ARE THERE BORDER EFFECTS IN THE EU WAGE FUNCTION?

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Abstract

We estimate a linear approximation of the market potential function for Europe as derived in geography and trade models. Using a spatial econometric estimation approach, border effects are identified by a differential impact of other regions' purchasing power, depending on whether two regions are located within the EU15 or outside the EU15. We find that intra-EU15 borders have an insignificant but EU15 external borders a significant effect on regional wage structures. We also illustrate the magnitude of EU external border effects. Our results imply that border effects are most pronounced for border regions of new member states, but relatively small for most regions of the EU15.

Keywords

Market Potential, Border Effects, Spatial Econometrics, EU Wage Function

I. Introduction

Since the fall of the Iron Curtain and the opening-up of the Central and Eastern European Countries (CEEC) at the beginning of the 1990s, major steps in economic integration have been undertaken between the EU, EFTA countries and the CEEC. Examples are the accession of Austria, Sweden and Finland, European Monetary Union and the enlargement of the EU15 by the 12 new member states which joined in the years 2004 and 2007. One of the common objectives of these projects was to reduce the economic significance of national borders. Given this objective, a number of recent studies aim at identifying and measuring border effects in the European Union on trade (see e.g. Nitsch, 2000; Chen, 2004) and prices (see e.g. Engel, Rogers, 2001; Beck, Weber, 2003; Foad, 2005).

In this paper we are also interested in the existence and size of border effects in Europe. In contrast to earlier contributions, we focus on border effects with respect to the regional wage structure. To this end, we estimate different versions of the market potential function, which has been one of the workhorse models of applied regional analysis since the contribution of Harris (1954) and has recently been theoretically founded in economic geography models (see Fujita, Krugman, Venables, 1999 for an overview). Our work is thus closely related to recent empirical literature on economic geography models, which mainly follows the seminal work by Hanson (2005) for the US and provides a number of estimations of the market potential function for the EU15 (Niebuhr, 2006; Brakman,

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Garretsen, Schramm, 2006) as well as individual EU countries (Roos, 2001; Brakman, Garretsen, Schramm, 2004; De Bruyne, 2003; Mion 2004; Fingleton, 2006) and groups of EU countries (see Head, Mayer, 2006; Redding, Venables, 2004) and the literature which uses economic geography models to discuss the regional effects of integration (see Krugman, Livas-Elizondo, 1996; Fujita, Krugman, Venables, 1999; Paluzzie, 2001; Crozet, Koenig-Soubeyran, 2004). In this literature, Niebuhr (2008) simulates the effect of EU-enlargement on border regions, Moncarz (2007) provides evidence that the foreign market potential has an important effect on spatial wage distribution in Argentina, and Brakman, Garretsen, Schramm (2002) find that German border regions have a wage level that is significantly lower than that of inland regions.

We differ from these contributions both in terms of methodology as well as focus. First, Niebuhr's (2008) focus is on simulating the general equilibrium effects of integration on border regions only, by making assumptions on integration-induced changes in cross-border transport costs. Our aim, by contrast, is to provide empirical estimates of border effects in the wage function, which can potentially impact all regions. Second, both in Moncarz (2007) and Brakman, Garretsen, Schramm (2002) focus on estimating the structural parameters of the wage function. Thus, in their applications the market potential outside the countries they analyze (Germany and Argentina) is an exogenous control variable. This paper, by contrast, explicitly models the cross-border interactions of regions by approximating the non-linear potential function to derive a linear specification (see also Combes, Lafourcade, 2001 or Mion, 2004) that can be used in a linear spatial econometrics approach.

We estimate our specification for a cross-section of NUTSII regions encompassing the EU15, the largest new EU member states, as well as Switzerland and Norway, using appropriate spatial econometric techniques, which account for the endogeneity of spatially-lagged endogenous variables. In contrast to the literature on border effects in goods prices and trade, which often finds sizable intra-EU border effects, our findings suggest that the impact of GDP and wages of regions across borders of countries within the EU15 on regional wage levels does not differ significantly from that of regions within the same country. Our results are thus closer to those of Overmann, Puga (2002), who find that regional linkages in unemployment rates are equally strong across national borders as within countries. There are, however, still substantial border effects with respect to EU external borders.

Finally, since the implications of our estimated border effects are hard to interpret from a geographical point of view, we illustrate the size of the EU external border effects in the wage function by assuming that the border effects between EU15 and new member states converge to those found currently among the EU15. These calculations suggest that border effects in the wage function have the strongest impact in the border regions of the accessions countries, while most regions of the incumbent countries remain virtually unaffected.

II. The Econometric Specification and Market Potential Function

The starting point in deriving our empirical specifications is the market potential function, which has also been termed the wage function in recent literature. This function relates the nominal wage rate w_i in region $i(i = 1 \dots N)$ to the spatially weighted sum of purchasing power (in terms of nominal GDP, y_i) of its neighbouring regions and has been one of the workhorse models of regional science, at least since the seminal work of Harris (1954). In its original form this function can be written as:[2]

$$w_i = \sum_{j=1}^{N} y_j f(d_{ij}), \tag{1}$$

where $f(d_{ij})$, is a distance decay function with, $f(d_{ij}) < 1$ and $f(d_{ij})' < 0$, and d_{ij} is the distance between two regions.
More recently, this function has received a theoretical foundation in the economic geography models of Krugman (1991b), Helpman (1998) and Hanson (2005). These models comprise a differentiated manufacturing good, which is produced under increasing returns and enters utility in terms of a CES subutility function, and a homogenous good. The overall utility function is Cobb-Douglas, with expenditure shares $0 < \mu < 1$ for the differentiated good and $1 - \mu$ for the homogenous one. While the differentiated good exhibits transportation costs depending on distance, the homogeneous good is costlessly tradable. The price of the homogeneous good is normalized to 1 so that the overall price index in region i is given by T_i^{μ}. The relation between the nominal wage rate w_i in region i and the spatially weighted sum of purchasing power is based on the following equilibrium condition (Krugman, 1991a; Hanson, 2005):

$$w_i = \left[\sum_{j=1}^{N} y_j f(d_{ij})^{\sigma-1} T_j^{\sigma-1} \right]^{\frac{1}{\sigma}}, \tag{2}$$

where the subscripts i and j index regions and $\sigma > 1$ denotes the elasticity of substitution between any two variants of manufacturing goods.[3] Equation (2) states that, in equilibrium, real wages are a function of distance weighted GDP as well as price indices. Taking the logs of (2) gives:

[2]Brakman, Garretsen, Schramm (2004) find that this market potential function provides a better model fit when analyzing the wage structure of Germany than either a fully-fledged economic geography specification or a wage curve estimate. Fingleton (2005), however, argues that the simple new economic geography model of wage determination is overly restrictive and should be augmented by further explanatory variables.
[3]The Helpman (1998) version of the model includes housing prices as an additional determinant of nominal wages. We skip them to simplify the exposition as they are unobserved in our data.

$$\ln w_i = \frac{1}{\sigma} \ln \left(\sum_{j=1}^{N} y_j f(d_{ij})^{\sigma-1} T_j^{\sigma-1} \right). \tag{3}$$

In empirically estimating equation (3) we – as virtually all contributions using European data[4] – face the problem that regional price indices are not available for most European countries. In the literature a number of solutions have been devised to circumvent this problem. These include using housing prices as an additional explanatory variable to eliminate the price index, as suggested by Helpman (1998), using trade data to estimate the real market potential of a region (e.g. Redding, Venables, 2004; Head, Mayer, 2006; Knaap, 2006), defining regional centres (e.g. Brakman, Garretsen, Schramm, 2004, 2006), assuming real wage equalisation (e.g. Roos, 2001; Mion, 2004; Hanson, 2005; Kiso, 2006; Niebuhr, 2006) or reverting to the original market potential function as formulated in equation (1) (e.g. Niebuhr, 2006; Moncarz, 2007).[5] Since we also lack data on regional exports and housing prices, only the last two of these solutions are open to us. Thus, we assume that in a benchmark case, long run equilibrium real wage rates equalize across regions (i.e. $\frac{w_i}{T_i^{\mu}} = \frac{w_j}{T_j^{\mu}} = \frac{\overline{w}}{\overline{T}^{\mu}} = \overline{\omega}$, for all $i \neq j$) which implies that $T_j = \left(\frac{w_j}{\overline{\omega}}\right)^{\frac{1}{\mu}}$.[6] This allows us to rewrite equation (3) as:

$$\begin{aligned} \ln(w_i) &= \frac{1}{\sigma} \ln \left(\sum_{j=1}^{N} y_j f(d_{ij})^{\sigma-1} \left(\frac{w_j}{\overline{\omega}}\right)^{\frac{\sigma-1}{\mu}} \right) = \frac{1-\sigma}{\sigma\mu} \ln(\overline{\omega}) \qquad (4) \\ &\quad + \frac{1}{\sigma} \ln \left(y_i w_i^{\frac{\sigma-1}{\mu}} + \sum_{j \neq i}^{N} y_j w_j^{\frac{\sigma-1}{\mu}} f(d_{ij})^{\sigma-1} \right). \end{aligned}$$

We introduce border effects by parametrizing $f(d_{ij})^{\sigma-1}$. For this we define three sets of ij pairs of regions. First, $\mathcal{F}_0$ is the set of all region pairs. This set of regions forms the base against which we measure the border effects. Second, $\mathcal{F}_{EU}$ denotes the set of pairs of regions i and j that are located within the EU15 but in different countries. Third, the set $\mathcal{F}_{NEU}$ comprises the all variants of ij pairs, where one region is located inside the EU15 and the other outside or where both of them are located in different countries outside the EU15. Finally, regional pairs i and j that are located within the same EU15 or non-EU15 country neither belong to $\mathcal{F}_{EU}$ nor to $\mathcal{F}_{NEU}$. Based on these three sets, we parameterize the distance decay function $f(d_{ij})^{\sigma-1}$ as follows:

[4] See Brackman, Garretsen, Schramm (2006) for a detailed account of the many problems faced by researchers who want to empirically implement economic geography models with European data.

[5] As noted by Niebuhr (2004), this implies that the price index is equal across all regions.

[6] We relax this assumption in our empirical application below by allowing for productivity differentials between country groups in Europe (see also Brakman, Garretsen, Schramm, 2006).

$$f(d_{ij})^{1-\sigma} = \begin{cases} (\rho_0 + \rho_{EU})\dfrac{e^{-\alpha d_{ij}}}{c} ij \in \mathcal{F}_{EU} \\ (\rho_0 + \rho_{NEU})\dfrac{e^{-\alpha d_{ij}}}{c} ij \in \mathcal{F}_{NEU}, \\ \rho_0 \dfrac{e^{-\alpha d_{ij}}}{c} ij \notin \mathcal{F}_{EU}; ij \notin \mathcal{F}_{NEU} \end{cases} \tag{5}$$

where $c = 1 + \max_i \sum_{i \neq j} e^{-\alpha d_{ij}}$ and the parameters ρ_0, ρ_{EU}, ρ_{NEU} measure the relative border effects. In the presence of EU15 border effects we conjecture $\rho_{EU} < 0$, $\rho_{NEU} < 0$ and $\rho_{EU} > \rho_{NEU}$. Following Mion (2004), we approximate the sum of the decay functions $f(d_{ij})^{\sigma-1}$ by a constant so that:

$$\begin{aligned} \sum_{j=1, j\neq i}^{N} f(d_{ij})^{\sigma-1} &= \rho_0 \sum_{j\neq i, ij\in\mathcal{F}_0} \frac{e^{-\alpha d_{ij}}}{c} + \rho_{EU} \sum_{j\neq i, ij\in\mathcal{F}_{EU}} \frac{e^{-\alpha d_{ij}}}{c} \\ &+ \rho_{NEU} \sum_{j\neq i, ij\in\mathcal{F}_{NEU}} \frac{e^{-\alpha d_{ij}}}{c} \approx \rho. \end{aligned} \tag{6}$$

This formulation implies that the spatial weight and, hence, the market potential of a region decreases with its distance to its neighbors, all else being equal. A similar spatial weighting scheme has been proposed by Kelejian, Prucha (2005), who argue that this is less restrictive than the row normalized spatial weighting scheme used in much of the spatial econometrics literature. From an economic point of view it is preferable, since it implies that the market potential of a region decreases the further away it is located from the other regions all else equal.[7]

Next we approximate the left and right hand side of (4) linearly around average values. In the Appendix[8] this approximation is derived as

$$\begin{aligned} \tilde{w}_i = K &+ \beta_1 \sum_{j\neq i, ij\in\mathcal{F}_0} \Theta^0_{ij}\tilde{w}_j + \beta_2 \sum_{j\neq i, ij\in\mathcal{F}_{EU}} \Theta^{EU}_{ij}\tilde{w}_j + \beta_3 \sum_{j\neq i, ij\in\mathcal{F}_{NEU}} \Theta^{NEU}_{ij}\tilde{w}_j + \\ &\beta_4 \tilde{y}_i + \beta_5 \sum_{j\neq i; ij\in\mathcal{F}_0} \Theta^0_{ij}\tilde{y}_j + \beta_6 \sum_{j\neq i, ij\in\mathcal{F}_{EU}} \Theta^{EU}_{ij}\tilde{y}_j + \beta_7 \sum_{j\neq i, ij\in\mathcal{F}_{NEU}} \Theta^{NEU}_{ij}\tilde{y}_j, \end{aligned} \tag{7}$$

[7]To see this, consider a region with a distance of say 500 kilometers to all other regions and compare it to another, which is located 1000 km away from the other regions. With a row normalized spatial weighting matrix both regions exhibit the same distribution of spatial weights. Hence, both regions face the same market potential, which is at odds with the theoretical model. In our setting, the second region exhibits a smaller market potential, because it is more distant to the others regions as compared to the first one.

[8]The linear approximation of the market potential function is a common strategy in applied work (see Combes, Lafourcade, 2001 and Mion, 2003 for recent examples.)

where $\tilde{x}_i$ is the percentage deviation of x_i from its mean $\overline{x}$ (i.e. $\tilde{x} = \frac{x_i - \overline{x}}{\overline{x}}, x_i \in \{w_i, y_i\}$) and K is a constant. The remaining parameters to be estimated are $\beta_1 = \frac{\rho_0(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_2 = \frac{\rho_{EU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_3 = \frac{\rho_{NEU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_4 = \frac{\mu}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_5 = \frac{\rho_0 \mu}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_6 = \frac{\rho_{EU} \mu}{1+\sigma(\mu(1+\rho)-1)}$, $\beta_7 = \frac{\rho_0 \mu}{1+\sigma(\mu(1+\rho)-1)}$. The spatial decay functions Θ^k_{ij} with $k \in \{0, EU, NEU\}$ are defined in the Appendix.

In vector notation the empirical specification can thus be written as:

$$\begin{aligned} \tilde{\mathrm{w}} \quad = \quad & \beta_1 \mathrm{W}^0 \tilde{\mathrm{w}} + \beta_2 \mathrm{W}^{EU} \tilde{\mathrm{w}} + \beta_3 \mathrm{W}^{NEU} \tilde{\mathrm{w}} + \beta_4 \tilde{\mathrm{Y}} + \beta_5 \mathrm{W}^0 \tilde{\mathrm{Y}} + \beta_6 \mathrm{W}^{EU} \tilde{\mathrm{Y}} + \\ & \beta_7 \mathrm{W}^{NEU} \tilde{\mathrm{Y}} + \gamma \mathrm{Z} + \mathrm{u}. \end{aligned} \tag{8}$$

where Z is a vector of explanatory variables entering the regression to proxy for otherwise unobservable price and wage differences not captured by the model (defined below) and also includes the constant (K). $\mathrm{W}^0, \mathrm{W}^{EU}$ and W^{NEU} are the $N \times N$ spatial weighting matrices, with N being the number of regions. u denotes the vector of errors which may be spatially autocorrelated such that $\mathrm{u} = \Phi \mathrm{W} \mathrm{u} + \varepsilon, \varepsilon_j \sim iid(0, \sigma^2_\varepsilon)$. Equation (8) forms the basic specification of the market potential function which is estimated below. Similarly proceeding in the same way as above with equation (1), the simple market potential function leads to an empirical specification, which can be represented by:

$$\tilde{\mathrm{w}} = \beta_4 \tilde{\mathrm{Y}} + \beta_5 \mathrm{W}^0 \tilde{\mathrm{Y}} + \beta_6 \mathrm{W}^{EU} \tilde{\mathrm{Y}} + \beta_7 \mathrm{W}^{NEU} \tilde{\mathrm{Y}} + \gamma \mathrm{Z} + \mathrm{u}. \tag{9}$$

This is our second empirical specification, and we refer to it as the "reduced form" specification.
Several comments concerning equation (8) are in order. First, in its strict form, the model implies a series of testable non-linear restrictions. In particular, from equation (8) it is easy to see that the following three restrictions should hold: $\frac{\beta_1}{\beta_2} = \frac{\beta_5}{\beta_6} = \frac{\rho_0}{\rho_{EU}}$, $\frac{\beta_1}{\beta_3} = \frac{\beta_5}{\beta_7} = \frac{\rho_0}{\rho_{NEU}}$ and $\frac{\beta_2}{\beta_3} = \frac{\beta_6}{\beta_7} = \frac{\rho_{EU}}{\rho_{NEU}}$. We use these restrictions to test the validity of the model in its strict form as specified in (8). Second, without the restrictions, the structural parameters of the market potential function are not identified. We have seven relevant estimated parameters, but only five in the theoretical model. We thus confine our inference on the signs of the estimated reduced form parameters. Estimating border effects is, however, still possible.

Third, the theoretical model is kept simple and, therefore, it is restrictive. There are a number of reasons to doubt the validity of the assumptions underlying equation (4). In particular, the theoretical model assumes real wage equalization and identical technologies across regions and countries. This is unrealistic in the context of European data, in particular since our sample contains Central and Eastern European regions with productivity levels much lower than the EU15 average. Aside from including border effects which account for imperfect real wage adjustments across national borders, we thus augment our baseline specification with additional variables to control for the fact that real wages may not equilibrate across regions. In particular, we assume that average wages of regions differ due to their economic structure, as measured by the share of agriculture and services in total employment. Productivity differentials are captured by country group effects (Eastern European Countries, Non-EU15-EFTA countries, and EU15 countries which are the base).[9]

III. Data

We use data on compensation per employee, nominal gross value added and sectoral employment for a total of 241 regions provided by Cambridge Econometrics, which is based on information from the Eurostat New Cronos database. Data are at the NUTSII level and comprise regions from the EU15 member states and a subset of the largest new EU member states (Hungary, Poland and the Czech Republic), as well as Switzerland and Norway. To avoid problems with non-contingent spaces (due to lacking data on the Balkans) we omitted Greece from the data. For German regions, wage data (compensation per employee) are available only at the level of NUTSI. Since this would bias our spatial regressions, we estimate proxies on NUTSII level using a fixed effects regression with region and time effects as well as GDP per capita, the share of workers in agriculture, manufacturing, construction and market services, as well as the employment rate as explanatory variables.[10]

For estimation, we use a cross section of averages over the periods 1999–2002.[11] The dependent variable is nominal compensation per employee. Regional income (in purchasing power parities), is approximated by nominal gross value added. Additional controls are the share of workers in agriculture, in market and in non market services (manufacturing and construction being the base), as well an EFTA (Switzerland and Norway) and a CEEC-dummy (Czech Republic, Hungary and Poland). Finally, distance is measured as the crow flies between the capitals of each NUTSII region.

Descriptive statistics for this data suggest that the presence of border effects in the European wage function could indeed have important effects on regional development in Europe. Table A1 (see the Appendix) displays the distance weighted purchasing power (gross value added; GVA) of all accessible regions aggregated to the country level (co-

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[9] Brackman, Garretsen, Schramm (2004) include productivity differentials in the baseline economic geography model. As in our specification, this leads to productivity entering linearly into the specification upon linearization.

[10] We checked whether this procedure changes qualitative results and found that this is not the case.

[11] This choice was guided by the combination of data availability and the attempt to eliminate some of the short run fluctuations from the data as well as basing estimates on the most recent time period available.

lumn 1). Column 2 reports the average distance weighted purchasing power of regions either located in another country but within the EU15 (i.e. the members of $\mathcal{F}_{EU}$) and column 3 that in different countries outside the EU15 (i.e. the members of $\mathcal{F}_{NEU}$). The residual in column 4 gives the purchasing power of the regions in their own country. Columns 5–7 report the corresponding breakdown in percent. This table shows that, for most of the countries considered in this paper (all but Germany, Spain, Italy and the UK), the majority of the distance weighted purchasing power is not located in their own country, but in other countries of the the EU 15. In particular, also for all of the new member states as well as the other non-EU countries in the sample (except for Norway), more than three quarters of the distance weighted purchasing power is located in EU15 countries.

IV. Estimation Procedure

A specific problem of the market potential function based on the above model is that many right hand side variables are endogenous. First, the model is not closed and ignores the fact that the income of a region is endogenous. Second, $\mathrm{W}^0\tilde{\mathrm{w}}$, $\mathrm{W}^{EU}\tilde{\mathrm{w}}$, and $\mathrm{W}^{NEU}\tilde{\mathrm{w}}$ are endogenous, as the vector of wage rates $\tilde{\mathrm{w}}$ shows up on the left and in a spatially weighted form also on the right hand side of the regression. To overcome these endogeneity problems, we apply the spatial GM-estimator of Kelejian, Prucha (1999), proceeding in three steps. Based on an initial (IV) regression, we first estimate the model, assuming $\Phi = 0$ by 2SLS which provides consistent estimates of the parameters and the residuals. Second, we estimate the spatial correlation parameter Φ using the first stage residuals to solve the GM-conditions put forward by Kelejian and Prucha (1999). Third, the final estimation results are derived using a Cochrane-Orcutt type transformation $v_i^*(\hat{\Phi}) = [(\mathrm{I} - \hat{\Phi}\mathrm{W})\mathrm{v}]_i$ for all variables in the model and applying 2SLS on the transformed data. Kelejian, Prucha (1999) show that this procedure leads to consistent estimates in the presence of spatially correlated errors. They suggest to use the spatially lagged values of all untransformed exogenous variables as instruments. In addition, we also use other outside instruments for a region's nominal income (see Table A2 in the Appendix). However, we include only those instruments which pass the Sargan over-identification test. Shea's R^2 as well as as F-tests show that these instruments are relevant.

We estimate several different models to see whether our estimation results are robust. Model 1 is a reduced form (i.e. the linearized version of the original potential function given in equation (9), which ignores spatially weighted wage rates) and treats regional income as an exogenous variable. Model 2 is the same as Model 1, but with regional income endogenous. Model 3 is the unrestricted structural form, which includes $\mathrm{W}^0\tilde{\mathrm{w}}$, $\mathrm{W}^{EU}\tilde{\mathrm{w}}$, and $\mathrm{W}^{NEU}\tilde{\mathrm{w}}$, while Model 4 accounts for the restrictions as illustrated above. In both Models 3 and 4, regional income is also endogenous and instrumented properly. Although subject to nonlinear restrictions, Model 4 is linear in the variables, so in the first stage we can use OLS projecting all variables on the instruments and the exogenous variables. The second stage utilizes the first stage predictions of the endogenous variables and applies NLSQ to account for the nonlinear parameter restrictions mentioned above.[12]

[12]For Model 4 the estimates of Φ are those derived for Model 3.

In spatial econometric models, the spatial decay parameter α is usually a fixed parameter. We set $\alpha = 1/100$ (see Table A2 in the Appendix).[13] The estimation results also indicate a significant spatial correlation of the error term (as evidenced by the significant Moran I-test of Kelejian, Prucha, 2001), so that the GM approach is indeed required.

V. Estimation Results

The results in Table A2 (see the Appendix) suggest that our control variables work well, indicating substantially lower wages in the new member states and higher ones in Switzerland and Norway (EFTA), as compared to the EU15. In addition, wages are significantly higher in regions with a high share of workers in market services, but lower in agricultural regions. Furthermore, experimentation with other variables suggest that the estimates are similar if we include a density indicator such as population per square kilometer to capture this effect. Also, the instruments work well enough to allow inferences on border effects, although some parameters (mostly those of the instrumented variables or of the income variables) are affected by multicollinearity. Specifically, in the unrestricted structural form models (model 3), this problem seems relevant.

Moving to the parameter estimates of our regressions, we find the robust and significant positive effect of own regional income. This effect is, however, smaller than that of other regions. This suggests that the purchasing power outside the home region is a more important determinant of the regional wage level than of the purchasing power of the own region. Furthermore, our results concerning the estimates of the reduced form parameters (model 1 and 2) suggest that the impact of gross value added of regions located in different countries of the EU15 (i.e. the members of $\mathcal{F}_{EU}$) on regional wages is not significantly different from the effect of equidistant regions in the same country. The hypothesis that the spatially weighted purchasing power of all regions and the spatially weighted purchasing power of regions in other EU countries exert the same impact thus cannot be rejected in the reduced form Models 1 and 2. According to these estimates, national borders within the EU do not seem to be a major impediment to spillovers in the demand potential of other regions. This stylized fact also carries over to the model when considering the restricted full specification in model 4. In this case too, the impact of gross value added of regions located in different countries of the EU15 on regional wages is not significantly different from the effect of equidistant regions in the same country.

The only model which disagrees with our finding of relatively small within EU15 border effects is Model 3. This model suggests that cross border wage effects within the EU15 are substantially lower than within countries, while with regard to income, we get the opposite result.[14] This finding is difficult to interpret from a theoretical perspective. It seems to be mainly due to econometric problems with the specification and the instruments. The parameter estimates (in particular those of the instrumented variables) of this specification

[13] We also looked at a number of smaller spatial decays to check for robustness of our results. In general this does not have a strong impact on findings. Since, specifications with $\alpha = 1/100$ produce the best fit, we concentrate on this case.

[14] With these parameter estimates, it is no surprise that Model 3 rejects the restrictions imposed on Model 4, although not at a 1% level of significance.

are strongly affected by multicollinearity, which makes inferences based on this model problematic.

Thus, while EU15 internal borders do not seem to be a major impediment to cross border spillovers in the regional wage structure, the differential impact of the spatially weighted purchasing power of regions from within the EU15, as compared to regions outside the EU15 is robust and substantial. In all estimated specifications (again with the exception of regional income in Model 3), the impact of the purchasing power of EU15 regions (W^{EU}) on wages in other EU15 regions is significantly higher than that observed with EU15-external borders (W^{NEU}). Furthermore, in all models, with the mentioned exception of Model 3, the corresponding parameters are significantly smaller than zero. This is observed in both the coefficients of spatially weighted wage rates and in spatially weighted income. The F-test of no external EU15 border effects rejects in all but one case (which again is model 3). Thus, the general view emerges that spatial spillovers in wages and income levels across external borders of the EU15 are substantially lower than across EU15-internal borders.

Our results thus indicate that the impact of GDP of regions across the borders of countries within the EU15 on regional wage levels in general does not statistically differ from that of regions within the same country. Our results, however, also suggest that external borders of the EU15 lead to pronounced extra-EU15 border effects in the European wage function irrespective of the specification chosen. This effect is difficult to quantify in general, however, since it depends on the location of regions.

To illustrate the size of border effects, we perform a simple calculation using the estimated coefficient of the within EU15 vs. EU15 – non EU15 market potential model for the most recent enlargement episode of the new member states of the EU in our sample (Czech Republic, Hungary and Poland). We base these calculations on the cross-section estimation results reported in Table A2 (see the Appendix). In a thought experiment, we ask how big the change in regional wage rates would be in the absence of EU15 external border effects holding the income levels constant. These calculations thus reflect the isolated impact of border effects at a given market potential, but ignore the long run general equilibrium effects. This is justified if a single region is small enough to have a negligible impact on its own market potential. Alternatively, one ccould account for the endogeneity of a region's own income by assuming that $Y_i = w_i L_i$. This would imply that the estimated border effects have to be multiplied by $1/(1-\beta_4)$ which results in an increase of the estimated effects of about 3.7–10.2 percent for all regions.

We compare this effect to the baseline of a 14 percent increase in nominal wages over 1991–2002 in the sample. In this way, we are able to base our projections on the estimated linear approximation, without relying on level information which cannot be inferred from the estimated model. Figure A1 (see the appendix) presents the estimated wage effects for all NUTSII regions in our sample in the form of a map. Three main findings emerge. First, border effects in the wage function are of a much higher magnitude for the new EU member states than for EU15 countries. Second, regions closest to the borders of the "old" and "new" EU are most strongly affected by border effects and, third, the combination of larger border effects in the new member states and in border regions implies border regions in the new member states are most strongly affected by border effects. In particular, our simulations suggest that the border effect in the wage functions implies a wage growth in regions in the new member states near to the EU15 border which should have been by 12 to 27 percentage points (Model 2) or 6 to 13 percentage points (Model 4) higher, relative to the actual development, if border effects had been of the same magnitude as within the EU15. The impact on EU15 regions is of substantially smaller magnitude and changes of relevant size are predicted for Austria and Germany only. Finally, regions more distant from the borders of the EU15 are more or less unaffected.

VI. Conclusion

In this paper, we estimate a linear approximation of the market potential function, as derived from geography and trade models. This model relates the wage rate in a region to its own and the spatially weighted purchasing power of the other regions. Using a spatial econometric estimation approach, we identify border effects differing between regions (i) in different countries within the EU15 or (ii) outside the EU15. In contrast to the existing literature, we thus explicitly model border effects and potential differences in steady state real wage levels.

Our findings suggest that the impact of GDP and wages of regions across borders of countries within the EU15 on regional wage levels does not differ from that of regions within the same country. However, there are still substantial border effects with respect to external borders of the EU15. These lead to pronounced extra-EU15 border effects in the wage function irrespective of the specification chosen. To illustrate the size of the estimated effects, we perform a simple calculation, using the estimated coefficient of the within EU15 vs. EU15 – non EU15 market potential model for the most recent enlargement of the new member states of the EU in our sample. These results suggest that border effects have a particularly pronounced impact on the wage structure in the border regions of new member states.

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Appendix

We approximate both the left and right hand side of the market potential function

$$\ln(w_i) = \frac{1-\sigma}{\sigma\mu}\ln(\overline{\omega})$$

$$+\frac{1}{\sigma}\ln\left(y_i w_i^{\frac{\sigma-1}{\mu}} + \sum_{j\neq i}^{N} y_j w_j^{\frac{\sigma-1}{\mu}} f(d_{ij})^{\sigma-1}\right)$$

linearly at the means of w_i and y_i using $\sum_{j\neq i}^{N} f(d_{ij})^{\sigma-1} \approx \rho$:

$$\ln\overline{w} + \frac{(w_i-\overline{w})}{\overline{w}}$$

$$\approx \frac{1-\sigma}{\sigma\mu}\ln(\overline{\omega}) + \frac{1}{\sigma}\ln\left(\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)\right)$$

$$+\frac{\sigma-1}{\sigma\mu}\frac{\overline{w}^{\frac{\sigma-1}{\mu}-1}(w_i-\overline{w})}{(\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)} + \frac{\sigma-1}{\sigma\mu}\frac{\sum_{j\neq i}^{N}\overline{yw}^{\frac{\sigma-1}{\mu}-1}f(d_{ij})^{\sigma-1}(w_j-\overline{w})}{\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)}$$

$$+\frac{1}{\sigma}\frac{\overline{w}^{\frac{\sigma-1}{\mu}}(y_i-\overline{y})}{\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)} + \frac{1}{\sigma}\frac{\sum_{j\neq i}^{N}\overline{w}^{\frac{\sigma-1}{\mu}}f(d_{ij})^{\sigma-1}(y_j-\overline{y})}{\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)}$$

$$= \frac{1-\sigma}{\sigma\mu}\ln(\overline{\omega}) + \frac{1}{\sigma}\ln\left((1+\rho)\overline{yw}^{\frac{\sigma-1}{\mu}}\right)$$

$$+\frac{\sigma-1}{(1+\rho)\sigma\mu}\frac{w_i-\overline{w}}{\overline{w}} + \frac{\sigma-1}{(1+\rho)\sigma\mu}\sum_{j\neq i}^{N}\frac{f(d_{ij})^{\sigma-1}(w_j-\overline{w})}{\overline{w}}$$

$$+\frac{1}{(1+\rho)\sigma}\frac{y_i-\overline{y}}{\overline{y}} + \frac{1}{(1+\rho)\sigma}\sum_{j\neq i}^{N}\frac{f(d_{ij})^{\sigma-1}(y_j-\overline{y})}{\overline{y}}$$

Denoting $\tilde{x}_i$ as the percentage deviation of x_i from its mean $\overline{x}$ (i.e. $\tilde{x} = \frac{x_i - \overline{x}}{\overline{x}}, x_i \in \{\pi_i, w_i, y_i\}$) and substituting for $\sum_{j \neq i}^{N} f(d_{ij})^{\sigma-1}$ we get

$$\ln \overline{w} + \overline{w}_i$$

$$\approx \frac{1-\sigma}{\sigma\mu} \ln(\overline{\omega}) + \frac{1}{\sigma} \ln\left(\overline{yw}^{\frac{\sigma-1}{\mu}}(1+\rho)\right) + \frac{\sigma-1}{\sigma\mu(1+\rho)}\tilde{w}_i$$

$$+\frac{\rho_0(\sigma-1)}{(1+\rho)\sigma\mu} \sum_{j \neq i \text{and} ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{w}_j + \frac{\rho_{EU}(\sigma-1)}{(1+\rho)\sigma\mu} \sum_{j \neq i \text{and} ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{w}_j$$

$$+\frac{\rho_{NEU}(\sigma-1)}{(1+\rho)\sigma\mu} \sum_{j \neq i \text{and} ij \in \mathcal{F}_{NEU}} \Theta_{ij}^{NEU} \tilde{w}_j + \frac{1}{\sigma(1+\rho)}\tilde{y}_i$$

$$+\frac{\rho_0}{\sigma(1+\rho)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{y}_j + \frac{\rho_{EU}}{\sigma(1+\rho)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{y}_j$$

$$+\frac{\rho_{NEU}}{\sigma(1+\rho)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_{NEU}} \Theta_{ij}^{NEU} \tilde{y}_j,$$

where $\Theta_{ij}^0 = \frac{e^{-\alpha d_{ij}}}{c}$ if $ij \in \mathcal{F}_0, \Theta_{ij}^{EU} = \frac{e^{-\alpha d_{ij}}}{c}$ for $ij \in \mathcal{F}_{EU}$, and $\Theta_{ij}^{NEU} = \frac{e^{-\alpha d_{ij}}}{c} ij \in \mathcal{F}_{NEU}$. Collecting terms and rearranging gives the basic specification to be estimated:

$$\tilde{w}_i = K + \frac{\rho_0(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{w}_j$$

$$+\frac{\rho_{EU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{w}_j$$

$$+\frac{\rho_{NEU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{and} ij \in \mathcal{F}_0} \Theta_{ij}^{NEU} \tilde{w}_j$$

$$+\frac{\mu}{1+\sigma(\mu(1+\rho)-1)}\tilde{y}_i+\frac{\rho_0\mu}{1+\sigma(\mu(1+\rho)-1)}\sum_{j\neq \mathrm{i} \mathrm{and} ij\in\mathcal{F}_0}\Theta^0_{ij}\tilde{y}_j$$

$$+\frac{\rho_{EU}\mu}{1+\sigma(\mu(1+\rho)-1)}\sum_{j\neq i \mathrm{and} ij\in\mathcal{F}_{EU}}\Theta^{EU}_{ij}\tilde{y}_j$$

$$+\frac{\rho_{NEU}\mu}{1+\sigma(\mu(1+\rho)-1)}\sum_{j\neq i \mathrm{and} ij\in\mathcal{F}_{NEU}}\Theta^{NEU}_{ij}\tilde{y}_j,$$

where $K=\frac{\sigma\mu(1+\rho)}{1+\sigma(\mu(1+\rho)-1)}\left[\frac{1-\sigma}{\sigma\mu}\ln(\overline{\omega})+\frac{\sigma(1-\mu)-1}{\sigma\mu}\ln\overline{w}+\frac{1}{\sigma}\ln(1+\rho)\overline{y}\right].$

Table A1 Market by country

	in bn Euro				in percent		
	Total	outside a country but within EU15	outside a country, outside EU15 or cross border EU	own country	outside a country but within EU15	outside a country, outside EU15 or cross border EU	own country
Austria	133.3	94.1	16.4	22.8	70.6	12.3	17.1
Belgium	370.5	308.0	7.9	54.7	83.1	2.1	14.8
Switzerland	183.8	0.0	153.6	30.2	0.0	83.6	16.4
Czech Republic	109.2	0.0	105.5	3.7	0.0	96.6	3.4
Germany	1111.8	302.3	57.5	752.0	27.2	5.2	67.6
Denmark	27.2	21.5	1.3	4.5	78.8	4.7	16.4
Spain	62.7	21.6	0.5	40.6	34.4	0.8	64.8
Finland	8.4	3.5	0.3	4.6	41.1	4.0	54.8
France	379.1	188.7	25.1	165.3	49.8	6.6	43.6
Hungary	30.6	0.0	26.5	4.2	0.0	86.4	13.6
Ireland	7.9	6.0	0.0	1.9	75.9	0.2	23.9
Italy	229.6	79.9	21.5	128.2	34.8	9.3	55.8
Luxemburg	33.9	32.4	1.5	0.0	95.6	4.4	0.0
Netherlands	356.7	268.9	4.9	82.9	75.4	1.4	23.2
Norway	14.5	0.0	9.9	4.6	0.0	68.4	31.6
Poland	76.8	0.0	59.8	17.0	0.0	77.9	22.1
Portugal	11.9	7.5	0.0	4.4	63.0	0.1	37.0
Sweden	26.0	13.6	3.1	9.3	52.4	11.9	35.8
U.K.	570.0	172.7	2.7	394.6	30.3	0.5	69.2

Note: Figures are based on the spatial weight $Wij = exp(-dij/100)/(1 + maxWi^*)$ *where max* Wi^* *is the maximum of the row sum of the not normalized spatial weighting matrix.*

Table A2 Estimates of the spatial market potential function

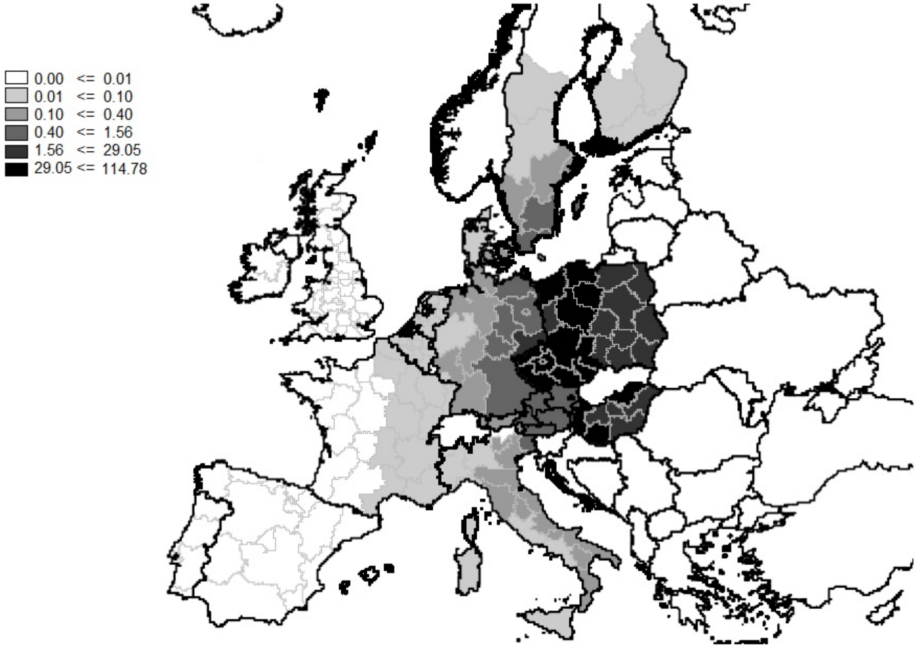
Dependent variable is nominal wage rate, averages 1999–2002, $\alpha = 1/100$.

	model 1: reduced form, OLS			model 2: reduced form, IV			model 3: structural form, IV			model 4: restricted structural form, IV		
	b	z		b	z		b	z		b	z	
W^0w	-	-		-	-		0,290	0,73		0,702	1,71	+
$W^{EU}w$	-	-		-	-		-0,940	-2,68	***	-0,258	-0,84	
$W^{NEU}w$	-	-		-	-		-3,152	-3,60	***	-1,309	-1,90	*
y	0,044	4,3	***	0,093	1,92	*	0,064	3,88	***	0,035	2,21	**
W^0y	0,420	3,3	***	0,364	2,62	***	0,560	3,70	***	0,313	2,15	**
$W^{EU}y$	0,295	1,5		0,468	1,64	*	0,806	2,96	***	-0,115	-	a)
$W^{NEU}y$	-0,671	-2,2	***	-0,396	-0,89		0,821	1,55	+	-0,583	-	a)
Share of workers, non-market services	-0,086	-1,4	+	-0,040	-0,50		-0,062	-0,98		-0,149	-2,33	**
Share of workers, market services	0,420	5,3	***	0,293	2,10	**	0,379	4,67	***	0,422	4,86	***
Share of workers, agriculture	-0,033	-2,2	**	-0,027	-1,58	+	-0,035	-2,37	***	-0,039	-2,45	**
East	-0,657	-11,3	**	-0,650	-11,46	***	-0,439	-5,48	***	-0,537	-6,70	***
Efta	0,514	8,52	**	0,508	8,12	***	0,391	5,57	***	0,487	7,91	***
R^2	0,74			0,74			0,84			0,83		
σ	0,03			0,03			0,03			-		
ρ	4,26			4,60			5,60			-		
Moran I (p-value)	0,000			0,000			0,000			-		
Instruments												
Relevance: Shea partial R^2 for W^0w	-			-			0,870			-		
Relevance: Shea partial R^2 for $W^{EU}w$	-			-			0,826			-		
Relevance: Shea partial R^2 for $W^{NEU}w$	-			-			0,587			-		
Relevance: Shea partial R^2 for y	-			0,046			0,337			-		
Validity, Sargan test (p-value)	-			0,217			0,127			-		
Endogeneity, Wu-Hausman (p-value)	-			0,284			0,285			-		
F-tests on border effects (p-value)												
w: $\rho_{EU}=0$, $\rho_{non\text{-}EU}=0$	-			-			0,001			0,085		
w: $\rho_{EU}=\rho_{non\text{-}EU}$	-			-			0,003			0,170		
y: $\rho_{EU}=0$, $\rho_{non\text{-}EU}=0$	0,013			0,012			0,012					
y: $\rho_{EU}=\rho_{non\text{-}EU}$	0,003			0,012			0,903			-		
Implied theoretical restriction	-			-			-			0,026		

*Notes: In model 1 y is exogenous, while it is endogenous in models 2–4. W^0w, $W^{EU}w$ and $W^{NEU}w$ are always treated as endogenous variables. Instruments comprise spatially lagged values of the exogenous variables. In models 2–4 additionally, country GDP, area, density and the employment rate (share of employed in total population) are used to instrument y. The instruments have been chosen so that the Sargan test in the second stage did not reject. All estimates and its standard errors are corrected for spatially autocorrelated errors following Kelejian and Prucha (1999). Spatial weights are $Wij = exp(-dij/100)/(1 + maxWi^*)$ where max Wi^* is the maximum of the row of spatial weighting matrix which is not normalized ; *** significant at 1%; ** significant at 5%; *significant at 10%; +significant at 15%; a) Implied by restriction.*

Figure A1 Border Effects of Reduced Form Specification

Simulation based on regression results for Specification II
(wage change in percent)



Source: own calculations