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ABSTRACT

Regional Wage and Employment Responses to Market Potential in the EU*

Recent theoretical work on economic geography emphasizes the interplay of transport costs and plant-level increasing returns. In these models, the spatial distribution of demand is a key determinant of economic outcomes. In one strand, it is argued that higher demand gives rise to a more than proportionate increase in production, a result known as the home market effect. Another strand emphasizes the effects of market sizes on factor prices. In this paper we highlight the theoretical connection between these two strands. We use data on 57 European regions to show how wages and employment respond to differentials in what we call real market potential, a discounted sum of demands derived from the theory.

JEL Classification: F12, F15, R11 and R12
Keywords: gravity equation, home market effects, new economic geography and wage equation

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1 Introduction

The academic attempt to describe, explain, and predict the spatial distribution of economic activity has come to be called, among other things, economic geography. Perhaps the best inspiration for this field comes from satellite pictures of the earth at night. Instead of the blues, greens, and browns of daytime photos, we see only the light generated by human activity. These lights appear to be highly concentrated, leading to the central question of economic geography: What forces cause agglomeration (here defined as the spatial concentration of mobile resources)? Until the 1990s, the field took an eclectic approach, content to allow for a variety of mechanisms. Models incorporated this eclecticism by specifying the agglomeration effect as a multiplicative factor in the production function depending on some measure of the amount of local activity.

The publication of Krugman (1991) marked a turning point for the economic geography literature. For the next decade, theorists concentrated with near exclusivity on models that moved agglomerative forces out of the production function and into the interaction between transport costs and plant-level scale economies. After the accumulation of a decade of theory, economists have begun to subject Krugman's approach—called New Economic Geography (NEG)—to empirical scrutiny. While it is too early to be sure, we consider the seminal contributions to the empirical literature to be Davis and Weinstein (1999,2003), Hanson (2005), and Redding and Venables (2004). These papers statistically link the spatial distribution of production and wages to the spatial distribution of demand.

This paper estimates the influence of a something we call *real market potential* (RMP) on wages and employment. We follow the Redding and Venables (2004) method of constructing this measure as a weighted sum of importer fixed effects estimated in a bilateral trade equation. The structural interpretation of the fixed effects allows for a close connection between theory and empirics. We extend their approach in two respects. First, while they related *per capita* incomes to a cross-section of nation-level market potentials, we incorporate industry, time and intra-national variation. The underlying theory relates to firm-level iso-profit functions, suggesting the importance of greater disaggregation in testing. Second, we consider two dimensions of adjustment to geographic variation in demand: *prices and quantities*. We investigate whether high demand leads to higher wages, higher employment, or both. These price and quantity aspects are interdependent in theory: the presence of a strong wage response to demand should dampen the production response. We argue that this combined treatment of price and quantity effects sheds light on the difficulty past studies have had in finding "home market effects"—more than proportionate production responses to demand variation.

The paper proceeds as follows. First, we use in Section 2 an augmented version the standard model of new economic geography to highlight, in Section 3, the common origins of the "home market effect" and "wage equation" econometric specifications. We show that these approaches can be seen as polar cases of a more general model that does not lend itself easily to estimation. Instead, we suggest two simple empirical strategies for integrating the analysis of wage and employment responses to market potential. Section 5 then proceeds to implement these strategies using a data set on an industry-level wages, employment, and bilateral trade spanning the period 1985–2000, and detailed in Section 4. The data, except for bilateral trade, are available at the regional level, allowing us to examine intra-national wage and employment responses. Section 6 concludes and offers insights for further investigation along this path.

2 Real Market Potential and Profit

In this section we show how the spatial distribution of demand affects the prospective profits of different production locations in the Dixit-Stiglitz-Krugman (DSK) model of monopolistic competition and trade. Let E_i denote total expenditure of region i on the representative industry.[1] In the standard model, E_i is given by multiplying total income by the expenditure-share parameter from an upper-level Cobb-Douglas utility function.[2] Thus, the E_i do not depend directly on goods prices but they would be influenced by wages and by migration.

The E_i constitute the total *local* demand available for *all* firms capable of serving market i. The demand relevant to a particular firm producing in region i differs from E_i for two reasons. First, that firm can export to other regions $j \neq i$ and thereby tap into their local demands. Second, that firm must divide each of the local markets with its competitors. The share of each market the firm obtains depends on its production and trade costs relative to its rivals. We now show how to formalize this measure of the size of the market using the standard DSK assumptions in a multi-region setting.

The DSK model assumes that within each industry, single-plant firms compete by offering a single-variety to consumers at delivered prices, p_{ij}, given as the product of a mill price p_i and the *ad valorem* trade cost, τ_{ij}. Trade costs include

[1] The empirics involve 13 manufacturing industries and 15 years. We estimate industry-year specific parameters. All variables except human capital have industry-year variation. We suppress industry and year subscripts to avoid subscript clutter.
[2] In our industry-level data, E comprises both final and intermediate consumption. The underlying theory involves downstream firms with production functions that are CES in intermediate inputs.

all transaction costs associated with moving goods across space and national borders. Assume further that all varieties substitute symmetrically for each other with a constant elasticity of substitution (CES), σ, and that firms from the same region charge the same mill price. These assumptions imply market shares in region j for a representative firm from i as

$$z_{ij} = \frac{p_i^{1-\sigma}\tau_{ij}^{1-\sigma}}{\sum_k n_k p_k^{1-\sigma}\tau_{kj}^{1-\sigma}}. \tag{1}$$

The denominator in (3) plays a key role in the empirical analysis of this paper. Redding and Venables (2004) describe it as the "sum of supply capacities, weighted by transport costs." They call it "supplier access" and abbreviate it as SA_j. We will call it the supply index and denote it

$$S_j = \sum_k n_k p_k^{1-\sigma}\tau_{kj}^{1-\sigma}. \tag{2}$$

A location that is served by a large number of nearby and low-price sources will have a high supply index, S_j, and will therefore be a market where it is difficult to obtain a high market share.

From (1), it is apparent that trade costs influence demand more when the elasticity of substitution is high. Indeed many results in the DSK framework depend on the term $\phi_{ij} \equiv \tau_{ij}^{1-\sigma}$, called the "phi-ness" of trade by Baldwin et al. (2003). It ranges from 0, where τ_{ij} and σ are high enough to eliminate all trade, to 1, where trade costs are negligible.

Total export sales for a firm from i to j are given by $x_{ij} = z_j E_j$. Substituting in (1) and utilizing the ϕ_{ij} and S_j notation we obtain

$$x_{ij} = p_i^{1-\sigma}\phi_{ij}E_j/S_j. \tag{3}$$

How profitable will those exports be? The DSK model assumes constant marginal costs, m_i, and a fixed cost per plant, f_i. Each firm maximizes gross profits in each market leading to a single mill price for each origin i that is a simple mark-up over marginal costs:

$$p_i = \frac{m_i\sigma}{\sigma - 1}.$$

The gross profit earned in each market j for a variety produced in region i is given by $\pi_{ij} = x_{ij}/\sigma$. Summing the profits earned in each market and subtracting the plant-specific fixed cost, f_i, we obtain the net profit to be earned in each potential location i:

$$\Pi_i = \sum_j x_{ij}/\sigma - f_i = \frac{1}{\sigma}m_i^{1-\sigma}\mathrm{RMP}_i - f_i, \tag{4}$$

where $\text{RMP}_i = \sum_j \phi_{ij} E_j / S_j$. RMP is an abbreviation of Real Market Potential. Redding and Venables (2004) derive the same term (except they do not use ϕ_{ij} notation) and call it "market access." We use the term "market potential" to reflect the similarity of RMP to the Harris (1954) original specification: $\sum_j E_j / D_{ij}$. Harris' market potential implicitly treats S_j as constant and approximates ϕ_{ij} with $1/D_{ij}$. We use the term "real" to underline the importance of discounting expenditures by the supply index, S_j. "Nominal" Market Potential (NMP) would be given by $\sum_j \phi_{ij} E_j$. NMP can be thought of as a pure measure of the size of the available market. RMP incorporates the notion that a large market that is extremely well-served by existing firms might offer considerably less potential for profits than a smaller market with fewer competitors in the vicinity.

In a spatial equilibrium where firms earn the same profit, we can normalize that profit level to zero and solve for an iso-profit equation relating production costs to market potential:

$$m_i^{\sigma-1} f_i \sigma = \text{RMP}_i \tag{5}$$

We intend to estimate the ways that wages and employment respond to demand. Hence we need to model the production side of the economy to incorporate labor. We follow the standard Krugman (1980) assumptions that labor is the only factor and there is both a fixed and variable component to firm-level labor requirements. Our innovation is to take into account human capital using a specification based on the Mincer equation in labor economics. In particular, labor requirement per firm, ℓ, depends on both output per firm, q, and average years of schooling, h as follows:

$$\ell_i = (\alpha + \beta q_i) \exp(-\rho h_i), \tag{6}$$

where α and β measure fixed and variable labor requirements in "effective" (education-adjusted) labor units. These assumptions imply fixed costs of $f_i = \alpha \exp(-\rho h_i) w_i$ and marginal costs of $m_i = \beta \exp(-\rho h_i) w_i$. Making these substitutions, the left-hand-side of (5) is given by $\beta^{\sigma-1} \alpha \sigma (\exp(-\rho h_i) w_i)^\sigma$. Solving for the wage, we obtain

$$w_i = \left(\frac{\text{RMP}_i}{\beta^{\sigma-1} \alpha \sigma} \right)^{1/\sigma} \exp(\rho h_i), \tag{7}$$

which, except for notation and the inclusion of human capital, is the same as (4.27) in Fujita et al. (1999).

Our production function assumptions imply a revised version of the S term used in RMP. Namely, the supply index should be re-expressed in terms of industry employment instead of the number of varieties. The model assumes all plants in the same location employ the same number of workers, ℓ_i. Output

per firm does not vary across locations in this model and is given by $q = (\alpha/\beta)(\sigma - 1)$. Hence industry employment, denoted L_i, is given by

$$L_i = n_i \exp(\rho h_i)(\alpha + \beta q_i) = \alpha\sigma \exp(-\rho h_i) n_i. \tag{8}$$

In contrast with the standard DSK model, employment is not strictly proportional to the number of firms. Human capital abundant areas have lower employment per firm. We obtain the new supply index by inverting (8) and substituting out n_i in (2), yielding

$$S_i = \kappa \sum_j L_j \exp(\sigma\rho h_j) w_j^{1-\sigma} \phi_{ij}, \tag{9}$$

where κ is a composite parameter given by $\beta^{1-\sigma}(\sigma - 1)^{\sigma-1}/(\sigma^\sigma \alpha)$. This equation tells us that the supply index, the term that discounts expenditures in the RMP summation, is increasing in the amount of education-adjusted employment that has good access (high ϕ_{ij}) to the market in question. Note that σ acts as amplifier: when it is large, human capital, wages, and transport costs have stronger impacts.

3 Two paths towards spatial equilibrium

A spatial equilibrium requires that all firms lie on the same iso-profit locus. If the economy of region i were off equation (5), then firms would have an incentive to choose different locations. If we take expenditure as exogenous (i.e., if we believe the upper-level Cobb-Douglas assumption is a good approximation and that industry wages and employment are small relative to national income), then the two endogenous variables at the industry level are wages and employment. Equilibrium can be attained through a change in wages or an opposite change in employment (an increase in L_i reduces RMP_i by increasing S_i).

Two important strands in the empirical literature examine polar cases of the equilibration mechanism. We now review these two approaches, and suggest how to bring them together in theory and empirics.

The first approach assumes factor price equalization. This fixes wages and leaves employment adjustment as the only mechanism for equalizing profits. In our version of the model, one assumes equalization of human-capital adjusted wages, that is $w_i \exp(-\rho h_i) = w_j \exp(-\rho h_j)$. With costs equalized, equal profits require equal real market potential: $\text{RMP}_i = \text{RMP}_j$. With two countries, RMP equalization leads to the piecewise linear share equation first identified by Helpman and Krugman (1985). Using λ_i to denote the share of output manufactured in region i and θ_i to denote region i's share of expenditures, we

have

$$\lambda_i = 1/2 + M(\theta_i - 1/2), \tag{10}$$

whenever $(1-1/M)/2 \leq \theta_i \leq (1+1/M)/2$. In the Helpman-Krugman version λ corresponds to the shares of the number of firms, production, and employment. In our human capital augmented version, λ_i can be expressed as a share of education-adjusted employment:

$$\lambda_i = L_i \exp(\rho_i h_i)/(L_i \exp(\rho_i h_i) + L_j \exp(\rho_j h_j))$$

The slope of the share equation, M, is greater than one and depends solely on the "phi-ness" of trade:

$$M = d\lambda^*/d\theta = (1+\phi)/(1-\phi) > 1.$$

A decrease in transport costs, which raises ϕ, increases the responsiveness of employment to home demand.

Researchers have tried to estimate M and test for whether it indeed exceeds one, as predicted in the DSK model. Davis and Weinstein (1999, 2003) introduced this empirical strategy and implement it with data on Japanese regions and OECD countries. Head and Ries (2001) use US-Canada panel data and also test whether trade liberalization increased M as predicted. Both studies find mixed results (Head and Mayer, 2004a, review in detail the findings of these and related papers).

The theory underlying estimation of M relies upon very restrictive assumptions. Some of these assumptions—constant elasticity demand, monopolistic competition, and iceberg transport costs—are not critical. The core prediction of a linear share equation remains valid under alternative frameworks (see Head, Mayer, and Ries, 2002). Other assumptions matter a great deal. Behrens, Lamorgese, Ottaviano, and Tabuchi (2004) show that testing for increasing returns using $M > 1$ as the criterion is only appropriate in a two-country world. They suggest alternative methods for multi-country implementations of the theory. These methods involve the assumption of RMP equalization, an assumption we will test directly in the beginning of our empirical section.

The other crucial assumption behind the test for $M > 1$ is factor price equalization.[3] The linear share equation derived by Helpman and Krugman (1985) requires an infinitely elastic supply of labor the increasing returns sector. To see this, consider the alternative case where the labour supply elasticity is

[3] Helpman and Krugman obtain factor price equalization by assuming that another sector with zero transport costs ties down the wage in both countries. See Davis (1998) and also Holmes and Stevens (2004).

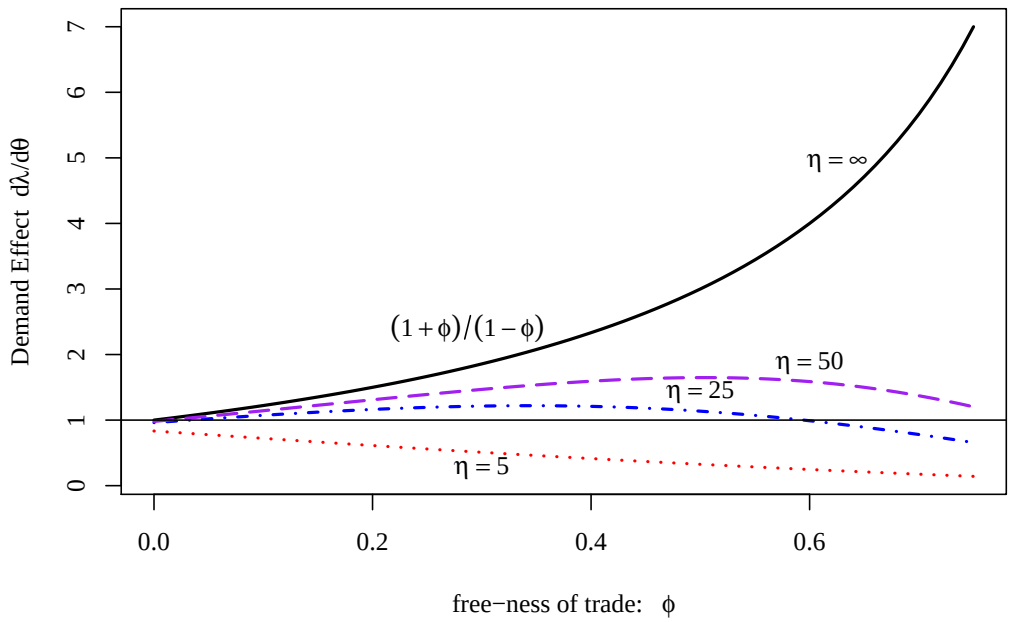

Fig. 1. Home market effects with imperfectly elastic labor supply.

given by

$$\eta \equiv \frac{dL/L}{dw/w} < \infty.$$

To analyze this case one must follow Fujita et al. (1999) and linearize the model to examine deviations around the symmetric equilibrium ($\lambda = \theta = 1/2$). We re-express Fujita et al.'s (1999) equation (4.42) using our notation as

$$\left[\sigma\frac{1+\phi}{1-\phi} + (1-\sigma)\frac{1-\phi}{1+\phi}\right]\frac{dw}{w} + \left[\frac{1+\phi}{1-\phi}\right]\frac{dL}{L} = \frac{dE}{E}. \tag{11}$$

Around symmetry, $d\lambda/d\theta = \frac{dL/L}{dE/E}$. Thus we can combine all these substitutions and re-express equation (11) as

$$d\lambda/d\theta = M/(1 + (1 + (M^2 - 1)\sigma)/\eta). \tag{12}$$

As $\eta \to \infty$ we obtain $d\lambda^*/d\theta = M > 1$. However, smaller elasticities of labour supply lead to bigger wages in the large market and this dampens or even destroys the result that $d\lambda^*/d\theta > 1$.

We illustrate in Figure 1, where $d\lambda^*/d\theta$ is graphed against ϕ for different values of the labor supply elasticity. The figure shows that wage responses can undo the more than proportional response of production to demand. For the lowest elasticity of labor supply ($\eta = 5$) that we depict, $d\lambda^*/d\theta < 1$ for all

levels of ϕ. Higher elasticities can generate $d\lambda^*/d\theta > 1$ but only for low trade free-ness. As trade becomes very free, the slope falls below one. With $\eta = 50$, $d\lambda^*/d\theta > 1$ for the range of ϕ depicted but it is not monotonic. Only as η becomes very large, and hence the labor supply curve becomes essentially flat, do the Helpman-Krugman results reassert themselves.

While this approach, integrating both employment and wage response to demand variation, offers some insights, it is too restrictive to use as the basis for empirical work. Instead we need methods that can accommodate multiple countries and large size asymmetries. Redding and Venables (2004) provide such an approach. This second polar path loads all the response to demand differences into wages. As Redding and Venables put it, "Here we take E_i and n_i as exogenous and simply ask, given the locations of expenditure *and of production*, what wages can manufacturing firms in each location afford to pay?" (emphasis added). In terms of equation (7), RMP is considered exogenous and wages fully adjust to equate profits across locations. In this paper we also estimate the wage equation as a first step. Then, we study the extent to which deviations from this iso-profit locus lead to wages and employment responses (the two paths of adjustment).

The initial wage-RMP relationship can be estimated by taking logs of equation (7), which gives a linear-in-logs equation:

$$\ln w_i = a + b \ln \mathrm{RMP}_i + \rho h_i + \epsilon_i, \tag{13}$$

where $a = -(1/\sigma)\ln(\beta^{\sigma-1}\alpha\sigma)$ and $b = 1/\sigma$. This equation can be estimated in number of different ways that we will consider in the following section. Here it is important to consider the interpretation of the error term, ϵ_i. That is, why are some regions off the iso-profit equation?

We consider two interpretations of ϵ_i. The first is that regions only *appear* to be off the iso-profit because ϵ_i captures omitted variables that raise wages without causing deviations from the locus. One case would be determinants of costs that are observed by firms and incorporated into wages but not observed by the econometrician. A second case is where RMP_i is mis-measured. The second interpretation is that the ϵ_i represent temporary deviations from equal profits. Positive residuals correspond to regions with wages that are unjustifiably high given market potential. Regions with negative residuals are "bargains" from the firms' perspectives. Such deviations might arise from recent shocks to the labor market or demand to which firms have not yet had time to respond. Alternatively, they might correspond to expectational errors. That is, a positive ϵ_i would occur when firms chose region i expecting labor costs to be lower or market potential to be higher.

We can discriminate between these interpretations using the following regression. Using the negative of the residual so that it will be increasing in the

attractiveness of region i,

$$-\hat{\epsilon}_i = \hat{a} + \hat{b} \ln \mathrm{RMP}_i + \hat{\rho} h_i - \ln w_i. \tag{14}$$

We then regress subsequent changes in w_i and L_i on initial levels of $-\hat{\epsilon}$. Using time subscripts we can express these equations as

$$\begin{aligned} \ln w_{i,t+\Delta} - \ln w_{it} &= -\gamma_w \hat{\epsilon}_{it}, \\ \ln L_{i,t+\Delta} - \ln L_{it} &= -\gamma_L \hat{\epsilon}_{it}, \end{aligned} \tag{15}$$

where γ_w and γ_L are the adjustment parameters for wages and employment. If ϵ_i represent measurement errors or omitted variables in the determinants of wages, then there is no reason for either wages or employment to adjust to them. Suppose for instance, that the variable h_i is omitted from equation 13. Estimated deviations from the regression prediction would in this case *not* imply deviations from the iso-profit curve for firms, which observe and take into account the different levels of h in each region. Firms are still on the iso-profit locus despite the omission of h_i in the regression; they have no reason to react to ϵ_i, and we would therefore expect in this case $\hat{\gamma}_w = \hat{\gamma}_L = 0$. However, if the shock or expectational error interpretations are correct, estimated deviations are indeed deviations from the iso-profit curve, and we expect $\hat{\gamma}_w > 0$ and $\hat{\gamma}_L > 0$. The upper bound on $\hat{\gamma}_w$ should be one (wages rise enough to fully eliminate the residual). We now turn to a description of the data used to estimate those relationships.

4 Data

The core empirical part of this paper explains the variance of industry-level wages and employment of European regions with the real market potential of those regions. We first describe the data sources of explained variables and then how explanatory ones are constructed.

4.1 Dependent variables

The set of regions under investigation incorporate 57 official Eurostat regions using the NUTS 1 level of detail for Germany (11 regions), France (8 regions), Italy (11 regions), the UK (11 regions), Spain (6 regions), the Netherlands (4 regions), and Belgium (4 regions). Ireland and Portugal are considered as single-region countries. NUTS 1 regions usually do not correspond to administrative areas in the different countries, but are instead groupings based on

a population range objective.[4] The advantage of using this level of geographical aggregation is that the availability of industry-level data is much better across regions and time. For Ireland and Portugal, the problem is simplified as national level data can be used.

There are two main sources of data for the industry-region data. The primary source is the regional domain of industry-level statistics (called SBS) in Eurostat CRONOS database. Data is available in this source in the NACE rev1 classification for the years 1985 to 2001. There are 13 industries in our dataset for which the real market potential calculation for all regions can be easily made. Regional data are difficult to collect in a consistent way in different countries. The problems are exacerbated when working with industry detail, due in particular to confidentiality issues. Those difficulties result in a well known missing data problem for this type of dataset, emphasized in Combes and Overman (2004). Data are mostly non-missing starting in 1993, when the new NACE rev1 classification was adopted. Early years however, present lots of missing data, which explains our use of the second source of data: the Eurostat publication *Structure and activity of industry annual inquiry, principal results, regional data*. It consists of 2-digit data in the old NACE classification (called NACE70, which has an easy correspondence at the two-digit level with NACE rev1), available for the same regions (in an older NUTS classification, but fairly easy to match with the new one). An electronic version of the old industry-region data comprises data for the years 1989 to 1992 but in fact 1992 has mostly missing values. We additionally used the printed version for the years 1985 and 1987. Our rule is to use the new data from SBS whenever it is available.

The wage variable w_i uses the ratio of the wage bill over the number of employees L_i in the NACE 2-digit industry-region. There are some concerns about comparability across countries. For instance, some countries report data for firms over 20 employees and some for the exhaustive set of firms (and some countries change to report exhaustive data at some point). Also, there are important variations in hours worked and the level of social charges across European countries that affect the production costs of firms located there but are not taken into account in w_i. For this reason, we always run industry-year regressions including country-level fixed effects, in order to capture those and other nation-specific differences, in particular those related to labor market institutions and taxes.

[4] The NUTS regulation states that the average size of NUTS 1 regions in a country should host between 3 and 7 million people.

4.2 Independent variables

Our principal explanatory variable is RMP_i, the real market potential of each region i. Its calculation, described briefly below, follows Head and Mayer (2004b), and the reader is referred to that paper for more detail.

The market potential of region i is expressed as $\mathrm{RMP}_i \equiv \sum_j \phi_{ij}(E_j/S_j)$, where ϕ_{ij} represents the ease of access of producers in i to consumers in region j and E_j is the expenditure of region j is discounted by the degree of competition for that market (S_j). RMP could be estimated in a single-step wage equation as in Hanson (2005), Brakman et al. (2004), and Mion (2004).[5] We follow a different strategy, pioneered by Redding and Venables (2004), that exploits the information from bilateral trade equations. The total value of exports from all n_i firms based in region i will be denoted $X_{ij} = n_i x_{ij}$. From the firm-level demand equation (3), we see that the log of bilateral export values is given by

$$\ln X_{ij} = \ln n_i - (\sigma - 1)\ln p_i + \ln \phi_{ij} + \ln E_j - \ln S_j. \tag{16}$$

Redding and Venables (2004) suggested that one could recover the unobserved country-specific variables using exporter and importer fixed effects. To see this, abbreviate the first two i-specific terms with $\mathrm{FX}_i = \ln n_i - (\sigma - 1)\ln p_i$ and the last two j-specific terms with $\mathrm{FM}_j = \ln E_j - lnS_j$.

The E/S component of real market potential can be estimated as the fixed effect on importer j, FM, in a bilateral trade equation. Unfortunately, bilateral trade data does not exist between the regions in our sample. Therefore we have to rely on bilateral trade data between nations to obtain the estimates used in the calculation of market potential.[6] Let I and J denote two European *countries* in our sample. The estimated equation explains exports from I to J, X_{IJ}, with importers and exporters fixed effects (FX_I and FM_J), and components of trade freeness, such that $\ln \phi_{IJ} \equiv -\delta \ln d_{IJ} - (\xi_J - \Lambda \mathrm{LANG}_{IJ})B_{IJ} + \zeta_{IJ}$ is a function of bilateral distance, the crossing of a national border (B_{IJ})[7] and sharing a common language ($\mathrm{LANG}_{IJ} \cdot B_{IJ}$):

$$\ln X_{IJ} = \mathrm{FX}_I + \mathrm{FM}_J - \delta \ln d_{IJ} - \xi_J B_{IJ} + \Lambda \mathrm{LANG}_{IJ} \cdot B_{IJ} + \zeta_{IJ}. \tag{17}$$

[5] This requires non-linear estimation since RMP is a non-linear function of the core parameters.

[6] The existing work on sub-national bilateral trade flows uses regional trade inside given countries, the United States for Wolf (2000) and France for Combes et al. (2005) for instance. These papers show that gravity type equations also provide a very good fit to those trade patterns with similar distance effect estimates.

[7] The evidence on trade-reducing effects of national borders is large and points to important differences in the level of those border effects depending on the importing country (see Anderson and van Wincoop, 2004).

Equation (17) requires the use of data on bilateral trade matched with production at the 2-digit industry level.[8] Consistent trade and production data are possible to construct using Eurostat sources (COMEXT and VISA databases respectively), for the 1980 to 1995 period and the fifteen 1995 members of the European Union, plus Switzerland and Norway. The trade regression is run for each of the 16 years and 13 industries, yielding industry, year and country-specific estimates to construct market potential.

Estimating equation (17) gives $E_J/S_J = \exp(\mathrm{FM}_J)$, which is then allocated to regions inside country I according to the GDP share of each constituent region: $E_j/S_j = (y_j/y_J)\exp(\mathrm{FM}_J)$. The GDP shares are obtained from the Eurostat REGIO database and are also used to allocate national expenditure E_J to different j regions, when we need to do so in the descriptive part of the empirics. Note that while lack of sub-national trade data forces us to choose an allocation rule for national competition-weighted expenditure (E/S), the other component of market potential, ϕ_{ij}, uses genuine regional-level information. There are three different cases in our data yielding three different formulas for ϕ_{ij}. When i and j belong to different countries, the bilateral level of trade freeness involves bilateral distance between the two countries, the cost of crossing the national border involved, and whether the two countries share a common language, with associated parameters from the trade equation estimation. Only bilateral distance affects trade freeness when i and j belong to the same country. Last, accessibility of a region to itself is modelled as the average distance between producers and consumers in a stylized representation of regional geography, which gives $\hat{\phi}_{ii} = d_{ii}^{-\hat{\delta}} = (2/3\sqrt{\mathrm{area}_i/\pi})^{-\hat{\delta}}$, where $-\hat{\delta}$ is the estimate on distance in the trade equation.

The other important determinant of wages in our theoretical framework is human capital. We use the labor force survey of Eurostat REGIO database, which gives the share of employment by highest level of education attained (primary, secondary or tertiary under the ISCED classification). Using this data, we calculate an average number of education years of workers in each region. This data is almost fully available across regions, but only exists for recent years (1999 to 2002). We therefore make the assumption that differences in human capital stocks vary relatively slowly over time and use the 1999–2002 averages for each region as a time-invariant regional characteristic.

[8] Production data is needed to construct the internal trade flows observations X_{II}, which enable identification of a country-specific border effect, $-\xi_J$. Internal trade is calculated as production minus total exports.

5 Results

Recall that under factor price equalization, adjustment takes place entirely through movements of firms, which requires equalization of RMP in all regions, through changes in the supply index, S. A testable implication is that RMP should be insensitive to its underlying components. In particular, suppose a location has large internal demand (high E_i) or is near to other large markets (low ϕ_{ij}s for high E_js). Then RMP equalization would imply adjustments in employment to increase S_i to offset these demand advantages.[9]

Figures 2 and 3 relate our estimates of RMP to distance to Brussels and regional expenditure for an illustrative industry (Electrical Machinery) in 1995. The first figure makes it clear that RMP becomes larger as one approaches the economic center of Europe. This relationship has already been illustrated in Redding and Schott (2003) using country-level data. It suggests a failure of factor price equalization (FPE), a failure that lends itself to an interesting interpretation in terms of our theory. Since the regions close to Brussels tend to have relatively high ϕ_{ij} to large E_j regions, the figure shows that S_i is not responding enough to offset these advantages.

Figure 3 reinforces the case against RMP equalization. High E_i regions tend to have higher RMP_i, which should *not* be the case if the competition index S_i adjusts fast enough to compensate for the advantages yielded by large E_i regions. The exceptions are the very small city-regions of Bremen (DE5), Hamburg (DE6), and Berlin (DE3). These areas earn their high RMP by virtue of very low internal distances, d_{ii}, which convert into very high ϕ_{ii}. This feature of the model should cause some concern since internal distances are set using area-based rules that may not fairly reflect true accessibility. With their national data, Redding and Venables (2004) use the assumption that distance has half the cost within nations than it has between nations to dampen the impact of small areas on ϕ_{ii}. This assumption is not not supported by the intra-national distance coefficients reported in Wolf (2000) and Combes et al. (2005). Both figures 2 and 3 suggest that the movements of firms underlying the changes in S_i do not sufficiently reduce the profits to be earned in high RMP regions. The theoretical framework developed in preceding sections then implies that the rest of the adjustment will be made through changes in factor prices, with high RMP regions yielding high factor rewards. This is indeed the case as can be seen in figure 4, where high levels of wages are to be found in areas of high market potential.

We now show that the figures depicting relationships for a single industry in

[9] The adjustment of S_i to variation in E_i and ϕ_{ij} is the multi-country analogue to adjustment in λ_i to θ_i in the two-country share equations. Unfortunately, there is no coefficient like M to use as a test for increasing returns.

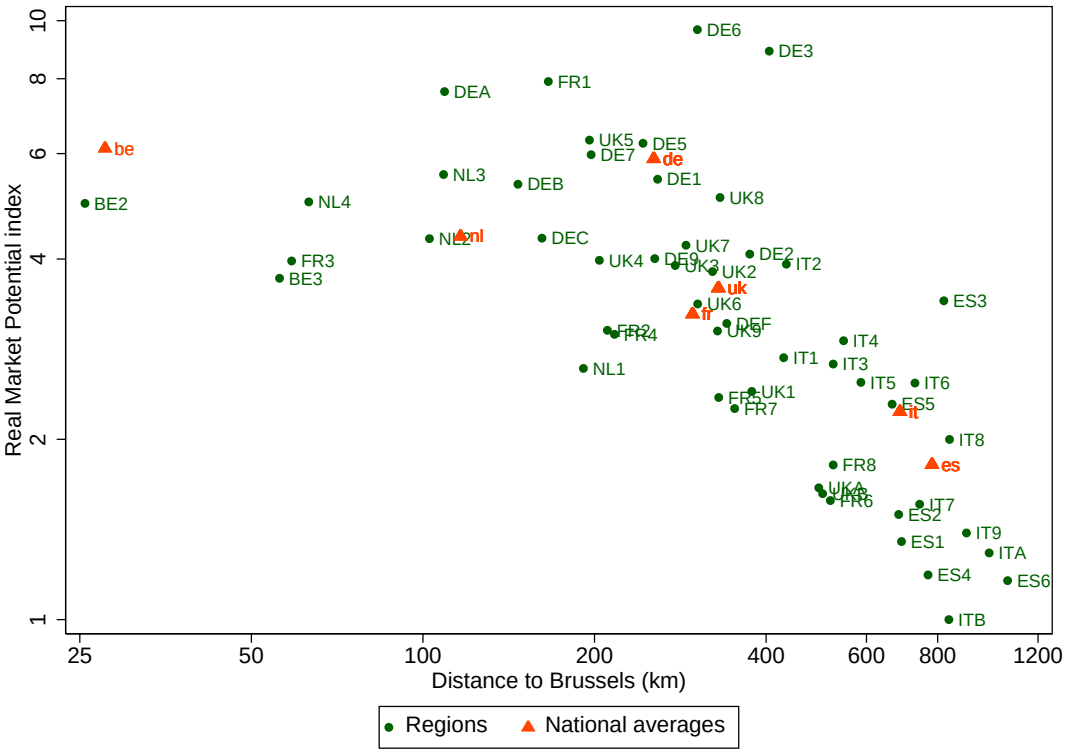

Fig. 2. RMP vs Distance to Brussels, Electric Machinery, 1995

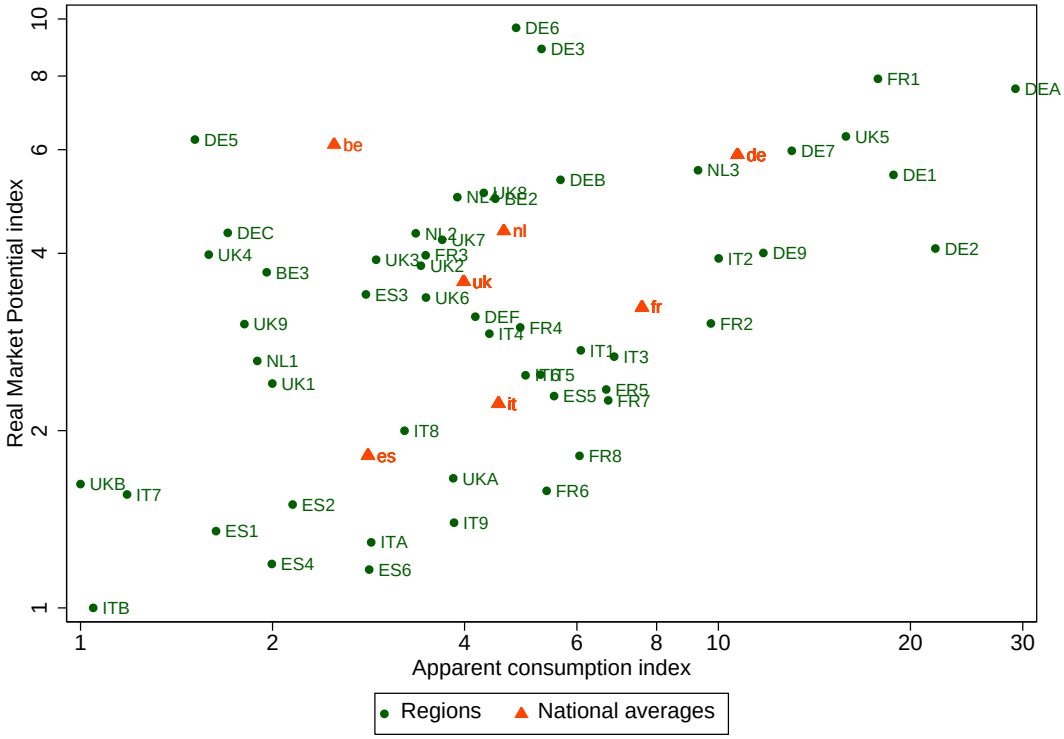

Fig. 3. RMP vs Expenditure, Electric Machinery, 1995

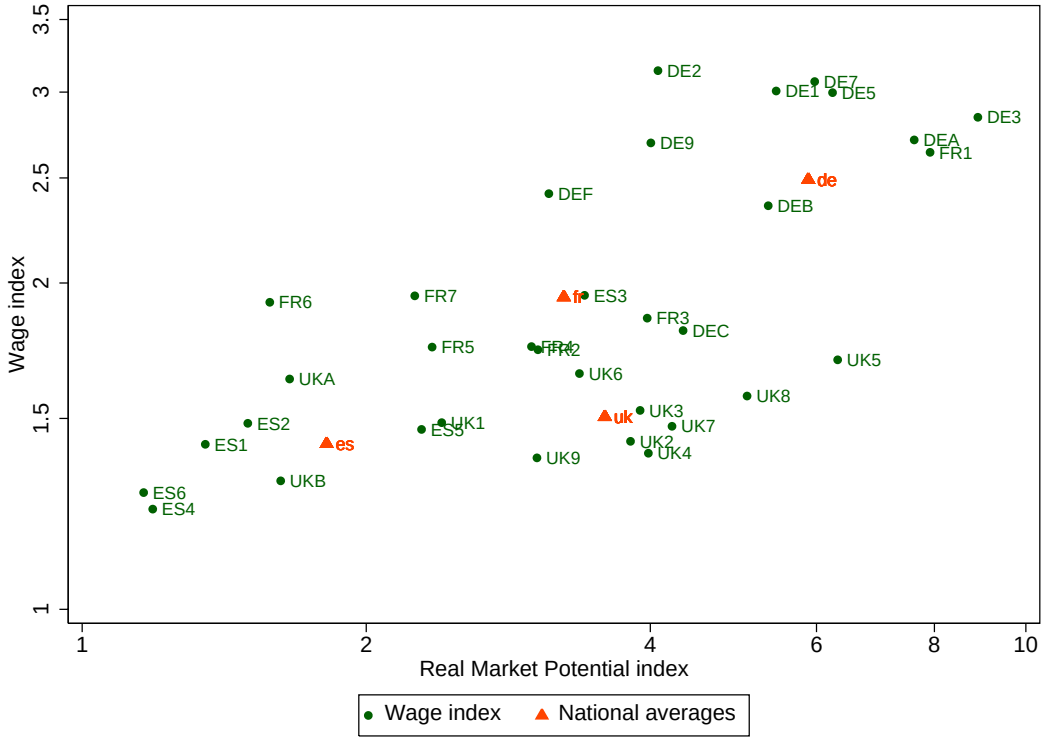

Fig. 4. Wages vs RMP, Electric Machinery, 1995.

a single year are broadly representative of other industries and years. We run the regressions of $\ln \mathrm{RMP}_i$ on $\ln d_{i,BE1}$ and $\ln E_i$ for each industry-year pair (thus there are usually 56 region observations in each regression). We then average the annual results by industry and report the coefficients in Table 1. The first four columns characterize the result for log distance to Brussels (BE1) as the explanatory variable and the second four columns show the corresponding results of log of apparent consumption. RMP is negatively related to distance to Brussels in all industries and on average this relationship is large (-.52) and very significant (-5.40). The positive correlations with $\ln E$ are less pronounced (mainly because of the problematic city-regions mentioned above). Nevertheless, the correlation is always positive and significant on average. The result that employment is not adjusting enough for RMP equalization to take place is therefore a general one, carrying over all industries in our sample. Therefore if profits are being equalized, it must be that it is being done through wage differences, and we now turn to investigating this issue.

Table 2 estimates a human-capital augmented version of the log wage equation.[10] We find that even after controlling for years of education, RMP is

[10] Redding and Schott (2003) consider human capital as their dependent variable. We consider it as a control variable. In our data, as with theirs, education and RMP are positively correlated. Hence RMP could have a direct effect on wages as well as an indirect effect via the channel of encouraging higher levels of education.

Table 1
Real market potential differences across regions

Industry	Distance to Brussels				Apparent consumption			
	Coefficient			t-stat	Coefficient			t-stat
	mean	min	max	mean	mean	min	max	mean
Clothing and Footwear	-0.68	-0.86	-0.57	-5.1	0.23	0.13	0.34	1.51
Textiles	-0.61	-0.80	-0.52	-4.99	0.11	0.06	0.16	0.84
Motor Vehicles and Parts	-0.61	-0.75	-0.46	-6.49	0.29	0.17	0.38	2.67
Rubber and Plastics	-0.61	-0.62	-0.58	-5.65	0.3	0.28	0.33	2.43
Paper, Printing, & Publishing	-0.60	-0.76	-0.52	-5.08	0.37	0.31	0.52	2.16
Non-metallic Mineral Products	-0.58	-0.68	-0.50	-5.02	0.24	0.16	0.34	1.53
Metal-Primary	-0.51	-0.69	-0.44	-5.52	0.33	0.29	0.37	3.03
Electronics	-0.45	-0.51	-0.39	-5.00	0.37	0.31	0.47	5.09
Office Machines	-0.44	-0.62	-0.30	-5.52	0.27	0.16	0.37	4.2
Precision Instruments	-0.44	-0.49	-0.35	-5.89	0.23	0.14	0.31	3.48
Chemicals & Fibres	-0.43	-0.53	-0.37	-5.96	0.28	0.26	0.32	3.06
Machinery	-0.43	-0.54	-0.38	-5.9	0.33	0.27	0.43	4.72
Food, Drink, & Tobacco	-0.41	-0.57	-0.37	-4.04	0.24	0.2	0.32	1.91
Average	-0.52	-0.65	-0.44	-5.4	0.28	0.21	0.36	2.82

associated with higher regional wages each of the manufacturing industries. In some industries the average effect obtains an elasticity of as high as 0.20 (Clothing and Footwear had a elasticity of .41 in one year). This would correspond in the model to a σ of 5, the value typically used in Krugman's illustrations of NEG, and very close to the 4.9 value found by Hanson (2005), in his estimation of market potential influence on wages across counties in the United States. The average industry has an elasticity of 0.12, corresponding to a σ of about 8, very similar to the result estimated by Head and Ries (2001) using an entirely different sample and methodology. The RMP effects on wages are generally significant (the average t-statistic being 3.16).

The results in columns (5)-(8) show that education also has an important influence on wages. The average return to a year of education is a high 0.14. Statistical significance varies across industries, with 7 industries showing t-statistics that would reject zero at the 5% level. These results are limited by our use of education averaged over the four years when data is available (1999–2002) to proxy for levels over the 1985–1995 period. Given the importance of regional education for regional wages, we believe the human-capital augmented

Table 2
Cross-sectional wage response to RMP and human capital

Industry	Real Market Potential				Average Years of Education			
	Coefficient			t-stat	Coefficient			t-stat
	mean	min	max	mean	mean	min	max	mean
Clothing and Footwear	0.20	0.10	0.41	4.59	0.23	0.09	0.30	3.44
Textiles	0.19	0.06	0.30	4.30	0.15	-0.09	0.23	1.99
Office Machines	0.19	-0.04	0.48	1.47	0.24	0.04	0.65	1.80
Precision Instruments	0.17	0.15	0.21	2.39	0.22	0.09	0.38	2.06
Electronics	0.16	0.13	0.19	3.91	0.15	0.07	0.24	2.97
Food, Drink, & Tobacco	0.14	0.10	0.18	5.90	0.04	-0.08	0.11	0.80
Machinery	0.14	0.11	0.18	4.12	0.13	0.09	0.18	2.69
Chemicals & Fibres	0.10	0.06	0.16	3.97	0.15	0.09	0.25	2.50
Non-metallic Mineral Products	0.08	0.05	0.09	3.96	0.14	0.10	0.16	2.55
Paper, Printing, & Publishing	0.06	0.03	0.09	1.96	0.09	0.05	0.13	1.60
Motor Vehicles and Parts	0.05	0.00	0.10	2.06	0.04	-0.01	0.08	0.61
Rubber and Plastics	0.04	0.02	0.06	1.58	0.07	0.02	0.12	1.01
Metal-Primary	0.03	-0.09	0.08	0.90	0.12	-0.03	0.48	1.09
Average	0.12	0.05	0.19	3.16	0.14	0.03	0.25	1.93

version of the wage equation should become the standard approach.

This type of regression is however subject to a potential simultaneity problem. Market potential, on the right end side of the estimated equation, is a weighted sum of regional expenditures in each of the industries. Those expenditures depend on incomes, and therefore on wages, raising a concern a reverse causality in the estimation. A positive shock to w_i will raise E_i and consequently increase RMP_i. [11] This will be all the more problematic since the ϕ_{ij} tend to be small relative to ϕ_{ii}: In the case of extremely high inter-regional transport costs ($\phi_{ij} = 0$, $\forall j \neq i$), only the local expenditure enters RMP_i.

We therefore need to find a good instrument for RMP, that is i) a variable that is not influenced by wages but impacts RMP, ii) a variable that does not

[11] This problem is general to all wage equations although it is here slightly smaller than in Redding and Venables (2004) or Hanson (2005) because of the industry-level nature of our empirics. For a lot of industries, a positive shock in the wage rate in i will only marginally affect local overall income and expenditure in the same industry.

Table 3
Robustness checks for market potential regressions

	Dependent Variable: ln regional wage				
Specification :	(1)	(2)	(3)	(4)	(5)
ln Real Mkt Potl (RMP)	0.112^a	0.096^a		0.100^a	0.079^a
	(0.004)	(0.004)		(0.007)	(0.005)
ln Harris Mkt Potl			0.175^a		
			(0.007)		
Avg years of education		0.122^a	0.145^a	0.121^a	0.133^a
		(0.008)	(0.008)	(0.009)	(0.008)
Ind/Year FEs	Yes	Yes	Yes	Yes	Yes
Country FEs	Yes	Yes	Yes	Yes	Yes
RMP_i Instrument	-	-	-	$\ln d_{i,\text{BE1}}$	$\ln \sum_j d_{ij}^{-1}$
No. obs.	5757	5757	5757	5757	5757
R^2 (within)	0.687	0.701	0.696	0.701	0.700
RMSE	.147	.144	.145	.144	.144

Note: Standard errors in parentheses: ^{a}, ^{b} and ^{c} represent respectively statistical significance at the 1%, 5% and 10% levels.

enter the wage equation directly. Redding and Venables (2004) use distance to nearest central place (Brussels, New York City, or Tokyo) as an instrument for the market potential of each country in the world. Although physical geography variables of this kind seem indeed to be instruments meetings the criteria above, the choice of the reference points raises an exogeneity issue. The three cities are chosen because of their extremely high market potential. We prefer the use of region i "centrality": $\ln \sum_j d_{ij}^{-1}$, as an instrument, because it does not incorporate any information on market sizes of regions, which are affected by the spatial distribution of wages.

Table 3 reports results of pooled regressions using industry-years and country fixed effects.[12] Column 1 uses the RMP variable constructed as before, with column 2 adding the average number of education years in the region. Estimates in this column are close to the average values on those two variables obtained when using industry level regressions in Table 2.

In column 3, RMP is replaced with the simpler and often used Harris (1954)

[12] Industry-level IV estimates had high standard errors and are not reported in order to save space.

market potential construction, $\text{HMP}_i = \sum_j \text{GDP}_j/d_{ij}$. The obtained coefficient is larger, but the fit of the regression is lower than with RMP. It is very close however, and the message of this comparison seems to be that results from the reduced form proposed by geographers 50 years ago are remarkably similar to the ones from the structural model. It should also be noted however that the structural interpretation of the coefficient (as $1/\sigma$) is lost in the reduced form version of the estimation. Column 4 uses distance to Brussels (the equivalent of the Redding and Venables method for our case) as an instrument for RMP, and shows that results are basically unchanged from OLS results in column 2. Our preferred instrument provides estimates in column 5. The changes in coefficients are more substantial, with the market potential elasticity falling to 0.079, implying $\sigma = 12.5$, and an increased coefficient on the cross-regional variance in years of education. Despite concerns about reverse causality, it seems that here—as in previous work—instrumentation using physical geography advantages does not eliminate the influence of market potential on wages.

As a last step, we collect the residuals from the regressions reported in Table 2 and use them as the explanatory variables in the next table. The dependent variables in Table 4 are 5-year changes in wages ($\ln w_{it} - \ln w_{i,t-5}$, columns 1-4) and ($\ln L_{it} - \ln L_{i,t-5}$, columns 5-8). Recall that we use negative residuals from $t-5$ so that we can interpret the coefficients as the (presumably) positive adjustment parameters γ_w and γ_L.

The results of Table 4 show fairly strong evidence of wage adjustment in the theoretically predicted direction for nearly every industry. The average adjustment coefficient for 5 year periods is 0.28. In one of the 5-year periods, the Machinery sector actually reached the theoretical full adjustment. Only non-metallic minerals shows almost no tendency towards wage increases in the previously "bargain" regions.

By contrast, columns (5)–(8) of Table 4 reveal a mixed bag of of employment adjustment parameters. There are cases like Office Machines (computers) where adjustment is estimated to be very high (perhaps implausibly so). On average, employment adjustment is not statistically significant. These results need not be seen as disappointments for the theory however. We have shown in Table 1 that RMP does not equalize and pointed out that theoretically this would be expected in the absence of factor price equalization. Table 2 found that even controlling for human capital, the high RMP areas pay higher wages. This static result supported wage response as a principal path towards spatial equilibrium. The significant dynamic wage adjustments coupled with mixed and mainly insignificant employment adjustments corroborate this hypothesis.

These results suggest that the residuals in the wage regression are not just omitted wage determinants but rather that they reflect shocks or expecta-

Table 4
Dynamic response to cross-sectional wage equation residuals

Industry	Wage adjustment				Employment adjustment			
	Coefficient			t-stat	Coefficient			t-stat
	mean	min	max	mean	mean	min	max	mean
Machinery	0.60	0.30	1.02	7.94	0.19	0.05	0.32	1.05
Office Machines	0.46	0.20	0.64	2.54	0.8	0.34	1.42	1.43
Clothing and Footwear	0.42	-0.01	0.84	3.27	-0.91	-2.02	-0.01	-1.40
Textiles	0.40	0.01	0.68	2.20	1.28	0.00	3.73	0.87
Motor Vehicles and Parts	0.39	0.16	0.69	3.73	0.45	0.04	1.22	1.30
Precision Instruments	0.30	0.03	0.45	1.48	0.16	0.04	0.30	0.4
Electronics	0.28	-0.08	0.48	2.46	1.07	-0.02	3.05	1.36
Metal-Primary	0.15	0.00	0.23	0.82	0.77	0.00	1.96	1.74
Paper, Printing, & Publishing	0.14	0.09	0.21	1.44	-0.12	-0.55	0.36	-0.12
Rubber and Plastics	0.13	0.03	0.21	1.68	0.36	0.21	0.46	1.88
Food, Drink, & Tobacco	0.12	0.08	0.18	1.23	-0.02	-0.34	0.17	0.27
Chemicals & Fibres	0.11	-0.09	0.26	1.07	0.50	0.19	0.74	1.55
Non-metallic Mineral Products	0.09	0.07	0.11	1.14	0.10	-0.25	0.51	-0.34
Average	0.28	0.06	0.46	2.38	0.36	-0.18	1.09	0.77

tional errors by firms. Regions that pay low wages relative to education and RMP levels, tend to move towards higher costs, thereby attenuating profit differences.

Caution is warranted when interpreting the wage response to the residuals from the first-step regression. Consider the following regression, run as a fixed-effects within estimation of five-years changes in wages on $-\hat{\epsilon}_{it}$, on residuals from the first step wage equation estimation (the pooled equivalent of industry-level estimation reported in Table 4):

$$\ln w_{i,t+5} - \ln w_{it} = 0.28(-\hat{\epsilon}_{it}) + \text{Country Effects} + e_{it}.$$

Up to now we have interpreted the 0.28 coefficient as a "catching-up" over five years of wages that were observed to be too low in time t with respect to their level of market potential (or the converse). Part of this "response" to residuals could in fact result from *regression to the mean*. "Unlucky" regions in year t could become more "average" in time $t + 5$, which would also yield a positive coefficient on the initial level of wages. This can be seen more

formally by recalling that $-\hat{\epsilon}_{it} = \hat{a} + \hat{b} \ln \mathrm{RMP}_{it} + \hat{\rho} h_{it} - \ln w_{it}$. The initial level of wages directly enters the definition of the residual used in the second step. We investigate the extent of regression to the mean in our case by including initial $\ln w_{it}$ as an additional control:

$$\ln w_{i,t+5} - \ln w_{it} = 0.13(-\hat{\epsilon}_{it}) - 0.15 \ln w_{it} + \text{Cty. Eff.} + e_{it}.$$

These results show that about half of the initial adjustment coefficient could be due to regression to the mean rather than adjustments by firms to deviations from the zero profit locus. Still, the adjustment process remains statistically significant and substantial in magnitude.

6 Conclusion

The Dixit-Stiglit-Krugman model of monopolistic competition with trade costs is the foundation of new economic geography models. It is not easy to test. We frame our analysis around the iso-profit condition of the model and two polar cases through which a spatial equilibrium can be reached. The first case is where factor prices are equalized and firms (and hence production and employment) choose locations based on the spatial distribution of demand. The second polar case takes the location of firms as given and solves for the maximum wage consistent with equal profits.

We investigate empirical implications of both both polar cases using data on 13 manufacturing industries and 57 regions in Europe from 1985 to 2000. Three sets of findings indicate that wage adjustment is the main path towards spatial equilibrium in this data. First, we show that real market potentials are not equalized as would be predicted by the model in the presence of factor price equalization. Instead real market potentials (RMP) vary as they would if there were insufficient adjustment of the supply index to local demand. Second, wages do respond to market potential. In cross section a 10% increase in RMP tends to raise average wages by 1.2%. Over time, a region where workers are paid 10% less than their market potential would warrant, will on average see a 2.8% above normal rise in average wages over the following 5 years. Employment also seems to adjust but not in a consistently significant way. The tests for RMP equalization and dynamic adjustment to wage equation residuals that we present here appear to be useful ways to assess the DSK model in a multi-country setting.

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