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**Working Paper**

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CESifo Working Paper, No. 1880

**Provided in Cooperation with:**

Ifo Institute – Leibniz Institute for Economic Research at the University of Munich

*Suggested Citation:* Huber, Peter; Pfaffermayr, Michael; Wolfmayr, Yvonne (2006) : Are there border effects in the EU wage function?, CESifo Working Paper, No. 1880, Center for Economic Studies and ifo Institute (CESifo), Munich

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# ARE THERE BORDER EFFECTS IN THE EU WAGE FUNCTION?

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CESIFO WORKING PAPER NO. 1880  
CATEGORY 10: EMPIRICAL AND THEORETICAL METHODS  
DECEMBER 2006

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# ARE THERE BORDER EFFECTS IN THE EU WAGE FUNCTION?

## 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 external borders a significant effect on regional wage structures. We illustrate the magnitude of EU external border effects by simulating the enlargement of the EU in May 2004. Our results suggest a large impact of the border for new member states, but a relatively small one for old members.

JEL Code: F10, R12, F12, C21.

Keywords: market potential, border effects, spatial econometrics.

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December 7, 2006

The authors would like to thank Thiess Büttner, Werner Mueller and the participants of the CESifo Conference on the Euro Area Enlargement and the AccessLab workshop in Vienna for helpful comments. We are also grateful to Irene Langer from the Austrian Institute of Economic Research for help with the data and research assistance. Lastly, we gratefully acknowledge financial support from the Austrian National Bank, Jubilaefonds Grant Nr. 10057 and from the 5th framework programme project AccessLab.

## 1 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 nineties major steps of economic integration have been undertaken between the EU, EFTA countries and the CEEC. Examples are the reduction of tariffs and other trade barriers with the completion of the Europe Agreements and the introduction of a pan-European cumulative tariff system which replaced the complex system of rules of origin in the European Union. These steps culminated in the accession of eight countries from the region in May 2004.

This accession has been associated with a number of concerns amongst which regional issues and labour market effects figured most prominently. In the public debate concerns about the intensified competition among border regions have often been voiced. However, the majority of economic studies so far mainly focussed on the analysis of wage and employment effects of trade integration for single countries (specifically, the US and the UK). The regional perspective still seems under-researched, although new economic geography models suggest major regional impacts of integration. These models offer two central predictions on the spatial structure of wages and the effects of integration on wages in border regions. First, falling transport costs across national borders (a synonym for integration in these models) may change the spatial structure of wage rates within a country (see Krugman and Livas, 1996; Fujita, Krugman and Venables, 1999; Paluzzie, 2001; Crozet and Koenig-Soubeyran, 2004) as well as between countries. As recently pointed out for instance by Brühlhart, Crozet and Koenig-Souberain (2004), the reduction in cross border transport costs implied by EU enlargement may change

the spatial structure of EU countries and accession countries. Second, economic geography models predict that regional wage levels follow a non-linear version of the market potential function proposed by Harris (1954).

In this paper we use these two predictions of economic geography models to test the significance of border effects of EU15-internal and external borders and thus provide evidence on the size of border effects in the European wage function. We linearly approximate the non-linear potential function implied by the core-periphery model to derive a simple linear specification (see also Combes and Lafourcade, 2001 or Mion, 2004). In contrast to the existing literature, 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, 2004, 2005) as well as individual EU countries (Roos, 2001; Brakman, Garretsen and Schramm, 2004; De Bruyne, 2003; Mion 2004) and groups of EU countries (see Head and Mayer, 2005) we explicitly model border effects. We argue that in a European context this extension may be important because on the one hand the countries in the EU are more strongly integrated than separate nations, but on the other hand they may not (yet) be fully integrated. This would lead us to expect some cross border interdependence of wages, which is less pronounced than within countries.

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. In contrast to the literature on border effects in goods prices and trade in the EU (see Nitsch, 2000, Beck and Weber, 2003) which finds sizeable 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. However, there are still substantial border effects with respect to EU external borders.

Finally, we illustrate the size of these EU external border effects by simulating the implication of the accession of the CEEC to the EU15 by assuming that in the long run border effects between EU15 and new member states will converge to those found currently among the EU15. These calculations suggest that border effects between the EU15 and accession countries are strongest in the border regions of the accessions countries, while most regions of the incumbent countries remain virtually unaffected. Overall, our empirical results thus suggest that accounting for border effects and steady state real wage differences in market potential estimations is important at least when focusing on European countries and that a reduction of border impediments has particularly strong effects on regions closer to the EU15 border.

## 2 THE ECONOMETRIC SPECIFICATION AND MARKET POTENTIAL FUNCTION

The starting point in deriving our empirical specification is the structural market potential function which has also been termed the wage function in recent literature. As pointed out by Fujita, Krugman and Venables (1999) this function which 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 neighboring regions, has been one of the work horse models of regional science at least since the seminal work of Harris (1954). This function, however, has received its theoretical foundation only recently in the economic geography models of Krugman (1991a),

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 homogenous good is costlessly tradable. The price of the homogenous good is normalized to 1 so that the overall price index in region  $i$  is given by  $T_i^\mu$ . 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 two equilibrium conditions (Krugman, 1991, Hanson, 2005).

$$(1) \quad \frac{w_i}{T_i^\mu} = \frac{w_j}{T_j^\mu} = \frac{\bar{w}}{\bar{T}^\mu} = \bar{w}, \quad i \neq j \Rightarrow T_j = \left(\frac{w_j}{\bar{w}}\right)^{\frac{1}{\mu}}$$

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

where the subscripts  $i$  and  $j$  index regions and  $\sigma > 1$  denotes the elasticity of substitution between any two variants of manufacturing goods.

Equation (1) states that in equilibrium real wages are equalized across all regions so that there is no incentive for workers to migrate. Forward and backward linkages induce spatial concentration of workers and firms and constitute the well known centripetal and centrifugal forces in the model (Krugman, 1991)<sup>1</sup>. The equilibrium wage rate of region  $i$  is determined by the market potential equation (2), which forms the basis of our econometric specification. Here, region  $j$ 's spatial weight is based on its distance to region  $i$ ,  $d_{ij}$ , according to the distance decay

function  $f(d_{ij})$  with,  $f(d_{ij}) < 1$  and  $f(d_{ij})' < 0$ . Taking the logs of (2) gives

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

Following Roos (2001), Mion (2004), Hanson (2005) and Niebuhr (2004) and others, we first eliminate the empirically unobservable price index ( $T_j$ ) in equation (2) to derive an estimable specification. For this, we follow the literature and substitute equation (1) into (3) to derive:

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

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:

$$(5) \quad f(d_{ij})^{1-\sigma} = \begin{cases} (\rho_0 + \rho_{EU}) \frac{e^{-\alpha d_{ij}}}{c} & ij \in \mathcal{F}_{EU} \\ (\rho_0 + \rho_{NEU}) \frac{e^{-\alpha d_{ij}}}{c} & ij \in \mathcal{F}_{NEU} \\ \rho_0 \frac{e^{-\alpha d_{ij}}}{c} & ij \notin \mathcal{F}_{EU} \text{ and } ij \notin \mathcal{F}_{NEU} \end{cases}$$



where  $c = 1 + \max_i \sum_{i \neq j} e^{-\alpha d_{ij}}$  and the parameters  $\rho_0$ ,  $\rho_{EU}$ ,  $\rho_{NEU}$  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

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

This formulation implies that the spatial weight and, hence, the market potential of a region decreases with its distance to its neighbors, all else equal. A similar spatial weighting scheme has been proposed by Kelejian and Prucha (2005) who argue that it is less restrictive than a 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.<sup>2</sup>

Next we approximate the left and right hand side of (4) linearly around average values. In the Appendix<sup>3</sup> this approximation is derived as

$$\begin{aligned} (6) \quad \tilde{w}_i &= K + \beta_1 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{w}_j + \beta_2 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{w}_j \\ &\quad + \beta_3 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{NEU}} \Theta_{ij}^{NEU} \tilde{w}_j + \beta_4 \tilde{y}_i + \beta_5 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{y}_j \\ &\quad + \beta_6 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{y}_j + \beta_7 \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{NEU}} \Theta_{ij}^{NEU} \tilde{y}_j, \end{aligned}$$

where  $\tilde{x}_i$  is the percentage deviation of  $x_i$  from its mean  $\bar{x}$  (i.e.  $\tilde{x} = \frac{x_i - \bar{x}}{\bar{x}}$ ,  $x_i \in$

$\{w_i, y_i\}$ ) and  $K$  is a constant. The remaining parameters to be estimated are  $\beta_1 = \frac{\rho_0(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_2 = \frac{\rho_{EU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_3 = \frac{\rho_{NEU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_4 = \frac{\mu}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_5 = \frac{\rho_0\mu}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_6 = \frac{\rho_{EU}\mu}{1+\sigma(\mu(1+\rho)-1)}$ ,  $\beta_7 = \frac{\rho_{NEU}\mu}{1+\sigma(\mu(1+\rho)-1)}$ . The spatial decay functions  $\Theta_{ij}^k$  with  $k \in \{0, EU, NEU\}$  are defined in the Appendix .

In vector notation the empirical specification can thus be written as

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

where  $\mathbf{Z}$  is a vector of explanatory variables entering the regression to proxy for otherwise unobservable price and wage differences not captured by the model and also includes the constant ( $K$ ).  $\mathbf{W}^0$ ,  $\mathbf{W}^{EU}$  and  $\mathbf{W}^{NEU}$  are the  $N \times N$  spatial weighting matrices with  $N$  being the number of regions.  $\mathbf{u}$  denotes the vector of errors which may be spatially autocorrelated such that  $\mathbf{u} = \phi \mathbf{W} \mathbf{u} + \boldsymbol{\varepsilon}$ ,  $\varepsilon_j \sim iid(0, \sigma_\varepsilon^2)$ . Equation (7) forms the basic specification of the market potential function which is estimated below.

Several comments concerning this specification are in order. First, in its strict form the model implies a series of testable non-linear restrictions. In particular, from equation (7) 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 (7). 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. In this way, 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 equalisation and identical technologies across regions and countries. This is, of course, 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 also by additional variables to control for the fact that real wages may not equilibrate across regions i.e. violate equation (1). 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 (see also Niebuhr, 2004). Productivity differentials are captured by country group effects (Eastern European Countries, Non-EU15-EFTA countries, and EU15 countries which are the base).

### **3 DATA AND ESTIMATION STRATEGY**

We use data of compensation per employee, nominal gross value added and sectorial 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 set. 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.<sup>4</sup>

**Table 1: Market potential by country**

	in bn Euro					in percent				
	Total	outside a	outside a	market	own country	Total	outside a	outside a	market	own country
		country but	country, outside EU15	or cross			potential shifted due to	country but	country, outside EU15	
Austria	133,3	94,1	16,4	6,2	22,8	70,6	12,3	4,6	17,1	
Belgium	370,5	308,0	7,9	0,5	54,7	83,1	2,1	0,1	14,8	
Switzerland	183,8	0,0	153,6	0,0	30,2	0,0	83,6	0,0	16,4	
Czech Republic	109,2	0,0	105,5	96,6	3,7	0,0	96,6	88,4	3,4	
Germany	1111,8	302,3	57,5	15,2	752,0	27,2	5,2	1,4	67,6	
Denmark	27,2	21,5	1,3	0,4	4,5	78,8	4,7	1,6	16,4	
Spain	62,7	21,6	0,5	0,0	40,6	34,4	0,8	0,0	64,8	
Finland	8,4	3,5	0,3	0,1	4,6	41,1	4,0	0,8	54,8	
France	379,1	188,7	25,1	0,4	165,3	49,8	6,6	0,1	43,6	
Hungary	30,6	0,0	26,5	22,4	4,2	0,0	86,4	73,3	13,6	
Ireland	7,9	6,0	0,0	0,0	1,9	75,9	0,2	0,0	23,9	
Italy	229,6	79,9	21,5	1,5	128,2	34,8	9,3	0,6	55,8	
Luxemburg	33,9	32,4	1,5	0,1	0,0	95,6	4,4	0,2	0,0	
Netherlands	356,7	268,9	4,9	0,7	82,9	75,4	1,4	0,2	23,2	
Norway	14,5	0,0	9,9	0,0	4,6	0,0	68,4	0,0	31,6	
Poland	76,8	0,0	59,8	53,8	17,0	0,0	77,9	70,1	22,1	
Portugal	11,9	7,5	0,0	0,0	4,4	63,0	0,1	0,0	37,0	
Sweden	26,0	13,6	3,1	0,6	9,3	52,4	11,9	2,4	35,8	
U.K.	570,0	172,7	2,7	0,1	394,6	30,3	0,5	0,0	69,2	

Note: Figures are based on the spatial weight  $w_{ij} = \exp(-d_{ij}/100)/(1 + \max W_i^*)$  where  $\max W_i^*$  is the maximum of the row sum of the not normalized spatial weighting matrix

For estimation we use a cross section of averages over the periods 1999-2002.<sup>5</sup> The dependent variable is nominal compensation per employee. Regional income (purchasing power), 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 fly distance between the capitals of each NUTSII region.

Table 1 displays the distance weighted purchasing power (gross value added; GVA) of all accessible regions aggregated to the country level (column 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  $\mathcal{F}_{NEU}$ ), while the mass of purchasing power affected by the EU accession of Czech Republic, Hungary and Poland is reported in column 4. The residual in column 5 gives the purchasing power of the regions in their own country. Columns 6 - 8 report the corresponding breakdown in percent. This table corroborates the results of Brülhart, Crozet and Koenig-Souberain (2004) and of Niebuhr (2004) which indicate that the additional market potential provided by the new EU member states to the existing EU15's market is small relative to the potential for the old member states. Austria, Sweden and Germany are the countries to gain most in terms of market potential by enlargement, but even here the market potential outside the EU15 amounts to less than 5 percent.

For countries more distant to the new member states, such as Spain or Portugal, the additional market potential in the new member states is negligible. In contrast, a substantial amount of the market potential for the new member states is located in the old EU member states. In the Czech Republic, Hungary, and Poland more than 70 percent of the total market potential is located in regions of the EU15.

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

so that it ignores the fact that the income of a region is endogenous. Second,  $\mathbf{W}^0\tilde{\mathbf{w}}$ ,  $\mathbf{W}^{EU}\tilde{\mathbf{w}}$ , and  $\mathbf{W}^{NEU}\tilde{\mathbf{w}}$  are endogenous as the vector of wage rates  $\tilde{\mathbf{w}}$  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 and 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  $\phi$  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  $v_i^*(\hat{\phi}) = [(\mathbf{I} - \hat{\phi}\mathbf{W})\mathbf{v}]_i$  for all variables in the model and applying 2SLS on the transformed data. Kelejian and 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 Tables 2 and 3). However, we include only those instruments which pass the Sargan overidentification test. Shea's  $R^2$  as well 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 (ignoring spatially weighted wage rates) and treats regional income as an exogenous variable.<sup>6</sup> Model 2 is the same as Model 1, but with regional income endogenous. Model 3 is the unrestricted structural form, which includes  $\mathbf{W}^0\tilde{\mathbf{w}}$ ,  $\mathbf{W}^{EU}\tilde{\mathbf{w}}$ , and  $\mathbf{W}^{NEU}\tilde{\mathbf{w}}$ , 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.<sup>7</sup> In spatial econometric models the spatial decay parameter  $\alpha$  is usually a fixed parameter. We set  $\alpha = 1/100$  (see Table 2).<sup>8</sup> The estimation results also indicate significant spatial correlation of the error term (as evidenced by the significant Moran I-test of Kelejian and Prucha, 2001) so that the GM approach is indeed required.

## 4 RESULTS

The results (in Table 2) suggest that our control variables work well, indicating substantiality lower wages in the CEEC 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.<sup>9</sup> 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 a robust and significant positive effect of own regional income. This effect is however, smaller than that of other regions in the same country in all specifications. This is not

in line with theory which assumes zero transportation costs within a region and, hence, the highest impact of demand on wages. One of the reasons for this somewhat unexpected result could be the correlation with the other controls such as  $\mathbf{W}^0\mathbf{y}$ . While this result is unexpected, 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. This implies that 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 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.<sup>10</sup> 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. As mentioned above, the parameters (in particular those of the instrumented variables) of this specification are strongly affected by multicollinearity which makes inferences based on this



model problematic.

**Table 2: Estimates of the spatial market potential function**  
 Dependent variable is nominal wage rate, averages 1999-2002,  $\square=1/100$

	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
$W^0_w$	-	-	-	-	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 **
$W^0_y$	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 ***
Etta	0,514	8,52 **	0,508	8,12 ***	0,391	5,57 ***	0,487	7,91 ***
R <sup>2</sup>	0,74		0,74		0,84		0,83	
$\square$	0,03		0,03		0,03		-	
$\square$	4,26		4,60		5,60		-	
Moran I (p-value)	0,000		0,000		0,000		-	
Instruments								
Relevance: Shea partial R <sup>2</sup> for $W^0_w$	-		-		0,870		-	
Relevance: Shea partial R <sup>2</sup> for $W^{EU}_w$	-		-		0,826		-	
Relevance: Shea partial R <sup>2</sup> for $W^{NEU}_w$	-		-		0,587		-	
Relevance: Shea partial R <sup>2</sup> 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: $\square_{EU}=0, \square_{non-EU}=0$	-		-		0,001		0,085	
W: $\square_{EU}=\square_{non-EU}$	-		-		0,003		0,170	
Y: $\square_{EU}=0, \square_{non-EU}=0$	0,013		0,012		0,012		-	
Y: $\square_{EU}=\square_{non-EU}$	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.  $W^0_w$ ,  $W^{EU}_w$  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  $W_{ij}=\exp(-d_{ij}/100)/(1+\max W_{ij})$  where  $\max W_{ij}$  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.

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 observed with EU15-external borders ( $W^{NEU}$ ). Further-

more, 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 cases (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 so far indicate that the impact of GDP of regions across 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 are a major impediment to trade and factor mobility, leading to pronounced extra-EU15 border effects irrespective of the specification chosen. To illustrate the size of these effects, we perform a simulation, 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 simulations on the cross section estimation results reported in Table 2 by setting up an experiment of thought, asking how big the additional change in the growth rate of wages would have been in the absence of EU15 external border effects as compared to the base of a 14 % 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. Since these simulations are based on cross-section estimates the resulting wage effects reflect long run adjustments. Also, they reflect the influence of market potential and the change in border effects

due to accession only, ignoring other major influences like productivity changes or pressures on factor price equalization resulting from increased and liberalized trade.

**Table 3: The estimated impact of EU-enlargement**

		GDP per capita-deviation from EU-mean			hypothetical growth differential in percentage points, reduced form, model 2			hypothetical growth differential in percentage points, structural form, model 4		
		EU15	New members	Efta	EU15	New members	Efta	EU15	New members	Efta
		Austria	1	49,53			1,09			0,57
Belgium	2	36,27			0,07			0,04		
Switzerland	3			64,89			0,00			0,00
Czech Republic	4		-77,00			27,97			13,03	
Germany	5	14,92			0,78			0,41		
Denmark	6	44,48			0,23			0,12		
Spain	7	-15,65			0,00			0,00		
Finland	8	17,37			0,02			0,01		
France	9	36,01			0,03			0,02		
Hungary	10		-74,02			12,20			5,69	
Ireland	11	1,45			0,00			0,00		
Italy	12	-12,44			0,19			0,10		
Luxemburg	13	65,41			0,10			0,05		
Netherlands	14	8,04			0,13			0,07		
Norway	15			45,20			0,00			0,00
Poland	16		-78,70			11,96			5,70	
Portugal	17	-54,22			0,00			0,00		
Sweden	18	33,79			0,12			0,07		
U.K.	19	7,27			0,01			0,00		

Note: GDP per capita is weighted by population; wage changes are weighted by the nominal wage rate

Figure 1 (at the end of the text) presents the simulated wage effects in the form of a map. Table 3 summarizes the simulation results at the level of countries. Three main findings emerge. First, wage effects due to a reduction of cross border transport costs (border effects) in the process of EU enlargement are of a much higher magnitude for the new EU member states in the sample than for EU15 countries. Second, regions closest to the borders of the "old" and "new" EU are to gain most in terms of wage increases. Third, the combination of larger wage effects in the new member states and in border regions implies that regional disparities

in wage rates within the new member states are likely to increase as well, since border regions have also been preferred regions in the period before accession<sup>11</sup>

In particular, our simulations suggest that wage growth in regions in the new member states near to the EU15 border 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. The results of Model 2 for the EU15 countries indicate the most pronounced wage effects for Austria (1.1 percentage points), followed by Germany (0.8), Denmark, Sweden and Italy. Within the group of the three new member countries, the Czech Republic is to be most affected.

## 5 CONCLUSIONS

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 major findings with respect to these estimates 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. External borders of the EU15 are a major impediment to trade and factor mobility, leading to pronounced extra-EU15 border effects irrespective of the specification chosen. In consequence EU-integration may have substantial effects on the wage structures of individual countries. To illustrate the size of these effects, we perform a simulation, 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. This simulation exercise suggests that the accession may lead to pronounced wage effects in the new member states, which get better access to a big market potential.

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## Appendix:

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

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

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

$$\begin{aligned} &\ln \bar{w} + \frac{(w_i - \bar{w})}{\bar{w}} \\ &\approx \frac{1-\sigma}{\sigma\mu} \ln(\bar{w}) + \frac{1}{\sigma} \ln \left( \bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1 + \rho) \right) \\ &\quad + \frac{\sigma-1}{\sigma\mu} \frac{\bar{w}^{\frac{\sigma-1}{\mu}-1} (w_i - \bar{w})}{\bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1+\rho)} + \frac{\sigma-1}{\sigma\mu} \frac{\sum_{j \neq i}^N \bar{y} \bar{w}^{\frac{\sigma-1}{\mu}-1} f(d_{ij})^{\sigma-1} (w_j - \bar{w})}{\bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1+\rho)} \\ &\quad + \frac{1}{\sigma} \frac{\bar{w}^{\frac{\sigma-1}{\mu}} (y_i - \bar{y})}{\bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1+\rho)} + \frac{1}{\sigma} \frac{\sum_{j \neq i}^N \bar{w}^{\frac{\sigma-1}{\mu}} f(d_{ij})^{\sigma-1} (y_j - \bar{y})}{\bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1+\rho)} \\ &= \frac{1-\sigma}{\sigma\mu} \ln(\bar{w}) + \frac{1}{\sigma} \ln \left( (1 + \rho) \bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} \right) \\ &\quad + \frac{\sigma-1}{(1+\rho)\sigma\mu} \frac{w_i - \bar{w}}{\bar{w}} + \frac{\sigma-1}{(1+\rho)\sigma\mu} \sum_{j \neq i}^N \frac{f(d_{ij})^{\sigma-1} (w_j - \bar{w})}{\bar{w}} \\ &\quad + \frac{1}{(1+\rho)\sigma} \frac{y_i - \bar{y}}{\bar{y}} + \frac{1}{(1+\rho)\sigma} \sum_{j \neq i}^N \frac{f(d_{ij})^{\sigma-1} (y_j - \bar{y})}{\bar{y}} \end{aligned}$$

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

$$\begin{aligned} &\ln \bar{w} + \tilde{w}_i \\ &\approx \frac{1-\sigma}{\sigma\mu} \ln(\bar{w}) + \frac{1}{\sigma} \ln \left( \bar{y} \bar{w}^{\frac{\sigma-1}{\mu}} (1 + \rho) \right) + \frac{\sigma-1}{\sigma\mu(1+\rho)} \tilde{w}_i \end{aligned}$$

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

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

$$\begin{aligned}
 \tilde{w}_i & = K + \frac{\rho_0(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{w}_j \\
 & + \frac{\rho_{EU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{w}_j \\
 & + \frac{\rho_{NEU}(\sigma-1)}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_0} \Theta_{ij}^{NEU} \tilde{w}_j \\
 & + \frac{\mu}{1+\sigma(\mu(1+\rho)-1)} \tilde{y}_i + \frac{\rho_0\mu}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_0} \Theta_{ij}^0 \tilde{y}_j \\
 & + \frac{\rho_{EU}\mu}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{EU}} \Theta_{ij}^{EU} \tilde{y}_j \\
 & + \frac{\rho_{NEU}\mu}{1+\sigma(\mu(1+\rho)-1)} \sum_{j \neq i \text{ and } ij \in \mathcal{F}_{NEU}} \Theta_{ij}^{NEU} \tilde{y}_j,
 \end{aligned}$$

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

## Notes

<sup>1</sup>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.

<sup>2</sup>To see this consider a region with a distance of say 500 kilometers to all other regions and compare it to a second one, 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.

<sup>3</sup>The linear approximation of the market potential function is a common strategy in applied work (see Combes and Lafourcade, 2001 and Mion, 2003 for recent examples.)

<sup>4</sup>We checked whether this procedure changes qualitative results and found that this is not the case

<sup>5</sup>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.

<sup>6</sup>This ‘reduced form’ may also be interpreted as an estimate of the market potential function as originally formulated by Harsanyi (1954).

<sup>7</sup>For Model 4 the estimates of  $\phi$  are those derived for Model 3.

<sup>8</sup>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.

<sup>9</sup>These results are available from the authors upon request.

<sup>10</sup>With these parameter estimates it is no surprise that Model 3 rejects the restrictions imposed on Model 4, although not at an 1% level of significance.

<sup>11</sup>These qualitative results are consistent with estimates in Niebuhr (2004) based on a model estimated for the EU15 regions.

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