Economic Geography within and between European Nations: The Role of Market Potential and Density across Space and Time

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Abstract

In explaining the uneven spatial distribution of economic activity, urban economics and new economic geography (NEG) dominate recent research in economics. A main difference between these two approaches is that NEG stresses the role of spatial linkages whereas urban economics does not do so. We estimate simple versions of these two views on economic geography and also establish if the relevance of spatial linkages varies across aggregation levels or time. For our sample of 14 European countries and 213 corresponding regions, we find that spatial linkages are more important at the country level and that its relevance varies across time.

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1 Introduction

In urban economics, cities or regions are like freely floating islands (Fujita and Mori, 2005) since spatial or "inter-city" interdependencies are typically not taken into account.[2] In new economic geography (NEG), the *inter*regional interdependencies are, however, at the heart of the analysis and this sets NEG apart from urban economics. This difference as to the understanding of the actual economic geography provides an opportunity to analyse the empirical relevance of these two views on economic geography (Combes, Duranton and Overman, 2005).

If the attractiveness of a region is best described by intraregional characteristics, this is evidence in favour of the urban economics' view on economic geography. If, in contrast, the interregional linkages are more relevant this provides evidence in favour of a view on economic geography like NEG that stresses spatial linkages between locations. Furthermore, the relevance of these two views could depend on the level of spatial aggregation or vary over time. Combes, Duranton, and Overman (2005) for instance argue that NEG is probably more relevant at the country level than at the regional or urban level. Data on different aggregation levels could thus help to reveal whether or not the explanatory power of the two approaches depends on the spatial aggregation level. The relevance of spatial linkages might also change over time, depending on policies or shocks that occur.

Using a data set for 14 European countries and a corresponding set of 213 (NUTSII) regions, we address the issues introduced above: the relevance of interregional vs intraregional economic geography, and the influence of spatial aggregation levels and the time period under consideration on these two views on economic geography. In doing so, we take the basic message of Leamer and Levinsohn (1995, p.1341) "estimate don't test" seriously. So, our paper is not meant as a test of urban economics versus NEG but rather we want to fund out how relevant spatial linkages actually are for our European case at hand. We also take their second message "don't treat theory too casually" seriously and hence explain how our two basic empirical specifications can be grounded upon economic theory.

In section 2 we explain the difference between urban economics and NEG in somewhat more detail and position our paper in the literature. In section 3 we

[2] See for instance the special issue of the Federal Reserve Bank of New York (2005) on urban dynamics in New York City that offers detailed information on urban aspects of New York at an impressively small scale.

introduce the two basic empirical specifications and indicate how they can be derived from NEG and urban economics. In section 4 we describe the data-set and present some descriptive statistics. Section 5 presents the main estimation results for the period 1975-2006, the period for which we have data for countries as well as NUTSII regions. In general, we find that spatial linkages or "between location" economic geography is more important at the country level than at the regional level. Section 6 presents additional estimation results for the 14 European countries for the period 1870-2006. Section 7 concludes.

2 Economic geography in urban economics and NEG

In their excellent survey of agglomeration theory, Ottaviano and Thisse (2004, p.2576) ask the question "where did we stand in 1990?", which is to say prior to the publication of the first NEG model by Krugman (1991). They observe that Krugman (1980) already incorporated (internal) increasing returns to scale and transport costs that together constitute the fundamental trade-off in spatial economics (Fujita and Thisse, 2002) and that together also give the foundation for the well-known *home market effect* in Krugman (1980). In Krugman (1991), the home market effect is combined with interregional factor (labor) mobility and thus endogenizes the spatial distribution of economic activity. Krugman (1991) and the subsequent NEG literature can in fact be seen as belonging to a much more extensive (and older) literature in regional economics or even economic geography at large, where spatial interdependencies are at the heart of the analysis. The performance of a region depends crucially on the developments in and characteristics of neighboring regions. Regions are therefore *not* "freely floating islands" in NEG (Fujita and Mori 2005, p. 395).[3] This non-trivial role of spatial linkages amounts to saying that it is above all "between location" economic geography that matters in (old and) NEG. A key prediction of NEG models is that *inter alia* factor prices (wages) are higher in regions with a large (real) market potential.[4] This prediction will be used in our empirical estimations.

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[3] For surveys of NEG see Baldwin et al. (2003), Combes, Mayer and Thisse. (2008), or Brakman, Garretsen and van Marrewijk (2009).

[4] A large market will attract firms and workers to the increasing returns sector; if labor supply from the constant returns sector is upward sloping (concave production function) economy wide increases of factor rewards are possible (see Head and Mayer, 2004 for a discussion).

A rather different view on the role of economic geography is offered by urban economics, where spatial or "inter-city" interdependencies are typically not taken into account.[5] Transport costs or distances between locations are not included in the analysis. Economic geography in the sense of spatial interdependencies *between* cities is at best implicitly taken into account like in Henderson's seminal model of urban systems (Henderson, 1974). In this model, cities specialize and trade with each other, but intercity distances do not matter and non-urban areas also play no role (Glaeser, 2008, ch. 3, Combes, Duranton and Overman, 2005). Apart from the well-known Marshallian scale economies, there is a whole range of scale economies that is called upon to explain the existence of cities and their variation in size (Rosenthal and Strange, 2004; Overman, Rice and Venables, 2008).[6] Compared to NEG, urban economics offers a more detailed analysis of location (city) specific agglomeration economies. This holds not only for positive but also for negative agglomeration (congestion) economies (see for an extensive survey Rosenthal and Strange, 2004 or Glaeser, 2008).

Despite their different stance on economic geography, the underlying NEG and urban economics models are analytically quite similar. In NEG models, economic geography can be decomposed into the economic geography of the home or own region and the economic geography of the relationship between the own region and the other regions (compare also the discussion of equations (1) and (3) in the next section). Given the theoretical "kinship" between the seminal urban economics and NEG model of Henderson (1974) and Krugman (1991) respectively, Combes, Duranton and Overman (2005) conclude that in the end it is an empirical question which model is applicable in which situation.[7] They argue that NEG is probably more relevant at a *larger spatial scale* where spatial interdependencies between locations are thought to be more important. Urban economics is thought to be more relevant at smaller spatial scales (regions or cities), where local (positive and negative) externalities are most important and between-city interactions and long distance relations are less important: "*we would argue that there is no inherent contradiction between the urban system approach and NEG: the latter is trying to explain broad*

[5] Note that this does not imply that regions do not sell or buy from other regions, only that costs or income are not dependent on the specific location of an 'island'.

[6] The standard analysis of the sources of (Marshallian) externalities is not without its problems, see Duranton and Puga (2004).

[7] See for a similar conclusion Combes et al (2006) and Overman, Rice and Venables (2008).

trends at large spatial scales while the former attempts to explain "spikes" of economic activity" (Combes, Duranton and Overman, 2005, p.330).

Empirical studies that systematically try to assess the relative importance of intraregional *vs* interregional economic geography are scarce. Typically, empirical studies focus on either interregional or spatial linkages like the NEG studies by Hanson (2005) or Redding and Venables (2004) or exclusively on intraregional or own-region variables as is the case in modern empirical urban economics (see Glaeser, 2008). There are some NEG studies that also include an urban economics variable like density (Breinlich, 2006), and there are also a few empirical urban economics papers that do likewise by taking spatial linkages into account (Ciccone (2002), Duranton and Overman (2005)). But there are to date just a handful of papers that give equal importance to both approaches to economic geography. Fingleton (2006) is an exception but he focuses on one spatial scale (UK regions) and on a relatively short time period only. Other recent important empirical studies that combine urban economics with (NEG) spatial linkages include Brülhart and Koenig (2006), Brülhart and Sbergami (2009), Eaton and Eckstein (1997) and Partridge et al (2008, 2009). Even though these studies differ in their empirical methodology and scope, they all convincingly show the importance of including both urban(ization) variables and spatial agglomeration variables.

Just like Fingleton (2006), our paper mainly differs from these studies because of our focus on the role of geographical scale and the time dimension. More specifically, we focus on two spatial scales (14 European countries for 1870-2006 and, from 1975 onwards, the corresponding NUTSII regions). One of the (justified) criticisms levied against NEG from, for instance "proper" economic geography (Martin, 1999, 2008), is that NEG models are scale invariant. We want to establish if indeed the relative strength of intraregional and interregional economic geography is scale-dependent. Are the spatial interdependencies emphasized by NEG indeed more relevant at the national level? Apart from the possibility of scale-dependency, we also want to find out if the strength of within and between region economic geography varies over time. Many of the empirical studies in urban economics or NEG (mainly) take a cross-section perspective, whereas spatial linkages may vary over time. One could for instance stipulate that spatial interdependencies become more important during periods of economic and political integration.

3 The wage equation and the use of density and market potential

The aim of this section is to briefly outline how our main empirical specifications can be based on urban economics or NEG models. We start with the urban economics approach and then concentrate on NEG. A simple model that is useful for our present purposes is conveniently summarized by Combes, Mayer and Thisse (2008, ch 11). Assume a profit maximizing firm with a Cobb-Douglas production function that uses labor and a (composite) of other inputs and that has all other markets as destination markets and maximizes profits. This firm pays the following wage[8]:

$$(1) \qquad w_r = \frac{\mu(1-\mu)^{(1-\mu)/\mu}}{n_r} \sum_{j \in n_r} s_j \left(\frac{p_j A_j}{q_j^{1-\mu}} \right)^{1/\mu},$$

where w_r = wage in region r; j = *firm j*; μ = share of labor in the production process; n_r = the number of firms in region r; s_j = labor productivity variable; p_j = price of good j; A_j = technology (Hicks-Neutral); q_j = price of (composite of) other inputs.

Equation (1) shows that wages in region r increase when the efficiency of labor s_j or the level of technology A_j increase in this region. Note that the overall impact of s_j and A_j, on wages in region r is a positive function of the number of firms j that are located in region r. This reflects *region specific*, positive agglomeration economies in region r. Also, an increased supply of intermediate production factors that results in lower intermediate product prices q_j allows for higher wages. The agglomeration of firms in region r also has its downside: more competition means a higher n_r and a lower p_j and this will result in lower wages. Firms in region r can sell their products to other regions, but the location of region r relative to other regions is not an issue, hence spatial linkages between regions r are absent, equation (1) only includes local, region-specific determinants of regional wages.

For empirical research, the main question is how to estimate equation (1). A straightforward procedure is as follows (again see also Combes, Mayer and Thisse, 2008, ch11). Taking logs of equation (1) gives:

$$(2) \qquad \ln w_r = \alpha_1 + \alpha_2 \ln Dens_r + \varepsilon_r,$$

where $\ln Dens_r = \ln \frac{1}{n_r} \sum_{j \in n_r} s_j \left(\frac{p_j A_j}{q_j^{1-\mu}} \right)^{1/\mu}$ and $Dens_r$ stands for the employment or population density in region r.

[8] See appendix A for the derivation of equation (1)

Apart from the potential impact of density, there are other variables that may be included as well. In a panel setting, the inclusion of region (city) fixed effects and time fixed effects captures the possible relevance of, respectively, cross-section and time-specific variation in regional wages. But just like in the case of a density measure, there may be other location-specific determinants of region wages that vary in the cross-section as well as the time dimension, like human capital or a region's economic specialization, that one may want to include in the estimation (see Overman, Rice and Venables 2008, eq. 8).[9] For our paper it is, however, imperative to note that equations (1) and (2) do not include variables that capture the spatial interdependencies between regions in the sense that somehow other regions have an impact on the wages in region *r*.

Ever since Harris (1954), market potential variables have been used in economic geography to capture the role of interregional spatial linkages. NEG provides a theoretical foundation for the use of market potential. In empirical applications Harris's simple market potential function is, however, still a good starting point as we will illustrate below. The equilibrium wage equation in NEG is the counterpart to wage equation (1) above. Equation (3) summarizes the by now well-known NEG wage equation[10]:

$$(3) \qquad \ln w_r = \frac{1}{\sigma}\ln RMP_r - \frac{1}{\sigma}\ln\left(\frac{a}{c}\right),$$

where $RMP_r = \sum_s \phi_{rs}\delta_s Y_s P_s^{\sigma-1}$, with $\phi_{rs} = \tau_{rs}^{-(\sigma-1)}$, a = constant, $c = \sigma^{-\sigma}/(\sigma-1)^{-(\sigma-1)}$; δ_s = the share of income spent on manufacturing goods in region *s*, Y_s = income in region *s;* P_s = manufacturing price index; τ_{rs} = the iceberg transportation costs between regions *r* and *s*; σ = elasticity of substitution between manufacturing varieties with $\sigma>1$

Equation (3) states that equilibrium wages in region *r* depend on *RMP* which stands for real market potential. This term captures the element of spatial linkages. Regions might be attractive because they represent a large market, reflected by $\delta_s Y_s$, but if it costly to trade with other regions, reflected by a low free-ness of trade, $\phi_{rs} = \tau_{rs}^{-(\sigma-1)}$, the market potential of region *r* is reduced. Together these two forces determine the nominal market potential of a region *r*. The inclusion of a price index *P* is responsible

[9] Ideally, one would like to have micro-data to estimate equation (2), see Combes, Duranton and Gobillon (2008).
[10] See appendix A for a derivation of equation (3).

for the ‘real’ in *RMP*. Our main concern is that equation (3) differs fundamentally from equation (1) because the location of a specific region is defined with respect to all other regions. The presence of spatial linkages (via the free-ness of trade) ensures that wages in region *r* (also) depend on the (real) income in other regions and the proximitiy of these regions.

Some difficulties that arise when using equation (3) for empirical purposes are, however, immediately clear. Trade or transport costs have to be approximated by a trade costs function because of the lack of (sufficient) transport data (Bosker and Garretsen, 2008). For regions, price indices are typically not available. Many estimates of NEG wage equations try to fix these and other problems (see Combes and Overman, 2004, Head and Mayer, 2004, Combes, Mayer and Thisse, 2008, ch. 12, or Brakman, Garretsen, and Van Marrewijk, 2009, ch. 5 for a survey of these attempts). Just like in the case of equation (1), when estimating equation (3) one should include other explanatory variables as well. Apart from time and region fixed effects, human capital and density(!) have for instance been included (Breinlich, 2006, Hering and Poncet, 2006).[11] As a first pass (and driven by data availability, see section 4), we reformulate equation (3) in terms of Harris’s simple market potential, where we proxy *RMP* from equation (3) by distance-weighted real income *MP*:

(4) $$\ln w_r = \beta_1 + \beta_2 \ln MP_r + \varepsilon_r \text{, with } MP_r = \sum_s \frac{\delta_s Y_s}{d_{rs}} \text{ and } d_{rs} = 1/\phi_{rs} .$$

Note finally that according to the model used to arrive at equation (3), (*R*)*MP* should include the own region’s income. In order to distinguish own region effects from foreign region effects, we distinguish between *domestic* and *foreign* MP where foreign *MP* excludes the own region. This provides the clearest contrast with wage equation (2).

4 Data set and summary statistics

We examine (changes over time) in the degree of spatial linkages at two different levels of aggregation within Europe. In doing so, we decided to restrict our sample to 14 European countries for the period 1870-2006 and to (if applicable) the corresponding 213 NUTSII regions (NUTS data are only available from 1975 onwards). The main data source for the country data is Maddison (2008). For the

[11] Density can be looked upon in terms of equation (3) as controlling for the fact that technology differs across regions.

regions we use data from Eurostat and Cambridge Econometrics. Our choice to cover both countries and regions and to do so for a rather long time-period has drawbacks as well. The main drawback is lack of (sufficient) data for some of the (control) variables that one might want to include, like (regional) price indices or human capital. In addition, regional data for the EU NUTSII regions only exist from the mid-1970s onwards. Similarly, and following for instance Redding and Venables (2004), we lack sufficient data on wages and therefore use GDP per capita instead.

Using the data set of Maddison (2008), we selected 14 countries in Europe for which annual data on income (GDP) and population (POP) are available for the period 1870-2006, see Table 1 below. The 14 countries are Austria, Belgium, Denmark, Finland, France, Germany, Italy, The Netherlands, Norway, Sweden, Switzerland, UK, Portugal and Spain.

Table 1 European countries; summary statistics, 1870-2006

	ln(for mar pot)	ln(gdp/cap)	ln(pop dens)	ln(urb pop dens)
Mean	4.97	8.52	4.25	3.42
St. error	0.023	0.019	0.025	0.033
Median	4.79	8.36	4.50	3.67
Kurtosis	-0.92	-1.09	-0.48	-0.16
Skewness	0.28	0.21	-0.78	-0.68
Minimum	2.91	6.84	1.65	-0.53
Maximum	7.37	10.24	5.98	5.76
Count	1,918	1,918	1,918	1,918

Correlation coefficients

	ln(for mar pot)	ln(gdp/cap)	ln(pop dens)	ln(urb pop dens)
1	1.000			
2	0.944	1.000		
3	0.454	0.326	1.000	
4	0.657	0.564	0.943	1.000

For mar pot = foreign market potential, see text for definition; gdp/cap = gdp per capita (1990, GK $); pop dens = population density (people/km^2); urb pop dens = urban population density (urban population/km^2).

Our main explanatory variables are population density (people/km^2) and foreign market potential. The dependent variable is GDP per capita. With equation (4) in mind, the foreign market potential (FMP) of country r is defined as $FMP_r = \sum_{s \neq r} \frac{Y_s}{d_{rs}}$ where Y_s is the GDP of country s and d_{rs} is the geodesic distance between the capital cities of countries r and s. We refer to this as *foreign* market potential because the GDP of country r is not included, see the end of section 3. Our main interest in Table 1 are the correlation coefficients. GDP per capita and foreign market potential have a strong positive correlation. The correlation between GDP per capita and density is, although positive, much weaker. The correlation coefficients between foreign market potential and the density measures also show that foreign market potential and density are clearly not perfectly correlated, which is important for the estimations (see below), where in line with the underlying theory (see sections 2 and 3) these 2 variables will be looked upon as measuring different aspects of economic geography.

Table 2 213 European regions; summary statistics, 1975-2006

	ln(for mar pot)	ln(gdp/cap)	ln(pop dens)	ln(work pop dens)
Mean	12.80	9.53	4.95	4.52
St. error	0.007	0.005	0.016	0.016
Median	12.88	9.59	4.95	4.49
Kurtosis	-0.47	-0.21	0.92	0.93
Skewness	-0.48	-0.34	0.13	0.10
Minimum	10.94	7.89	1.18	0.61
Maximum	13.88	10.78	9.09	8.73
Count	6,816	6,816	6,816	6,816

correlation coefficients

	ln(for mar pot)	ln(gdp/cap)	ln(pop dens)	ln(work pop dens)
1	1.000			
2	0.636	1.000		
3	0.472	0.212	1.000	
4	0.476	0.215	0.999	1.000

For mar pot = foreign market potential; gdp/cap = income per capita (constant 1995 euros); pop dens = population density (people/km^2); work pop dens = working population density (working population/km^2); for definitions see also Table 1.

Table 2 shows the summary statistics for our data set on 213 European regions. The sample period is 1975-2006. The bottom part of Table 2 indicates that for the European regions there is a positive correlation between GDP per capita and foreign market potential, but it is lower than comparable correlations with respect to countries. The same is true for the correlation between GDP per capita and density, here the correlation coefficient (0.21) is actually quite low. In line with the case of the 14 countries, although there is a positive correlation between foreign market potential and density, the correlation coefficient (approximately 0.5) indicates a far from perfect correlation.[12]

5 Estimation results: comparing European regions and nations

In this section we present our main estimation results. We thus basically set out to estimate the "density" equation (2) and the "market potential" equation (4) for our sample of 213 European regions (section 5.1) and 14 European countries (section 5.2). In doing so, we are not only interested in the possible different outcomes for these two spatial scales but also in the possible changes in the relevance of density or market potential over time. Having said this, the focus in this section is on the comparison for the period 1975-2006 on the relevance of market potential and density at two different spatial scales or aggregation levels, regions *vs* countries. Our data set for regions only starts in 1975 (first year with NUTS II data for EU regions). For the group of 14 countries, we can go back much further in time and this will be the topic of section 6.

5.1 Regional GDP, density and market potential

Table 3 shows the panel estimation results for GDP per capita for our full sample of EU regions for 1975-2006. We include region and time fixed effects to deal with non-observed variables that do not change over time or are constant over regions, but may affect income per capita. It would be remarkable if only the variables that are of interest in this paper would explain the bulk of GDP per capita. The inclusion of time and region fixed effects increases the explanatory power of the model. The results confirm that there is a strong positive correlation between foreign market potential and income per capita for our sample period 1975-2006. Recall, that foreign market

[12] Note that the sample period is different from Table 1. This is due to data availability: NUTS data on European regions are only available from 1975 onwards.

potential does not include the own-region's income. As explained in section 3, we think that the choice for foreign market potential best captures the idea of within-region economic geography against between–region economic geography. Density is population density.[13]

The first two columns in Table 3 show that, in isolation, there is a positive correlation between foreign market potential and GDP per capita on the one hand and between density and GDP per capita on the other hand. Foreign market potential and density contribute positively to GDP per capita. This is also true when both variables are simultaneously included, see column 3. The main conclusion from Table 3 is that both market potential and density have a significant positive impact on regional GDP per capita and that the impact of market potential seems relatively stronger. This suggests that at the regional level both views on economic geography matter. As to the economic significance of the baseline case (last column of Table 3): the average contribution of foreign market potential to explaining GDP per capita, calculated as the estimated coefficient multiplied by the mean of foreign market potential divided by the mean of GDP per capita (see Feenstra, 2004, p. 123), is 34.3 per cent. Similarly, the average contribution of population density is only 4.2 per cent. Thus at the regional level foreign market potential is economically more important.[14]

Table 3 Income per capita, market potential, and density; European regions
Dependent variable is ln(GDP per capita), panel estimates (t-statistics), 1975-2006

Ln(foreign market potential)	0.321 (36.7)		0.255 (23.4)
Ln(population density)		0.090 (37.9)	0.081 (34.7)
Time fixed effects	yes	yes	yes
Region fixed effects	yes	yes	yes
$\overline{R}^2$	0.782	0.800	0.815
F-statistic	521	580	625
Observations	6,816	6,816	6,816

[13] We also used working population density as an alternative in this and subsequent estimates, as well as foreign market potential defined on population instead of GDP. The results are similar, and available upon request.

[14] Foreign market potential is even more important at the country level since population density is either not significant or of the wrong sign, see below.

The findings in Table 3 are subject to at least two important caveats. First, both density and market potential are potentially endogenous. To correct for this, we also performed IV estimations with a region's *area* and *distance to Brussels* as instruments. The instruments are significant and have the correct sign and the IV estimations lead to similar conclusions (see Appendix B, Table 1B for these IV results). Second, we may overestimate the role of market potential or density because due to limited data availability we did not include other possible time and cross-section *varying* independent regional variables (like human capital), see also our discussion of equation (2) in section 3 and Overman, Rice and Venables (2008). Variables like human capital or interregional trade are not or not sufficiently available for our sample period 1975-2006 for the NUTSII regions (see also Breinlich, 2006).[15]

Table 4 GDP per capita, market potential, and density; European regions
Dependent variable is ln(GDP per capita), t-stats in parentheses; 14-year moving observations; time and region fixed effects included

end year 14-year period	1988	1990	1992	1994	1996
Ln(foreign market potential)	0.237	0.239	0.237	0.234	0.237
	(14.0)	(14.3)	(14.2)	(14.1)	(14.5)
Ln(population density)	0.077	0.078	0.079	0.080	0.081
	(21.4)	(21.8)	(22.0)	(22.5)	(23.1)
$\overline{R}^2$	0.804	0.803	0.803	0.802	0.802
F-statistic	391	391	389	389	387
Observations	2769	2769	2769	2769	2769
end year 14-year period	1998	2000	2002	2004	2006
Ln(foreign market potential)	0.244	0.252	0.256	0.258	0.263
	(15.1)	(15.5)	(15.7)	(15.7)	(15.9)
Ln(population density)	0.082	0.082	0.082	0.084	0.086
	(23.6)	(23.6)	(23.6)	(24.1)	(24.4)
$\overline{R}^2$	0.800	0.798	0.794	0.792	0.787
F-statistic	384	377	369	364	353
Observations	2769	2769	2769	2769	2769

Table 4 repeats the exercise of Table 3, but for different time periods. Since we are also interested in the development of the market potential and density variable over time, Table 4 gives for 14-year periods the estimation results for the same specification as in the third column of Table 3 (starting with the period 1975-1988;

[15] For the NUTSII regions Eurostat provides education measures only from the mid-1990s onwards.

the years in the column heading of Table 4 specify the end year of each of the 14-year periods). Both the value of the foreign market potential coefficient and density coefficient are stable over time (see also Figure 1 below).

All in all, the conclusion must be that for our set of 213 European regions both the market potential coefficient and the density coefficient have a positive impact on income per capita and that this impact is relatively constant across the sample period 1975-2006 with the size of the estimated market potential elasticity being consistently larger than the density elasticity.

5.2 Country GDP, density and market potential

Instead of regions, we now look at the corresponding set of 14 European *countries* for the same sample period 1975-2006. Table 5a gives the results of the panel estimations with time and country fixed effects. As in case of the European regions, we also performed IV estimations with a country's *area* and *distance to Brussels* as instruments. Additionally , we also use *GDP in the year 1000* as an instrument. The instruments are significant and have the correct sign and the IV estimates lead to similar conclusions (see Appendix B, Table 2B for these IV results).

Education is included as a control variable to capture the possible impact of human capital on GDP per capita. It is measured as the average years of schooling for the population over the age of 15 using the Barro Lee data.[16] Education contributes positively to GDP per capita. Our main interest is, however, with the relevance of density and market potential for GDP per capita at the country level. With respect to density we do not only look at population density but also at *urban* population density (defined as urban population per km^2), based on data from McCann and Acs (2008) and the World Development Indicators online.[17] The reason for this is that at the country level (as opposed to the regional or city level) a low population density can still go along with the population being concentrated in a few regions or cities to the

[16] This data is available on the World Bank website, see edstats – additional resources – archived data. The 5-year interval observations are interpolated for our purposes.

[17] Urban population density calculations are based on data from McCann and Acs (2008) for the years 1800 and 1890 (for Denmark, Norway, Sweden and Finland the Scandinavian data are used, for Austria the German data are used, and for Great Britain the England & Wales data are used) and World Bank WDI online data for the years 1960-2007. It is an indication only as intermediate years are interpolated, but it does capture the basic differences between countries in the 19th and 20th century urbanization process.

effect that economic interactions still mainly take place in areas with a high population density.

Table 5a GDP per capita, market potential, and density, European countries
Dependent variable is ln(income per capita), panel estimates (t-statistics), 1975-2006

Ln(for. market potential)	0.521 (3.4)			0.496 (3.4)	0.539 (3.5)
Ln(population density)		-0.821 (-5.5)		-0.806 (-5.5)	
Ln(urban population density)			-0.050 (-1.0)		-0.066 (-1.3)
Average years education	0.050 (9.0)	0.054 (10.2)	0.053 (9.7)	0.051 (9.6)	0.050 (9.1)
Time fixed effects	yes	yes	yes	yes	yes
Country fixed effects	yes	yes	yes	yes	yes
$\overline{R}^2$	0.966	0.967	0.965	0.968	0.966
F-statistic	424	443	413	439	411
Observations	448	448	448	448	448

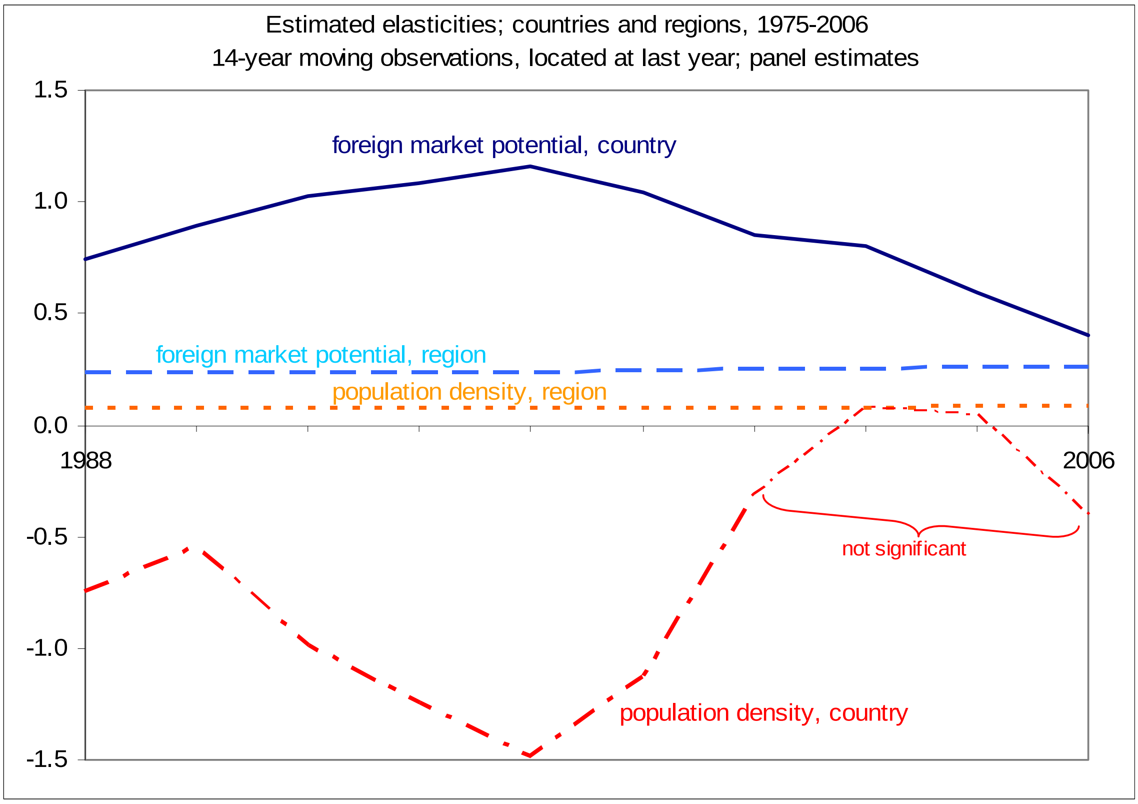
***b.** different sub-periods, country**

End year 14-year period	1988	1990	1992	1994	1996
Ln(foreign market potential)	0.740 (5.0)	0.893 (5.4)	1.023 (5.6)	1.088 (5.9)	1.163 (5.6)
Ln(population density)	-0.740 (-3.4)	-0.542 (-2.3)	-0.985 (-3.9)	-1.243 (-4.5)	-1.487 (-5.0)
$\overline{R}^2$	0.988	0.987	0.982	0.976	0.970
F-statistic	682	607	450	333	267
Observations	182	182	182	182	182
end year 14-year period	1998	2000	2002	2004	2006
Ln(foreign market potential)	1.044 (4.8)	0.850 (4.0)	0.805 (4.0)	0.594 (3.2)	0.403 (2.4)
Ln(population density)	-1.128 (-3.4)	-0.309 (-0.8)	0.082 (0.2)	0.045 (0.1)	-0.404 (-1.2)
$\overline{R}^2$	0.965	0.964	0.970	0.972	0.973
F-statistic	228	223	265	286	297
Observations	182	182	182	182	182

*Time and country fixed effects are included as well as avg. years of education

For both measures of density shown in Table 5a, the impact on GDP is either not significant (urban population density) or significantly negative (population density). This is a main difference with the estimation results at the regional level in Table 3 and this result also holds when we use alternative measures, such as market potential in terms of population (instead of GDP).[18] Again panel estimates are preferred as these allow us to incorporate country- and time fixed effects.

*Figure 1 Estimated elasticities; countries and regions, panel estimates, 1975-2006**



*Time and country fixed effects are included as well as average years of schooling.

As a mirror image to Table 4, Table 5b shows the results for the 14 European countries for the sub-samples of 14 year periods (the years in the heading of the columns refers to the last year in each 14 year period). In table 5b the market potential coefficient is always significantly positive and steadily increasing until 1996 and decreases afterwards, whereas density is much more volatile and not always significant. This is thus a clear difference compared to the similar regional estimations. Figure 1 shows the development over time of estimated coefficients

[18] Note that the R^2 is rather high which, given the long time period involved, might be due to a positive time trend in the variables concerned. Panel estimates in first differences – implying the inclusion of time fixed effects only - confirm the panel estimates described in the main text, see Table 3B in appendix B.

(interpolation connects the point estimates) for both foreign market potential and population density. The figure summarizes not only the main findings for the period 1975-2006 at the country level with respect to the (relative) importance of market potential and population density but does the same for the region level (using the regional estimations from Table 4). Bear in mind from the discussion in sections 2 and 3 that foreign market potential is our approximation of the role of economic geography in the sense of spatial interdependencies between locations, whereas (population) density does the same for the role of the economic geography of the location itself.

Based on Figure 1, the following conclusions can be reached. First, market potential has a significantly positive impact on GDP per capita at both the country and regional level, but consistently more so at the country level, although the difference becomes smaller over time. Second, population density consistently has a positive impact on GDP per capita at the regional level, but this is no longer true at the country level. These findings, as illustrated by Figure 1, thus seem to indicate that spatial interdependencies (*in casu* market potential) matter more on a higher level of spatial aggregation (confirming the suggestions made by, for instance, Combes, Duranton and Overman, 2005, see section 2) whereas location-specific economic geography (*in casu* (urban) population density) matters primarily at a lower level of spatial aggregation.

As an illustration that our specification with country- and time fixed effects and the inclusion of foreign market potential adequately deals with spatial autocorrelation issues, Figure 2 provides the evolution over time of Moran's I of the estimation errors associated with the baseline estimations (column 3 in Table 3 and column 4 in Table 5a).[19] This simple measure of spatial autocorrelation is low and never statistically significant.[20]

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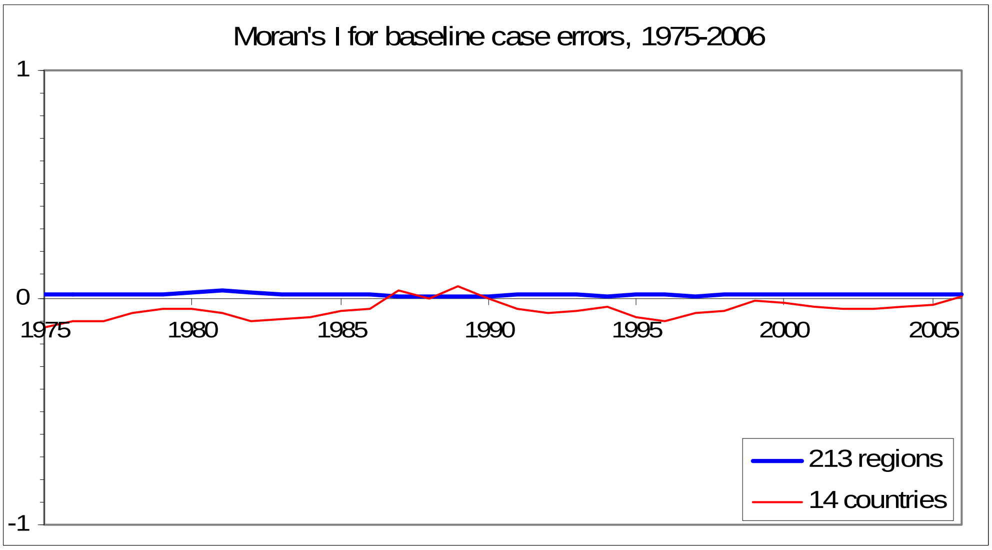
[19] Moran's I is defined as: $I = \frac{N}{\sum_r \sum_s w_{rs}} \frac{\sum_r \sum_s w_{rs} z_r z_s}{\sum_r z_r^2}$, where r and s are region-indices; w_{rs} is a measure of contiguity of regions r en s (our's is proportional to the inverse of the distance between them); and z_r is a measure of relative economic activity. Let x_r be some measure of economic activity in region r, where we use (i) ln(gdp per capita), (ii) growth rate gdp per capita, or (iii) gdp/km^2, then the measure of relative economic activity in region r used is: $z_r = x_r - \bar{x}$.

[20] The Moran's I for the country errors fluctuates more than the one for the region errors as it is based on fewer observations. We also calculated the correlation coefficients for the whole period per spatial country and region pairing and graphed this relative to the log of their bilateral distances to find no

Figure 2 Moran's I for baseline case error terms



Apart from the level of spatial aggregation, we are also interested in the behavior of our two between-location and within-location economic variables, market potential and (population) density, over time. The sample period used so far, 1975-2006, thus allows us to do so for a 30 year period. For countries, we can, however, go back much further in time. This is the topic of the next section.

6 Market potential and density at the country level 1870-2006.

Table 6 gives the panel estimates for the 14 European countries for the whole sample period 1870-2006 (apart from the sample period, the specification is similar to the one underlying Table 5a). Again, we find that the market potential coefficient is significantly positive and, as opposed to Table 5a, that the density coefficient is also significantly positive for this longer sample period.[21] In line with our discussion of Table 5a, at the country level we also replaced population density with *urban* population density, and also in that case the market potential and density coefficient remain significantly positive (see third column Table 6).[22]

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remaining spatial dimension of the error terms (a meta regression of these data – which is available upon request - confirmed this).

[21] As in the case of European countries for the period 1975-2006, we also performed IV estimations with a country's *area*, *distance to Brussels* and *GDP in the year 1000*, as instruments. The instruments are significant and have the correct sign and the IV estimates lead to similar conclusions (results are available upon request).

[22] Urbanization data are from McCann and Acs (2008) for the initial period and World Development Indicators from 1960 onwards; the period 1870-1959 is based on interpolations of the percent of urban

Table 6 GDP per capita, market potential, and density; 14 countries, 1870-2006
Dependent variable is ln(GDP per capita), panel estimates (t-statistics)

Ln(for. market pot. Gdp)	0.405 (5.8)	0.353 (5.0)		0.338 (5.5)
Ln(population density)	0.242 (6.3)		0.216 (5.6)	
Ln(urban population density)				0.392 (25.4)
Time fixed effects	Yes	yes	yes	Yes
Country fixed effects	Yes	yes	yes	Yes
$\overline{R}^2$	0.964	0.963	0.963	0.973
F-statistic	1,227	1,231	1,235	1,665
Observations	1,918	1,918	1,918	1,918

Note that the period 1870-2006 includes the economic crisis of the 1930s, two world wars as well as 2 periods (following WWI and WWII) of limited international trade and factor mobility. Given these and other large shocks, it is instructive to take a closer look at separate sub-periods and maybe not focus too much on the estimation results for the whole (rather heterogeneous) sample period. Table 7 and the corresponding Figure 3 below show the development of both foreign market potential and density elasticities for sub-sample estimations with 32-year sub-periods.

The foreign market potential is positive except in the inter-bellum and the period including WWII, which is also the period that includes the Great Depression and protectionist measures that went hand in hand with the economic downturn. The slow return to more liberalized trade after WWII war is reflected in the foreign market potential variable that is insignificant in the mid-period of 1870-2006, but slowly becomes positive and significant when 32 year period estimates fully start to cover the post-WWII world (see estimation result for 32-year period ending in 1976 in Table 7).

population for missing data; in this period for Sweden, Denmark, Norway, and Finland the Scandinavia data are used, for Great Britain the England & Wales data, and for Austria the German data.

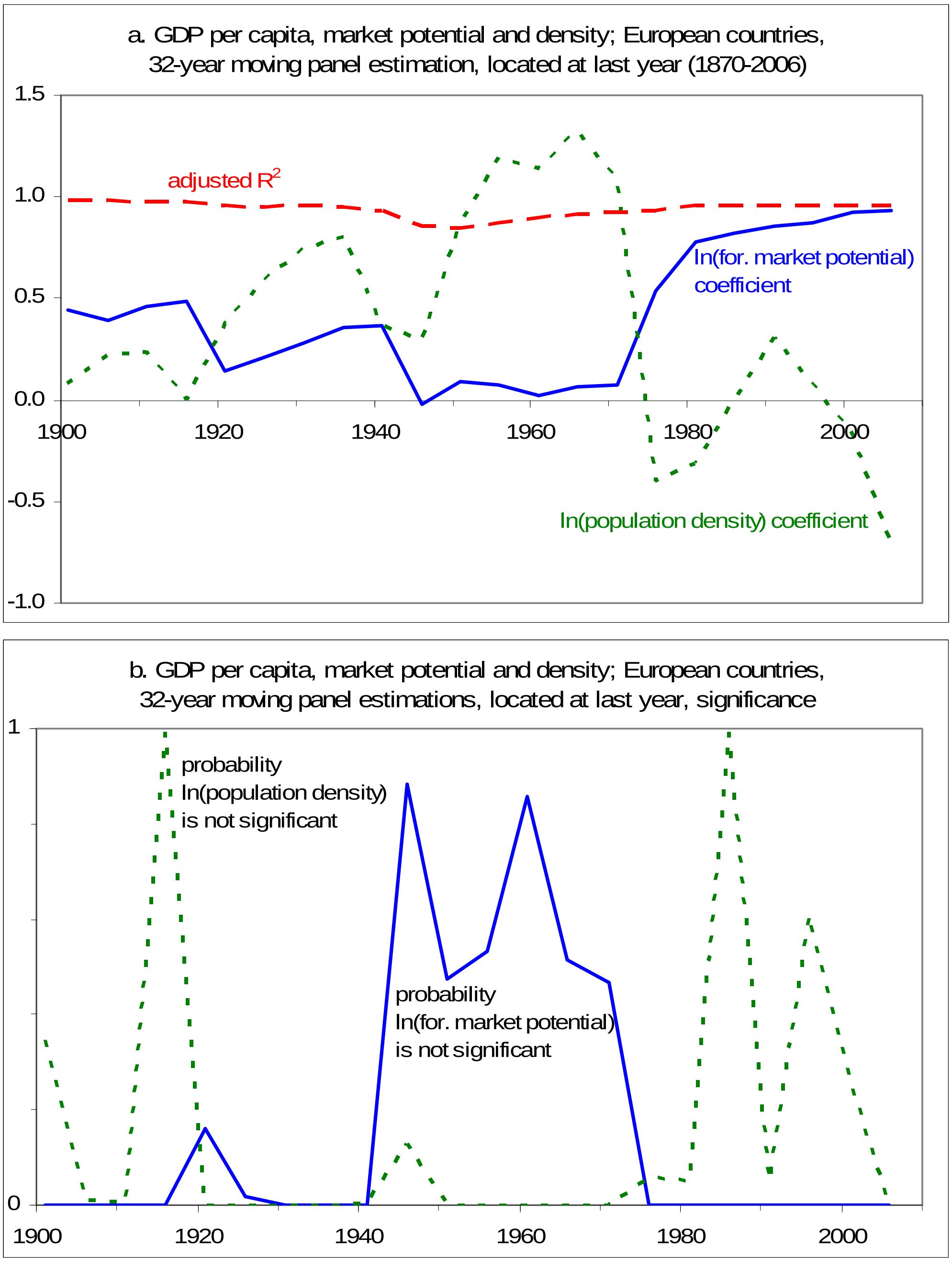
Table 7 GDP per capita, market potential, and density, 14 countries, 1870-2006

Dependent variable is ln(GDP per capita), t-statistics in parentheses

Panel estimates with time and country fixed effects

end year 32-year period	1901	1906	1911	1916	1921	1926
Ln(foreign market potential)	0.444	0.389	0.456	0.482	0.139	0.209
	(5.9)	(4.9)	(5.8)	(5.7)	(1.4)	(2.3)
Ln(population density)	0.082	0.219	0.235	-0.001	0.370	0.593
	(0.9)	(2.6)	(2.7)	(0.0)	(3.4)	(5.6)
$\overline{R}^2$	0.981	0.982	0.980	0.975	0.955	0.952
F-statistic	1,089	1,148	1,028	825	457	426
Observations	448	448	448	448	448	448
end year 32-year period	1931	1936	1941	1946	1951	1956
Ln(foreign market potential)	0.280	0.353	0.370	-0.019	0.088	0.071
	(3.4)	(4.1)	(3.9)	(-0.1)	(0.7)	(0.6)
Ln(population density)	0.748	0.802	0.367	0.301	0.876	1.193
	(7.5)	(7.7)	(2.9)	(1.5)	(4.0)	(5.7)
$\overline{R}^2$	0.956	0.951	0.930	0.859	0.847	0.872
F-statistic	465	415	284	131	119	146
Observations	448	448	448	448	448	448
end year 32-year period	1961	1966	1971	1976	1981	1986
Ln(foreign market potential)	0.019	0.062	0.072	0.539	0.782	0.823
	(0.2)	(0.7)	(0.7)	(5.8)	(10.6)	(11.1)
Ln(population density)	1.137	1.324	1.082	-0.398	-0.317	-0.002
	(5.6)	(6.7)	(5.2)	(-1.9)	(-2.0)	(0.0)
$\overline{R}^2$	0.899	0.919	0.923	0.936	0.962	0.962
F-statistic	191	244	255	312	534	541
Observations	448	448	448	448	448	448
end year 32-year period	1991	1996	2001	2006		All
Ln(foreign market potential)	0.854	0.875	0.926	0.937		0.405
	(12.4)	(12.4)	(13.0)	(12.6)		(5.8)
Ln(population density)	0.306	0.078	-0.172	-0.720		0.242
	(2.0)	(0.5)	(-1.1)	(-4.5)		(6.3)
$\overline{R}^2$	0.961	0.960	0.958	0.962		0.964
F-statistic	523	506	488	535		1,227
Observations	448	448	448	448		1,918

Figure 3 Estimated elasticities, countries, 1870-2006



The development over time is most readily seen from Figure 3. In this sense the foreign market potential variable seems to have a close relation with the general trend of globalization: the first wave of globalization ending around WW I and the second wave staring after WW II. This leads to the conclusion that the more recent period and the period ending in 1914 are alike in this sense. The mid-period seems to be the exception. When it comes to the significance of density, the estimation results in Table 7 display a much more erratic picture. As Figure 3b shows, density is mostly (but not always) significant and with the expected positive sign for the density coefficient in the period before and just after WWII but from thereon the density coefficient, in line with Table 5b and Figure 1, largely becomes insignificant.

7. Conclusions

Two approaches dominate recent research in economics on the uneven spatial distribution of economic activity: urban economics and new economic geography (NEG). A main difference between the two approaches is that urban economics neglects spatial interdependencies between regions whereas NEG stresses the relevance of spatial linkages between regions. There is not much systematic evidence yet on the relevance of these (complementary) views on the role of economic geography for different aggregation levels and time periods. This paper tries to fill this gap. In particular, for our data set with 14 European countries and 213 regions we investigate whether the impact on GDP per capita of our two approximations of the within-location and between-location geography view (market potential and density, respectively) depends on the level of spatial aggregation (country vs region) or varies over time. By and large, we find that market potential is more relevant at the country level, whereas density is more relevant at the regional level. Our findings support the idea that spatial interdependencies are more relevant at higher levels of spatial aggregation.

Appendix A Derivation of wage equations (1) and (3)

Derivation of equation (1)

The set-up is straightforward. Consider a firm *j* in region *r* that uses labor *l* and a (composite) input *k* in its production process to produce *y*:

$y_j = A_j (s_j l_j)^{\mu} k_j^{1-\mu}$; where A_j = technology (Hicks-Neutral); μ = share of labor in the production process; s_j = labor productivity variable

The profits of this firm, that exports to all regions *s*, are:

$$\pi_j = \sum_s p_{js} y_{js} - w_j l_j - q_j k_j = p_j y_j - w_j l_j - q_j k_j \text{, where } p_j = \sum_s p_{js} \frac{y_{js}}{y_j}$$

where w_r = wage in region *r*; p_j = price of good *j*; q_j = price of (composite of) other inputs. The first order conditions are:

$$w_j = \mu p_j A_j s_j^{\mu} \left(\frac{k_j}{l_j} \right)^{1-\mu}, \quad q_j = (1-\mu) p_j A_j s_j^{\mu} \left(\frac{k_j}{l_j} \right)^{-\mu}$$

Substituting the second equation into the first gives the (individual) firm wage equation:

$$w_j = \mu (1-\mu)^{(1-\mu)/\mu} s_j \left(\frac{p_j A_j}{q_j^{1-\mu}} \right)^{1-\mu}$$

Summing over all firms n_r in region *r* gives equation (1) in the text:

$$\text{(1)} \qquad w_r = \frac{\mu (1-\mu)^{(1-\mu)/\mu}}{n_r} \sum_{j \in n_r} s_j \left(\frac{p_j A_j}{q_j^{1-\mu}} \right)^{1-\mu}$$

Derivation of equation (3)

It is by now well-known that operating profits of a firm in region *r* operating in *s* – needed to cover the fixed costs of production - in a monopolistic competition setting can be formulated as follows:

$$\pi_{rs} = (p_r - mc_r) \tau_{rs} x_{rs} = mc_r \frac{\tau_{rs} x_{rs}}{\sigma - 1},$$

where p_r = is the mill-price of the product of a firm located in *r*; mc_r = marginal costs of this firm; τ_{rs} = the iceberg transportation costs between regions *r* and *s*; x_{rs} = the quantity that a firm located in *r* sells in *s* (it is multiplied by τ_{rs}; because a part of the product melts during transportation); σ = elasticity of substitution between varieties. The second equality follows from mark-up pricing over *mc*.

Assuming a CES-utility function, utility maximization gives:

$x_{rs} = (p_r \tau_{rs})^{-\sigma} \delta_s Y_s P_s^{\sigma-1}$, where $P_s = \left(\sum_r n_r (p_r \tau_{rs})^{-(\sigma-1)} \right)^{-1/(\sigma-1)}$, and δ_s = the share of the good in income of *s*.

Total profits – including fixed costs, F_r – can be derived as the sum over profits in all destination regions. Using the equations above and the definition of operating profits, total profits are:

$$\Pi_r = \sum_s \pi_{rs} - F_r = \sigma^{-\sigma} / (\sigma - 1)^{-(\sigma-1)} mc_r^{-(\sigma-1)} RMP_r - F_r,$$

where $RMP_r = \sum_s \phi_{rs} \delta_s Y_s^{\sigma-1} P_s^{\sigma-1}$

Assuming zero total profits we have, after rewriting:

$$mc_r = \left(\frac{\sigma^{-\sigma} / (\sigma-1)^{-(\sigma-1)} RMP_r}{F_r} \right)^{1/(\sigma-1)}$$

We are now very close to a wage equation comparable to equation (1); we only have to model marginal costs. We can for example assume that the production process uses only labor, that is, marginal costs are for example, $mc_r = aw_r^\alpha$, substituting this in the equation above gives equation (3) in the main text:[23]

$$\ln w_r = \frac{1}{\sigma} \ln RMP_r - \frac{1}{\sigma} \ln\left(\frac{a}{c}\right), \text{ where } c = \sigma^{-\sigma} / (\sigma-1)^{-(\sigma-1)}$$

Appendix B Sensitivity analyses

Table 1B GDP per capita, market potential, and density, European regions
Dependent variable is ln(income per capita), t-statistics in parentheses, 1975-2006

Two stage least squares; area and ln distance to Brussels as instrument			
Ln(for. Market potential)	0.498 (30.6)		0.400 (18.0)
Ln(population density)		0.126 (27.3)	0.040 (6.0)
Time fixed effects	yes	yes	Yes
Region fixed effects	yes	yes	yes
$\overline{R}^2$	0.774	0.793	0.803
F-statistic	508	547	571
Observations	6,816	6,816	6,816

First stage results

Dependent variable	Ln(population density)	ln(for. market pot. gdp)
ln(distance to Brussels)	-0.598 (-21.4)	-0.389 (-80.7)
area*	-27.10 (-40.9)	-1.86 (-16.3)
Time fixed effects	yes	yes
Country fixed effects	yes	yes
$\overline{R}^2$	0.567	0.929
F-statistic	187	1,867
Observations	6,816	6,816

* area coefficient × one million

Note that the instruments are significant and have the expected negative sign

[23] Using other inputs is straightforward and adds other costs factors.

Table 2B Income per capita, market potential, and density, European countries
Dependent variable is ln(income per capita), t-statistics in parentheses, 1975-2006

Two stage least squares; area, ln distance to Brussels, and ln GDP in the year 1000 as instrument

ln(for. market potential)	0.161 (7.6)		0.413 (15.2)
ln(population density)		0.006 (0.7)	-0.112 (-11.5)
Time fixed effects	yes	yes	yes
Country fixed effects	no	no	no
$\overline{R}^2$	0.606	0.476	0.771
F-statistic	39	27	71
Observations	448	448	448

First stage results

Dependent variable	Ln(population density)	ln(for. market potential)
ln(distance to Brussels)	-0.406 (-21.6)	-0.306 (-34.7)
area*	-3.83 (-34.4)	-0.69 (-13.1)
ln(GDP_{1000})	0.534 (41.2)	0.023 (3.8)
Time fixed effects	yes	yes
Country fixed effects	no	no
$\overline{R}^2$	0.898	0.868
F-statistic	219	165
Observations	448	448

* area coefficient × one million

Note, that the instruments are significant; *distance to Brussels* and *Area* have, as in the case for regions, the expected negative sign, whereas the additional instrument *GDP in the year 1000* has a positive sign.

Table 3B GDP per capita, market potential, and density, European countries
Dependent variable is dln(income per capita), panel estimates (t-statistics), 1975-2006

dln(for. market pot. gdp)	0.734 (8.8)		0.722 (8.7)
dln(population density)		-0.766 (-2.9)	-0.656 (-2.7)
Time fixed effects	yes	yes	yes
Country fixed effects	no	no	no
$\overline{R}^2$	0.292	0.181	0.302
F-statistic	12.5	7.2	12.4
Observations	448	448	448

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