

# Regional Wage and Employment Responses to Market Potential in the EU<sup>★</sup>

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## Abstract

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. We highlight the theoretical connection between these two strands. Using data on 57 European regions, we 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, R12.

*Key words:* Home market effects, wage equation, gravity equation, new economic geography

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<sup>★</sup> This paper is produced as part of a CEPR Research Network on The Economic Geography of Europe: Measurement, Testing and Policy Simulations, funded by the European Commission under the Research Training Network Programme (Contract No: HPRN-CT-2000-00069). The paper was written while the first author was visiting PSE-Jourdan in 2004, and benefited from very helpful comments by two referees, David Weinstein, Guy Laroque, Frank Portier, and participants in the Empirics of New Economic Geography Conference in HWWA (Hamburg), the Séminaire Roy (Paris), and seminars at the University of Nottingham, Université de Toulouse I, Université Libre de Bruxelles, and Université de Rennes.

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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 economy as a multiplicative external effect 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.

NEG is not the only framework attempting to explain wage differences across regions. Even considering just the field of regional and urban economics, at least two important alternative hypotheses have been tested to explain spatial inequality. Most notably, models involving technological spillovers and human capital externalities also yield wage equations that link regional wages to some measure of the density of local economic activity. Most related to our work, Ciccone (2002) shows how wages in European regions are positively associated with the population density of the region. Dekle and Eaton (1999) explain a share-weighted index of wages and land rents in Japanese regions with an expression that adds nearby incomes discounted by distance. Both papers view their findings as support for technological spillovers. The main difference between the approaches is that NEG builds on a particular set of market structure assumptions in which scale economies are internal to the firm, whereas the employment density approach can be thought of as an approximation for a variety of spillover processes.

The NEG wage equation we use here is also related to the Productivity and

Trade literature (P&T). Our framework explains wages with market potential, which is an index of the export possibilities of firms located in the country/region, while Frankel and Romer (1999), Rodrik et al. (2004) or Alcalá and Ciccone (2004) are recent examples of work explaining the level of income per capita or its growth with trade openness, measured as the sum of imports and exports over GDP. Here again the main difference between the two types of literature resides in the structure imposed to the trade term. While the NEG approach emphasizes the structural interpretation of this term, the P&T approach places much more weight on the exogeneity of the trade variable. We adopt the NEG path here, while also following P&T by proposing several instrumenting strategies for market potential.<sup>1</sup>

Our theory reveals that a complex construction of access to demands originating from all regions—the real market potential (RMP)—is a central feature of the economic fortunes of a region. We estimate the influence of RMP on wages, following the Redding and Venables (2004) method. That is, we construct RMP 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 geographic demand variation.

The paper proceeds as follows. First, we use in Section 2 an augmented version of 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

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<sup>1</sup> The additional import term in the P&T approach is *not* a key difference with NEG. Indeed, with trade in intermediate goods, proximity to important sources of inputs yields lower costs and higher wages to countries. This results in an additional independent variable—called supplier access by Redding and Venables (2004)—that is an index of import possibilities of firms. A much more important difference is again the source of externalities mediated by trade. The P&T literature typically invokes technological spillovers compatible with perfect competition, while in NEG the external effects of trade work through a combination of increasing returns, trade costs and imperfect competition.

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. There are  $K + 1$  industries of which  $K$  have increasing returns to scale (IRS) and imperfect competition. Sector 0 is a numeraire sector with constant (or even decreasing) returns and perfect competition. As we discuss in the next section, the interactions between the IRS industries and sector 0 determine the way agglomeration forces manifest themselves in general equilibrium.<sup>2</sup>

Let  $E_i$  denote total expenditure of region  $i$  on the representative IRS industry.<sup>3</sup> 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.<sup>4</sup> 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 incorporate these considerations in a formal measure of the size of the market in a multi-region setting.

<sup>2</sup> For fully developed models of these interactions, see Davis (1998), Puga (1999) and Holmes and Stephens (2005).

<sup>3</sup> The empirics involve  $K = 13$  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.

<sup>4</sup> 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.

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,  $\tau_{ij}$ . Trade costs include 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),  $\sigma$ , 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

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

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

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

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  $\tau_{ij}$  and  $\sigma$  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  $x_{ij} = z_{ij} E_j$ . Substituting in (1) and utilizing the  $\phi_{ij}$  and  $S_j$  notation we obtain

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

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  $i$ :

$$\Pi_i = \sum_j x_{ij}/\sigma - f_i = \frac{1}{\sigma} m_i^{1-\sigma} \text{RMP}_i - f_i, \quad (4)$$

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  $\phi_{ij}$  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  $\phi_{ij}$  with  $1/D_{ij}$ . We use the term “real” to underline the importance of discounting expenditures by the supply index,  $S_j$ , which is inversely related to the local industry price index. “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 empirical work, we wish to examine the relationship between the observed spatial distribution of expenditures,  $E_i$ , and the spatial pattern of wages and employment. Hence we need to restate the profit equation in terms of these variables. 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. However, we modify the model to take into account cross-regional variation in human capital. In particular, we assume that labor requirement per firm,  $\ell$ , depends on both output per firm,  $q$ , and average years of schooling,  $h$  as follows:

$$\ell_i = (\alpha + \beta q_i) \exp(-\rho h_i), \quad (5)$$

where  $\alpha$  and  $\beta$  measure fixed and variable labor requirements in “effective” (education-adjusted) labor units. The return to human capital, denoted  $\rho$ , shows the percentage increase in productivity from an extra year of education. These assumptions imply fixed costs of  $f_i = \alpha \exp(-\rho h_i) w_i$  and marginal costs of  $m_i = \beta \exp(-\rho h_i) w_i$ . Profits can therefore be restated in terms of wages as

$$\Pi_i = \frac{1}{\sigma} (\beta \exp(-\rho h_i) w_i)^{1-\sigma} \text{RMP}_i - f_i = \alpha \exp(-\rho h_i) w_i. \quad (6)$$

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,  $\ell_i$ . Output per firm does not vary across locations in this model and is given by  $q =$

$(\alpha/\beta)(\sigma - 1)$ . Hence industry employment in a region, denoted  $L_i$ , is given by

$$L_i = n_i \exp(\rho h_i)(\alpha + \beta q_i) = \alpha \sigma \exp(-\rho h_i) n_i. \quad (7)$$

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 (7) and substituting out  $n_i$  in (2), yielding

$$S_i = \kappa \sum_j L_j \exp(\sigma \rho h_j) w_j^{1-\sigma} \phi_{ij}, \quad (8)$$

where  $\kappa$  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  $\phi_{ij}$ ) to the market in question. Note that  $\sigma$  acts as amplifier: when it is large, human capital, wages, and transport costs have stronger impacts.

### 3 Two paths towards spatial equilibrium

Spatial equilibrium requires that markets clear and no mobile agent has a unilateral incentive to relocate. For firms, this means that profits should be the same in all regions:  $\Pi_i = \bar{\Pi}$ . If workers are perfectly mobile, spatial equilibrium also requires real wage equalization. We will consider the worker's condition later, but now concentrate on the equilibrium condition for firms. With free entry, the equal profit level is zero, so we solve for an iso-profit equation,  $\Pi_i = 0$ , relating production costs in region  $i$ —which depend on wages and human capital in that region—to market potential:

$$\beta^{\sigma-1} \alpha \sigma (w_i \exp(-\rho h_i))^\sigma = \text{RMP}_i. \quad (9)$$

Consider the effect of a positive shock to expenditure,  $E_i$ , in a region. Other things equal,  $\text{RMP}_i$  would rise, breaking the equality in (9) and requiring an adjustment for the economy to return to equilibrium. We consider two paths towards equilibrium: The first way to restore equality is to raise  $w_i$ . The second path would be a rise in the supply index,  $S_i$ , pushing  $\text{RMP}_i$  back down to its initial level, restoring equality. This change in  $S_i$  could be achieved by an increase in the number of firms in the industry-region which would require an increase in the industry-region employment,  $L_i$ . Raising  $S_i$  leads to increased competition and reduced profits in region  $i$ .

The relative magnitudes of price ( $w_i$ ) or quantity ( $L_i$ ) adjustment to cross-regional variation in demand  $E_i$  depends chiefly on the mobility of workers

between sectors and between regions. One polar case assumes that frictionless international trade in sector 0 ties down  $w_i$  and that there is no inter-regional migration. Rather, sector 0 supplies a pool of workers sufficient to allow for all adjustment to take place on the production side. In that case, sector 0 output must be positive in all regions. A second polar case assumes that labour is not available to the industry-region from either other sectors or other regions. This induces a wage rise in high demand regions.

Two important strands in the empirical literature investigate these two polar cases of the equilibration mechanism. We now review the theoretical and empirical linkages between the two approaches.

The first approach assumes factor price equalization. This makes wages invariant to demand 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:  $\text{RMP}_i = \text{RMP}_j$ .

In a two-country model, RMP equalization leads to the piecewise linear share equation first identified by Helpman and Krugman (1985). Using  $\lambda = n_1/(n_1 + n_2)$  to denote the share of output manufactured in region 1 and  $\theta = E_1/(E_1 + E_2)$  to denote region 1's share of expenditures, we have

$$\lambda = 1/2 + M(\theta - 1/2), \quad (10)$$

whenever  $(1 - 1/M)/2 \leq \theta \leq (1 + 1/M)/2$ . In the Helpman-Krugman version  $\lambda$  corresponds to the shares of the number of firms, production, and employment.<sup>5</sup> 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  $\phi$ , increases the responsiveness of employment to home demand.

Researchers have tried to estimate  $M$  and test whether it 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).

<sup>5</sup> In our human capital augmented version,  $\lambda$  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 theory underlying estimation of  $M$  relies upon very restrictive assumptions. The first assumption is factor price equalization (FPE). If, on the other hand, wages in a region are increasing in demand in that region, then Head and Mayer (2004a) show that the magnification effect can be overturned. It also turns out that the share equation of Helpman and Krugman (1985) only applies in a two-country world. Behrens, Lamorgese, Ottaviano, and Tabuchi (2004) show that testing for increasing returns using  $M > 1$  as the criterion is inappropriate in a multi-country world. They suggest alternative methods for multi-country implementations of the theory. Their methods assume FPE and this leads to RMP equalization. We present some tests for RMP equalization in the results section as an alternative way to assess the FPE approach to equilibrium in the DSK model.

Redding and Venables (2004) pioneer the second polar path that 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?”

Solving for the wage in equation 9, we obtain

$$w_i = \left( \frac{\text{RMP}_i}{\beta^{\sigma-1}\alpha\sigma} \right)^{1/\sigma} \exp(\rho h_i). \quad (11)$$

Except for notation and the inclusion of human capital, (11) is the same as (4.27) in Fujita et al. (1999).

In terms of equation (11), 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 wage and employment responses.

The initial wage-RMP relationship can be estimated by taking logs of equation (11), which gives a linear-in-logs equation:

$$\ln w_i = a + b \ln \text{RMP}_i + \rho h_i + \epsilon_i, \quad (12)$$

where  $a = -(1/\sigma) \ln(\beta^{\sigma-1}\alpha\sigma)$  and  $b = 1/\sigma$ . The intercept,  $a$ , depends on the input requirement coefficients  $\alpha$  and  $\beta$ . These are likely to vary across industries, in part because of variation in capital intensities. For this reason we always estimate (12) with industry specific constants. Furthermore  $b = 1/\sigma$  will also vary by industry, as our theory implies that this parameter is a measure of product differentiation (and, indirectly, increasing returns) in the sector considered. Returns to human capital,  $\rho$ , also may differ across industries, for instance because of different skill intensities. Most of our estimations therefore estimate industry-specific  $b$  and  $\rho$ .

Equation (12) is our principal empirical tool. Like alternative measures of other agglomeration forces, it sums economic activity in all relevant regions, discounted by their spatial separation. This makes wages depend on local and non-local economic activity. The NEG approach used here determines the relative weights based on the geographic pattern of trade in the considered industry. This contrasts with alternative approaches that stipulate discounting functions without specifying the cause of the discount. A more fundamental distinction is that  $RMP_i$  incorporates the supply index  $S_i$ , which summarizes the level of competition faced by a representative firm in region  $i$ . This supply index is an increasing function of the number of competitors located nearby and affects wages negatively. On the contrary, in spillover models the proximity of firms from the same industry is likely to enhance productivity in  $i$  and therefore the wage paid. This potentially provides a discriminating hypothesis between competing explanations. It is not clear, however, how one would implement such a test since we do not observe  $S_i$  directly and are forced to estimate  $RMP_i$  as a block using the method described in section 4.2. Alternatively, one can compare results from the impact of structural ( $RMP_i$ ) and non-structural versions of the market potential. We explore this path in section 5.

Equation (12) derives solely from the *firm's* spatial equilibrium condition. By focussing on this equation, the home market effect literature and the Redding-Venables wage equations implicitly or explicitly assume workers to be immobile. Worker mobility complicates matters considerably. This is because workers care about *real* wages, introducing a second spatial equilibrium condition that also depends on both wages and the supply index.<sup>6</sup> To obtain stable, interior asymmetric distributions of workers that satisfy the firm and worker equilibrium conditions, one could follow Helpman (1998) and add a housing sector. Areas with high demand have high nominal wages to keep firms in equilibrium while high housing prices equalize real wages. Hanson (2005) follows this approach in his study of wage variation across US counties.

Our study is at the regional level in Europe. Migration between regions in different EU nations seems small enough to approximate as zero.<sup>7</sup> Even migration *within* EU countries is small relative to the US.<sup>8</sup> The absence of large-scale migration in Europe might mean that mobility costs are high enough to

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<sup>6</sup> Recall that the price index for an increasing returns industry is inversely related to the supply index.

<sup>7</sup> Puga (2002) reports that “only 1.5% of EU citizens live in a Member State different from where they were born.”

<sup>8</sup> Obstfeld and Peri (1998) show that the average interregional net migration rate over the period 1970–1995 is two to four times lower in the UK, Germany and Italy than in the United States. They also find econometric evidence of much lower migration response to shocks in labor demand for European countries, as compared to the United States.

make it reasonable to ignore the workers' spatial equilibrium condition. However, if this inference were incorrect, it could lead to bias in the estimation of (12). For example, suppose there is a shock to housing availability in region  $i$ . This would induce in-migration, raising expenditure,  $E_i$ . But it would also tend to reduce wages in region  $i$  since the price level would be lower. This means that RMP would not be independent of the error term,  $\epsilon_i$  in (12), making OLS inconsistent. We therefore use instrumental variables as a robustness check.

The standard theory treats the wage equation as a relationship that holds at all points in time. Thus, it can be estimated in cross-section (Redding and Venables, 2004) or in time-differences (Hanson, 2005). We will begin by estimating equation (12) as a set of annual cross-sections that we then average to generate a single estimate of the RMP elasticity for each industry. This may be thought of as the long-run relationship.

The problem with these approaches is that, at any given moment, the actual wage may differ from the wage that would put a region on the iso-profit equation. If large changes in wages incur adjustment costs, then we should expect only *partial adjustment* to deviations in regional wages from the iso-profit relationship. Following Nerlove (1958) we can formalize these dynamics by first reformulating equation (12) as an equation for the equilibrium wage, denoted  $w^*$ :

$$\ln w_{it}^* = a_t + b \ln \text{RMP}_{it} + \rho h_i. \quad (13)$$

The  $a_t$  are year-specific intercepts and regional education attainment  $h_i$  is assumed constant due to data limitations. In the partial adjustment model, actual wages,  $w_{it}$ , move towards equilibrium wages,  $w_{it}^*$ , according to

$$\ln w_{it} - \ln w_{i,t-1} = \gamma(\ln w_{it}^* - \ln w_{i,t-1}) + u_{it}. \quad (14)$$

Nerlove defined  $\gamma$  as the “elasticity of adjustment.” In this expression, the  $u_{it}$  are IID errors in the adjustment process. Substituting (13) into (14) yields the dynamic estimating equation

$$\ln w_{it} - \ln w_{i,t-1} = a'_t + b' \ln \text{RMP}_{it} + c' \ln w_{i,t-1} + \rho' h_i + u_{it}, \quad (15)$$

where  $a'_t \equiv \gamma a_t$ ,  $b' \equiv \gamma b$ ,  $c' \equiv -\gamma$ , and  $\rho' \equiv \gamma \rho$ .

Equation 15 can be estimated via OLS as long as the adjustment errors  $u_{it}$  are not serially correlated. By estimating  $\gamma = -c'$  we can assess the speed of wage adjustment. One can then recover an estimate of the long-run equilibrium elasticity of RMP  $b$  by dividing the short-run elasticity,  $b'$  by  $\gamma$ .

We also should consider the possible role of employment adjustment. It would take the form of a change in real market potential from  $t-1$  to  $t$ . This is taken into account in (15) since the equation conditions on contemporaneous RMP.

Estimated  $\gamma$  can therefore be thought as the wage adjustment parameter after employment adjustment has potentially taken place. Estimation of (15) does not, however, reveal the existence and size of this employment adjustment, which is also of interest. As there is no closed form for  $L_{it}$ , we cannot readily extend the approach above to estimation of an employment adjustment parameter. Nevertheless, for comparison purposes, we also estimated an *ad hoc* regression of changes in employment on one-year lagged levels of the deviations from the cross-section wage equation (12). That is we estimate

$$\ln L_{it} - \ln L_{i,t-1} = \eta \left( \hat{a} + \hat{b} \ln \text{RMP}_{i,t-1} + \hat{\rho} h_i - \ln w_{i,t-1} \right). \quad (16)$$

The estimate of  $\eta$  indicates how much employment in an industry-region increases if, in the preceding year, its RMP was high relative to the education-adjusted wage. By comparing estimates of  $\gamma$  and  $\eta$  we hope to offer additional insights into the main modes of regional adjustment to deviations from the iso-profit equation.

## 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.<sup>9</sup> 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 Eu-

<sup>9</sup> The NUTS regulation states that the average size of NUTS 1 regions in a country should host between 3 and 7 million people.

rostat 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.

#### 4.2 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  $RMP_i \equiv \sum_j \phi_{ij}(E_j/S_j)$ , where  $\phi_{ij}$  represents the ease of access of producers in  $i$  to consumers in region  $j$  and  $E_j$  (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).<sup>10</sup> We follow a different strategy, pioneered by Redding and Venables (2004), that exploits the information from bilateral trade equations, which we view as part of the core empirical content of the theory. 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

$$\ln X_{ij} = \ln n_i - (\sigma - 1) \ln p_i + \ln \phi_{ij} + \ln E_j - \ln S_j. \quad (17)$$

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  $\text{FX}_i = \ln n_i - (\sigma - 1) \ln p_i$  and the last two  $j$ -specific terms with  $\text{FM}_j = \ln E_j - \ln S_j$ .

The  $E/S$  component of real market potential can be estimated as the exponential of the fixed effect on importer  $j$ ,  $\text{FM}$ , in a bilateral trade equation. Unfortunately, bilateral trade data for the regions in our sample are not available. Therefore we have to rely on bilateral trade data between nations to obtain the estimates used in the calculation of market potential.<sup>11</sup> 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 ( $\text{FX}_I$  and  $\text{FM}_J$ ), and a three-component model of trade freeness. We assume

$$\phi_{IJ} = d_{IJ}^{-\delta} \exp[(\xi_J - \Lambda \text{LANG}_{IJ})B_{IJ} + \zeta_{IJ}] \quad (18)$$

The first component is bilateral distance,  $D_{IJ}$ , measured as the weighted average of region-to-region distances for the two countries. The second component is a reduction in freeness due to crossing a national border ( $B_{IJ} = 1$  if  $I \neq J$  and zero otherwise). Following results in other papers (see Anderson and van Wincoop, 2004), we allow border effects,  $-\xi_J$  to vary across countries. The model is parameterized so that sharing a common language dampens the border effect ( $\text{LANG}_{IJ} = 1$  for pairs of countries that share at least one official language). The unmeasured determinants of trade freeness are captured in  $\zeta_{IJ}$ , which is assumed to be an independent, zero-mean residual. Substituting (18) into (17) yields the estimating equation

$$\ln X_{IJ} = \text{FX}_I + \text{FM}_J - \delta \ln d_{IJ} - \xi_J B_{IJ} + \Lambda \text{LANG}_{IJ} \cdot B_{IJ} + \zeta_{IJ}. \quad (19)$$

Equation (19) requires the use of data on bilateral trade matched with produc-

<sup>10</sup> This requires non-linear estimation since RMP is a non-linear function of the core parameters.

<sup>11</sup> 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.

tion at the 2-digit industry level.<sup>12</sup> Consistent trade and production data are constructed by Eurostat (COMEXT and VISA databases respectively). Our sample comprises the period from 1980 to 1995 and the fifteen 1995 members of the European Union, plus Switzerland and Norway. We estimate the trade regression for each of the 16 years and 13 industries, yielding industry, year and country-specific estimates to construct market potential.

Estimating equation (19) allows us to calculate  $E_J/S_J = \exp(\text{FM}_J)$ . Assuming homotheticity, regional expenditure is given by  $E_j = (y_j/y_J)E_J$ , where  $y_j/y_J$  is region  $j$ 's share of national GDP.<sup>13</sup> We then must assume that  $S_j$ , the supply index, is approximately constant *within* countries, i.e.  $S_j = S_J, \forall j \in J$ . Combining these assumptions yields  $E_j/S_j = (y_j/y_J) \exp(\text{FM}_J)$ . The calculation of RMP also uses information on inter-regional distances, national borders, and language commonality combined with the parameters estimated using nation-level bilateral trade to obtain an estimate of the freeness of trade between each pair of regions:

$$\hat{\phi}_{ij} = d_{ij}^{-\delta} \exp[(\hat{\xi}_J - \hat{\Lambda} \text{LANG}_{ij}) B_{ij}] \quad (20)$$

The indicators for common language and crossing a national border are constructed such that  $\text{LANG}_{ij} = 1$  and  $B_{ij} = 0$  for pairs from the same country ( $I = J$ ). Bilateral distance,  $d_{ij}$  is the great circle distance from the center of region  $i$  to the center of region  $j$  for  $i \neq j$ . A region's distance to itself is approximated as the average distance from the region center to all other points in the region, assuming the center is literally at the center of a disk-shaped region. These assumptions imply  $\hat{\phi}_{ii} = d_{ii}^{-\delta} = (2/3\sqrt{\text{area}_i/\pi})^{-\delta}$ . Combining the estimated bilateral freeness estimates, fixed effects, and our expenditure allocation rule, the real market potential of each region is calculated as

$$\widehat{\text{RMP}}_i = \sum_j \hat{\phi}_{ij} (y_j/y_J) \exp(\text{FM}_J). \quad (21)$$

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.

<sup>12</sup> 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.

<sup>13</sup> The GDP shares are obtained from the Eurostat REGIO database.

## 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  $\phi_{ij}$ s for high  $E_j$ s). Then RMP equalization would imply adjustments in employment to increase  $S_i$  to offset these demand advantages.<sup>14</sup>

Figures 1 and 2 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  $\phi_{ij}$  to large  $E_j$  regions, the figure shows that  $S_i$  is not responding enough to offset these advantages.

Figure 2 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  $\phi_{ii}$ . 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. Both figures 1 and 2 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 3, 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 a single year are broadly representative of other industries and years. We run the regressions of  $\ln RMP_i$  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

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<sup>14</sup>The adjustment of  $S_i$  to variation in  $E_i$  and  $\phi_{ij}$  is the multi-country analogue to adjustment in  $\lambda_i$  to  $\theta_i$  in the two-country share equations. Unfortunately, there is no coefficient like  $M$  to use as a test for increasing returns.

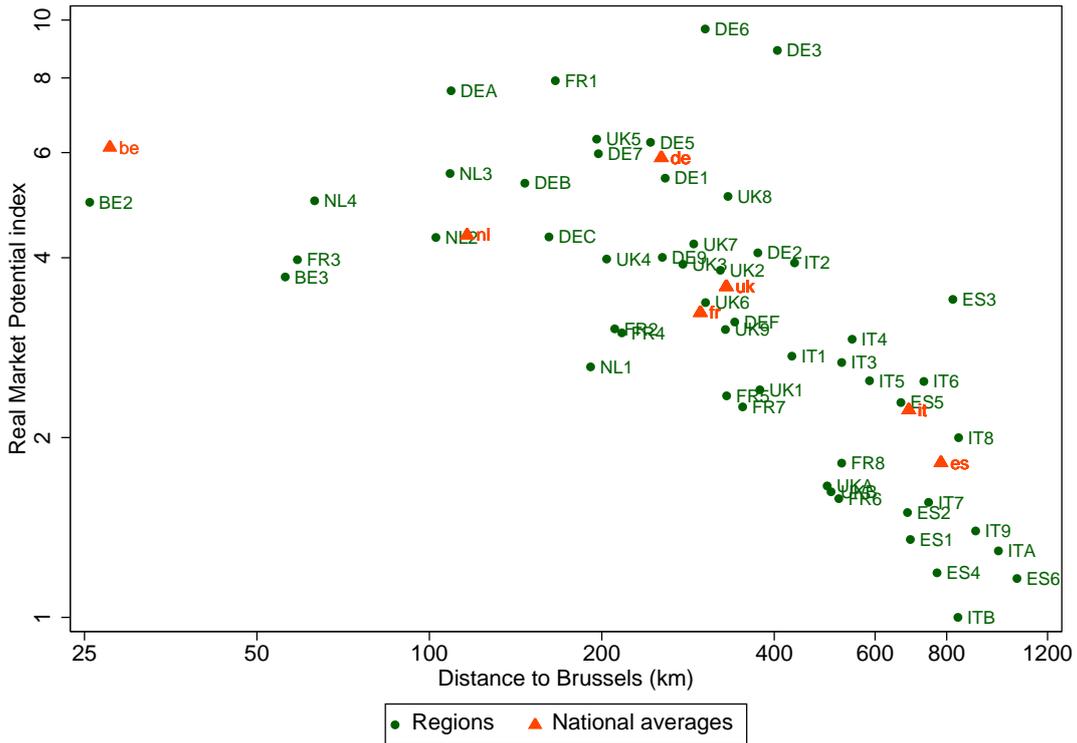


Fig. 1. RMP vs Distance to Brussels, Electric Machinery, 1995

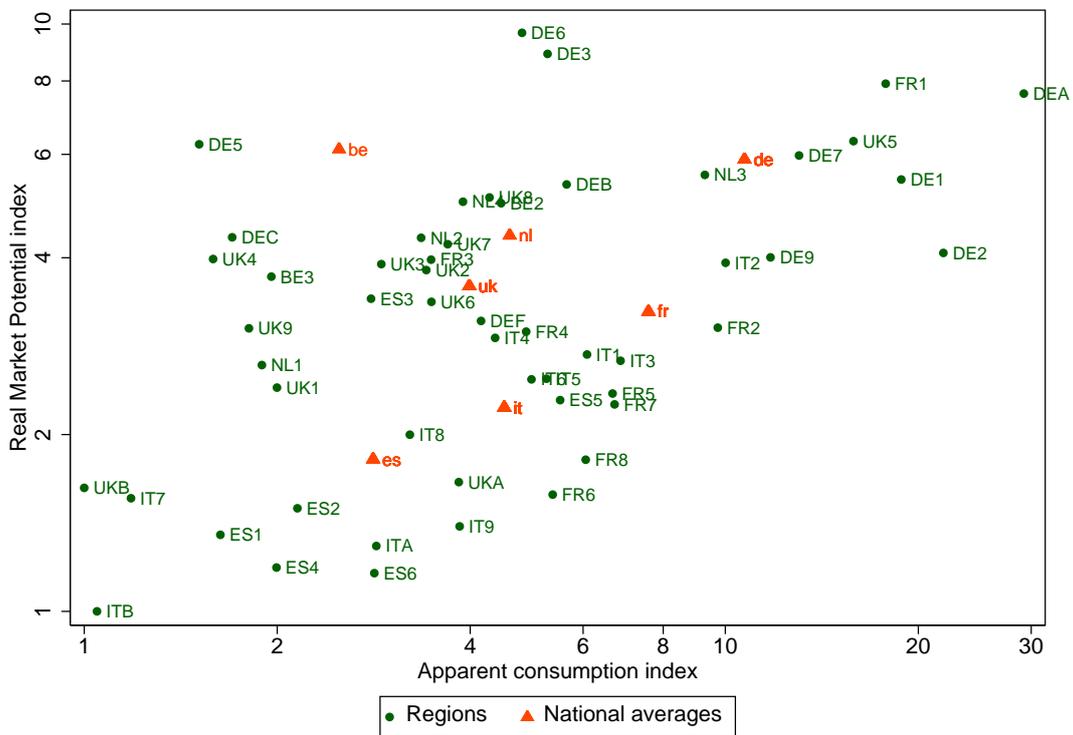


Fig. 2. RMP vs Expenditure, Electric Machinery, 1995



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
<b>Average</b>	-0.52	-0.65	-0.44	-5.4	0.28	0.21	0.36	2.82

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  $\sigma$  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. Those estimates can be compared to existing results on Mincerian returns to human capital, with the caveat that we rely here on aggregate rather than individual data. A massive literature in labor economics uses individual level data to investigate this relationship. Most work finds private returns to human capital for European samples to be half the values we obtain here. Large coefficients on aggregate data such as ours might be interpreted as evidence of human capital externalities. This would however conflict with some recent estimates in labor

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
<b>Average</b>	0.12	0.05	0.19	3.16	0.14	0.03	0.25	1.93

economics that fail to find such externalities (Acemoglu and Angrist, 2001, Ciccone and Peri, forthcoming). Several shortcomings to the human capital part of our estimation have to be emphasized as possible explanations of this discrepancy. First, our results are limited by our use of education averaged over the four years when the data are available (1999–2002) to proxy for levels over the 1985–1995 period. Another limitation is the use of regional averages, rather than individual data used in the studies cited above. An important and comforting point to note is that our principal variable of interest, market potential, could be overestimated if the returns to human capital were *underestimated* for some reason, which does not appear to be the case.

Inclusion of individual levels of schooling in NEG wage equations is a new and welcomed improvement to the literature, that allows for comparisons with the important set of estimates provided by labor economists. Recent work by economic geographers finds that geographic variation in individual skills accounts for a large amount of the intra-national geographic variation of in-

dividual wages in the UK, France, and Italy.<sup>16</sup> Combes et al (2004) argue that failure to control for cross-regional variation in skill composition biases estimates of agglomeration effects upwards. When we re-estimate the wage equations with education omitted, we find that the average coefficients on real market potential are indeed inflated for all industries. The average across all industries rises to .14, compared to the .12 reported in column 1 of Table 2. These findings suggest that the human-capital augmented version of the wage equation should become the standard approach.

Our results using industry-regions in the EU appear to corroborate results from other studies (referred to previously) in which measures of market potential have significant impacts on wages. There are, however, some specific features of the market potential variable we use that cause concerns.

First, the explanatory variable  $\widehat{\text{RMP}}$  is generated using coefficients estimated in another regression. Pagan (1984) shows how OLS standard errors understate true standard errors except in the case where  $b = 0$ , i.e. where RMP has no effect. Our focus is on the magnitude of  $b$ , and Pagan (1984) establishes that OLS coefficients are efficient estimators under fairly standard assumptions. He also shows that the OLS  $t$ -statistic can be used to test the null hypothesis of no effect of the generated variable.

Second, there is 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  $\text{RMP}_i$ .<sup>17</sup> This will be all the more problematic since the  $\phi_{ij}$  tend to be small relative to  $\phi_{ii}$ : In the case of extremely high inter-regional transport costs ( $\phi_{ij} = 0, \forall j \neq i$ ), only the local expenditure enters  $\text{RMP}_i$ . To the extent that workers relocate to regions offering higher real wages (as discussed in section 3), expenditure will be even more endogenous.

One way to deal with the direct feedback from  $w_i$  to  $E_i$  would be to calculate market potential by summing over  $j \neq i$ . This is the approach taken in several specifications estimated by Redding and Venables (2004) and also by Mion and Naticchioni (2005). The exclusion of the own-region contribution has the secondary benefit of obviating the need to specify a particular intra-regional distance  $d_{ii}$ . The area-based approximation we use can lead to problems of in-

<sup>16</sup> See Duranton and Monastiriotis (2002) for the UK, Combes, Duranton and Gobillon (2004) for France, and Mion and Naticchioni (2005) for Italy.

<sup>17</sup> This is problem for all wage equations although it is slightly smaller here 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.

terpretation. Essentially the local market potential is given by  $E_i/\sqrt{\text{AREA}_i}$ . As  $E_i$  must be closely related to total employment in region  $i$ , the local RMP contribution is very similar to a measure of employment density. Although including the local term is problematic, *excluding* it is a far-from-ideal approach. The main reason is that non-local RMP (NLRMP) treats regions as if they were infinitely far from themselves. This causes inaccurate inversions for the peripheral regions around the major capitals. For example in electronics in 1995, the use of NLRMP causes the region including London (South-East) to fall from a rank of 6th to 31st. Meanwhile, its neighbor (East Anglia) jumps from a rank of 20th to 3rd place. While it is useful to compare results of RMP with those obtained for NLRMP, we do not view NLRMP as the preferred specification.

A more promising approach to the simultaneity problem with RMP is to find a good instrument, that is i) a variable that is not influenced by wages or worker location choices but does have an impact on RMP, ii) a variable that does not enter the wage equation directly. Redding and Venables (2004) use distance to the nearest central place (Brussels, New York City, or Tokyo) as an instrument for the market potential of each country in the world. We first follow this precedent and take (inverse) distance to Brussels as an instrument for RMP (IV1). Although physical geography variables of this kind seem to meet the criteria above, the choice of the reference points raises an endogeneity issue. The three cities are chosen with the knowledge that they are high-wage centers. We prefer to use region  $i$  “centrality,” measured as  $\ln \sum_j d_{ij}^{-1}$ , as an instrument, because it does not explicitly impose a center. We consider two forms for this variable. In “EU centrality” (IV2) we sum across all NUTS1 regions and countries used in our trade estimation. As pointed out to us by a referee, the restriction to EU regions implicitly determines a center. Furthermore, the location and prosperity of the European Union was itself the outcome of an endogenous process. To respond to these concerns, we also construct an instrument we call “Global centrality” (IV3). For each region in our sample, we calculated the distance to the center of every inhabited 1 degree by 1 degree cell in the world population grid.<sup>18</sup> The sum of these inverse distances depends on almost entirely exogenous geographic features such as the location of bodies of water and uninhabitable climates (deserts, ice).

Table 3 displays the results of our investigation of the problems we have identified in the RMP variable. It reports results of pooled regressions (13 industries, 11 years, 57 regions) using fixed effects for industry-years and countries.<sup>19</sup> All specifications control for average years of education. The first row uses the RMP constructed as before. Estimates in this column are slightly smaller (.10

<sup>18</sup> Data provided at [www.na.unep.net/datasets/datalist.php3](http://www.na.unep.net/datasets/datalist.php3).

<sup>19</sup> Industry-level IV estimates had high standard errors and are not reported in order to save space.

Table 3  
Robustness of Market Potential effects to alternative specifications

	Measure or Instrument for Market Potential of region $i$	1% Sigf.	Coef.
(1)	$\widehat{\text{RMP}}_i = \sum_j \hat{\phi}_{ij}(y_j/y_J) \exp(\text{FM}_J)$	Yes	0.0963
(2)	Harris: $\text{HMP}_i = \sum_j E_j/d_{ij}$	Yes	0.1749
(3)	Non-local: $\text{NLRMP}_i = \sum_{j \neq i} \hat{\phi}_{ij}(y_j/y_J) \exp(\text{FM}_J)$	Yes	0.0785
(4)	IV1: Inverse distance to Brussels	Yes	0.0996
(5)	IV2: EU centrality $\sum_{j \in \text{EU}} d_{ij}^{-1}$	Yes	0.0790
(6)	IV3: Global centrality $\sum_j d_{ij}^{-1}$	Yes	0.0877

Note: Regressions on stacked data (13 industries, 11 years, 57 regions). All regressions include the region's average years of education, fixed effects for industry-year pairs and country fixed effects.

vs .12) than the average value obtained in the industry level regressions in Table 2.

The next row in Table 3 replaces RMP with the Harris (1954) form of market potential:  $\text{HMP}_i = \sum_j E_j/d_{ij}$ , where  $E$  represents regional expenditure in an industry. This variable does not require coefficients estimated from a previous regression, which accounts in part for its continued use in empirical work. We obtain a larger coefficient than with RMP and the root mean squared error (RMSE) of the regressions are approximately the same (.144 vs .145) It is somewhat discouraging that results from a reduced form proposed by geographers 50 years ago are so similar to the ones from the structural model. However, the Harris form does not retain the structural interpretation of the coefficient (as  $1/\sigma$ ) on log market potential.

Row 3 of Table 3 estimates the effect of log NLRMP, which differs from RMP only by excluding the own region. The change in specification leads to smaller estimated impacts of market potential. One interpretation is that full RMP is building in an urban density effect through the division by an area-based internal distance measure. A second interpretation is that the exclusion of the important contribution of the local market causes attenuation bias. Note that the (unreported) coefficient on education jumps from .12 to .19 in this specification.

Overall, the relevance of local density and of the reduced form of market potential make it impossible to rule out technological spillovers and human capital externalities as alternative explanations of regional wage differentials. As stated above, a more rigorous discriminating test—which goes beyond the ambitions of this paper—might involve first a separate estimation of the supply potential  $S_i$ , and then an assessment of its role on factors' income.

The final three rows consider instrumental variable (IV) estimations of the wage equation. The return to education in these regressions ranges between .12 and .13. Row 4 uses the inverse distance to Brussels (the equivalent of the Redding and Venables method) as an instrument for RMP, and shows that results are basically unchanged from OLS results in the first row. Centrality within the European Union is the IV in row 5. This knocks down the market potential elasticity to 0.0785, implying  $\sigma = 12.7$ . Row 6 uses a measure of global centrality as the IV. This most exogenous of the instruments considered actually pushes the impact of market potential back up towards the OLS results. Despite concerns about reverse causality, it seems that here—as in Redding and Venables (2004)—instrumentation using physical geography advantages does not eliminate the influence of market potential on wages.

One might be concerned about weakness of the instruments, considering how close their coefficients are from the original OLS estimate. The first-stage results of IV regressions (available upon request), are reassuring on this topic. The explanatory power of each of the instruments is strong, with a minimum  $t$ -statistic of 2.91 (for IV3), and a fairly good overall fit of those first regressions (a minimum within  $R^2$  of 0.565 again for IV3). The Fisher test that each of the three instruments would be irrelevant in the first-stage of the instrumentation (would not explain market potential variance) reveals values of 12.55, 30.98, and 8.45 respectively, which are above or around values usually considered to protect the econometrician against the weakness of instruments (see Frankel and Romer, 1999 or Alcalá and Ciccone, 2005 for applications to the productivity and trade literature).

All of the results shown up until now are based on the *cross-sectional* relationship between RMP and wages. We now consider the estimated dynamic equations for wage and employment changes in a region, respectively (15) and (16). These specifications allow for gradual responses in to deviations from the iso-profit equation.

The regressions reported in Table 4 control for education, year effects, and country effects. The standard errors are clustered around regions since multiple observations for the same region are unlikely to be independent. Column (1) of Table 4 shows—in descending order—estimates  $b' = \gamma b$ , the short-run elasticity of wages with respect to real market potential. The adjacent column shows the  $t$ -statistics for the hypothesis of no effect. Compared to the static estimates  $b$  shown in Table 2, the  $b'$  coefficients are smaller, as expected, and even negative for 3 industries. The average  $t$ -statistic is 2.22. To obtain the long run elasticity one must divide by the wage adjustment parameter  $\gamma$ , which equals minus the coefficient on the lagged wage. The rate of adjustment is estimated to be fairly slow.<sup>20</sup> Nevertheless, it appears statistically signifi-

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<sup>20</sup> Adjustment rates may be biased downwards due to serial correlation in the error

Table 4  
Dynamic wage and employment adjustment to deviations from the iso-profit curve

Industry	RMP (SR): $b'$		Wage adj.: $\gamma$		$\sigma$	Emp. adj.: $\eta$	
	coef.	$t$ -stat.	coef.	$t$	$\gamma/b'$	coef.	$t$
Machinery	0.088	2.28	0.51	2.36	5.75	0.05	1.18
Precision Instruments	0.040	2.71	0.10	2.77	2.49	0.07	1.27
Food, Drink, & Tobacco	0.038	4.60	0.22	4.67	5.85	0.01	0.08
Electronics	0.032	3.44	0.09	2.84	2.90	0.18	0.88
Motor Vehicles and Parts	0.027	4.65	0.26	6.74	9.64	0.08	1.61
Chemicals & Fibres	0.023	3.10	0.16	4.67	6.82	0.15	1.20
Non-metallic Mineral Products	0.018	5.06	0.14	6.36	7.88	-0.06	-1.55
Paper, Printing, & Publishing	0.016	2.65	0.16	3.32	9.95	0.06	2.26
Rubber and Plastics	0.010	3.39	0.11	3.86	10.48	0.10	2.66
Textiles	0.003	0.49	0.07	3.38	23.33	-0.11	-0.88
Metal-Primary	-0.003	-0.54	0.09	1.78	-	0.14	1.36
Clothing and Footwear	-0.005	-0.71	0.02	0.89	-	-0.01	-0.21
Office Machines	-0.081	-2.27	0.04	1.05	-	-0.09	-0.93
Average	0.020	2.22	0.15	3.44	8.51	0.04	0.69

cant in 10 out of 13 industries. For the average industry wages adjust to close 15% of the gap between actual and equilibrium wages each year. This implies a half-life of deviations given by  $\ln(1 - .15)/\ln(1/2) = 4.26$  years. Rather than report the long run elasticities, we instead invert to find the implied value of the structural parameter  $\sigma$  for each industry. It is reassuring that in 9 out of the 13 industries, these estimated  $\sigma$  are within the range that the literature has found in estimations and used in simulations.<sup>21</sup>

The results reported in the final two columns of Table 4 reveal a mixed and mainly insignificant pattern of employment adjustment to deviations from the static wage equation. There are just two industries exhibiting positive and significant (at the 5% level) employment adjustment. Negative adjustment occurs in a minority of cases but it is never statistically significant.

term  $u_{it}$  in equation (15).

<sup>21</sup> The most comparable study to this one is Breinlich (2005). Using income per capita (rather than industrial wages) and NUTS2 regions (instead of NUTS1), he estimates a  $\sigma$  of 6.7. Head and Ries (2001) provide a brief summary of other estimates.

Let us now summarize the regression results. 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 shown in Table 4 corroborate this hypothesis.

## 6 Conclusion

The Dixit-Stiglitz-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, although responsiveness differs substantially across industries. For the average industry cross-section, a 10% increase in RMP raises wages by 1.2%. Over time, the adjustment to differences between the actual and equilibrium wages occurs at a rate close to 15% per year on average, implying a half-life of deviations of about 4 years. Employment also seems to adjust but not in a consistently significant way.

The only alternative hypothesis to market potential that we have considered is that human capital variation drives regional wage variation. Despite data limitations, our results suggest an important role for both human capital and market potential. This concurs with other recent work. However, more than one model could predict a relationship between wages and a distance-discounted potential term. Hence, there is a need for empirical methods that discriminate between Krugman-type mechanisms and alternative models of spatial interactions.

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