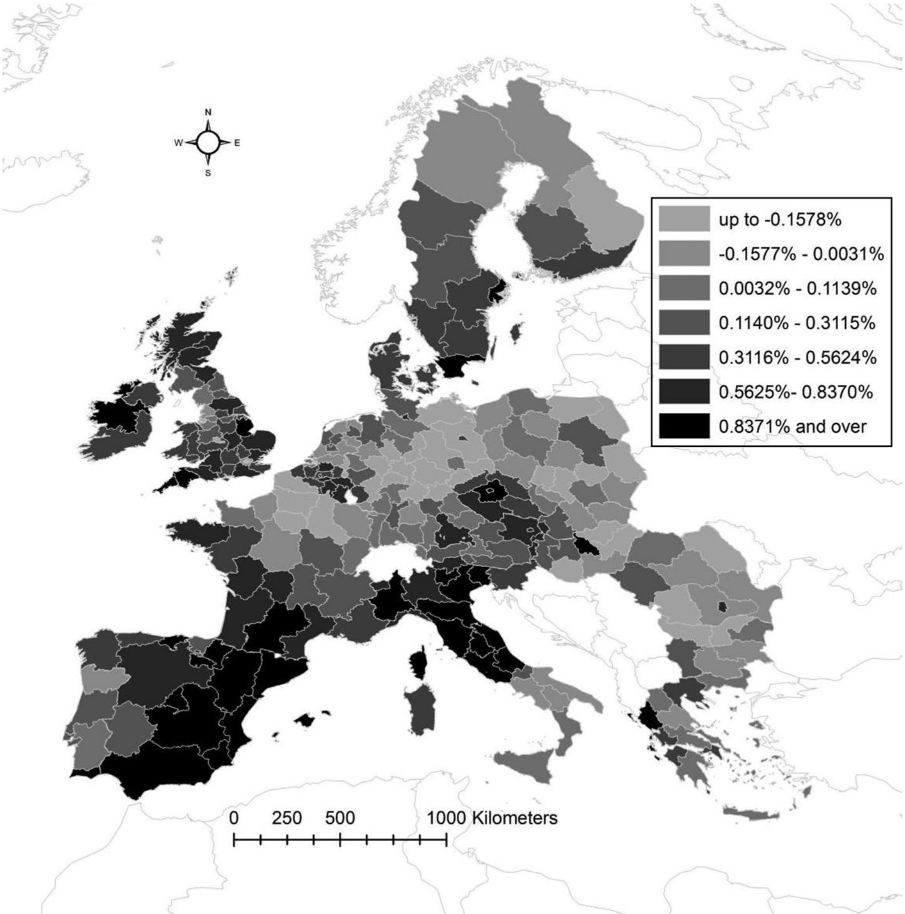

Fig. 1 Regional net-migration rates, average 2006–2008. (Note: Classes are defined as quantiles)

5.2 Explanatory variables

In order to reduce endogeneity and to take into account that the act of migration usually occurs with a considerable time lag after the migration decision is taken, the explanatory variables are lagged in time with respect to the dependent variable. It should be noted that regional net-migration data before 2005 are not available for a large number of regions, including all Czech, Finnish, German, Greek, Irish and Scottish regions, among others. For this reason, a panel data approach is infeasible. Instead, the explanatory variables are average values of observations over the years 2003, 2004 and 2005 and hence the estimations cover up to a 3 year lagged migration response. Furthermore, the explanatory variables are split into two groups, namely some core explanatory variables that essentially represent Greenwood's (1978) selection, and some further explanatory variables that are mentioned in the literature as possibly being influential, as argued above. The discussion below includes notes on the expected signs of the variables within one region, where from Eqs. (5) and (6) it

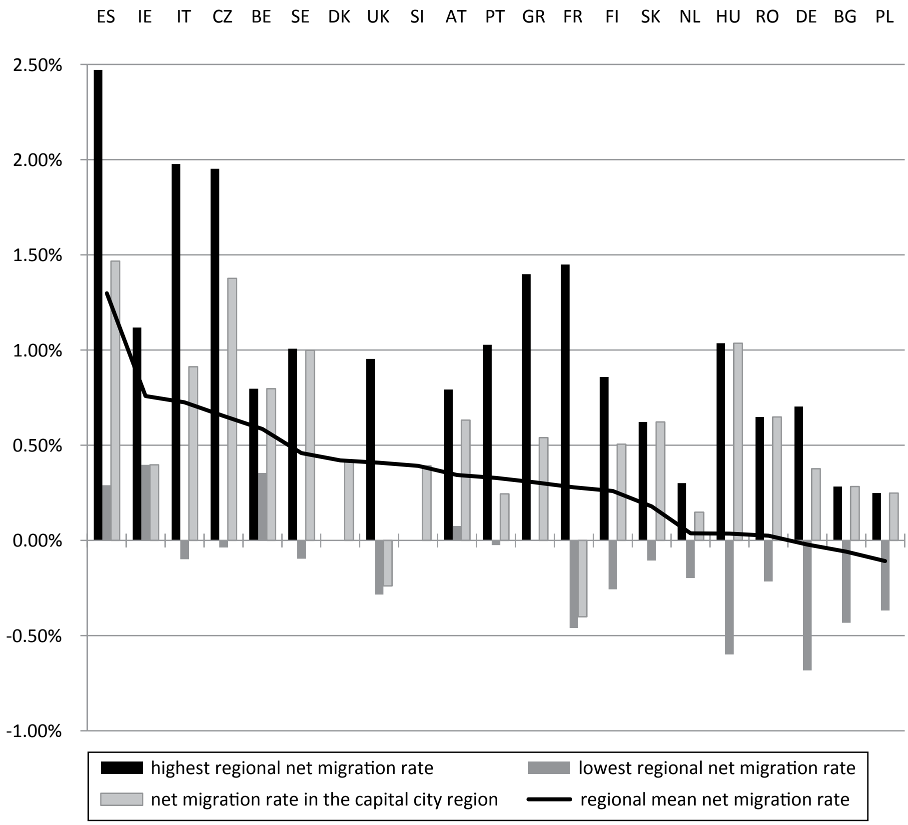

Fig. 2 Regional variations in net-migration rates, average 2006–2008

implicitly follows that contrary signs are expected for the non-lagged and spatially lagged variables.

5.3 The core explanatory variables

The first group of explanatory variables covers human capital, unemployment, income, economic growth and population density. In order to account for the role of *human capital* in shaping migration patterns, first the share of the regional population with a tertiary education is employed as a proxy for highly qualified personnel. Alternative measures include the human resources (as measured by persons) in science and technology as a share of the population or as a share of employees. These alternative measures are highly correlated and for this reason provide similar results. A positive sign is expected due to the presence of human capital intensive industries in some regions (which may further attract human capital), study-related migration, and/or higher levels of productivity as a consequence of available human resources.

Probably the most commonly considered variable in migration studies is the rate of *unemployment*, which is presumably highly correlated with the probability of finding a job and hence expected to have a negative influence on in-migration and a positive effect on out-migration. As regards migrants' income expectations, regional data on primary and the respective secondary distribution of *income* of households is available, where the latter considers social benefits and cash-transfers received, as well as taxes and social contributions paid. As the expected disposable income is supposed to be a relevant pull factor for potential migrants in standard models of migration (Todaro 1969), the secondary rather than the primary household income is considered as a determinant of net-migration.

A further explanatory variable is the per capita *growth* rate of the gross regional product (GRP) in real terms, which captures a region's value addition through production and is expected to exert a positive influence on net-migration as it is likely to boost overall labour demand. Moreover, migrants may take growth as a signal that income levels, even if low, are likely to rise in the near future. Finally, the population *density* controls for potential agglomeration effects within countries, particularly in urban areas. The variable is specified for each region as the natural logarithm of the number of inhabitants divided by area, and is expected to have a positive sign.

5.4 Further explanatory variables

The second group of explanatory variables amends the first and covers the employment rate, the price levels, the share of young persons in the population, as well as labour market restrictions. According to Ederveen et al. (2007), net-migration is negatively determined by a region's female labour participation as the latter crowds out in-migration. Drawing on that finding, the regional *employment* rate is employed, defined as the fraction of persons in the working age population who work either self-employed, employed, or in family business. The variable is highly correlated with the regional female participation rate and hence yields similar results.

A variable that is often considered to influence the migration decision is the *price level* which is taken in this study as the ratio of GRP at current prices to GRP at purchasing power parities (PPP). Hence this variable is expected to capture the costs of living[11] (where higher values are associated with lower price levels). A region is also expected to be more attractive if it has a relatively large share of young persons in working age among the population (Myrdal 1957). This may stem from the fact that migrants themselves tend to be relatively young (Eurofound 2006) and hence may prefer destinations that offer amenities typically appreciated by similarly aged persons. For this reason we consider the share of persons aged 20–39 as *young population*.

Finally, a dummy variable is generated where the regions in Austria and Germany take on a value of one, as these countries *restricted* the access of citizens from the new member states to their labour markets during the entire observation period since the countries' accession to the EU. Every other country either never imposed any restrictions, or did so only for a brief period of time (up to April 2006) and/or in

[11] GRP at PPP is standardised so that for the EU as a whole, GRP at current market prices and GRP at PPP have identical values.

specific sectors.[12] If the restrictions had an effect, the coefficient should be negative. In the next section, the results based on a selection of the variables described above are presented.[13]

6 Econometric results

6.1 The baseline estimates

Table 1 displays the results of estimating Eqs. (7) and (8) using the core variables described in the previous section. The first column (labelled "non-spatial") reports the results of the most simplest specification, where a region's net-migration rate is explained solely by the economic attributes of that particular region.[14] In the remaining columns, the results are shown which concern the potential influence on a region's net-migration rate exerted by the economic conditions in that region's neighbourhood. Specifically, the variables are lagged in space according to the two methods specified above with $k = 125$ and $r = 0.5$ for the SLXM and SDEM (see Eqs. (9)–(10)).[15] As regards the non-weighted variables, a region's net-migration rate is negatively related to its unemployment rate and positively related to its human capital endowment, disposable household income level and GRP growth rate. Moreover, the net-migration rates tend to be higher if a region happens to have a high population density, although the effect is weak. Note also that the estimates' coefficients as well as the respective significance levels are almost identical for the SLXM and SDEM specifications.

Of the spatially weighted variables, three are highly significant and have the opposite sign as compared to the sign of their corresponding non-weighted variables (as suggested in Eq. (6)), namely human capital, unemployment and growth. Note that the presence of neighbouring regions with high population densities, which naturally include capital cities and other urban areas, does not appear to have a significant effect on a region's net-migration rate. This could be due to the circumstance that, even if the capital city acts as a job magnet for residents in neighbouring regions, home-ownership and housing-costs in general provide incentives to commute to rather than reside in the capital region (Eurofound 2006). The coefficient for spatial autocorrelation of the error terms is positive and highly significant irrespective of the column-standardisation scheme, which hints at further spatial relationships that are not captured by the data.

Overall, the test statistics indicate that the inclusion of space greatly improves on the results, with the likelihood ratio test preferring the inclusion of the spatially lagged

[12] For details see http://www.euractiv.com/enlargement/eu-25-member-states-grapple-free-labour-market/article-117775; accessed 12-May-2015.

[13] The estimation results with the alternative, highly correlated explanatory variables suggested above are available upon request.

[14] This roughly coincides with the approach taken in Rodríguez-Pose and Ketterer (2012).

[15] With these parameters, the most centrally located region is Cologne (Köln) with a row sum of 1.982, the most peripheral region is Sardinia (Sardegna) with 0.099, the median regions are Central Hungary (Közép-Magyarország) and Central Transdanubia (Közép-Dunántúl) with 0.995 each.

Table 1 Estimations with $k=125$ and $r=0.5$ for different specifications

	Non-spatial	Method 1, SLXM	Method 1, SDEM	Method 2, SLXM	Method 2, SDEM
Constant	−0.0122 (0.0523)	−0.0124 (0.0607)	−0.0156 (0.0181)	−0.0123 (0.0628)	−0.0158 (0.0167)
Human capital	0.0002 (0.9832)	0.0173 (0.0434)	0.0173 (0.0343)	0.0168 (0.0508)	0.0170 (0.0384)
Unemployment	−0.0284 (0.0001)	−0.0360 (0.0000)	−0.0354 (0.0000)	−0.0366 (0.0000)	−0.0360 (0.0000)
Income	0.0019 (0.0027)	0.0019 (0.0067)	0.0023 (0.0012)	0.0019 (0.0067)	0.0023 (0.0011)
Growth	0.0007 (0.001)	0.0007 (0.0004)	0.0007 (0.0003)	0.0007 (0.0007)	0.0007 (0.0004)
Density	−0.0003 (0.2153)	0.0005 (0.0509)	0.0005 (0.0829)	0.0005 (0.0522)	0.0005 (0.0864)
W_Human capital		−0.1968 (0.0002)	−0.1786 (0.0022)	−0.1945 (0.0002)	−0.1701 (0.0040)
W_Unemployment		0.1457 (0.0083)	0.1565 (0.0089)	0.1412 (0.0102)	0.1592 (0.0085)
W_Income		0.0006 (0.7590)	−0.0011 (0.5896)	0.0006 (0.7489)	−0.0014 (0.5140)
W_Growth		−0.0081 (0.0000)	−0.0067 (0.0002)	−0.0079 (0.0000)	−0.0066 (0.0003)
W_Density		0.0036 (0.2852)	0.0056 (0.1100)	0.0035 (0.3008)	0.0059 (0.0982)
Spatial autocorr.			0.8623 (0.0049)		0.8954 (0.0027)
Residual SE	0.0047	0.0040	0.0039	0.0041	0.0039
F-statistic	10.86 (0.0000)	16.41 (0.0000)		15.91 (0.0000)	
Wald			103.05 (0.0000)		192.38 (0.0000)
LIK	989.39	1029.61	1033.58	1028.07	1032.59
AIC	−1964.79	−2035.22	−2041.15	−2032.14	−2039.17
BP	1.7534 (0.8821)	20.8906 (0.0219)	16.3578 (0.0898)	21.1137 (0.0203)	16.0478 (0.0983)

Methods 1 and 2 refer to column-standardised and transposed row-standardised weight matrices, respectively, as described in the text, p-values are in parentheses. Calculations have been carried out with *R* using the *spdep* package by Bivand (2015).

Wald is the square of the asymptotic standard error, *LIK* and *AIC* refer to the values of the maximised log-likelihood and the Akaike information criterion, respectively, *BP* is the spatially adjusted version of the Breusch-Pagan test for heteroskedasticity, using studentised values (see Anselin 1988).

variables with a p-level of zero in each documented case. As expected, the results of the spatial estimations in Table 1 are very similar to each other, from which it follows that the spatially lagged variables' estimates are robust to varying specifications. It is nevertheless interesting to note that the log-likelihood, Akaike information criterion and Breusch-Pagan values improve with the SDEM in comparison to the SLXM. It should also be noted that although human capital is not significant in the non-spatial specification, in the SLXM and SDEM it has both a spatial and non-spatial effect. This indicates that it is *relative* levels of human capital that determine interregional migration. That said, the impact of the spatially weighted human capital variable is higher and has lower *p*-values than the non-weighted variables. This result recalls a phenomenon frequently found in regional growth regressions, namely a negative impact of human capital endowments in neighbouring regions (among them Olejnik 2008; Ramos et al. 2010; Fischer et al. 2009; Sardadvar 2012; Resende et al. 2013).

Furthermore, it is interesting to compare the coefficients of income and growth, where the effect of income is much higher than that of growth for the non-lagged variables. However, when comparing the spatially lagged values it is remarkable that the negative impact of growth increases by about tenfold, while income in neighbouring regions has no significant effect. A comparison of the coefficients for unemployment underlines this effect. Considering that growth and unemployment reflect labour demand and hence expected future income, these results indicate that migration and therefore future development of a region is largely influenced by the developments of neighbouring regions.

6.2 Variations and extensions

A comparison of estimations which apply different distance functions generally supports the results. In Table 2, the estimations for method 1 with $r=0$ (which is identical to a weight matrix with no distance function) and $r=0.25$ are displayed.[16] Perhaps the most interesting difference is the non-significance of lagged unemployment in the case of $r=0$, i.e. in case all k neighbouring regions are assigned equal weights. Considering that a lower r means that regions which are classified as neighbours and which are more remote are given relatively more weight, the non-significance indicates that the spatial effect of unemployment is strongly tied to relative distance. However, in view of the various test statistics, including the significance level of the spatial autocorrelation coefficient, the results of Table 1 are preferred over those in Table 2.

Table 3 presents the results when the specifications in Table 1 are augmented by additional variables. As can be seen, a low price level exerts a positive effect on net-migration. The proportion of persons in their twenties and thirties also has a positive and highly significant influence, while the proportion of residents with a tertiary education becomes non-significant within the region, but remains negative and significant for neighbouring regions. In contrast, the employment rate brings no significant result. Note that the effect of population density now becomes even weaker, which is probably due to collinearity with human capital, the share of young people and the employment rate.[17] At the same time, the effects of unemployment and growth

[16] Note that with these changes in parameters, respective row sums and centrality/peripherality rankings change, too. With $r=0.25$, Cologne (Köln) remains the most centrally located region with a row sum of 1.994, but the most peripheral region is now Northern Finland (Pohjois-Suomi) with 0.087. With $r=0$, Brussels (Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest) becomes the most centrally located region with is with a row sum of 1.932, and Sardinia (Sardegna) is again the most peripheral region with a row sum of 0.091.

[17] A natural extension of this specification would be to include all variables in their weighted form. However, the interdependence of employment, young population, human capital and population density as well as the weak variation of the price level among the regions within a country lead to estimation problems, which is why the respective results are not listed here.

Table 2 Estimations with method 1 and $k=125$ for different values of r

	$r=0$, SLXM	$r=0$, SDEM	$r=0.25$, SLXM	$r=0.25$, SDEM
Constant	−0.0192	−0.0203	−0.0155	−0.0175
	(0.0026)	(0.0009)	(0.0159)	(0.0053)
Human capital	0.0098	0.0106	0.0132	0.0138
	(0.2275)	(0.1770)	(0.1108)	(0.0819)
Unemployment	−0.0279	−0.0269	−0.0311	−0.0304
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Income	0.0026	0.0027	0.0022	0.0024
	(0.0001)	(0.0000)	(0.0011)	(0.0002)
Growth	0.0006	0.0006	0.0006	0.0006
	(0.0038)	(0.0015)	(0.0019)	(0.0009)
Density	0.0004	0.0003	0.0005	0.0004
	(0.1591)	(0.1698)	(0.0744)	(0.0964)
W_Human capital	−0.2282	−0.2178	−0.2092	−0.1973
	(0.0001)	(0.0005)	(0.0002)	(0.0011)
W_Unemployment	0.0680	0.0796	0.1200	0.1316
	(0.2339)	(0.1712)	(0.0429)	(0.0327)
W_Income	0.0039	0.0024	0.0022	0.0007
	(0.0732)	(0.2825)	(0.2955)	(0.7664)
W_Growth	−0.0055	−0.0047	−0.0073	−0.0062
	(0.0004)	(0.0015)	(0.0000)	(0.0003)
W_Density	−0.0013	0.0007	0.0011	0.0031
	(0.7151)	(0.8515)	(0.7714)	(0.4123)
Spatial autocorr.		0.7436		0.7963
		(0.0637)		(0.0279)
Residual SE	0.0041	0.0040	0.0040	0.0039
F-statistic	15.23		16.15	
	(0.0000)		(0.0000)	
Wald		21.96		40.008
		(0.0000)		(0.0000)
LIK	1025.90	1027.62	1028.82	1031.23
AIC	−2027.80	−2029.24	−2033.63	−2036.47
BP	22.6245	19.2323	22.4155	18.4249
	(0.0122)	(0.0374)	(0.0131)	(0.0482)

See notes in Table 1

in neighbouring regions become stronger and the dummy variable capturing restrictions in the freedom of movement for workers is negative and highly significant. Considering that each of the regions for which the restrictions dummy equals one are relatively centrally located,[18] the increases in values support the interpretation that centrally located are strongly affected by developments in neighbouring regions.

6.3 Summary and comparison of results

The coefficients of the non-lagged as well as spatially lagged values of human capital, unemployment and growth are significant and have the expected signs, indicating

[18] With $k=125$ and $r=0.5$, the least central of Austrian and German regions is Burgenland with a row sum of 1.265.

Table 3 Estimations with $k=125$ and $r=0.5$ and additional variables

	Method 1, SLXM	Method 1, SDEM	Method 2, SLXM	Method 2, SDEM
Constant	−0.1069	−0.1065	−0.1067	−0.1059
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Human capital	0.0090	0.0083	0.0091	0.0084
	(0.3084)	(0.3279)	(0.3045)	(0.3246)
Unemployment	−0.0321	−0.0306	−0.0334	−0.0317
	(0.0007)	(0.0008)	(0.0005)	(0.0006)
Income	0.0105	0.0106	0.0105	0.0106
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Growth	0.0004	0.0004	0.0004	0.0004
	(0.0409)	(0.0228)	(0.0559)	(0.0311)
Density	−0.0002	−0.0002	−0.0002	−0.0002
	(0.5127)	(0.5961)	(0.5124)	(0.6096)
Employment	−0.0026	−0.0018	−0.0039	−0.0029
	(0.7459)	(0.8207)	(0.6326)	(0.7094)
Price level	0.0106	0.0105	0.0106	0.0104
	(0.0001)	(0.0000)	(0.0001)	(0.0000)
Young population	0.0278	0.0209	0.0281	0.02100
	(0.0340)	(0.0977)	(0.0326)	(0.0976)
Restrictions	−0.0027	−0.0026	−0.0029	−0.0028
	(0.0043)	(0.0051)	(0.0025)	(0.0031)
W_Human capital	−0.1299	−0.1234	−0.1253	−0.1177
	(0.0151)	(0.0316)	(0.0187)	(0.0401)
W_Unemployment	0.1833	0.1817	0.1775	0.1776
	(0.0011)	(0.0017)	(0.0015)	(0.0021)
W_Income	−0.0017	−0.0026	−0.0016	−0.0025
	(0.3983)	(0.1997)	(0.4288)	(0.2058)
W_Growth	−0.0071	−0.0060	−0.0067	−0.0056
	(0.0001)	(0.0007)	(0.0001)	(0.0014)
W_Density	0.0053	0.0064	0.0050	0.0061
	(0.1076)	(0.0558)	(0.1335)	(0.0675)
Spatial autocorr.		0.8097		0.8237
		(0.0219)		(0.0159)
Residual SE	0.0039	0.0037	0.0039	0.0037
F-statistic	14.59		14.32	
	(0.0000)		(0.0000)	
Wald		48.1404		57.9910
		(0.0000)		(0.0000)
LIK	1042.46	1045.09	1041.38	1044.29
AIC	−2052.91	−2056.17	−2050.77	−2054.58
BP	54.2728	48.3050	54.5980	48.1401
	(0.0000)	(0.0000)	(0.0000)	(0.0000)

See notes in Table 1

that they act as important push and pull forces. If, for instance, from the viewpoint of a region its growth increases, its net-migration rate will increase. If growth increases in its neighbouring regions, its net-migration rate will decrease. If both things happen, the overall effect depends on the relative magnitudes. The sum of coefficients, however, is not zero, which may be due to the effect that centrally located regions are affected more strongly by developments beyond their borders, as the column-standardised weight matrices assign greater weight to these regions. In addition, due to third-country migration, the total sum of effects is not expected to equal zero.

The key results are demonstrated to be robust with respect to minor variations in r and k in Eqs. (9) and (10) (further variations can be found in Table 4 in Appendix B). Beyond certain values of r and k, however, the explanatory power decreases, but not to the extent that spatial effects would disappear. All in all, the results in Table 1 are those which are closest to the model framework and also preferred according to the test statistics. From this it follows that the role of distance with respect to migration within the EU is most noticeable when a column-standardised spatial weights matrix which includes half of the total number of regions as nearest regions in connection with a square-root inverse distance function is applied.

7 Concluding remarks

The main objective of this paper was to explore the determinants of interregional net-migration flows in the enlarged European Union. Owing to the recency of the enlargement rounds, this approach represents a first step towards understanding respective contemporaneous migration patterns. The model framework's point of departure is the assumption that migration decisions are driven by comparative assessments of alternatives. It is the relative level of unemployment, income etc. that determines migration patterns, i.e. the factors which determine in-migration in one region are the same which determine out-migration in at least one other region. In addition, the model exposes the role of the relative location in space in influencing migration patterns. If a variable exerts strong push or pull forces within one region, it is expected to have the respective opposite effect in other neighbouring regions, with the effect decreasing with distance.

The model framework corresponds to a spatial econometric model specification with a column-standardised spatial weight matrix. The application of a column-standardisation leads to centrally located regions being more strongly affected by other regions' attributes. A spatially autocorrelated error term may be added to the econometric specification in order to capture spatial impacts caused by non-observable variables. The econometric specification represents a spatial lag of X model or, if a spatial autocorrelation coefficient is included, a spatial Durbin error model.

The empirical application yields four main insights. Firstly, the basic results support the economic theory insofar as net-migration at the regional level responds positively to an increase in the average disposable household income, gross regional product growth, population density and human capital endowment, and negatively to an increase in the regional unemployment rate. Since a change in each explanatory variable may simultaneously affect inflows and outflows of migration to different extents and in the same or in different directions (see, for example, Greenwood 1975; Fidrmuc 2004), the robust signs show that these variables can be categorised as either push or pull factors at the macroeconomic level.

Secondly, as predicted by the model, the spatially lagged variables' coefficients tend to have the opposite signs. Of these, human capital, unemployment and the gross regional product growth turn out to be robust to varying specifications, indicating that changes in the neighbouring regions have considerable effects on net-migration within one particular region. In this context it is remarkable that the spatially weighted effects of unemployment and growth in neighbouring regions on net-migration are much stronger than the effects within regions, indicating that especially centrally located regions are exposed to changes in labour demand outside their borders. In addition, the inclusion of a spatially autocorrelated error term improves on the results but does not change inference regarding the explanatory variables. However, its positive and significant values suggest that other forces that are not captured by the data are at work and have a spatial impact.

Thirdly, the estimation methods suggest that the response of migration to changes in the neighbouring regions' economic conditions is most pronounced when the cut-off number of neighbouring NUTS2 regions is set at 125 (which corresponds to half of the number of regions included in the sample), though moderate variations concerning the weight matrix or the distance function do not change the main insights. This shows that intra-EU migration patterns are shaped by distance, and it also means that more centrally located regions are affected more strongly by occurrences in neighbouring regions. The considerable number of immigrant workers from the new member states who have moved to relatively far away destinations such as the British Isles, Scandinavia or Spain in the time period considered in the present study might support the notion that distance plays no role in deciding where to migrate to. Quite the contrary, the present paper's results show that migration and therefore the future development of a region is largely influenced by the developments taking shape in its neighbouring regions. This notion is underlined by the negative influence of restriction laws, providing evidence that the net-migration rates of the regions of Austria and Germany, which are centrally located and close to the new member states' regions, would have been significantly higher without these restrictions.

Fourthly, human capital plays an important role in explaining migration within the European internal market at the macro level, and more research is needed to study the effects of supply and demand of different forms of human capital. The issue of human capital is not only interesting as such but should rather also invoke some interest with respect to the recently discussed issue of brain drain and brain competition within the EU (see Reiner 2010). Considering the acknowledged role which human capital plays in terms of economic growth, this issue is relevant in connection with the EU's convergence objective.

The coincidence of vast regional income differences and free movement of people has the potential to reshape the interregional distribution of people within the EU. At the same time, the internal market provides a rare opportunity to study migration patterns across various national and regional economies with no legal barriers. That said, when considering the importance of interregional migration with respect to demographic, social and economic dynamics, data availability is remarkably scarce. Empirical studies in some years' time may perhaps benefit from improved data quality such as migration data between pairs of regions encompassing large parts of Europe, or longer time spans of data which would allow for longer observation periods. This study's contributions lie in implementing space into a macro model of migration, applying column-standardised weight matrices that allow capturing the relative centrality/peripherality of individual regions, and demonstrating that interregional net-migration rates within the European Union are shaped by changes in variables not only within one region, but rather by any change in the system of regions.

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Appendix A: Regions of the observation area

The study covers the European territory of the EU on the NUTS2 level. Due to lack of data, the classification used in this study deviates from the official classification as of December 2011 in the following cases: Cyprus, Estonia, Latvia, Lithuania, Luxemburg, and Malta are not included; the NUTS2 regions Brandenburg–Nordost and Brandenburg–Südwest as well as the NUTS2 regions of Denmark and Slovenia have been merged to one region, respectively. By focussing on Europe, the study excludes the French regions Guadeloupe, Martinique, Guyana and Réunion, the Portuguese regions Região Autónoma dos Açores and Região Autónoma da Madeira, and the Spanish regions Ciudad Autónoma de Ceuta, Ciudad Autónoma de Melilla and Canarias. The following list contains the official names of all included regions sorted alphabetically by the corresponding nation states:

- Austria (9 regions): Burgenland; Niederösterreich; Wien; Kärnten; Steiermark; Oberösterreich; Salzburg; Tirol; Vorarlberg
- Belgium (11 regions): Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest; Prov. Antwerpen; Prov. Limburg (BE); Prov. Oost-Vlaanderen; Prov. Vlaams-Brabant; Prov. West-Vlaanderen; Prov. Brabant Wallon; Prov. Hainaut; Prov. Liège; Prov. Luxembourg (BE); Prov. Namur
- Bulgaria (6 regions): Severozapaden; Severen tsentralen; Severoiztochen; Yugoiztochen; Yugozapaden; Yuzhen tsentralen
- Czech Republic (8 regions): Praha; Střední Čechy; Jihozápad; Severozápad; Severovýchod; Jihovýchod; Střední Morava; Moravskoslezsko
- Denmark (1 region): Danmark
- Finland (5 regions): Itä-Suomi; Etelä-Suomi; Länsi-Suomi; Pohjois-Suomi; Åland
- France (22 regions): Île-de-France; Champagne-Ardenne; Picardie; Haute-Normandie; Centre; Basse-Normandie; Bourgogne; Nord—Pas-de-Calais; Lorraine; Alsace; Franche-Comté; Pays de la Loire; Bretagne; Poitou-Charentes; Aquitaine; Midi-Pyrénées; Limousin; Rhône-Alpes; Auvergne; Languedoc-Roussillon; Provence-Alpes-Côte d'Azur; Corse
- Germany (38 regions): Stuttgart; Karlsruhe; Freiburg; Tübingen; Oberbayern; Niederbayern; Oberpfalz; Oberfranken; Mittelfranken; Unterfranken; Schwaben; Berlin; Brandenburg—Nordost & Brandenburg—Südwest; Bremen; Hamburg; Darmstadt; Gießen; Kassel; Mecklenburg-Vorpommern; Braunschweig; Hannover; Lüneburg; Weser-Ems; Düsseldorf; Köln; Münster; Detmold; Arnsberg;

Koblenz; Trier; Rheinhessen-Pfalz; Saarland; Chemnitz; Dresden; Leipzig; Sachsen-Anhalt; Schleswig-Holstein; Thüringen

- Greece (13 regions): Anatoliki Makedonia, Thraki; Kentriki Makedonia; Dytiki Makedonia; Thessalia; Ipeiros; Ionia Nisia; Dytiki Ellada; Sterea Ellada; Peloponnisos; Attiki; Voreio Aigaio; Notio Aigaio; Kriti
- Hungary (7 regions): Közép-Magyarország; Közép-Dunántúl; Nyugat-Dunántúl; Dél-Dunántúl; Észak-Magyarország; Észak-Alföld; Dél-Alföld
- Ireland (2 regions): Border, Midland and Western; Southern and Eastern
- Italy (21 regions): Piemonte; Valle d'Aosta/Vallée d'Aoste; Liguria; Lombardia; Provincia Autonoma Bolzano/Bozen; Provincia Autonoma Trento; Veneto; Friuli-Venezia Giulia; Emilia-Romagna; Toscana; Umbria; Marche; Lazio; Abruzzo; Molise; Campania; Puglia; Basilicata; Calabria; Sicilia; Sardegna
- Netherlands (12 regions): Groningen; Friesland; Drenthe; Overijssel; Gelderland; Flevoland; Utrecht; Noord-Holland; Zuid-Holland; Zeeland; Noord-Brabant; Limburg (NL)
- Poland (16 regions): Łódzkie; Mazowieckie; Małopolskie; Śląskie; Lubelskie; Podkarpackie; Świętokrzyskie; Podlaskie; Wielkopolskie; Zachodniopomorskie; Lubuskie; Dolnośląskie; Opolskie; Kujawsko-Pomorskie; Warmińsko-Mazurskie; Pomorskie
- Portugal (5 regions): Norte; Algarve; Centro (PT); Lisboa; Alentejo
- Romania (8 regions): Nord-Vest; Centru; Nord-Est; Sud-Est; Sud—Muntenia; Bucuresti—Ilfov; Sud-Vest Oltenia; Vest
- Slovakia (4 regions): Bratislavský kraj; Západné Slovensko; Stredné Slovensko; Východné Slovensko
- Slovenia (1 region): Slovenija
- Spain (16 regions): Galicia; Principado de Asturias; Cantabria; País Vasco; Comunidad Foral de Navarra; La Rioja; Aragón; Comunidad de Madrid; Castilla y León; Castilla-La Mancha; Extremadura; Cataluña; Comunidad Valenciana; Illes Balears; Andalucía; Región de Murcia
- Sweden (8 regions): Stockholm; Östra Mellansverige; Sydsverige; Norra Mellansverige; Mellersta Norrland; Övre Norrland; Småland med öarna; Västsverige
- United Kingdom (37 regions): Tees Valley and Durham; Northumberland and Tyne and Wear; Cumbria; Cheshire; Greater Manchester; Lancashire; Merseyside; East Riding and North Lincolnshire; North Yorkshire; South Yorkshire; West Yorkshire; Derbyshire and Nottinghamshire; Leicestershire, Rutland and Northamptonshire; Lincolnshire; Herefordshire, Worcestershire and Warwickshire; Shropshire and Staffordshire; West Midlands; East Anglia; Bedfordshire and Hertfordshire; Essex; Inner London; Outer London; Berkshire, Buckinghamshire and Oxfordshire; Surrey, East and West Sussex; Hampshire and Isle of Wight; Kent; Gloucestershire, Wiltshire and North Somerset; Dorset and Somerset; Cornwall and Isles of Scilly; Devon; West Wales and the Valleys; East Wales; North Eastern Scotland; Eastern Scotland; South Western Scotland; Highlands and Islands; Northern Ireland

Appendix B: Additional results and summary statistics

Table 4 Estimations with method 1 and $r = 0.5$ for different values of k

	k = 75, SLXM	k = 100, SLXM	k = 150, SLXM	k = 200, SLXM
Constant	−0.0133	−0.0115	−0.0042	0.0033
	(0.0421)	(0.0806)	(0.5693)	(0.6425)
Human capital	0.0063	0.0071	0.0127	0.0156
	(0.4797)	(0.4154)	(0.1411)	(0.0736)
Unemployment	−0.0328	−0.0366	−0.0340	−0.0246
	(0.0000)	(0.0000)	(0.0000)	(0.0006)
Income	0.0017	0.0016	0.0009	−0.0001
	(0.0107)	(0.0177)	(0.2498)	(0.9330)
Growth	0.0007	0.0007	0.0008	0.0009
	(0.0010)	(0.0004)	(0.0001)	(0.0000)
Density	0.0007	0.0008	0.0005	0.0003
	(0.0131)	(0.0065)	(0.0780)	(0.3847)
W_ Human capital	−0.0458	−0.0798	−0.2863	−0.5549
	(0.1075)	(0.0337)	(0.0000)	(0.0000)
W_Unemployment	0.0132	0.0478	0.0205	−0.2698
	(0.6241)	(0.2272)	(0.7785)	(0.0042)
W_Income	0.0029	0.0036	0.0068	0.0177
	(0.0061)	(0.0085)	(0.0077)	(0.0000)
W_Growth	−0.0012	−0.0033	−0.0086	−0.0093
	(0.2180)	(0.0149)	(0.0005)	(0.0019)
W_Density	−0.0046	−0.0049	−0.0031	−0.0116
	(0.0202)	(0.0511)	(0.4773)	(0.0409)
Residual SE	0.0043	0.0041	0.0042	0.0042
F-statistic	12.12	14.37	13.75	13.89
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
LIK	1015.57	1023.14	1021.08	1021.55
AIC	−2007.15	−2022.29	−2018.17	−2019.11
BP	8.9942	15.1385	14.1799	21.4838
	(0.5327)	(0.1271)	(0.1649)	(0.0180)

See notes in Table 1

Table 5 Descriptive statistics

	Mean or percentage	Minimum value	Maximum value	Standard deviation
Net-migration	0.0032	−0.0071	0.0228	0.0051
Human capital	0.1135	0.0400	0.2357	0.0426
Unemployment	0.0877	0.0250	0.2457	0.0486
Income	9.299	7.074	10.11	0.7064
Growth	2.384	−0.8667	7.550	1.677
Density	5.010	1.194	9.120	1.166
Activity rate	0.4280	0.2511	0.6350	0.0535
Price level	1.187	0.7351	2.861	0.4896
Young population	0.2801	0.2167	0.4250	0.0261
Restrictions	0.1840	0	1	0.3883

Income and density are the natural logarithms of the values, growth is the average yearly real GRP change expressed as a percentage

Table 6 Correlation coefficients

	Net-mig.	HC	Unempl.	Income	Growth	Density	Employ.	Price	Young	Restrict.
Net-mig.	1	0.1399	−0.3536	0.2404	0.0865	−0.0307	0.2084	−0.2018	0.1571	−0.2538
HC	0.1399	1	−0.2089	0.4692	−0.0674	0.3322	0.4645	−0.4027	−0.0738	0.0618
Unempl.	−0.3536	−0.2089	1	−0.4434	0.1048	−0.1053	−0.6997	0.3864	0.2003	0.0425
Income	0.2404	0.4692	−0.4434	1	−0.5251	0.2397	0.4093	−0.9710	−0.3486	0.3020
Growth	0.0865	−0.0674	0.1048	−0.5251	1	−0.1899	−0.0419	0.5333	0.3094	−0.3235
Density	−0.0307	0.3322	−0.1053	0.2397	−0.1899	1	0.1820	−0.1419	0.2698	0.1803
Employ.	0.2084	0.4645	−0.6997	0.4093	−0.0419	0.1820	1	−0.3367	−0.1128	0.1253
Price	−0.2018	−0.4027	0.3864	−0.9710	0.5333	−0.1419	−0.3367	1	0.3761	−0.2354
Young	0.1571	−0.0738	0.2003	−0.3486	0.3094	0.2698	−0.1128	0.3761	1	−0.1286
Restrict.	−0.2538	0.0618	0.0425	0.3020	−0.3235	0.1803	0.1253	−0.2354	−0.1286	1

See notes in Table 5

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