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Market Access, Regional Price Level and Wage Disparities: The German Case

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Abstract. In this paper we use the NEG framework of the Helpman model to investigate the spatial distribution of wages across German labour market regions under different assumptions. As the assumptions of equal regional price level and equal real wages are strongly rejected for the German economy, standard approaches may fail to reveal the role of market access in explaining regional wage disparities. In part substantial changes occur when market potential is measured with the aid of regional price levels. With the so-called price index approach, the importance of market access in explaining regional wage differentials is clearly revealed. When controlling for heterogeneity of labour force and spatial dependence, the relationship still remains highly significant. From the price index approach, limited demand linkages of reasonable reach are inferred.

JEL classification: R11, R12, R15

Key words: New Economic Geography, market access, wage disparities, regional price levels

1. Introduction

Incomes and wages are not evenly distributed across space. In agglomerations where economic activities concentrate, workforce is higher remunerated than in peripheral regions. Concentration of economic activities across space is observed both at a regional, national and international scale. In Germany, wages are up 110 percent higher in agglomerations like Munich, Düsseldorf/Cologne, Stuttgart and Hamburg than in peripheral regions at the district level. If regions are delineated functionally by commuter flows (Eckey, 2001), the difference decreases to a maximum of 80 percent. Although regional policy provided large amounts of funds to promote a catch-up of peripheral regions, disparities in wages have virtually not changed during the period 1995 - 2004. The lack of success in levelling out income disparities has triggered a discussion on the efficiency of regional development strategies (Eckey and Kosfeld, 2005). In particular the growth pole concept has experienced a revival in EU regional policy. Economic growth effects may be larger by investment in growth poles than by supporting solely rural depressed regions (Eckey et al., 2008).

In explaining the formation of the spatial structures of production and wages by New Economic Geography (NEG), market access plays a predominant role. Firm located in regions with good access to large markets experience greater demand for their products. Because of lower transport costs and cost savings from large-scale production, they can afford to pay their workers higher wages according to increased demand for labour. Thus, increasing returns to scale and transport costs act as forces towards agglomeration. When workers are attracted by high wages and low prices of manufactured goods, housing prices will tend to rise. By worsening living conditions, congestions effects in densely populated regions act towards dispersion. The economic landscape is shaped by the tension of these centripetal and centrifugal forces.

NEG models share much of the structure regarding the modern industrial sector (Fujita et al., 1999). Differences occur especially in modelling centrifugal forces (Krugman, 1991; Helpman, 1998, Südekum, 2007). Moreover, the model structure can be enhanced by introducing intermediate factors of production (Krugman and Venables, 1995; Redding and Venables, 2004). Hanson (1998, 2005) has been the first to derive a testable equation relating regional wages to a measure of market access in order to study the spatial distribution of wages in the U.S. He establishes substantial effects of market access on regional wages. Although most of the parameter estimates are meaningful interpretable, demand linkages turn out to be very limited. In his study on spatial externalities across Italian regions, Mion (2004) points to possible biases introduced by spatial aggregation. While Kiso (2005) uses likewise the Helpman model as the theoretical frame for studying the spatial distribution of factor earnings across Japanese prefectures, Niebuhr (2004), De Bruyne (2003) and Pires (2006) estimate a wage equation for EU, Belgian and Spanish regions derived from Krugman's original model. The international NEG approach put forth by Redding and Venables (2004) is adapted for regional analysis of the spatial income structure in the European Union by Breinlich (2006), in Spain by Lopez-Rodriguez and Faina (2007) and in China by Hering and Poncet (2007, 2008) and Poncet (2008).

The importance of market access in explaining disparities of wages in Germany has been investigated by Roos (2001) and Brakman et al. (2004). While Roos adopted the Helpman model with housing stock as an explanatory variable of West German wages, Brakman et al. (2004) mainly rely on land prices of German districts within the same modelling framework. In both studies, the market potential function of Harris (1954) is additionally employed for comparative purposes. From the viewpoint of NEG models the simplified market potential is obtained under the assumption of equal regional price indices in the manufacturing sector. In contrast, the well-established Helpman-Hanson approach is based on the assumption of equal real wages across space. As is shown in this paper, both assumptions have to be strongly rejected for the German economy.

The assumptions of equal regional price level or equal real wages are usually met in order to cope with the lack of regional price indices. Brakman et al. (2004) face this problem by additionally using a “simplified price index” of manufactures that is directly derived from regional wages. Studies on determinants of regional price level, however, show that the wage rate is only one among other price determinants (Roos, 2006; Kosfeld et al., 2008). In order to capture the forces shaping the economic landscape according to NEG theory, the used concept of the market potential should involve at least some estimates of regional price levels. As Brakman et al. (2004) have shown, even a simplified price index approach can change the picture on the effects of geography substantially. This problem is not only present in Helpman-Krugman-type NEG models but as well present in the approach of Redding and Venables (2004), where as a standard feature regional price levels are estimated by a dummy variable approach.

This paper adds to the literature in three ways. First, the Helpman model is estimated and tested without invoking the assumptions of equal regional price indices or real wages. Instead, we adopt the price index approach suggested by Brakman et al. (2004) in order to capture the geography of market access more adequately. Because of the lack of official data, the price level series constructed by Kosfeld et al. (2008) is used to proxy the price index of manufactures. Econometric results of this approach are compared with those of the simple market potential approach and the housing rent approach. Secondly, it is well-known that administrative areas are often partitioned arbitrarily. In spatial statistics this problem is known as a specific facet of the modifiable areal unit problem (MAUP) (Arbia, 1989). We address this problem by relying on functional instead of administrative regions. In particular we refer to labour market regions that are delineated on the basis of commuter flows and thus correspond to travel-to-work areas (Eckey, 2001). Thirdly, we deal with the problem of spatial dependence in the wage equation by modelling spatial error processes. As commuter flows across regions are considerably reduced but not eliminated with regional labour markets, region-specific shocks may still spill over to surrounding regions. Moreover, geo-referenced variables controlling for worker characteristics are expected to be spatially autocorrelated. When some of these variables are omitted, efficiency losses may be serious. In estimating NEG models, spatial error dependence is only accounted for in exceptional cases (e.g. Mion, 2006; Niebuhr, 2006).

The subsequent sections are organized as follows. In section 2, the theoretical framework for different approaches to estimating the NEG wage equation is exposed. Section 3 discusses econometric issues. The regional system and data are explained in section 4. In section 5, we test for equality of price levels and wages across German labour market regions. The regression results are discussed in section 6. Section 7 concludes.

2. Theoretical framework

Helpman's NEG model (Helpman, 1998) is in many respects equally structured as Krugman's original core-periphery model (Krugman, 1991). In both models, regional economies consist of two sectors where goods are produced with labour as the single production factor. Mobile workers are employed in the industrial sector where varieties of manufactures are produced under increasing returns to scale. The market structure of differentiated goods is characterised by monopolistic competition. In Krugman's traditional sector a freely traded agricultural good is produced by immobile farmers under constant returns to scale. Helpman (1998) replaces the agricultural sector by the housing sector as a centripetal force. Although the agricultural good only serves as a metaphor for a tradable good produced by immobile labour, the Helpman model is assessed to be more appealing as it allows for less extreme agglomeration patterns (Roos, 2001; Brakman et al., 2004). We therefore refer to this theoretical framework for substantiating alternative estimation and testing strategies of a NEG-based wage equation.

All consumers in the economy have identical tastes. They maximize utility function U of Cobb-Douglas type,

(2.1) $U = M^{\mu} \cdot H^{1-\mu}$,

where M is the consumption of manufacturing goods and H the consumption of housing. The parameter μ, $0 < \mu < 1$, renders the expenditure share on manufactures. Consumption of the composite differentiated good M is given by the Dixit-Stiglitz CES function

(2.2) $$M = \left[\sum_{i=1}^{n} c_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

with c_i as consumption of variety i. The parameter σ, σ > 1, is the elasticity of substitution between any pair of varieties. It reflects the substitutability of product varieties in consumers' eyes. Consumers love variety. Given a fixed amount of consumption, utility is higher for a larger number of differentiated goods. The increase of utility in response to a growing number of varieties, n, will be small for a high degree of substitutability.

Manufactured goods are produced with labour as the only production factor. Increasing returns to scale in the industrial sector are modelled by fixed and variable labour requirement:

(2.3) $$\ell_i = F + b \cdot x_i .$$

ℓ_i denotes labour input necessary to produce the quantity x_i of variety i. Independent of production level x_i, the fixed labour input amounts to F. Variable labour input increases linearly by the factor b. Due to increasing returns to scale, each firm produces only one variety. Optimal output and labour requirement results from profit maximisation subject to the zero-profit-condition on virtue of free market entry.[1] It characterises a short-run equilibrium where wages w_r may differ across regions. The same amount of equilibrium output $x=\alpha(\sigma-1)/\beta$ is produced with labour input $\ell=\alpha\sigma$ for all varieties. This implies that the manufacturing sector can only expand by new firms producing additional varieties. Firms set prices as a mark-up over marginal costs $b \cdot w_r$:

(2.4) $$p_r = b \cdot w_r \cdot \frac{\sigma}{\sigma - 1} .$$

The mark-up is the higher the more difficult varieties can be substituted by one another. Below it becomes clear that σ can as well be interpreted as price elasticity of demand. Thus, with low price elasticity mark-up tends to be larger.

Firms supply produced manufactures to all regions. While goods are sold in the home region for the mill price p_i, transport costs incur in interregional trade. They are modelled by an "iceberg technology". In order that one unit of a variety arrives at destination s,

(2.5) $$T_{rs} = T(d_{rs}), \quad dT(d_{rs})/d\,d_{rs} > 0 ,$$

[1] The zero-profit condition is given by $\pi_i = p_i \cdot x_i + w_r \cdot (F + b \cdot x_i) = 0$. As equilibrium mill prices p_i only depend on substitution elasticity σ, marginal labour requirement b and regional wages w_r, they are the same for all varieties in region r (cf. Fujita and Thisse, 2002, pp. 308).

units must be shipped from region r. The part T_{rs}-1 that "melts" away increases with distance d_{rs} between regions r and s. Thus, consumers located in region s have to pay the price

$$(2.6) \quad p_{rs} = p_r \cdot T_{rs}$$

with $T_{rs} > 1$ for $r \neq s$ and $T_{rr} = 1$ for one unit of variety i that is produced in region r.[2] Transport costs amount to $p_r \cdot (T_{rs}-1)$.

As labour costs need not be identical across all regions, mill prices for manufactures may, however, differ across regions. Let n_s be the number of varieties produced in region s. Using (2.6), the price index P_r^M of differentiated products supplied and consumed in region r is given by

$$(2.7) \quad P_r^M = \left(\sum_{s=1}^{R} n_s \cdot p_s^{1-\sigma} \cdot T_{sr}^{1-\sigma} \right)^{1/(1-\sigma)}$$

with R as the number of regions. It is defined to match with the demand function

$$(2.8) \quad c_i = p_i^{-\sigma} \cdot (P^M)^{\sigma-1} \cdot \mu \cdot Y$$

for variety i.[3] With the optimal number of varieties $n = \lambda_r L / \alpha\sigma$, the price index of manufactures reads

$$(2.9) \quad P_r^M = \kappa_1 \cdot \left(\sum_{s=1}^{R} \lambda_s \cdot p_s^{1-\sigma} \cdot T_{sr}^{1-\sigma} \right)^{1/(1-\sigma)} \quad \text{with} \quad \kappa_1 = \left(\frac{\gamma L}{\alpha\sigma} \right)^{1/(1-\sigma)}.$$

According to (2.9), the price index P_r^M can basically be interpreted as a weighted average of prices p_s of the variants. In virtue of lower transport costs, the price index of manufactures P^M is relatively low in regions where consumers have good access to large markets. Due to competition effects, P^M is also the lower, the larger the number of varieties produced in the economy.

As stock of housing, H_r, is fixed in all regions, prices for housing tend to be high in densely populated centres and low in sparsely populated areas. In equilibrium, housing income and housing expenditures must be equal:

$$(2.10) \quad P_r^H \cdot H_r = (1-\mu) Y_r .$$

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[2] Because of the same labour requirement for producing different varieties and mark-up pricing in monopolistic competition, mill prices are the same for all variants of the differentiated good in a source region r:

[3] The demand function (2.8) is obtained from maximising the composite differentiated good (2.2) subject to the budget constraint $\sum_i p_i \cdot c_i = \mu \cdot Y$ where μY is income earned in the manufacturing sector.

When income Y_r rises with immigration of firms and workers, housing rents P_r^H will increase if housing stock H_r is constant:

(2.11) $P_r^H = (1-\mu)Y_r \cdot H_r^{-1}$.

Thus, overall regional price level,

(2.12) $P_r = (P^M)^{\mu} \cdot (P^H)^{1-\mu}$,

depends on the relative strength of centrifugal and centripetal forces. While transport costs act as an agglomeration force, housing costs operate towards dispersion.

By equating region's r supply (= level of production) of the differentiated product with total demand from all regions, one obtains the wage equation:

(2.13) $w_r = \kappa_2 \cdot \left(\sum_{s=1}^{R} Y_s \cdot T_{rs}^{1-\sigma} \cdot (P_s^M)^{\sigma-1} \right)^{1/\sigma}$ with $\kappa_2 = \frac{\sigma-1}{\sigma} b^{(1-\sigma)/\sigma} \left(\frac{\mu}{(\sigma-1)F} \right)^{1/\sigma}$.

Regional wages are determined by distance-weighted purchasing power and competition. On the one hand, nominal wages will be high in regions with good access to large markets. They tend to increase with income in surrounding regions and decrease with rising transport costs. On the other hand, strong competition among firms will exert a downward-pressure on prices and thus on nominal wages.

Short-run equilibria are compatible with different wage rates across regions. In the long-run, however, workers will react to differences in real wages. Because of factor mobility, they will leave a low-wage region and move to a high-wage region in order to realise a higher utility level.[4] When real wages are equalised across space,

(2.14) $\omega_r = \frac{w_r}{P_r} = \omega$ for all r,

workers have no more incentives to migrate. Thus, (2.14) characterises the spatial equilibrium in the long run.

When the price index of manufactures, P_r^M, is not known at the required regional level, condition (2.14) can be used for alternative representations of the wage equation. Provided that prices of housing services, P_r^H, are available, the price index P_r^M can be replaced by

[4] Indirect utility is equivalent to maximising real wage.

$P_r^M = \omega \cdot [w_r/(P_r^H)^{1-\mu}]^{1/\mu}$. Substituting this expression in (2.13), the wage equation takes the form

$$(2.15)\quad w_r = \kappa_3 \cdot \left(\sum_{s=1}^{R} Y_s \cdot T_{rs}^{1-\sigma} \cdot (P_s^H)^{(\mu-1)(\sigma-1)/\mu} \cdot w_r^{(\sigma-1)/\mu} \right)^{1/\sigma}$$

with $\kappa_3 = \frac{\sigma - 1}{\sigma} b^{(1-\sigma)/\sigma} \left(\frac{\mu}{(\sigma-1)F} \right)^{1/\sigma} \omega$.

Wage equation (2.15) is a function of income, housing rents and wages of the own and surrounding regions in due consideration of distance decay. In case of a lack of housing rents, the wage equation can be alternatively based on housing stock (Mion, 2004; Hanson, 2005).

3. Econometric issues

In NEG theory market potential plays a prominent role in determining wages. Market potential is here defined by the sum of market capacities $Y_s \cdot (P_s^M)^{\sigma-1}$ of all regions in due consideration of transport costs. Transport costs are assumed to be an increasing function of distance. For econometric estimation of the wage equation, we assume that the fraction $1/T_{rs}$ of one unit of a variety shipped in region r that arrives at region s is given by the exponential decay function:

$$(3.1)\quad 1/T_{rs} = e^{-\tau \cdot d_{rs}}.$$

With (3.1), regional wages are determined by the distance-weighted sum of market capacities of all regions. Taking the logarithms of both sides of (2.13) and adding a disturbance variable ε_1, the econometric model of the original wage equation reads

$$(3.2)\quad \log(w_r) = \kappa_2^* + \frac{1}{\sigma} \cdot \log\left(\sum_{s=1}^{R} Y_s \cdot e^{-\tau(\sigma-1)} \cdot (P_s^M)^{\sigma-1} \right) + \varepsilon_{1r}$$

with $\kappa_2^* = \log(\kappa_2)$. Econometric estimation of the wage equation in the form (3.2) presupposes knowledge of regional price indices of manufacturing goods. In this case we speak of the price index (PI) approach to explaining spatial wage disparities on the basis of NEG theory.

In case of lacking knowledge of P_s^M, the NEG wage equation can be estimated in a restricted form. Assuming equal price indices P_s^M in all regions, the econometric model (3.2) is simplified to

$$(3.3) \quad \log(w_r) = \kappa_2^* + \frac{1}{\sigma}\theta \cdot \log\left(\sum_{s=1}^{R} Y_s \cdot e^{-\tau(\sigma-1)}\right) + \varepsilon_{2r}$$

with θ as the (σ-1)*th* power of the uniform price index P^M and ε_2 as a new disturbance variable. This approach adopts the market potential concept by Harris (1954), who defines market potential of a region as the distance-weighted sum of purchasing power of all other locations. Based on NEG theory, additionally structural parameters can be estimated and interpreted. Equation (3.3) renders the simplified market potential (SMP) approach to estimation and testing of the wage equation.

Another approach to estimate the wage equation in absence of price indices of manufactures is to assume equal real wages in all regions. Provided that knowledge on regional housing rents is available, the estimation equation can be based on (2.15):

$$(3.4) \quad \log(w_r) = \kappa_3^* + \frac{1}{\sigma}\log\left(\sum_{s=1}^{R} Y_s \cdot T_{rs}^{1-\sigma} \cdot (P_s^H)^{(\mu-1)(\sigma-1)/\mu} \cdot w_r^{(\sigma-1)/\mu}\right) + \varepsilon_{3r}\,.$$

In the housing rent (HR) approach the parameter κ_3^* is the logarithm of the constants κ_3. The disturbance variable ε_{3r} captures the effects of all variables on regional wages that are not included in the NEG model.

We will estimate and test additionally two quantities which play an important role in NEG theory. The quantity σ/(σ-1) reflects of price mark-up due to monopolistic power. In case of σ/(σ-1) > 1 the differentiated product is produced under increasing returns to scale. The lower σ, the higher is the ratio σ/(σ-1) and therewith economies to scale. The restriction σ(1-μ) < 1 reflects the "no black hole condition". In this case transport costs play a role in determining the spatial equilibrium. Decreasing transport costs act towards dispersion. If this condition does not hold, changes in transport costs do not influence the spatial distribution of firms. Dispersion is then a stable equilibrium independently of transport costs.

Econometric estimation of the empirical models of the wage equation poses several problems. First, it has to be discussed to what extent the spatial distribution of wages is affected by factors outside NEG theory. In the literature, particularly the relevance of geographical characteristics (e.g. temperature, precipitation, seashore), composition of labour force and sectoral composition of regional economies is debated (see Brakmam et al., 2004; Kiso, 2005; Niebuhr, 2006; Rodriguez and Faina, 2007). When regional characteristics are sufficiently constant over time, they can be captured in form of a difference specification.[5] However, Roos (2001) and Niebuhr (2006) find a very poor fit of the differenced wage equation for West German and EU regions. Parameter estimates partly become insignificant and are often not consistent with theory. The adverse results cast doubt on the invariability of regional characteristics. Pires (2006) additionally points to the loss of information coming along with time differencing. Thus, like Brakman et al. (2004), de Bruyne (2003), Kiso (2005) and Mion (2004) we favour controlling for regional characteristics in the level approach.

Secondly, we have to choose the scale of the spatial units we use in econometric analysis. NEG theory leaves it an open question whether cores are, for instance, single cities or agglomerations consisting of several cities. In this context, Niebuhr (2006) brings the concept of the relevant market into effect. German states seem to be too large areas for analysing wage differentials as they are composed of overlapping labour markets. On the other hand, because of commuter flows, labour demand and supply is not adequately captured at the district level. Hence, we define spatial units used in this study functionally as travel-to-work regions. Using commuter flows across German districts, Eckey (2001) has identified 180 labour market regions from a regional system of 439 districts, some of which represent centres of production and others are rural areas (see section 5). The lower the spatial level, the more relevant local amenities may influence economic activity. At a larger scale spatial level, locational advantages and disadvantages tend to balance. Thus, with travel-to-work regions we in particular have to control for heterogeneity of work force.

Thirdly, the choice of the estimation method has to be debated. The NEG wage equation is fundamentally nonlinear. Although it can be linearised (Mion, 2004), nonlinear least-squares (NLS) estimation is preferred in empirical research (Brakman et al., 2004; De Bruyne, 2003; Hanson, 2005; Niebuhr, 2006; Roos, 2001). Ranges for reasonable starting values are suggested by previous studies. Since the estimated regression coefficients are locally but not globally optimal, it may be advisable to check optimality by using different starting values from the given ranges.

However, NLS estimates are expected to suffer from endogeneity of explanatory variables. The wage rate w_r is not an addend in econometric models with known or identical regional

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[5] Taking the difference between two years eliminates fixed effects. Thus, the difference specification controls for effects of all other variables that do not change substantially over time.

price indices but under the assumption of equal real wages across regions. In all specifications the endogeneity problem is present due to the fact that wages w_r and income Y_r are simultaneously determined. In order to account for a possible endogeneity bias, the method of nonlinear instrument variables (NIV) (Mion, 2004; Niebuhr, 2006) or the method of generalised moments (GMM) (Hanson, 2005; Kiso, 2005) could be applied. Both methods aim at eliminating the correlation of income and/or wages with the disturbance term. Instrument variables are in particular given by the temporal lags of income and wages. In case of known regional price indices, lagged values of this variable can be used as well. In our study we apply the NIV method by making use of all lagged explanatory variables as instruments. As a variable outside the model, lagged population is used as an additional instrument.

Fourthly, spatial dependence of the errors can generally give rise to biased estimates of the regression coefficients or their standard errors (cf. Anselin, 1998). Substantive spatial autocorrelation can be captured by the spatial lag model that involves a spatially lagged endogenous variable as an additional determinant in the regression equation. All explanatory variables suggested by the Helpman model are already included in the NEG wage equation by combining their values in the region under consideration with the distance-weighted values of the other regions. The latter values exactly define a spatial lag of the respective variable. Moreover, in the housing approach the spatial lag of wages as the dependent variable is directly included in the regression model. This indirectly also holds for the price index approach, as goods prices are determined by local wages up to a constant factor according to the mark-up pricing rule (2.4).

Thus, an additional introduction of spatially lagged wages has no sound theoretical basis. We therefore ascribe existing spatial error dependence to measurement errors and omitted variables. Although we already work with functional regions, they only approximate the scale of the underlying spatial process because commuter flows are minimised but not completely eliminated. As a result, spatial error autocorrelation may occur (Anselin, 1988). The errors of the wage equations as well lose their independence when spatially autocorrelated variables are omitted. Although we control for workers characteristics and sectoral composition, we cannot be sure that these variables capture all relevant regional characteristics exhaustively. Both sources of spatial dependence can be modelled by a spatial error process (Anselin, 1988).

The spatial error process adopted here is given by

$$(3.6) \quad \varepsilon_r = \lambda \cdot \sum_{s=1}^{R} w_{rs} \cdot \varepsilon_s + \nu_r$$

with the autoregressive parameter λ and distance-based weights w_{rs} (cf. Anselin and Bera, 1998). The innovations ν_r are assumed to be independently normally distributed random variables with zero expectation and constant variance. The standardised spatial weights w_{rs} are derived from distances d_{rs} between centres of regions r and s according to the gravity model of spatial interaction (cf. Sen and Smith, 1995; Porojan, 2001). The unstandardised weights are defined by

$$(3.7) \quad w^*_{rs} = \begin{cases} 1/d^2_{rs} \text{ for } d_{rs} \le d_c \\ 0 \text{ for } r = s \text{ or } d_{rs} > d_c \end{cases} .$$

d_c is a cut-off parameter intended to capture the scope of spatial interaction. In order to account for accessibility to other regions, we use car travel time instead of physical distance as a more adequate distance measure.[6] By using the standardised weights $w_{rs} = w^*_{rs}/\sum_s w^*_{rs}$, the autoregressive parameter λ is restricted to the interval -1 to 1. The spatial lag $\sum_s w_{rs} \cdot \varepsilon_s$ measures a weighted average of the errors in the d_c neighbourhood of region r.

4. Regional System and Data

For estimating different versions of the NEG wage equation, the spatial units used in the analysis have to be delimitated in an appropriate way. As NEG theory most notably aims at explaining wage differentials between agglomerated and peripheral regions, the tense between agglomeration and dispersion forces at work cannot adequately revealed in large areas like states. On the other hand, the boundaries of small areas like districts will usually not match the scale of local labour markets. In Germany, on average 53% of the employees bounded to the social security system are commuters who travel to their workplaces across administrative boundaries. Commuter flows are expected to affect the estimated structure of the wage equation by generating artificial spatial patterns.[7]

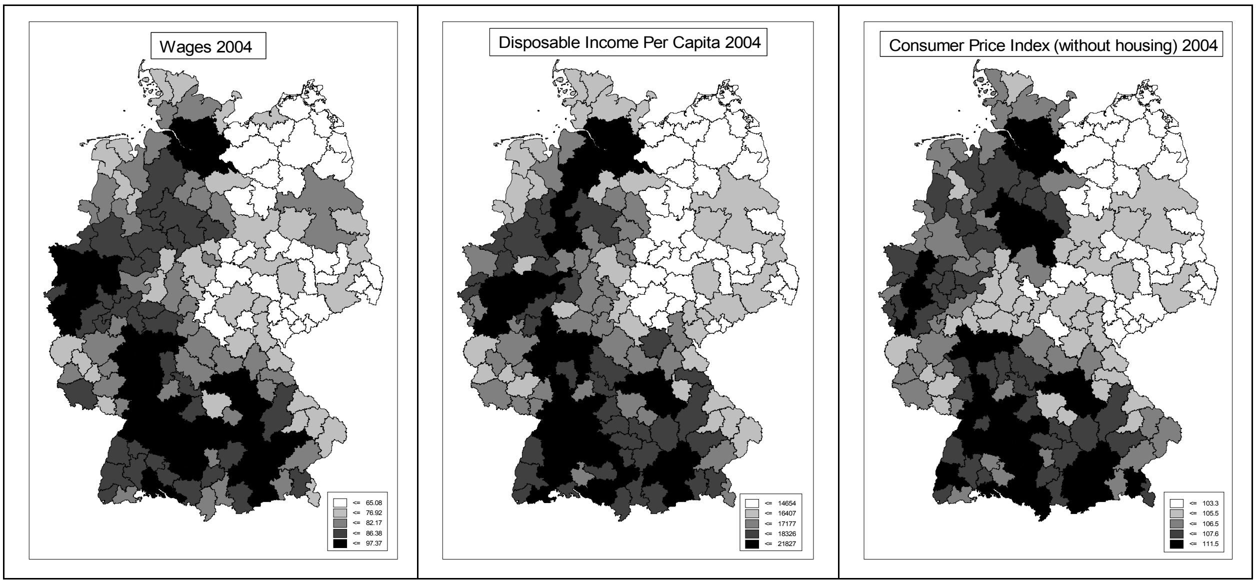
Spatial autocorrelation due to inadequate delineation of areal units is largely avoided by working with travel-to-work areas. We particularly refer to labour market regions that are

[6] Travel time between regional centres is calculated with the program Visum for traffic system modelling and rating.

[7] The effect of the selection of spatial units on analysis is in the statistical literature known as the modifiable areal unit problem (MAUP) (cf. Arbia, 1986; Unwin, 1996),

delineated by commuter flows. Using data on job commuters across German districts, Eckey (2001) defined 180 regional labour markets of which 133 are located in the western and 47 in the eastern part of Germany. With these functional regions the average share of commuters decreases to 21%. On average, a regional labour market consists of 2.4 districts.

Figure 1: Wage, Disposable Income and Consumer Price Index



Notes: The quintile maps portray the spatial distribution of nominal wages, disposable income per capita and the CPI without housing. Regions with low (high) values are bright (dark) shaded.

District data on wages are provided by the Institute for Employment Research (IAB). In particular we use daily average gross wages and salaries of full-time employees subject to the social security system. They include taxes and payroll deductions of the employees, but not social security contributions of the employers. Figure 1 shows that spatially coherent high-wage regions are located in South Germany: Rhine/Main, Stuttgart/Karlsruhe and Munich/ Nuremberg. The two other high-wage regions are the Rhine-Ruhr area and the Greater Hamburg area. With the exception of the Greater Berlin area, all East German labour markets are low-wage regions belonging to the first or second quintile class.

Market potential is measured by distance-weighted disposable income. Figure 1 reveals that, by and large, high-income regions match with high-wage regions. A coherent area around Bremen/Hanover is additionally identified as a high-income area. Thus, as NEG theory predicts, wages are especially high in areas with high economic activity. Moreover, the spatial distribution of income is well in accordance with that of the regional price level. We use the consumer price index without housing (CPI-H) as a proxy for the price index of differentiated goods. The index is estimated for all German districts in an econometric study of Kosfeld et al. (2008). Data on housing rents (HRI) at the district level are provided by the Federal Office for Building and Regional Planning (BBR). Net housing rents are surveyed by online search.

Regional data on labour market characteristics and sectoral composition is available for employees subject to the social security system from the regional database GENESIS of the Federal Statistical Office Germany Data. Labour market characteristics affecting the wage level may be the qualification and gender of workers and the share of part-time workers. Employees with a university degree or a degree at a technical college comprise the group of high-qualified workers. The variables are measured relative to labour force. The shares of workers in industry are used to control for the sectoral composition of labour force. Descriptive statistics of all variables used in this study are displayed in Table 4.1.

Table 4.1: Descriptive statistics of labour market variables

Variable	Mean	S.D.	Min	Max
Wage[a]	77.41	10.53	53.66	97.37
Disposable income[b]	7876	11010	1039	69182
Consumer price index (without housing)[c]	103.6	2.4	96.7	109.0
Housing rent index[d,c]	92.9	15.3	68.2	174.7
High-qualified workers[b]	0.072	0.028	0.031	0.175
Female workers[b]	0.457	0.035	0.367	0.541
Part-time workers[b]	0.158	0.022	0.103	0.221
Industry[b]	0.303	0.074	0.146	0.547

Notes: a Institute for Employment Research (IAB), b Regional database GENESIS, Federal Statistical Office Germany, Federal Statistical Office Germany, c Kosfeld et al. (2008), d Federal Office for Building and Regional Planning (BBR)

5. Testing for equality of regional price levels and real wages

Because of a lack of regional price indices, econometric estimation of the NEG wage equation is ordinarily not based on the price index (PI) approach. However, in a strict sense all other approaches are only applicable if certain conditions are met. While the simple market potential (SMP) approach assumes that the price index of manufactures is equal across all regions, the housing rent (HR) approach presupposes identical real wages. In empirical studies the validity of these assumptions is normally not tested.

We apply analysis of variance (ANOVA) in order to test for both assumptions. For this, the variances of the consumer price index without housing (CPI-H) and real wages are decomposed in between and within variations. We conduct two different one-way analyses of variance. First, we use the German states as a relevant factor. Because of well-known east-west and north-south gradients we expect that both variables vary much more substantial between than within German states. Secondly, regional price level and real wages may also differ between urban and rural regions due to different strength of centripetal and centrifugal forces. We test this hypothesis using an urban/rural factor in explaining the variances of both variables. A differentiation between these types of regions is made on the basis of population size and density. Regional labour markets with population density larger than 250 inhabitants per square kilometre and population size larger than 500,000 inhabitants are defined as urban regions.

Table 5.1 displays the ANOVA results for the consumer price index without housing. For the German states, already the between sum of squares is a multiple of the within sum of squares. As the F value of 37.712 exceeds the critical value at the 1% significant level of 2.150 noticeably, the null hypothesis of an equal CPI-H across German states is clearly rejected. Although the between sum of squares is lower than the within sum of squares, the ANOVA F value is as well highly significant with the urban/rural factor. The results of both one-way analyses of variance clearly reject the hypothesis of equal regional price levels.

Table 5.1: ANOVA tables for consumer price index (without housing)

Source of variation	Sum of squared deviations	Degrees of freedom	Mean squared deviations	F statistic[a]
		Factor: German states		
Between	844.905	15	56.327	37.712
Within	244.951	164	1.494	(2.150)
Total	1089.857	179	6.089	
		Factor: Urban/Rural regions		
Between	196.147	1	196.147	39.067
Within	893.709	178	5.021	(6.779)
Total	1089.857	179	6.089	

Note: a Critical F value for a significant level of 1% in parenthesis

The ANOVA results for real wages are reported in Table 5.2. In case of the state factor the ratio of between and within sum of squares amounts to 7.5. Compared with the consumer price index (without housing), the F statistic more than doubles. Using urban/rural regions as a factor, the test statistic drops markedly without questioning significance. Thus, regional wages differ as well highly significantly across space.

Table 5.2: ANOVA tables for real wages

Source of variation	Sum of squared deviations	Degrees of freedom	Mean squared deviations	F statistic[a]
		Factor: German states		
Between	9947.329	15	663.155	82.474
Within	1318.688	164	8.041	(2.150)
Total	11266.020	179	62.939	
		Factor: Urban/Rural regions		
Between	1340.140	1	1340.140	24.033
Within	9925.877	178	55.763	(6.779)
Total	11266.857	179	62.939	

Note: a Critical F value for a significant level of 1% in parenthesis

Tables 5.1 and 5.2 show that the rejection of the assumptions of equal regional price levels and real wages is not specific to the choice of the factor. In differentiating between urban and rural regions instead of German states, the significance is retained. This exhibits robustness of the ANOVA results against regional classification.

6. Estimation results

We estimate the wage equation (2.13) of the Helpman model under different assumptions regarding price level and wage equalisation using both the NLS and the NIV method. In the baseline regressions we do not control for worker characteristics and spatial dependencies. Subsequently, we analyse the effects of different controls for heterogeneity on estimation results. While we initially only control for East-West differences, we next take worker characteristics and sectoral composition into account. Our final regression models allow additionally for spatial error dependence.

Table 6.1 reports the results of the baseline estimation. First of all, it is established that the regression coefficient of market access (α coefficient) is significantly estimated in all cases. Thus, market access exerts a substantial influence on wages independently of how it is measured and which estimation method is applied. The effect is, however, considerably greater with the simple market potential (SMP) and price index (PI) approach than with the housing rent (HR) approach. As the α coefficient is the reciprocal value of the elasticity of substitution, high estimates for σ come along with the HR approach and low values with the MP and PI approaches. A larger deviation between the NLS and NIV estimates only occurs with the former approach. The null of unity is clearly rejected for σ in all cases. Thus, the inequality $\sigma/(\sigma-1)>1$ holds indicating increasing returns to scale and imperfect competition.

The estimate for σ by the simple market potential approach lies in the range reported by previous studies (Hanson, 2004; Mion, 2004; Brakman et al., 2004; Kiso, 2005; Niebuhr, 2006; Pires, 2006). As Brakman et al. (2004) do not give results for the MP approach without controls, our estimate for the elasticity of substitution of short 4.5 cannot be compared for Germany as a whole. While it appears to be low in relation to the implied estimate of 12.5 of Roos (2001) for West Germany,[8] it differs only slightly with the value of 5.6 reported by Niebuhr (2004) for the European Union. The values for σ of 5.1 inferred by the price index approach exceed the SMP estimate by 16 percent.

The estimates for σ obtained with the housing rent approach are extraordinarily high.[9] Although the assumption of equal real wages across space is clearly rejected, an additional explanation may be indicated. As we will discuss below, the estimates for σ with the other approaches tend to increase substantially when control variables are taken into account. In the housing rent approach, these characteristics are already captured by distant-weighted wages as an explanatory variable. In this case, labour market variables should not exhibit additional explanatory effects. The high values of the determination strongly support this interpretation.

While the NLS estimate for the expenditure share of manufactures, μ, does not satisfy the restriction $0<\mu<1$, the NIV estimate does. However, it is clearly overrated. The value for μ inferred by Roos (2001) for the West German economy of about 0.86 is a more feasible estimate in view of a share of housing of about 0.21 in the basket of commodities (Statistisches Bundesamt, 2003). Some overestimation of μ is also reported by Hanson (1998, 2005) for the United States and Mion (2004) for Italy. The HR estimates are clearly in favour to the no-black hole condition ($\sigma(1-\mu)<1$). According to this result trade costs play a role in determining the spatial equilibrium.

In all cases the estimate of the distance decay parameter τ is highly significant with the expected sign. However, the estimates differ in part considerably among the different

8 The additionally applied difference specification by Roos (2001) failed in producing meaningful results.
9 A comparable outcome can be observed with housing stock instead of housing rents as an exploratory variable.

approaches. The absolute value of the distance decay parameter is roughly twice as high with the simple market potential and price index approach as with the housing rent approach. Niebuhr (2004) reports an extremely low SMP estimate and also the implied estimate of about -0.0025 of Roos (2001) is considerably lower in absolute terms than our estimate of barely -0.009. Using housing stock as an explanatory variable the estimate of Roos (2001) takes a value of -0.003 for West Germany implying lower transport costs than suggested by our HR estimate of less than -0.004. As the estimates will change when controls are introduced for heterogeneous regional labour force, we leave the detailed interpretation of the distance decay parameter until the discussion of the final specifications. The preliminary role of the baseline estimation is as well stressed by highly significant spatial autocorrelation of the errors.

Table 6.1: Baseline estimation of NEG wage equation

	NLS			NIV		
	SMP appr.	HR appr.	PI appr.	SMP appr.	HR appr.	PI appr.
α	0.226** (0.016)	0.016** (0.003)	0.195** (0.015)	0.226** (0.016)	0.020** (0.003)	0.194** (0.015)
σ	4.416** (0.316)	61.911** (10.827)	5.129** (0.397)	4.426** (0.319)	51.209** (8.334)	5.147** (0.401)
τ	-0.0089** (0.0009)	-0.0047** (0.0002)	-0.0079** (0.0008)	-0.0088** (0.)	-0.0041** (0.0002)	-0.0079** (0.0008)
μ	-	1.051** (0.017)	-	-	0.998 (0.005)	-
$\sigma/(\sigma-1)$	1.293	1.016	1.242	1.292	1.020	1.241
$\sigma(1-\mu)$	-	-3.169	-	-	0.093	-
$\overline{R}^2$	0.571	0.967	0.653	0.568	0.958	0.645
SER	0.094	0.026	0.085	0.0940	0.029	0.085
BIC	-1.830	-4.367	-2.030	-1.822	-4.129	-2.018
MI	0.662** (14.342)	0.330** (7.486)	0.632** (13.899)	0.664** (14.390)	0.137** (3.335)	0.636** (13.364)

Notes: α Regression coefficient of market access, $\overline{R}^2$ Adjusted coefficient of determination, SER Standard error of regression, BIC Bayes information criterion, MI Moran's I (Standardised Moran's I)
Standard errors of parameter estimates in parentheses
(*) Significance at 10% level, * Significance at the 5% level, ** Significance at the 1% level
Significance test on σ: H_0: $\sigma \leq 1$, H_1: $\sigma > 1$, Significance test on μ: H_0: $\mu \geq 1$, H_1: $\mu < 1$

The estimates of the structural parameters already change substantially when we account for a west-east gradient in wages by including an East dummy variable (Table 6.2). As labour productivity in East Germany reached 2004 only 76 percent of West German standard, the wage gap is not expected to be solely explained by market access. Indeed, with the simple market potential and price index approach the east dummy (ED) turns out to be highly significant. While ED explains about 90 percent of the wage gap of about 25 percent with the former approach, it captures almost 80 percent with the latter one. The lack of significance of the east coefficient with the HR approach indicates that the explanatory variables – in particular distance-weighted wages – already capture the west-east gradient.

While especially the NIV estimate of the elasticity of substitution, σ, is virtually unchanged with the housing rent approach, the changes with the simple market potential and price index approach are conspicuous. The elasticity of substitution is rated twice to thrice as high as in the regressions without the east dummy variable. Noticeable differences between the NLS and NIV method only occur for HR approach

Table 6.2: NIV estimation of NEG wage equation with East dummy

	NLS			NIV		
	SMP appr.	HR appr.	PI appr.	SMP appr.	HR appr.	PI appr.
α	0.088** (0.010)	0.014** (0.003)	0.069** (0.008)	0.088** (0.010)	0.019** (0.003)	0.069** (0.008)
σ	11.385** (1.260)	70.515** (15.446)	14.583** (1.683)	11.426** (1.268)	51.728** (8.767)	14.475** (1.733)
τ	-0.0054** (0.0007)	-0.0045** (0.0003)	-0.0051** (0.0007)	-0.0054** (0.)	-0.0040** (0.0002)	-0.0050** (0.0006
μ	-	1.073** (0.021)	-	-	0.998 (0.005)	-
East	-0.221 (0.011	-0.010(*) (0.006)	-0.194** (0.010)	-0.221 (0.011	-0.007 (0.006)	-0.194 (0.010
σ/(σ-1)	1.096	1.014	1.074	1.096	1.019	1.074
σ(1-μ)	-	-5.137	-	-	0.023	-
$\overline{R}^2$	0.852	0.967	0.879	0.852	0.958	0.875
SER	0.055	0.026	0.050	0.055	0.029	0.051
BIC	-2.873	-4.356	-3.071	-2.871	-4.108	-3.039
MI	0.428** (9.544)	0.318** (7.308)	0.416** (9.377)	0.429** (9.550)	0.145** (3.356)	0.419** (9.212)

Notes: α Regression coefficient of market access, $\overline{R}^2$ Adjusted coefficient of determination, SER Standard error of regression, BIC Bayes information criterion, MI Moran's I (Standardised Moran's I)
Standard errors of parameter estimates in parentheses
(*) Significance at 10% level, * Significance at the 5% level, ** Significance at the 1% level
Significance test on σ: H_0: σ ≤ 1, H_1: σ > 1, Significance test on μ: H_0: μ ≥ 1, H_1: μ < 1

The inclusion of the dummy variable raises the coefficient of determination with the SMP and PI approaches markedly. However, differences of wages may still result from heterogeneous labour force within both parts of the economy. When omitted worker characteristics are spatially autocorrelated, spatial error dependence is expected. The highly significant Moran coefficients may be due to these omitted variables.

In order to adequately account for heterogeneous labour force across space, worker characteristics and sectoral composition should be explicitly taken into account (Table 6.3). Inasmuch labour market variables act differently in both parts of the German economy because of structural differences, they should enter the regression equation in form of interaction terms. In particular part-time employment plays a prominent role in East German labour markets, while the share of female workers is not negligible for explaining West German wages. Both variables have the expected negative sign. As expected, high qualified workers generally earn above-average wages. Different signs arise for the shares of industrial workers in both parts of the economy. While industrial workers in West Germany earn above-average wages, their remuneration is substandard in East Germany. This may be explained by the high proportion of female workers in East Germany industry exerting a downward pressure on wages. An additional inclusion of the share of female workers in East German regions has no further wage-reducing effect. Using the labour markets variables in this form supersedes an inclusion of the east-west dummy in the regression equations.

The structural parameters inferred by the housing rent approach are again close to those of the baseline estimation. Spatial variation of wages is captured to a large extent by the explanatory variables involved in the Helpman model. Most of the control variables are insignificant. Only the interactions FEM*WEST and IND*EAST affect wages substantially. The coefficients of determination are nearly unchanged with both estimation methods.

The changes observed with the simple market potential and price index approach are not negligible. The estimates for the elasticity of substitution, σ, increases once more. Although the bias of the SMA estimate for σ becomes obvious, it is considerably larger when σ is estimated on the basis of equal regional wages. The mark-up over marginal costs of 5 1/2 percent implied by the PI approach is considerable underrated by the HR approach.

Although Roos (2001) does not interpret the simple market potential approach as a special case of the Helpman model, his implied estimates for σ show a comparable tendency as ours. When allowing for heterogenous labour force, the value for σ increases from 12.5 to 20. From the study of Brakman et al. (2004) a value for σ of 20 is as well implied by the estimated regression coefficient of the market potential. In contrast, using the housing approach, the authors infer very low values for the elasticity of substitution between 3 and 5. Roos' (2001) estimate for σ is about 6.

An increase of the implied estimate for σ is as well observed in the study of Lopez-Rodriguez and Faina (2007). Using only one and two control variables the value for σ resulting from the estimated regression coefficient of market access in the Helpman model rises from 2.5 to 10. This effect is even stronger evidenced for the Krugman model by Niebuhr (2008). For the year 1985 her estimate of the elasticity of substitution increases from about 8 to 22 after controlling for regional characteristics. The 2000 estimates for σ of 110 without controls and 135 with controls are questionable because of the extremely low implied mark-ups. Applying the simple market potential approach, the estimate of σ increases from 6 to 12 (Niebuhr, 2006).

Brakman et al. (2004) estimate the NEG wage equation additionally without invoking real wage equalisation. This is, however, only possible if regional price indices of manufactures are available. Though at the time of their study no regional price indices for Germany were available, the authors claim to work with a "simplified price index". According to this approach, regional price levels are simply determined by distance-weighted average wages of all regions. Using these simplified indices the estimate for σ decreases substantially to a value of about 3.7 as against with the implied SMP estimate of 20. Although mark-up pricing in case of a single production factor is not in variance with this approach, it is disputable whether wages uniquely determine price level in real markets. Roos (2006) and Kosfeld et al. (2008) found that wage is only one price determinant among others like internal and external demand, size of population and population density. The extent of the bias resulting from a poor performance of the simplified price indices is difficult to assess. Recent empirical research of Hering and Poncet (2008) and Poncet (2008) inferred estimates for σ in a range between 15 and 25 for China by employing a two-step procedure for calculating market access before it is used as an explanatory variable in the wage equation (see Redding and Venables, 2004). Albeit using a different approach, these values are well in line with our SMP and PI estimates for σ.

Although spatial dependence is reduced to a large extent, significant spatial error autocorrelation is still present. The reduction of Moran's I is obtained by incorporating spatially autocorrelated controls into the regression models. Thus, the part of error autocorrelation that is due to these formerly omitted variables is eliminated. Remaining spatial error dependence is accounted for by a spatial error process in the last step.

Table 6.3: NIV estimation of NEG wage equation with control variables

	NLS			NIV		
	SMP appr.	HR appr.	PI appr.	SMP appr.	HR appr.	PI appr.
α	0.065** (0.010)	0.014** (0.004)	0.054** (0.009)	0.064* (0.010)	0.017** (0.004)	0.053** (0.009)
σ	15.416** (2.336)	69.227** (17.998)	18.488** (2.994)	15.472* (2.349)	58.343** (12.896)	18.904** (3.169)
τ	-0.0021** (0.0004)	-0.0045** (0.0003)	-0.0019** (0.0004)	-0.0021* (0.)	-0.0037** (0.0002)	-0.0019** (0.0004)
μ	-	1.078** (0.022)	-	-	0.998 (0.0005)	-
σ/(σ-1)	1.069	1.015	1.057	1.069	1.017	1.056
σ(1-μ)	-	-5.381	-	-	0.097	-
QUAL +	1.525** (0.168)	-0.116 (0.106)	1.420** (0.158)	1.524** (0.169)	0.103 (0.106)	1.439** (0.160)
PART* EAST	-1.119** (0.323)	-0.244 (0.191)	-1.053** (0.287)	-1.121** (0.323)	-0.248 (0.215)	-1.011** (0.290)
FEM* WEST	-0.223* (0.097)	-0.176** (0.058)	-0.261** (0.086)	-0.224* (0.097)	-0.192** (0.066)	-0.251** (0.088)
IND* WEST	0.256** (0.050)	-0.037 (0.031)	0.241** (0.045)	0.255** (0.050)	-0.001 (0.035)	0.249** (0.045)
IND* EAST	-0.527** (0.097)	-0.235** (0.058)	-0.523** (0.087)	-0.528** (0.097)	-0.235** (0.066)	-0.526** (0.088)
$\overline{R}^2$	0.918	0.970	0.935	0.918	0.961	0.933
SER	0.041	0.025	0.036	0.041	0.028	0.037
BIC	-3.373	-4.358	-3.599	-3.372	-4.095	-3.575
MI	0.254** (6.003)	0.284** (6.780)	0.184** (4.584)	0.253** (5.997)	0.153** (3.911)	0.191** (4.723)

Notes: α Regression coefficient of market access, $\overline{R}^2$ Adjusted coefficient of determination, SER Standard error of regression, BIC Bayes information criterion, MI Moran's I (Standardised Moran's I)
Standard errors of parameter estimates in parentheses
(*) Significance at 10% level, * Significance at the 5% level, ** Significance at the 1% level
Significance test on σ: H_0: σ ≤ 1, H_1: σ > 1, Significance test on μ: H_0: μ ≥ 1, H_1: μ < 1

The spatial error processes adopted in the final specifications make use of a distance-based weights matrix. As with the measure of market access we use travel time instead of physical distances in order to account for accessibility of surrounding regions. For establishing a reasonable cut-off value for travel time we analysed spatial error dependence between a region and its neighbouring regions of different order. We found positive and significant spatial autocorrelation up to a neighbourhood of second order. In order to capture spatial dependence, we therefore choose as a cut-off value the double average travel time of 75 minutes between immediate neighbours. Up to this distance the weights are formed according to the gravity model of spatial interaction and subsequently standardised. NLS estimation is no more considered in this part of analysis.

Table 6.4: Spatial error model of NEG wage equation with control variables

	Market pot. approach	Rent approach	Price index approach
β	0.065** (0.010)	0.016** (0.004)	0.061** (0.008)
σ	12.834** (1.504)	63.929** (14.963)	16.452** (2.299)
τ	-0.0024** (0.0004)	-0.0039** (0.0002)	-0.0021** (0.0003)
μ	-	0.9996** (0.005)	-
σ/(σ-1)	1.085	1.016	1.065
σ(1-μ)	-	0.025	-
QUAL+	1.370** (0.152)	0.187$^{(*)}$ (0.106)	1.301** (0.152)
PART*EAST	-1.322** (0.292)	-0.416$^{(*)}$ (0.213)	-1.189** (0.276)
FEM* WEST	-0.257** (0.087)	-0.234** (0.065)	-0.279** (0.083)
IND* WEST	0.202** (0.046)	0.004 (0.034)	0.208** (0.043)
IND* EAST	-0.443** (0.088)	-0.231** (0.064)	-0.462** (0.083)
λ	0.996** (0.152)	0.749** (0.214)	0.844** (0.174)
$\overline{R}^2$	0.934	0.964	0.941
SER	0.0366	0.0273	0.0347
BIC	-3.567	-4.133	-3.676
MI	-0.060 (-0.810)	-0.013 (0.282)	-0.006 (0.122)

Notes: α Regression coefficient of market access, $\overline{R}^2$ Adjusted coefficient of determination, SER Standard error of regression, BIC Bayes information criterion, MI Moran's I (Standardised Moran's I)
Standard errors of parameter estimates in parentheses
$^{(*)}$ Significance at 10% level, * Significance at the 5% level, ** Significance at the 1% level
Significance test on σ: H_0: σ ≤ 1, H_1: σ > 1, Significance test on μ: H_0: μ ≥ 1, H_1: μ < 1

As expected the estimates for the autoregressive parameter λ are all positive and significant. They all lie in the range between -1 and 1 necessary for a stable error process. The values of Moran's I no more point to spatial dependence in the relationships. However, because of nonlinear estimation, the outcome of the Moran tests should be checked against the residual map patterns.[10] Figure 6.1 shows a tendency to random patterns of the residuals with all employed approaches. This means that potential spatial effects from omitted variables or measurement errors are adequately captured by the spatial error process (3.6). The insignificance of the Moran coefficients is well in line with the random map patterns.

[10] The Moran test has only an approximative character here as it is originally developed for the OLS residuals (Cliff and Ord, 1981; Anselin, 1988).

Fig. 6.2: Map patterns of SEM residuals

Simple market potential appr.	Housing rent approach	Price index approach
Moran' I = -0.060	Moran's I = -0.013	Moran' I = -0.006

Notes: The quintile maps portray the spatial distribution of the residuals of the spatial error models (SEM residuals) for the three different approaches employed to estimate the NEG wage equation. Regions with low (high) values are bright (dark) shaded.

By comparing Tables 6.3 and 6.4 is it concluded that the elasticity of substitution is slightly overestimated without accounting for spatially autocorrelated errors. While the SMP estimate for σ decreases from 15 1/2 to 13, the PI estimate drops from 19 to 16 1/2. The estimate for σ with the housing rent approach diminishes by 5 1/2 units form 64 to 58 1/2, whereas that of μ remains virtually unchanged. The price mark-up over marginal costs of 8.5 percent implied by the simple market potential approach overrates that of the price index approach by 2 percentage points. The implied mark-up value by the price index approach of 6 1/2 percent is also lower than the estimates of about 9 percent found by Roos (2001) for West Germany as well as by Niebuhr (2006) for the European Union. The estimates of Brakman et al. (2004) ranging from 25 to 48 percent are noticeably higher. With the housing rent approach we adopt additionally, the estimate for the mark-up remains extremely low.

Although the distance decay parameter τ is highly significantly estimated with all approaches, some differences are salient. While the SMP and PI estimate for τ lie close together, the HR estimate is substantially lower. The underrating of τ comes along with a pronounced over-estimation of μ. In all it appears to be more difficult to identify the estimates for the parameters σ, τ and μ simultaneously than only for the first two ones. In particular the overrating of μ prevents valid inferences on σ and τ. In the following we therefore focus on interpreting the distance decay implied by the price index approach.

For a proper interpretation of the role of transport costs, the distance decay parameter τ has to combined with the elasticity of substitution σ. Using the estimated values from the price index approach, the spatial discount factor $\tau\cdot(\sigma-1)$ takes the value -0.0331. For an average speed of 80 km/h the half-life distance amounts to roughly 25 km. The half-life distance corresponding with Roos' estimates of about 35 km should be treated with caution, because of the insignificance of the estimated distance decay parameter.[11] While the distance decay estimates of Brakman et al. (2004) corresponds with extremely low half-life distances between 2 and 8 km,[12] Niebuhr (2006) derives a value of 260 km for the EU countries. There is strong evidence that the estimate of the distance decay parameter is not independent from the spatial units under analysis. Using large areas (Niebuhr, 2006; Pires, 2006) demand effects reported tend to decay more slowly than with small areas (Roos, 2001; Brakman et al., 2004; Hansen, 2005).

7. Conclusion

Despite large promotion of lagging regions by regional policy, persistent disparities of wages exist across space in Germany. Different approaches aim at explaining such wage differentials. We have examined the relevance of New Economic Geography (NEG) to account for regional variation in wages. In previous studies, substantive differences of the geographic extent of demand linkages are established. As it seems to depend on the regional scale of investigation, the modifiable unit problem calls attention. We address this problem by delineating regional labour markets as functional regions instead of analysing purely administrative defined regions.

With regard to the theoretical assumption of homogenous labour input in the manufacturing sector, we control for workforce characteristics and sectoral composition. As the disturbances are still significantly spatially autocorrelated, spatial error processes are introduced in the final regression models. In all specifications, economic geography turns out to be relevant in explaining the spatial structure of wages. In accordance with NEG theory, firms with good access to large markets are able to pay there workers higher wages because of savings in transport costs and increasing returns to scale. Although the effect of market access on wages declines when controlling for heterogenous labour, it still remains highly significant.

[11] See Roos (2001). Insignificant results also partly occur in Mion (2004) and Kiso (2005).
[12] Brakman et al. (2004) report also some estimates for τ with an opposite sign.

As both the assumptions of equal regional price levels and equal regional wages are strongly rejected for Germany, the price index approach is preferable in estimating and testing NEG models. With this approach, estimates of structural parameters of the Helpman model are meaningful interpretable. Large deviations of the implied structural parameters come along with the housing rent approach. The estimate of the size of the manufacturing sector is unrealistically high. Although the simple market potential approach turns out to be much more robust, the PI and SMP estimates for the elasticity of substitution and the price mark-up differ substantially from each other.

The price index approach implies demand linkages of reasonable reach. Neither the extremely slow decay of geographic linkages found by Niebuhr (2006) with EU NUTS 2 regions, nor the extremely rapid decay established by Brakman et al. (2004) with German districts are corroborated. Our findings of relative limited demand linkages for Germany as a whole are close to those of Roos (2001) for West German regions. However, while the housing stock approach fails to prove significance (Roos 2001), the distance decay parameter is highly significantly estimated with the price index approach.

The study shows that the estimated structural parameters of the Helpman model can be seriously biased when regional price disparities are ignored. Brakman et al. (2004) already obtain a clearer picture of the forces shaping the economic landscape by using a simplified price index of manufactures. As regional price indices are only provided as an exception by official statistics, econometric studies on regional price levels may be an option of coping with this problem. The price index approach seems to improve the knowledge on regional interactions substantially. The use of econometric estimated price levels proves to be advantageous for understanding the mechanism of Helpman-Krugman-type NEG models. It is expected to also enrich empirical analysis of NEG models with final and intermediate goods (Redding and Venables, 2004), where at the present stage estimates for price indices are obtained as coefficients of dummy variables in the trade equation.

References

Anselin, L. (1988), Spatial Econometrics: Methods and Models, Kluwer, Dordrecht.

Anselin, L., Bera, A.K. (1998), Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics, in: Ullah, A., Giles, D. (eds.), Handbook of Applied Economic Statistics, Dekker, New York, 237-289.

Arbia, G. (1986), The MAUP and the Spatial Autocorrelation Problem: Towards a Joint Approach, Metron 44, 391-407.

Brakman, S., Garretsen, H., Schramm, M. (2004), The Spatial Distribution of Wages: Estimating the Helpman-Hanson Model for Germany, Journal of Regional Science 44, 437-466.

Breinlich, H. (2006), The Spatial Income Structure in the European Union – What Role for Economic Geography?, Journal of Economic Geography 6, 593-617.

Cliff, A and Ord, J. (1981), Spatial Processes: Models & Applications, Pion, London.

De Bruyne, K. (2003), The Location of Economic Activity. Is there a Spatial Employment Structure in Belgium?, Discussion Paper, KULeuven.

Eckey, H.-F. (2001), Der wirtschaftliche Entwicklungsstand in den Regionen des Vereinigten Deutschlands, Economic Discussion Papers, No. 20/01, Institute of Economics, University of Kassel.

Eckey, H.-F., Kosfeld, R. (2005), Regionaler Wirkungsgrad und räumliche Ausstrahlungseffekte der Investitionsförderung, Jahrbuch für Regionalwissenschaft 25, 149-173.

Eckey, H.-F., Kosfeld, R., Muraro, N. (2005), Auswirkungen der Bevölkerungsentwicklung auf das wirtschaftliche Niveau der Regionen in Deutschland, Economic Discussion Papers, University of Kassel.

Fujita, M., Thisse, J.-F. (2002), Economics of Agglomeration, Cambridge University Press, Cambridge, UK.

Hanson, G.H. (2005), Market Potential, Increasing Returns, and Geographic Concentration, Journal of International Economics 67, 1-24.

Harris, C.D. (1954), The Market as a Factor in the Localization of Industry in the United States, Annals of the Association of American Geographers 44, 315-348.

Helpman, E. (1998), The Size of Regions, in: Pines, D., Sadka, E., Zilcha, I. (eds.), Topics in Public Economics, Cambridge University Press, Cambridge, 33-54.

Hering, L., Poncet, S. (2007), Economic Geography, Spatial Dependence and Income Equality in China, CEPII Working Paper 2007-22.

Hering, L., Poncet, S. (2008), Market Access Impact on Individual Wages: Evidence from China, forthcoming: Review of Economics and Statistics.

Kiso, T. (2005), Does New Economic Geography Explain the Spatial Distribution of Wages in Japan?, Discussion Paper, Graduate School of Economics, University of Tokyo.

Kosfeld, R., Eckey, H.-F., Lauridsen, J. (2008), Disparities in Prices and Income across German NUTS 3 Regions, Applied Economics Quarterly 54, 123-141.

Krugman, P. (1991), Increasing Returns and Economic Geography, Journal of Political Economy 99, 483-499.

Lopez-Rodriguez, J., Faina, A. (2007), Regional Wage Disparities in Europe: What Role for Market Access?, Investigaciones Regionales 11, 5-23.

Mion, G. (2004), Spatial Externalities and Empirical Analysis: The Case of Italy, Journal of Urban Economics 56, 97-118.

Niebuhr, A. (2006), Market Access and Regional Disparities. New Economic Geography in Europe, Annals of Regional Science 40, 313-334.

Pires, A.J.G. (2006), Estimating Krugman's Economic Geography Model for the. Spanish Regions, Spanish Economic Review 8, 83-112.

Poncet, S. (2008), Impact of Economic Geography on Wages: Disentangling Channels of Influence, Working Paper, CEPII, Paris.

Porojan, A. (2001), Trade Flows and Spatial Effects: The Gravity Model Revisited, Open Economies Review 12, 265-280.

Redding, S., Venables, A.J. (2004), Economic Geography and International Equality, Journal of International Economics 62, 53-82.

Roos, M. (2001), Wages and Market Potential in Germany, Jahrbuch für Regionalwissenschaft 21, 171-195.

Roos, M. (2006), Regional Price Levels in Germany, Applied Economics 38, 1553-1566.

Sen, A., Smith, T.E. (1995), Gravity Models of Spatial Interaction Behaviour, Springer, New York.

Statistisches Bundesamt (ed.) (2003), Verbraucherpreisindex auf Basis 2000, Wiesbaden.

Südekum, J. (2007), Regional Costs-of-Living with Congestion and Amenity Differences - An Economic Geography Perspective, forthcoming: Annals of Regional Science.

Unwin, D.J. (1996), GIS, spatial analysis and spatial statistics, Progress in Human Geography 20, 540-551.