

# **Economic geography and development in the European space**

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## CONTENTS

Acknowledgments.....	5
Abstract .....	7
Resumen.....	7
Resume.....	7
Introduction.....	9
I    Research framework and goals.....	11
II   Theoretical framework.....	12
III  Empirical framework.....	12
Chapter 1:    Market Potential and spatial dependencies in the European regions .....	15
1.1  Introduction .....	17
1.2  Theoretical framework: the NEG wage equation and Harris’s Market Potential.....	18
1.3  Data and econometric specifications .....	20
1.4  European regional spatial dependencies .....	22
1.5  Market Potential and other spatial lags: the role of different weighting schemes .....	24
1.6  Modeling spatial dependencies: the case of Europe .....	26
1.7  Conclusions .....	29
Chapter 2:    Market Potential and the curse of distance in European regions.....	31
2.1  Introduction .....	33
2.2  Theoretical and econometric framework .....	34
2.3  Data, measurement issues and samples of regions .....	36
2.4  The European spatial core-periphery pattern and regional convergence.....	39
2.5  Baseline pooled estimation: global sample and regimes .....	42
2.6  Cross-sectional interactions: spatial models and instrumental variables.....	43
2.7  Time-varying estimations by year .....	47
2.8  Conclusions .....	49
Chapter 3:    The observational equivalence of the NEG wage-type equation .....	51
3.1  Introduction .....	53
3.2  Theoretical framework.....	55
3.2.1  The NEG basic model: the demand side .....	55
3.2.2  The generalized wage equation .....	61
3.2.3  The generalized wage-type equation with human and physical capital.....	68
3.3  Econometric specification .....	72
3.3.1  Harris’s (1954) Market Potential and the NEG.....	72
3.3.2  Benchmark specification of the cross-sectional wage-type equation and data.....	76
3.4  The OLS cross-sectional wage-type equation in EU NUTS 2 regions: results .....	79
3.4.1  The cross-sectional benchmark equation for year 2008.....	79
3.4.2  The benchmark equation with alternative dependent variables.....	81
3.4.3  Harris’s Market Potential as a scale variable.....	82
3.4.4  External Market Potential as a measure of the nearest neighbor’s scale .....	84
3.5  Conclusions .....	88
Conclusions and contributions .....	91
I    Conclusions of the doctoral thesis.....	93

II	Contributions of the doctoral thesis .....	94
	Long summaries in Spanish and Galician languages .....	97
I	Resumen largo .....	99
II	Resumo longo .....	104
	References .....	111
	Annexes .....	119
Appendix A.	Data description .....	121
Appendix B.	Chapter 3: Adaptation of different wage equations to Table 3.2 .....	124
Appendix C.	Chapter 3: Correlations among variables in logs for the year 2008 .....	128

## FIGURES

Figure 1.1.	Market Potential and residuals of per capita GVA on Market Potential (year 2008) .....	23
Figure 1.2.	The effects of standardizing distances and reducing the number of neighbors .....	25
Figure 2.1.	Log GVA per capita (year 2008) versus average distance to the other regions .....	40
Figure 2.2.	Cloropleth maps of the logs of GVA per capita and Market Potential (year 2008) .....	41
Figure 2.3.	Cloropleth maps of the log of GVA per capita by regimes (year 2008) .....	41
Figure 2.4.	Time-varying cross-sectional elasticities of GVA per capita to Market Potential .....	47
Figure 2.5.	Time-varying elasticities of External Market Potential as unique explanatory variable ....	48
Figure 3.1.	Cloropleth maps of the logs of per capita GVA and Market Potential (year 2008) .....	77
Figure 3.2.	Log of per capita GVA in year 2008: Countries and regions .....	78
Figure 3.3.	220 benchmark regressions with two EMP variables by number of neighbors .....	85
Figure 3.4.	220 benchmark regressions with EMP by number of neighbors .....	86
Figure 3.5.	220 regressions with only EMP by number of neighbors as explanatory variable .....	87

## TABLES

Table 1.1.	Spatial autocorrelation of variables (logs) and OLS residuals .....	23
Table 1.2.	Cross-sectional correlations (year 2008) .....	26
Table 1.3.	OLS cross-sectional estimations for 220 European regions (year 2008) .....	27
Table 1.4.	Lagrange Multiplier diagnostics for spatial dependence on the OLS residuals .....	28
Table 1.5.	ML estimations of spatial models .....	28
Table 1.6.	Effects (impacts) of variables in the SAR models .....	28
Table 2.1.	Summary statistics by regime: pooled means 1995-2008 and average economic growth ...	38
Table 2.2.	Pooled OLS estimation of alternative specifications (1995-2008, 206 EU regions) .....	43
Table 2.3.	Baseline pooled OLS estimation by regimes (1995-2008, 206 regions) .....	43
Table 2.4.	Cross-sectional estimations with Market Potential (year 2008, 206 regions) .....	46
Table 2.5.	Cross-sectional estimations with External Market Potential (year 2008, 206 regions) .....	46
Table 2.6.	Alternative pooled estimates of Market Potential and their cross-sectional change .....	48
Table 3.1.	Alternative dependent variables: correlations year 2008 (206 regions) .....	54
Table 3.2.	Adaptation of several NEG models to the generalized wage equation .....	67
Table 3.3.	Benchmark cross-sectional equation for the year 2008 (206 regions) .....	80
Table 3.4.	Estimation with alternative dependent variables (206 regions) .....	81
Table 3.5.	Estimation with alternative “Market Potential” (206 regions) .....	83

Table C.1. Variables included in Table 3.3: correlations year 2008 (206 regions).....	128
Table C.2. Alternative variables to build IMP for Table 3.4: correlations year 2008 (206 regions) ...	128
Table C.3. Alternative variables to build EMP for Table 3.4: correlations year 2008 (206 regions) ..	129





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## Abstract

Chapter 1 reinterprets the New Economic Geography (NEG) *wage equation* by distinguishing two different types of spatial dependencies: global trend and local autocorrelation. It is shown that a measure of *Market Potential* in the wage equation is able to capture a global core-periphery pattern, while the standard weights matrix of Spatial Econometrics tends to be designed to capture short-distance interactions.

The ‘curse of distance’ is the tendency of peripheral regions to have lower income because of being far from the main markets, as measured by *Market Potential*. Chapter 2 finds evidence that the European regional cross-sectional elasticity of per capita income to Market Potential has been decreasing over the period 1995-2008. However, some results are sensitive to the specification and the estimation method.

Chapter 3 proposes a two-step procedure to show that many empirical wage equations actually proxy an underlying production function augmented with information about the nearest neighbor(-s). First, the wage equation is generalized and expanded to include capital stock. Second, a benchmark wage-type equation is estimated by redefining the key variables in ways ‘forbidden’ by NEG. The findings are similar to those of a standard wage equation, which is the essence of the observational equivalence of NEG theory.

## Resumen

El Capítulo 1 reinterpreta la *ecuación de salarios* de la Nueva Geografía Económica (NEG) distinguiendo dos tipos de dependencias espaciales: tendencia global y autocorrelación local. Se muestra que el *Potencial de Mercado* puede capturar un patrón global centro-periferia, mientras que la típica matriz de pesos en Econometría Espacial captura interacciones a cortas distancias.

La “maldición de la distancia” es la tendencia de las regiones periféricas a tener menor ingreso por estar lejos de los principales mercados, medidos por el *Potencial de Mercado*. El Capítulo 2 encuentra indicios de que la elasticidad transversal del ingreso per cápita de las regiones europeas con respecto al Potencial de Mercado se redujo durante el periodo 1995-2008. Sin embargo, algunos resultados son sensibles a la especificación y al método de estimación.

El Capítulo 3 muestra que muchas ecuaciones de salarios empíricas realmente estiman una función de producción subyacente aumentada con información sobre el(los) vecino(-s) más cercano(-s). Primero la ecuación de salarios se generaliza y expande con stock de capital. Después se estima una ecuación tipo-salarios redefiniendo las variables de formas “prohibidas” por la NEG. Los resultados se asemejan a los de una ecuación de salarios convencional, de acuerdo con la equivalencia observacional de la NEG.

## Resume

O Capítulo 1 reinterpreta a *ecuación de salarios* da Nova Xeografía Económica (NEG) distinguindo dous tipos de dependencias espaciais: tendencia global e autocorrelación local. Móstrase que o *Potencial de Mercado* pode capturar un patrón global centro-periferia, mentres que a típica matriz de pesos en Econometría Espacial tende a estar deseñada para capturar interaccións a curtas distancias.

A “maldición da distancia” é a tendencia das rexións periféricas a ter menor ingreso por estar lonxe dos principais mercados, medidos polo *Potencial de Mercado*. O Capítulo 2 encontra indicios de que a elasticidade transversal do ingreso per cápita das rexións europeas con respecto ao Potencial de Mercado se reduciu durante o período 1995-2008. Non obstante, algúns resultados son sensibles á especificación e ao método de estimación.

O Capítulo 3 propón un procedemento en dous pasos para mostrar que moitas ecuacións de salarios empíricas realmente estiman unha función de produción subxacente aumentada con información sobre o(os) veciño(-s) máis próximo(-s). Primeiro a ecuación de salarios xeneralízase e expande con stock de capital. Despois estímase unha ecuación tipo-salarios redefinindo as variables de xeitos "prohibidos" pola NEG. Os resultados aseméllanse aos dunha ecuación de salarios convencional, o que é a esencia da equivalencia observacional da teoría NEG.

## **Introduction**



## I Research framework and goals

The so-called *wage equation* of the New Economic Geography (NEG) predicts that regional income is a positive function of the regional access to the main international markets, as captured by a variable *Market Access* or *Real Market Potential*, which is a weighted sum of the market size of the other regions. The key interaction among regions in this framework depends on trade costs, which are usually proxies by distances in the empirical work. The wage equation has been considered empirically very successful to confirm a relationship between market access and the spatial distribution of economic activity (Redding, 2011).

The present doctoral thesis has three goals: 1) envisaging a new way of interpreting the wage equation; 2) studying if the cross-sectional effects of distance on the European regional income per capita have been decreasing during the last years; and 3) proposing a procedure to test the *observational equivalence* of the wage equation, i.e., the existence of alternative explanations that are consistent with the data.

Chapter 1 proposes to distinguish two different types of spatial dependencies studied in the NEG and Spatial Econometrics literatures. On one hand, as in Geostatistics, a core-periphery spatial structure is viewed here as a ‘regional’ or ‘global’ *spatial trend*, in which the values of the variable change systematically with the geographic space coordinates. That is the global spatial dependence captured by the NEG’s Market Potential. On the other hand, most of the techniques of Spatial Econometrics are designed to capture short-distance or *local spatial patterns*. The chapter studies the characteristics that allow considering both types of spatial patterns when estimating a wage equation for the European regions. It emphasizes that *Market Potential* can be seen as a spatially lagged endogenous variable and analyzes its similarities and differences with other types of spatial lags.

The NEG wage equation predicts that peripheral regions tend to have lower income because of their lower Market Potential. Chapter 2 analyzes this ‘curse of distance’ over time. This goal is especially relevant because of the implementation of active transport and regional policies during the last decades, which should reduce the consequences of peripherality. The focus of the chapter is on analyzing the robustness of a wage equation for different specifications, different subsamples of regions, the inclusion or exclusion of a proxy for the internal market size, the use of instrumental variables and the estimation of standard Spatial Econometrics models.

The final research line of this thesis goes back to the roots of the wage equation, in order to question its empirical interpretation. The *observational* (or *Marshallian*) *equivalence* of the NEG wage equation has been mentioned by different authors. However, there are not commonly accepted approaches to empirically test such equivalence. Chapter 3 proposes a two-step procedure to empirically check whether wage equations are actually proxying an underlying production function augmented with locational information about the nearest neighbor(-s) economic development. First, deriving a *wage-type* equation with emphasis on marginal costs, instead on wages, and encompassing several wage equations found in the literature. In order to highlight the similarity of wage equation to an expanded production function, the derivation of that wage-type equation adds capital stock as explanatory variable. Second, repeating the estimation of a benchmark wage-type equation by redefining the key variables of the model in alternative ways from those commonly used by the NEG empirical literature.

## II Theoretical framework

The theoretical basis of this thesis lies in the New Economic Geography and in Spatial Econometrics. The NEG offers an explanation about the effects of location on the income gradients. Spatial Econometrics provides a tool box to correct a regression model for the effects of residual spatial autocorrelation.

Chapter 1 makes extensive use of concepts from both approaches to distinguish the long and short distance spatial dependencies that are most usually captured by them. This leads to reveal some caveats that might appear when both types of spatial dependencies are simultaneously captured in an empirical wage equation.

Chapter 2 continues to use the NEG framework but it is more oriented to issues of measurement. Spatial Econometric models are considered as part of the robustness analysis of the empirical wage equation used to study the evolution over time of the cross-sectional effects of Market Potential. Additionally, the estimation of a wage equation for different periods of time is related to two other strands of the empirical literature, the '*distance puzzle*' in international trade and *convergence* in growth literature.

The first half of Chapter 3 is purely theoretical. It emphasizes the theoretical ambiguity of NEG as empirical guidelines and offers a new derivation of a wage-type equation. The final specification of the wage equation includes human capital and, as a novelty, capital stock. This last variable is taken into account in Chapter 2 to estimate the direct effects of Market Potential, collect the exogenous effects of the European regional and transport policies and allow to obtain a range of estimated effects of Market Potential when the analysis is repeated omitting those control variables. In Chapter 3 the inclusion of capital stock is derived from micro-fundamentals in order to compare the wage-type equation with a production function such as the one frequently used in development accounting exercises.

## III Empirical framework

Given that the wage equation makes a long term prediction about the spatial distribution of income, the empirical analysis in this thesis is mainly cross-sectional, using data from Cambridge Econometrics and Eurostat (the human capital variable) for a sample of European regions.

Chapter 1 analyzes a cross-sectional sample of 220 regions from 17 European countries for the year 2008. In Chapters 2 and 3, the sample is reduced to 206 regions because of the lack of capital stock data for Norway and Switzerland but their 14 regions are included to compute Market Potential. The sample period considered in Chapter 2 is 1995-2008. In order to complete the data set for this sample period, the missing data of human capital were imputed with a polynomial of degree 2 on the regional time trend of each region. Chapter 3 returns the focus to the cross-section for year 2008.

The dependent variable in the wage equations analyzed here is the logarithm of per capita gross value added (GVA). Market Potential is proxied by Harris's (1954) indicator, defined as the inverse distance weighted sum of the GVA of all the others regions in the sample. Given that the issue of measuring the internal market size is problematic, the three chapters of the thesis analyze the robustness of results to the inclusion of a proxy for the internal component of Market Potential, instead of considering the *External Market Potential*. Human capital is proxied by the share



of the population who has successfully completed education in Science and Technology (S&T) at the third level and is employed in a S&T occupation. The data Appendix offers additional discussion about these variables.

Spatial Error Models (SEM) and Spatial Autoregressive (SAR) models were estimated for the cross-sectional analysis of Chapters 1 and 2. Chapter 2 compares the series of cross-sectional estimations for each of the years since 1995 to 2008 with the estimation of a pooled model for the same period. Additionally, instrumental variables are used to analyze the possible effects of endogeneity on the estimates of Market Potential. An original contribution of Chapter 2 is the analysis of the evolution over time of the cross-sectional effects of Market Potential for a sample of 206 regions and for four 'regimes' of regions defined as Poor-Rich and Central-Peripheral.

The attention of Chapter 3 is oriented to science methodology. Simple OLS estimations are enough to empirically illustrate the arguments of this chapter. Four types of empirical exercises are shown in Chapter 3. First, the cross-sectional benchmark equation is analyzed by parts to check that it has an appropriate specification. Second, the equation is estimated for alternative dependent variables, including income per person and wages in the aggregate regional economy and the analogous for the sectors of manufacturing and services. Third, the equation is estimated replacing a conventional measure of Market Potential based on gross value added by alternative measures with the same structure but based on different variables, such as productivity, population or density variables. Fourth, alternative specifications of the equation are estimated 220 times with External Market Potential re-defined to include just the nearest neighbor, the two nearest neighbors, the three nearest ones... and so on.



## Chapter 1: Market Potential and spatial dependencies in the European regions<sup>1</sup>

### Abstract

This chapter reinterprets the New Economic Geography (NEG) *wage equation* by distinguishing two different types of spatial dependencies: global spatial trend and local spatial autocorrelation. A measure of *Market Potential* in the wage equation is able to capture a global core-periphery pattern, while the standard weights matrix of Spatial Econometrics tends to be designed to capture short-distance interactions among neighbors. Using cross-sectional European regional data, the chapter compares different weighting schemes to build spatial lags. The results show that the estimation of a wage equation can simultaneously capture the core-periphery structure and the local spatial dependence.

#### Keywords:

NEG, core-periphery model, wage equation, global spatial trend, spatial autocorrelation, spatial lag

**JEL codes:** C21, F12, R12

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<sup>1</sup> Revised and resubmitted to *Regional Studies*. A previous version of this Chapter has been published as *Funcas working paper 714*, April-2013.



## 1.1 Introduction

The so called ‘wage equation’ of the New Economic Geography (NEG) has been widely studied in the empirical literature (Redding, 2011). It predicts that regional wages are a function of a variable called *Market Potential* or *Market Access*, which is a weighted sum of the market size of the other regions. The weights are inversely related with bilateral trade costs, usually proxied by distances. According to Spatial Econometrics, this sum can be seen as a spatially lagged endogenous variable (Mion, 2004). This is because the measure of market size or economic activity on the right-hand side of the wage equation is closely associated with the dependent variable.

Within the NEG literature, the estimation of a wage equation frequently needs to be corrected for residual’s spatial autocorrelation. Therefore, if Spatial Econometrics uses a spatial lag of the dependent variable to correct a regression model for spatial autocorrelation: why does not Market Potential capture this spatial pattern? What does the spatial lag represent in each literature? If Market Potential is a different type of spatial lag, how are the results affected if both types of spatial lags are jointly considered in the same equation?

This chapter envisages a new way of interpreting the wage equation by distinguishing the two different types of spatial dependencies studied in the NEG and Spatial econometrics literatures. On one hand, as in Geostatistics, a core-periphery spatial structure is viewed here as a ‘regional’ or ‘global’ *spatial trend*, in which the values of the variable change systematically with the geographic space coordinates. That is the global spatial dependence captured by the NEG’s Market Potential. On the other hand, most of the techniques of Spatial Econometrics are designed to capture short-distance or *local spatial patterns*. The chapter studies the characteristics that allow considering both types of spatial patterns when estimating a wage equation for the European regions.

The approach follows two strands of the empirical literature. One bulk of the literature has used the NEG framework to study the effects of peripherality on economic development: Redding and Schott (2003), Redding and Venables (2004), López-Rodríguez *et al.* (2007), Bouhol and de Serres (2010) or López-Rodríguez and Acevedo-Villalobos (2013). As it is well known, the regional spatial distribution of economic activity and population in Europe, and in some of its countries, follows a core-periphery pattern: Keeble *et al.* (1982), Faña and López-Rodríguez (2006), Le Gallo and Dall’erba (2006) or López-Rodríguez *et al.* (2011). The key variable in the estimation of the wage equation, Market Potential, is able to capture this spatial structure and the effects of peripherality on the income gradients.

However, Market Potential does not seem to adequately capture spatial autocorrelation. A second bulk of the literature uses spatial econometric techniques to estimate an equation including a variable of Market Potential. See Niebuhr (2006) or Fingleton’s extensive work (Fingleton and Fischer, 2010) within the studies about the wage equation. Out of the NEG framework, there exists a research line started by Blonigen *et al.* (2007) analyzing foreign direct investment (FDI). Blanco (2012) specifically distinguishes the evaluation of two different forms of spatial interdependence of FDI: Market Potential and spatial autocorrelation. However, none of these authors discusses the particularities of such a distinction.

Using a cross-sectional sample of European regions, the chapter analyzes alternative weighting schemes to build different types of spatial lags and compare them with Harris’s (1954) measure

of Market Potential. The simple structure of this measure facilitates to disentangle the differential elements considered by the general perspectives of Geographical Economics and Spatial Econometrics on spatial dependence. Additionally, Harris's measure shares some of the same relevant features of other empirical definitions of Market Potential, such as those employed by Redding and Venables (2004), Hanson (2005) or Niebuhr (2006). The chapter also addresses some controversial methodological details, such as the role of internal markets in the estimation of a wage equation or the effects of using standardized distances to model spatial autocorrelation. Finally, attention is paid to some problematic issues when global and local spatial dependencies are simultaneously considered in a NEG wage equation

The main results of the analysis show that the estimation of a NEG wage equation can simultaneously capture the global core-periphery structure and spatial dependence at short distances. However, this achievement will be qualified by several caveats, which are mainly provoked by the endogeneity of Market Potential and the common elements in the weighting schemes of this variable and the matrix used to collect local spatial autocorrelation.

The rest of the chapter is organized as follows. The following section presents a short introduction to the concept of Market Potential and to the NEG wage equation. Section 1.3 introduces the data and the econometric specifications. Section 1.4 outlines the global and local spatial dependencies and the empirical differences among types of spatial lags. Section 1.5 compares the data when building spatial lags using different weighting schemes. Section 1.6 presents alternative estimations of the wage equation. The final section concludes and an Appendix describes the data.

## 1.2 Theoretical framework: the NEG wage equation and Harris's Market Potential

Following Harris (1954), the market potential of a geographical observation (region  $i$ ) is defined as the summation of markets ( $M$ ) accessible to  $i$  divided by their 'distances' ( $d_{ij}$ ) to that point  $i$ . When the calculation is done on areal units, a correction for the size of the internal market of each area (self-potential) is necessary in order to measure the accessibility of its firms to the markets. Therefore, considering the  $R - 1$  possible markets of other  $j$  regions, the Harris's Market Potential ( $HMP$ ) of region  $i$  can be decomposed into its *Internal* ( $IMP$ ) and *External* ( $EMP$ ) components:

$$HMP_i = \sum_{j=1}^R \frac{M_j}{d_{ij}} = \frac{M_i}{d_{ii}} + \sum_{j \neq i}^{R-1} \frac{M_j}{d_{ij}} = IMP_i + EMP_i \quad (1.1)$$

where the distance to the own regional market ( $d_{ii}$ ) is measured by within region distances, as discussed in the next section. Part of the focus of this paper is on the construction and interpretation of External Market Potential. Versions of this last variable have been called 'non-local' (Head and Mayer, 2006), 'surrounding' (Blonigen *et al.*, 2007) or 'foreign' (Brakman *et al.*, 2009a) market potential.

Harris's approach has been widely used in Regional Economics. One reason is that it offers a way of capturing Tobler's (1970) first law of Geography, which would be much quoted later by the Spatial Econometrics literature: 'Everything is related to everything else, but near things are more related than distant things'. In the nineties, Krugman's general equilibrium setting provides microeconomic foundations to the physical analogies of Harris's indicator (Krugman, 1993). The

NEG ‘wage equation’ predicts that regional wages are a function of the size of the markets available to each region. Here the final basic equation is presented following Head and Mayer (2006) and Combes *et al.* (2008).

In particular, the NEG wage equation explains the equilibrium industrial nominal wages of each region  $i$  ( $w_i$ ) as a function of the sum of a product of two elements for all the  $j = 1, \dots, R$  regions to which industrial goods are exported. On one hand it is region  $j$ ’s volume of demand of individual manufacturing varieties. This element is the quotient between their demand of manufacturing goods ( $\mu_j E_j$ ) and an index capturing the level of competition in  $j$ ’s market ( $S_j$ ), where  $E_j$  and  $\mu_j$  are  $j$ ’s total expenditure and manufacturing share of expenditure, respectively. On the other hand, the second element determines  $j$ ’s demand of the specific variety produced in region  $i$ . It is the transport cost from region  $i$  to  $j$  destination ( $T_{ij}$ ), to the power of one minus the elasticity of substitution among the varieties of industrial goods ( $\sigma > 1$ ) or range of product differentiation. A market clearing condition defines the wage equation:

$$w_i = \left( \sum_{j=1}^R T_{ij}^{1-\sigma} \frac{\mu_j E_j}{S_j} \right)^{1/\sigma} = (RMP_i)^{1/\sigma} \quad (1.2)$$

Redding and Venables (2004) call *Market Access* to the expression between brackets. Here the name given by Head and Mayer (2006), *Real Market Potential* ( $RMP_i$ ), is used to keep continuity with the tradition from Harris (1954) to Fujita *et al.* (1999). The ‘real’ is added to underline the importance of discounting expenditures by the competition or supply index  $S_j = \sum_{i=1}^R T_{ij}^{1-\sigma} n_i p_i^{1-\sigma}$ , where  $n_i$  is the number of manufactured goods sold in  $j$  market and produced in any region  $i$  and  $p_i$  is the mill price of those goods.

Head and Mayer (2006) reserve the name ‘Nominal Market Potential’ to an expression such as  $\sum_{j=1}^R T_{ij}^{1-\sigma} \mu_j E_j$ . The ‘nominal’ refers to the absence of an adjustment for variation in the competition index ( $S_j = S = 1$ ). Assuming that the share of manufacturing goods on expenditure is the same in all regions ( $\mu_j = \mu = 1$ ), as Fujita *et al.* (1999, chap. 4) consider, and that  $T_{ij}^{1-\sigma} = T_{ij}^{-1}$ , the nominal Market Potential becomes the original formulation used by Harris (1954) and in subsequent work of geographers:  $HMP_i = \sum_{j=1}^R T_{ij}^{-1} E_j$ , where expenditure  $E_j$  measures the size of the markets ( $M_j$ ) and trade costs are usually proxied by geographical distances ( $T_{ij} = d_{ij}$ )<sup>2</sup>. Once distance is taken as the proxy of trade costs, Harris’s definition of Market Potential implies  $T_{ij}^{1-\sigma} = d_{ij}^{1-\sigma} = d_{ij}^{-1}$ . Indeed, a trade elasticity to distance of -1 is an extremely robust empirical finding in the literature of gravity equations. The mean distance elasticity of trade calculated in Head and Mayer’s (2015) meta-analysis of 2508 estimates is -0.9. Taking just the estimations using country fixed effects or ratio-type methods, the mean elasticity is -1.1.

Therefore, the main difference between  $RMP_i$  and  $HMP_i$  is that the latter measure is not corrected by the NEG’s competition index  $S_j$ , which is not directly measurable. Combes *et al.* (2008, p. 305) conclude that Harris’s market potential is at best a rough approximation of the RMP. However, using European regional data both Breinlich (2006) and Head and Mayer (2006) find similar results with a Harris’s definition of Market Potential than with a more sophisticated structural estimation of the NEG wage equation.

<sup>2</sup> Breinlich (2006), as well as some other authors, finds that using travel times does not alter too much the results for the European regions.

### 1.3 Data and econometric specifications

Taking logarithms to the wage equation (1.2) and proxying  $RMP_i$  with  $HMP_i$ , the econometric specification considered in this paper for a cross-sectional regression is:

$$\ln w_i = C + \beta \ln HMP_i + u_i \quad (1.3)$$

In this work wages are proxied with per capita income, as it is frequent in the NEG literature (Redding and Venables, 2004; Brakman *et al.*, 2009a). This variable provides generality to the discussion about the spatial structure of economic activity and spatial dependence. Here it is represented by per capita gross value added (GVA). Market Potential is built with GVA too. Some of the regressions estimated in this paper include a control variable of per capita human capital too, proxied by a variable of human resources in Science and Technology (S&T). Head and Mayer (2006) or Breinlich (2006), among others, have controlled the estimation for human capital too. Details about the variables and the sample are provided in the Appendix.

The term  $u_i$  is supposed to collect the effects of omitted variables and departures from the assumptions of the theoretical model, which are assumed to be randomly distributed under OLS estimation. However, as it will be shown later, the estimation of this equation with European regional data results in spatially autocorrelated residuals. When the data generation process includes spatial dependence in the endogenous or the explanatory variables and those spatial effects are omitted, the estimator of the coefficients for the remaining variables is biased and inconsistent. In contrast, ignoring spatial dependence in the disturbances, if present, will only cause a loss of efficiency (LeSage and Pace, 2009, p. 156).

In order to test and model spatial autocorrelation it is necessary to choose a neighborhood criterion (who is linked with who) and to build a spatial weights matrix ( $W$ ) assigning weights to the areas that are considered to be linked. The tests considered later, the Moran's I and the Lagrange Multiplier tests, use this  $W$  matrix to check if a variable is spatially autocorrelated or a model follows a particular process of spatial dependence. These tests can detect misspecification instead of a true process of spatial autocorrelation. The most obvious reason for misspecification is the omission of relevant explanatory variables, justifying the need of controlling the estimation of a wage equation. The control variable of human capital reduces but do not solve this issue.

The problem of misspecification and spatial autocorrelation is very related with the focus of this paper: Bivand *et al.* (2008, p. 60) show that even a gentle global regional trend induces apparent spatial autocorrelation in the Moran's indicator, unmasked when a correct model is fitted. As it will be shown in the next section, Market Potential is able to capture a global core-periphery pattern in the data, which is a global spatial trend. This global spatial dependence could be called 'polarization' too, considering that the geographical position of the observations matters in the global dimension, not only in the local one, as that word has been used too. Alternative expressions might be 'long distance' or 'large scale' spatial structure. On the contrary, spatial autocorrelation is emphasized here as an average 'local' phenomenon of spatial dependence<sup>3</sup>.

Spatial Econometrics uses the  $W$  matrix to specify a variety of spatial models. LeSage and Pace (2009, chap. 2) discuss some of their motivations. In this work only two simple spatial models are considered. Though different authors use the name Spatial Autoregressive (SAR)

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<sup>3</sup> The words 'global' and 'local' are not always used with the same meaning in Spatial Econometrics. A 'global' measure of spatial autocorrelation is the one applying a common weights matrix to the space of observations, even if that matrix is designed to capture local dependence.



Model for a variety of specification, here it is referred to the model capturing an endogenous interaction effect, also known as Spatial Lag Model. A cross-sectional SAR model can arise from time-dependence of decisions by economic agents located at various point in space when decisions depend on those of neighbors. It has the form:

$$Y = \rho WY + X\beta + u \quad (1.4)$$

The second basic spatial model is the Spatial Error Model (SEM), which captures interaction effects among the error terms. A cross-sectional SEM model can be motivated by spatially auto-correlated omitted variables. Its specification is:

$$\begin{aligned} Y &= X\beta + u \\ u &= \lambda Wu + \varepsilon \end{aligned} \quad (1.5)$$

There are many ways of selecting  $W$  for describing an unknown structure of average spatial interaction in a particular sample of data, if such a structure exists. Usually the elements of this matrix,  $w_{ij}$ , are row-standardized (normalized), with the sum of all weights for region  $i$ . The main argument is technical, due to the need of inverting a linear combination of the  $W$  matrix in order to estimate the spatial model<sup>4</sup>. An advantage of standardization is that the spatial lag of a variable  $X$  for each region can be interpreted as the weighted average of  $X$  for its ‘neighbors’ (however defined):  $(WX)_i = \sum_j \frac{w_{ij}}{\sum_j w_{ij}} X_j$ . When  $W$  is a binary matrix, with 1 if two regions are considered as neighbors and 0 otherwise, standardization by rows implies that the spatial lag of a variable is the mean value of the variable for the neighbors.

A rule of parsimony in Spatial Econometrics recommends not to impose a strong structure on the  $W$  matrix when trying to capture an unknown distribution of spatial dependence (Griffith, 1996). Moreover, in order to capture local spatial patterns it seems more useful to restrict the neighborhood criterion. The baseline spatial matrix considered in this paper is a row-standardized binary weight matrix to the 5 nearest neighbors. A  $W$  matrix with 5 neighbors allows checking for possible average interactions among each region and its surroundings and it is enough for the purpose of distinguishing global and local spatial patterns. For reasons analyzed by LeSage and Pace (2012), the main results of the paper about this distinction do not depend on using a somewhat lower or higher number of neighbors to model local autocorrelation.

As pointed by Anselin (1988, pp. 23–24) when  $w_{ij}$  represents a distance decay, scaling the rows so that the weights sum to one losses the economic interpretation of that distance decay. On the contrary, Market Potential is an index of accessibility to the markets, which requires considering absolute distances (proxying trade costs). However, both approaches to spatial dependence are related. The external component of Harris’s Market Potential in equation (1.1) is a non-standardized inverse distance spatial lag of the regional internal markets. The next section discusses the specific differences between Market Potential and some other spatial lags frequently used by Spatial Econometrics<sup>5</sup>.

<sup>4</sup> Row-standardization guarantees that the maximum eigenvalue of  $W$  is 1 and that the estimated spatial parameter is between -1 and 1. Standardization avoids that this parameter could imply explosive models with unknown properties. Alternatively, Kelejian and Prucha (2010) propose to divide each element of  $W$  by the spectral radius of  $W$ , the maximum absolute value of its eigenvalues. This novel method is not discussed here.

<sup>5</sup> The heterogeneous size of the observational units (and, therefore, sample selection) is always an issue when modeling space (see Figure 1.1). That is related with the large literature about the modifiable areal unit problem and is out of the scope of this paper.

Given that Market Potential can be viewed as a spatial lag of the dependent variable, it is an endogenous variable, which biases the estimation of a wage equation. Therefore, the NEG empirical literature has estimated the wage equation by instrumental variables. In a similar way, the generalized spatial two stage least squares procedure of Kelejian and Prucha (1998) to estimate a SAR model instruments the spatial lag of the endogenous variable with the spatial lags of the explanatory variables. This last procedure is problematic in a wage equation because one of the explanatory variables is another type of spatial lag of the dependent variable.

Indeed, this issue has important consequences. When calculating the total effects of a SAR model, as it will be done in the next section, the simultaneous endogenous effects of per capita GVA and GVA Market Potential should be considered. Moreover, a Spatial Error Model of equation (1.3) contains a form of spatial lag of the dependent variable too. It is actually very similar to a Spatial Autocorrelation (SAC) model, which includes spatial dependence in both the dependent variable and the errors. Therefore, the elasticities of variables should be estimated through total effects too. The discussion is out of the scope of this paper. The endogeneity of these spatial lags is not empirically addressed here in order to focus on the different types of spatial dependence captured by them.

On the other hand, a practical issue to calculate Market Potential is how to measure internal distances ( $d_{ii}$ ) to proxy the internal market component of equation (1.1). The standard method assumes that regions are circular so the radius of region  $i$  is  $r_i = \sqrt{area_i/\pi}$ . In this paper internal distances are measured following Keeble *et al.* (1982), who chose  $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$  to allow for the likely clustering of economic activity in and around the ‘centre’. This is similar to the 40% of the radius considered by Cambridge Econometrics (2014). Excluding the own regional market in  $HMP_i$  introduces measurement error by reducing the access measure of some economically larger locations (Breinlich, 2006; Head and Mayer, 2006), as the capital cities tend to be. But including it aggravates the general endogeneity problem of Market Potential. The calculation of internal distances as 1/3 of the radius increases the role of the internal market when compared with the 2/3 used by some authors, which facilitates to check possible differences of results when using  $HMP_i$  or  $EMP_i$ .

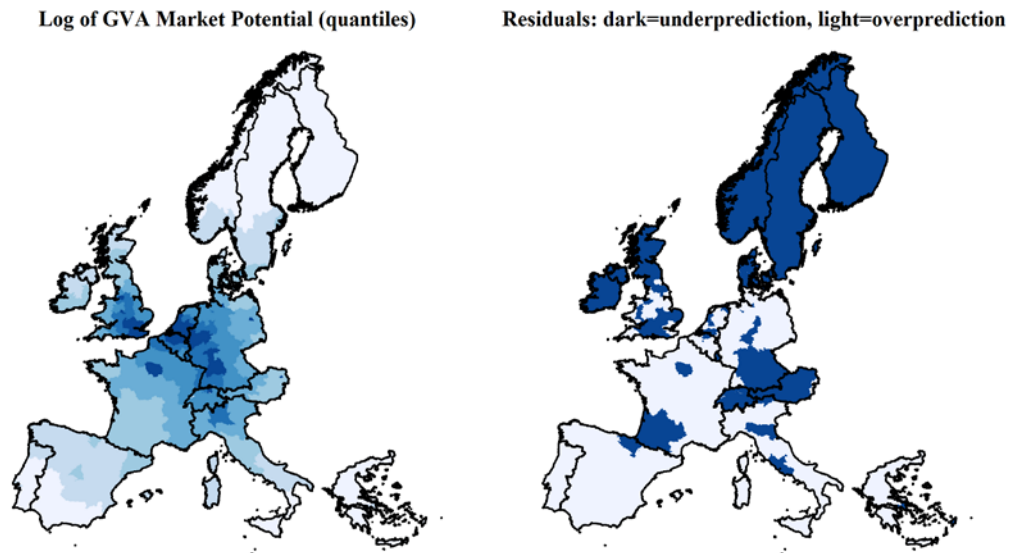
## 1.4 European regional spatial dependencies

As it is discussed in the introductory section, previous literature has shown that the European regional spatial distribution of economic activity follows a core-periphery pattern, with just a few high per capita income regions out of the geographical center of Europe, particularly those in Nordic countries. The economically central regions (with high per capita GVA) are mainly located around the so called *blue banana*, from West England in the North to Milan in the South. They are geographically central regions too.

Figure 1.1 shows maps of the regional Market Potential ( $HMP_i$ ) in Europe in the year 2008 and the residuals of a regression of per capita GVA on Market Potential. Both variables are in natural logarithmic form, as this is the form in which they are considered by the wage equation under scrutiny. The values of the log of Market Potential are divided in seven quantiles, which helps to visualize their global spatial pattern. Darker colors are associated with higher values of the variables. Alternatively, and in order to simplify the visualization of spatial autocorrelation, the right map of the figure only distinguishes two types of values depending of the sign of the

residuals. Negative residuals, in dark color, indicate that Market Potential over-predicts the per capita GVA of those regions, while positive residuals point out to under-predictions.

**Figure 1.1. Market Potential and residuals of per capita GVA on Market Potential (year 2008)**



In spite of the general visual limitations of choropleth maps, the left map of Figure 1.1 shows that the Market Potential variable is able to capture a global core-periphery spatial trend. However, this attractive feature of the Market Potential variable has a disadvantage too. The map on the right of Figure 1 shows that the residuals of a wage equation present strong local spatial dependence. If Market Potential tends to under-predict a region it tends to under-predict their neighbors too. Therefore, the residuals of the regression are going to be spatially autocorrelated: they will be high (positive) in close under-predicted regions and low (negative) in close over-predicted regions. OLS just distributes the under and over predictions to get a zero mean of residuals.

This local clustering of residuals is tested in Table 1.1. Moran's I is calculated for the logs of the variables and for the residuals of OLS regressions of the log of per capita GVA on the logs of the Market Potential variables. The zero p-values of Moran's test in Table 1.1 reject the null hypothesis of absence of spatial autocorrelation at short distances.

**Table 1.1. Spatial autocorrelation of variables (logs) and OLS residuals**

	Moran's I statistic	p-value
Per capita GVA	0.617	0.000
Market Potential	0.854	0.000
External Market Potential	0.921	0.000
Residuals Market Potential	0.587	0.000
Residuals External Market Potential	0.494	0.000

Note: Cross-section of 220 regions for the year 2008. The residuals are those of the regression of the log of per capita GVA on the logs of the Market Potential variables. Moran's tests use the randomisation assumption for the variables and the normality assumption for the residuals. The alternative hypothesis for the p-values is that Moran's I is greater than expected under the null hypothesis of absence of spatial autocorrelation. The weights matrix is a row-standardized binary matrix to the 5 nearest neighbors.

In summary, capturing the global core-periphery pattern of the European per capita GVA with a variable of Market Potential tends to come at the cost of spatially autocorrelated residuals at short distances. The violation of the OLS assumptions calls for the estimation of the Spatial Econometrics models. Before that, the following section emphasizes the differences between Market Potential and other types of spatial lags frequently used in Spatial Econometrics.

### 1.5 Market Potential and other spatial lags: the role of different weighting schemes

The key element to explain why Market Potential does not correct the estimated wage equation for residual's local spatial autocorrelation is that it is built as a weighted sum of all the regions in the sample. The values of (External) Market Potential are smoothed when summing the GVA of all the regions in the sample (see Figure 1.1). Therefore, when Market Potential is a dependent variable in a regression model its marginal effects among close neighbors are similar, generating clustered residuals at short distances.

Figure 1.2 illustrates these effects as well as two differences between Market Potential and some other types of spatial lags. The three plots in Figure 1.2 show how the logarithms of *EMP* and alternative measures using standardized weights vary with the logarithm of the mean distance of each region to all the other regions in the sample. The values of *EMP*, on the left plot<sup>6</sup>, smoothly decrease with the distance from the European geographical center. This combination of a sum for all the regions in the sample and the weights with absolute inverse distances is what allows Market Potential to capture the global core-periphery structure of the European regional economic activity. The inverse distance weights make the highest values of Market Potential to be geographically centered on the *blue banana*. However, the sum effect makes this variable to be more spatially autocorrelated than per capita GVA (Table 1.1). Market Potential exaggerates the global (core-periphery) regional trend in per capita GVA (not shown), as it is expected when trying to capture a stylized property of the data. These smoothing effects of the Harris's accessibility index and the use of absolute distances are common to other empirical definitions of Market Potential, such as those of Redding and Venables (2004), Hanson (2005) or Niebuhr (2006), widely used in the literature, though they are not studied in the present discussion.

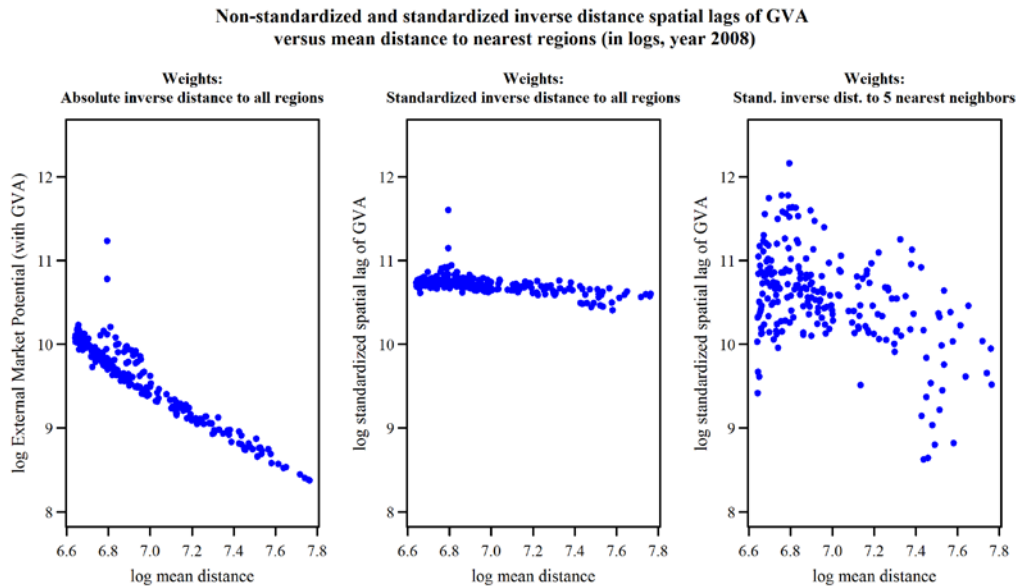
The smoothing effects of the sum for all the neighbors can be observed in the central plot of Figure 1.2 too. However, now the weights are standardized, which reduces the dispersion of the variable in the distance dimension. In the standardized version of *EMP*, the discount factor of distance and the economic interpretation of accessibility are lost. In this case the sum of the spatial weights is 1 for all regions, while in *EMP* ranks from 0.1 to 0.7 in this sample, according to the degree of peripherality of each region.

On the contrary, attending a rule of parsimony and trying to capture an average local spatial pattern, Spatial Econometrics tends to restrict the criterion of neighborhood. The right plot of Figure 1.2 shows the standardized version of the log of *EMP* for only the 5 nearest neighbors. Now the log of the spatial lag of GVA presents high dispersion in the distance dimension, according to the GVA size of the neighbors in the nearby distances. Indeed, the role of the standardized distances in this variable is not that important. The right plot is very similar (not shown)

<sup>6</sup> The two outliers at the top of the first two plots of Figure 1.2 correspond to Inner and Outer London, which have a somewhat arbitrary small distance between centroids.

when the spatial lag is built with the baseline  $W$  matrix used in this paper, a standardized binary matrix to the 5 nearest neighbors. The reason is that a criterion of distance is implicit in some way when the list of neighbors is reduced to the 5 nearest ones. However, if the binary matrix is used, some outliers in the right plot disappear, what can be relevant when estimating spatial models.

**Figure 1.2. The effects of standardizing distances and reducing the number of neighbors**



There are two additional differences between Market Potential and some of the spatial lags most frequently used in Spatial Econometrics. On one side, under the framework of the wage equation discussed here, Market Potential is a spatial lag of GVA while a spatial lag of the dependent variable in a SAR model is a spatial lag of per capita GVA. On the other side, there is what it can be called the ‘lag of log’ versus the ‘log of lag’ issue. In the wage equation Market Potential is considered in log form, so it appears as a log of a spatial lag. For reasons of comparability Figure 1.2 presents the logs of different types of spatial lags. However, Spatial Econometrics builds spatially lagged variables applying the  $W$  matrix to the variables such as they are included in the regression. Therefore, if the variables are in logarithms,  $W$  is used to build spatial lags of logarithms.

In order to illustrate the empirical differences among these types of spatial lags, Table 1.2 shows their correlations. The dependent variable of the wage equation is called variable (1) and the Market Potential variables are called (2) and (3). Several other types of spatial lags appear in the table too. The logs of the spatial lags of GVA, numbered as (4) to (6), are shown to compare their weighting schemes with the one of variable (3), External Market Potential, which was plotted on the left of Figure 1.2. The two additional plots of Figure 1.2 were the log of the spatial lag of GVA using standardized inverse distances and considering all regions, as in variable (4), or the 5 nearest ones, as in (5). The similar correlations of this last variable to variable (6) confirm the limited role of the inverse distance weighting scheme when the weights are standardized and only a few neighbors are considered. The comparison of variables (6) and (7) shows the ‘lag of log’ versus ‘log of lag’ issue. The spatial lag of a log, as it is built in SAR models, is more correlated

with the dependent variable (1) than the log of a spatial lag. Variables (8) to (10) are different spatial lags of the log of per capita GVA, instead of GVA. Variable (10) is the one that it will be added as explanatory variable of the wage equation in the SAR models of the next section.

**Table 1.2. Cross-sectional correlations (year 2008)**

Variable	(1) log per capita GVA	(2) log Market Potential	(3) log External Market Potential	(4) (5) (6) log spatial lag of GVA			(7) Spatial lag of log GVA	(8) (9) (10) Spatial lag of log per capita GVA		
Neighbors		All	All	All	5 nearest	5 nearest	5 nearest	All	All	5 nearest
Weights		Absolute inverse distance	Absolute inverse distance	Standardized inverse distance	Standardized inverse distance	Standardized binary	Standardized binary	Absolute inverse distance	Standardized inverse distance	Standardized binary
(1)	1.00	0.56	0.48	0.29	0.25	0.23	0.33	0.48	0.70	0.75
(2)	0.56	1.00	0.96	0.64	0.50	0.47	0.59	0.93	0.65	0.53
(3)	0.48	0.96	1.00	0.69	0.54	0.52	0.63	0.96	0.70	0.58
(4)	0.29	0.64	0.69	1.00	0.77	0.71	0.72	0.54	0.59	0.45
(5)	0.25	0.50	0.54	0.77	1.00	0.98	0.92	0.39	0.47	0.46
(6)	0.23	0.47	0.52	0.71	0.98	1.00	0.93	0.37	0.43	0.44
(7)	0.33	0.59	0.63	0.72	0.92	0.93	1.00	0.48	0.53	0.51
(8)	0.48	0.93	0.96	0.54	0.39	0.37	0.48	1.00	0.67	0.54
(9)	0.70	0.65	0.70	0.59	0.47	0.43	0.53	0.67	1.00	0.91
(10)	0.75	0.53	0.58	0.45	0.46	0.44	0.51	0.54	0.91	1.00

Note: The baseline  $W$  matrix used in the following tables corresponds to the weighting scheme of variables (6), (7) and (10).

The correlation of the log of  $EMP$ , (3), with the dependent variable (1) is relevant, 0.48. That correlation is reduced to 0.25-0.23 when the weights are standardized and only the 5 nearest neighbors are used to build the variables (5) and (6). The log of  $EMP$  and a spatial lag of the log of per capita GVA built with absolute inverse distances to all the regions capture the same information, as it is revealed by the 0.96 correlation between variables (3) and (8). However, the comparison of variables (7) and (10) shows the important role of considering GVA or per capita GVA when a few neighbors are used: the correlation with the dependent variable increases from 0.33 to 0.75. The correlation of variable (10) with the log of  $EMP$  is still high, 0.58, what might create some multi-collinearity problems in the SAR models of Table 1.5 below. Nevertheless, a correlation of 0.58 might be qualified as not very severe when considering the importance of capturing two different spatial patterns of the data, i.e., global and local spatial dependencies.

## 1.6 Modeling spatial dependencies: the case of Europe

The last step of this discussion is to model the global core-periphery spatial structure of the European regional economic activity at the same time that the short-distance spatial autocorrelation studied above.

Table 1.3 shows the OLS cross-sectional estimation of four alternative specifications of equation (1.3). Two conclusions can be drawn from the results. First, External Market Potential and Human Capital explain around half of the dispersion of per capita GVA, approximately in the same proportion each of them. Consistently with the previous results, the improvement of the R-squared is very small when including the internal component of Market Potential in columns (1) and (2). Second, as in Table 1.1, the p-values of Moran's  $I$  show that the residuals of all the estimations are spatially autocorrelated.



In order to correct these regressions for spatial autocorrelation the proper spatial model can be selected with Lagrange Multiplier diagnostics for the presence of a spatially lagged dependent variable or error dependence. The description of the decision rule by Florax *et al.* (2003) was followed here and is based on a comparison of the LM tests for the same specification. Adapting it to the terminology in R *spdep* package (Bivand, 2014) the simple tests are named LMerr and LMlag, while RLMerr and RLMlag are their versions robust to the possible presence of the other type of spatial dependence. The null hypothesis for LMlag and RLMlag is  $\rho = 0$  in equation (1.4), while for LMerr and RLMerr is  $\lambda = 0$  in equation (1.5). If the p-value of a test is very close to zero the test is significant, meaning that the alternative hypothesis of an erroneously omitted spatial process of the type under consideration is accepted.

**Table 1.3. OLS cross-sectional estimations for 220 European regions (year 2008)**

	(1)	(2)	(3)	(4)
(Intercept)	6.450*** (0.356)	8.411*** (0.339)	6.803*** (0.397)	8.696*** (0.354)
log Market Potential	0.365*** (0.037)	0.285*** (0.030)		
log External Market Potential			0.333*** (0.041)	0.270*** (0.033)
log Human Capital		0.527*** (0.048)		0.569*** (0.049)
R-squared	0.313	0.556	0.229	0.521
Adj. R-squared	0.310	0.552	0.225	0.517
F	99.37	135.77	64.66	118.03
AIC	73.63	-20.28	99.11	-3.69
p-value Moran's I	0.000	0.000	0.000	0.000
Moran's I residuals	0.587	0.563	0.494	0.509
Sum squared errors	17.52	11.33	19.67	12.21

Note: Table displays coefficients: \* significant at 10% level; \*\* at 5% level; \*\*\* at 1% level. Standard errors are in brackets. The dependent variable is the log of per capita GVA.

The results of these tests are shown in Table 1.4. Following the decision rule the SEM is chosen in all cases except in the specification of External Market Potential without human capital. However Table 1.5 presents the maximum likelihood estimation of both spatial models for three reasons: the specifications and spatial models studied here are simple, each type of model has different motivations and the SAR model is apparently more critical for a Market Potential variable. The coefficients of the variables of the SAR and SEM models are not comparable (LeSage and Pace, 2009, chap. 2). Therefore, Table 1.6 shows the total effects of the variables in the SAR specifications using standard techniques. However, as it was discussed before, both the estimates of the SEM models and the total effects of the SAR models should be considered as rough estimations of elasticities, given that they do not consider the simultaneous relationship between per capita GVA and GVA Market Potential.

Therefore, the focus of this exercise is on the statistical significance of the variables, more than on the estimates. However, it should be noted that when controlling for human capital the OLS estimates of the two Market Potential variables in Table 1.3 have similar magnitude to the SEM estimates in Table 1.5 and to the total effects of those variables in Table 1.6. Market Potential has a significant positive effect in all the specifications but the external component is only significant at 5% level in some spatial specifications. However, both  $\rho$  and *EMP* are significant at 1% level in the SAR specification of column (4), in spite of the 0.58 correlation showed in Table 1.2.

Three additional robustness analyses were done and are available upon request. First, all the calculations in this paper were repeated for a broader sample including 54 additional regions from the Central and Eastern countries of the European Union. Second, all the estimations for both samples were repeated using the standardized inverse distance weight matrix to the 5 nearest neighbors, as in variable (5) of Table 1.2, which makes a difference for some observations. Third, the spatial models were estimated with country dummies too.

**Table 1.4. Lagrange Multiplier diagnostics for spatial dependence on the OLS residuals**

	<i>Without Human Capital</i>		<i>With Human Capital</i>	
	Statistic	p-value	Statistic	p-value
Equations (1) and (2) with Market Potential				
LMerr	213.924	0.000	196.428	0.000
LMlag	159.486	0.000	108.188	0.000
RLMerr	60.867	0.000	88.310	0.000
RLMlag	6.429	0.011	0.070	0.791
Equations (3) and (4) with External Market Potential				
LMerr	151.171	0.000	160.512	0.000
LMlag	152.924	0.000	103.469	0.000
RLMerr	0.790	0.374	57.077	0.000
RLMlag	2.543	0.111	0.034	0.853

Note: LM tests on the OLS residuals of the estimations in Table 1.3.

**Table 1.5. ML estimations of spatial models**

	Spatial Lag Model (SAR)				Spatial Error Model (SEM)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\rho$	0.629*** (0.060)	0.513*** (0.055)	0.674*** (0.058)	0.540*** (0.057)				
$\lambda$					0.819*** (0.038)	0.746*** (0.049)	0.682*** (0.057)	0.703*** (0.055)
(Intercept)	1.878*** (0.449)	4.181*** (0.520)	2.185*** (0.510)	4.492*** (0.569)	4.133*** (0.545)	7.509*** (0.542)	7.596*** (0.748)	9.617*** (0.622)
log Market Potential	0.187*** (0.037)	0.161*** (0.029)			0.607*** (0.057)	0.364*** (0.050)		
log External MP			0.111** (0.036)	0.109*** (0.031)			0.249** (0.079)	0.179** (0.063)
log Human Capital		0.393*** (0.044)		0.418*** (0.048)		0.460*** (0.049)		0.596*** (0.049)
AIC	-20.40	-96.20	4.38	-75.04	-75.30	-144.45	6.11	-104.00
p-value LMerr resid	0.267	0.000	0.334	0.015	0.521	0.627	0.329	0.479
p-value Moran's I	0.107	0.000	0.806	0.005	0.704	0.647	0.809	0.726
Moran's I residuals	0.045	0.143	-0.039	0.097	-0.026	-0.019	-0.039	-0.028
Residual variance	0.047	0.034	0.052	0.038	0.034	0.025	0.052	0.031
Sum squared errors	10.42	7.56	11.48	8.26	7.44	5.60	11.53	6.87

Note: SAR and SEM estimations of the four specifications in Table 1.3.

**Table 1.6. Effects (impacts) of variables in the SAR models**

	<i>Direct</i>	<i>Indirect</i>	<i>Total</i>
(1) log Market Potential	0.207	0.298	0.505
(2) log Market Potential	0.171	0.160	0.331
log Human Capital	0.416	0.390	0.806
(3) log External Market Potential	0.125	0.215	0.340
(4) log External Market Potential	0.116	0.120	0.236
log Human Capital	0.446	0.462	0.908

Note: Impacts of the explanatory variables in columns (1) to (4) of Table 1.5.



The significance of External Market Potential is sensitive to these changes. For instance, focusing on the SEM specification in column (8) of Table 1.5, *EMP* is not significant in the sample of 274 regions. In the sample of 220 regions it is only significant at 10% level when the standardized inverse distance  $W$  matrix is used. However, in both samples and with both weight matrices *EMP* becomes significant at 1% level when country dummies are included in the regression.

This simple exercise shows that the empirical validity of the NEG must deal with several complications when the wage equation is estimated with Spatial Econometrics techniques. The simultaneous consideration of two different types of spatial dependence introduces endogeneity problems in a variable of Market Potential that are similar to those of a spatial lag of the dependent variable. That does not only affect the estimation techniques to correct the biases generated by both variables but the evaluation of impacts in both SAR and SEM models too. Multicollinearity problems are sensitive to the selection of the  $W$  matrix to capture local spatial dependence. The problematic consideration of Internal Market Potential appears to be a critical issue when estimating spatial models. The results can be sample dependent and sensitive to the inclusion of country dummies.

## 1.7 Conclusions

Under the theoretical approach of the NEG and using common statistical techniques from Spatial Econometrics, this chapter shows the features that allow a wage equation to capture both the global core-periphery spatial structure of the European regional economic activity and the short-distance interactions among close neighbors.

Using a Harris's (1954) measure of Market Potential, it is shown that the combination of a sum for all the regions in the sample with a weighting scheme based on absolute distances is what allows Market Potential to capture the global spatial trend. However, the smoothing effects of the sum make the residuals of an estimated wage equation to be spatially autocorrelated at short ranges. These features are common to other empirical measures of Market Potential used in the literature, though they are not studied here.

Harris's Market Potential is a non-standardized inverse distance spatial lag of whatever indicator be used to measure market size, GVA here. Its comparison with other spatial lags frequently used in Spatial Econometrics reveals four differences: the number of neighbors considered in the sum; the standardization of the weights; the reference to the dependent variable in SAR models (instead of market size); and the 'lag of log' versus 'log of lag' issue. Those differences are empirically analyzed. Additionally, SAR and SEM models are estimated for a cross-sectional wage equation of the European regions and the robustness of the results is discussed too.

The analysis shows that the achievement of simultaneously capturing two different types of spatial dependence in a simple equation comes with a number of caveats. The Market Potential variable induces endogeneity problems similar to those of a spatial lag of the dependent variable, affecting the calculation of total effects. Multicollinearity is sensitive to the selection of the spatial weights matrix. The problematic consideration of the internal markets can be critical when estimating spatial models. The results might be sample dependent and sensitive to the inclusion of country dummies. These challenges have been only partially addressed in the literature and do not obscure the important achievement of capturing a global spatial trend and an average local pattern of spatial dependence in an empirical wage equation.



## Chapter 2: Market Potential and the curse of distance in European regions<sup>7</sup>

### Abstract

In the context of the New Economic Geography (NEG) wage equation, the ‘curse of distance’ is the tendency of peripheral regions to have lower income because of being far from the main markets, as captured by a variable *Market Potential*. This pattern is consistent with the core-periphery spatial distribution of the European regional economic activity. Nevertheless, during the last decades, the European Union has been implemented active transport and regional policies, which should mitigate the consequences of peripherality. This paper analyzes the changes of the cross-sectional effects of Market Potential on the European regional income per capita during the sample period 1995-2008.

The paper finds evidence that the cross-sectional elasticity of per capita income to Market Potential has been decreasing over the sample period. However, some results are sensitive to changes in the specification of the wage equation or the estimation method.

#### Key words:

NEG, wage equation, distance, core-periphery, regional policy, European regions

**JEL codes:** C21, F12, R11, R12

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<sup>7</sup> Submitted to *Munich Personal RePEc Archive* (MPRA).



## 2.1 Introduction

The so-called *wage equation* of the New Economic Geography (NEG) predicts that peripheral regions tend to have lower income because of their lower access to the main international markets, as captured by a variable *Market Access* or *Real Market Potential*. Consistently with this ‘curse of distance’, an expression coined by Bouhol and de Serres (2010), the regional spatial distribution of economic activity in Europe follows a core-periphery pattern that has been studied by Clark *et al.* (1969) and Keeble *et al.* (1982) or Faña and López-Rodríguez (2005).

Income per capita is negatively correlated with geographical peripherality in Europe. However, during the last decades, the European Union has been implemented active transport and regional policies, which should mitigate the consequences of peripherality. Using the NEG framework, the goal of this paper is study if the cross-sectional effects of distance on the European regional income per capita have been decreasing during the last years.

This goal is related with three strands of the empirical literature. First, the NEG wage equation appears to be empirically very successful (Redding, 2011). Inside this framework, some works have analyzed the effects of peripherality (Redding and Schott, 2003; Redding and Venables, 2004; Bouhol and de Serres, 2010). Several authors have estimated a wage equation for the European regions in different periods of time (Breinlich, 2006; López-Rodríguez and Faña, 2006). However, different from our paper, these works have not focused on the evolution of the cross-sectional wage equation over time or have not conducted a sensitivity analysis of their results. Second, there exists a vast literature on economic convergence in the European regions (Monfort, 2008; Borsi and Metiu, 2013), analyzing the patterns of economic growth in relation with the initial levels of income. However, if peripherality is associated with lower levels of income per capita, this literature is closely related with the debate about the curse of distance. In the present paper both economic and geographical peripherality are simultaneously considered.

A third strand of the empirical literature is the one studying the so-called ‘missing globalization puzzle’ or ‘distance puzzle’ (Disdier and Head, 2008). This debate refers to the estimation of a non-decreasing elasticity of trade to distance in spite of globalization. A number of different explanations or qualifications of the ‘puzzle’ has been proposed in the trade literature. The distance puzzle is about the effects of distance on trade over time while the curse of distance is a trade based prediction about the effects of distance on income. The debate about the distance puzzle directly affects the estimation of a wage equation over time when the *Market Potential* variable is built with the results of gravity equations estimated for bilateral trade data, as in Redding and Venables’s (2004) methodology. However, both Breinlich (2006) and Head and Mayer (2006) find similar results when estimating a wage equation for the European regions using Redding and Venables’s method or the more parsimonious measure of Market Potential defined by Harris (1954). The approach followed in this paper avoids the problems of interpretation derived by the distance puzzle debate making use of Harris’s measure to successively estimate a cross-sectional wage equation for the European regions from 1995 to 2008.

Harris’s (1954) *Market Potential* is an inverse distance weighted spatial lag of the income of all the others regions considered in the sample. Given that the weighting scheme of the variable is the same for any period, possible different estimates of Market Potential when the wage equation is estimated for different years can be directly interpreted as signs of a changing effect of dis-

tance. At least, the estimation of those time-varying parameters is a useful first approximation to the analysis of the curse of distance over time.

This analysis has its own limitations. In the NEG literature distances proxy trade costs, but all the empirical estimations of the wage equation using measures of distance are affected by other possible meanings of *distance* (Rodríguez-Pose, 2011), such as informational interaction or cultural proximity. Additionally, Market Potential is a spatial lag of income, which is the dependent variable, or a closely related variable, in the wage equation. Therefore, Chapter 1 argued that the estimation of the impact of Market Potential should be assessed through total effects, as LeSage and Pace (2009) emphasized for spatial autoregressive models. This issue has been largely ignored by the previous literature and is beyond the scope of the present work. The attention of this research is focused on analyzing the robustness of the results for different specifications of the wage equation, the inclusion or exclusion of a proxy for the internal market size, the use of instrumental variables and the estimation of standard Spatial Econometrics models.

In this chapter it is presented a baseline specification of the wage equation which includes two control variables of physical and human capital. This specification allows to estimate the direct effects of Market Potential (Boulhol *et al.*, 2008; Breinlich, 2006) which are lower than when the estimation omits control variables. A baseline wage equation with control variables has three advantages. First, the control variables could partially collect the exogenous effects of the European regional and transport policies. Second, it is a prudent approach to quantify the effects of Market Potential. Third, it allows to obtain a range of estimated effects of Market Potential when the analysis is repeated omitting those control variables.

A common problem to the three lines of research previously mentioned (wage equation, convergence and distance puzzle) is that the results are sample dependent. An original contribution of the present work is to study the evolution over time of the cross-sectional effects of Market Potential for a full sample of 206 regions and for four ‘regimes’ of regions defined as Poor-Rich and Central-Peripheral. The focus on the curse of distance makes to pay special attention to the latter subsample.

This chapter finds evidence that the cross-sectional elasticity of per capita income to Market Potential is decreasing along the period analyzed. However, some results are sensitive to changes in the specification of the wage equation or the estimation method.

The rest of the chapter is organized as follows. The next section briefly introduces the theoretical framework and discusses the econometric strategy. Section 2.3 presents the data and the four regimes of regions. Section 2.4 illustrates the relation between income per capita and distance in the European regions, and the relationship between the curse of distance and economic convergence. Section 2.5 shows the baseline pooled OLS estimations for the sample period 1995-2008. In section 2.6 a cross-sectional estimation is corrected for residual spatial autocorrelations and three instrumental variables of Market Potential are studied. Section 2.7 presents the time-varying cross-sectional estimations of the wage equation. A final section concludes and an Appendix explains data details.

## **2.2 Theoretical and econometric framework**

The so called ‘wage equation’ of the NEG predicts that regional wages are a function of the size of the markets available to each region. In particular, it explains the equilibrium industrial

nominal wages of each region  $i$  ( $w_i$ ) as a function of the sum of a product of two elements for all the  $j = 1, \dots, R$  regions to which industrial goods are exported. On one hand it is region  $j$ 's volume of demand of individual manufacturing varieties. This element is the quotient between their demand of manufacturing goods ( $\mu_j E_j$ ) and an index capturing the level of competition in  $j$ 's market ( $S_j$ ), where  $E_j$  and  $\mu_j$  are  $j$ 's total expenditure and manufacturing share of expenditure, respectively. On the other hand, the second element determines  $j$ 's demand of the specific variety produced in region  $i$ . It is the transport cost from region  $i$  to  $j$  destination ( $T_{ij}$ ), to the power of one minus the elasticity of substitution among the varieties of industrial goods ( $\sigma > 1$ ) or range of product differentiation. A market clearing condition defines the wage equation:

$$w_i = \left( \sum_{j=1}^R T_{ij}^{1-\sigma} \frac{\mu_j E_j}{S_j} \right)^{1/\sigma} = (RMP_i)^{1/\sigma} \quad (2.1)$$

Following Head and Mayer (2006), the expression between brackets is called *Real Market Potential* ( $RMP_i$ ) here. Redding and Venables (2004) call it *Market Access*. Krugman (1992, 1993) emphasized the similarity of this expression with Harris's (1954) measure of Market Potential:  $HMP_i = \sum_{j=1}^R T_{ij}^{-1} E_j$ . For this last indicator Harris's (1954) or Clark *et al.* (1969) carefully estimated transport cost though data restrictions frequently force to proxy trade costs with physical distances (see the data Appendix for alternatives). In Harris's index,  $E_j$  is usually a measure of the size of the market. As Combes *et al.* (2008) summarize, in order to go from  $RMP_i$  to  $HMP_i$  it is necessary to assume that the share of manufacturing goods on expenditure is the same in all regions ( $\mu_j = \mu = 1$ ), the same that Fujita *et al.* (1999, chap. 4) did, and that  $T_{ij}^{1-\sigma} = T_{ij}^{-1}$ . When trade costs are proxied by geographical distances ( $T_{ij} = d_{ij}$ ) this last assumption can be justified by the robust finding in the gravity equations literature of a trade elasticity to distance close to -1 (Head and Mayer, 2015). Therefore, the main difference of  $HMP_i$  with respect to  $RMP_i$  is the absence of an adjustment for variation in the competition index ( $S_j = S = 1$ ), which is not directly measurable. The next section justify why  $HMP_i$  is preferred in this work instead of alternative proxies of  $RMP_i$  utilized in NEG empirical literature.

A standard wage equation, such as equation (2.1), has been extended by Head and Mayer (2006) to control for human capital. A similar approach can be followed to include capital stock per worker. A version of the cross-sectional wage equation in logarithmic form for region  $i = 1, \dots, n$  can be:

$$\ln w_i = \alpha + \beta_1 \ln k_i + \beta_2 \ln h_i + \beta_3 \ln RMP_i \quad (2.2)$$

where  $w_i$  are wages,  $k_i$  is per capita capital stock,  $h_i$  is per capita human capital stock. Equation (2.2) has an intercept ( $\alpha$ ) derived from the parameters of the model that are assumed to be common in all regions. The control variables can be considered as proxies for exogenous regional technological differences or for exogenous effects of regional and transport policies.

Generalizing the notation, an econometric version of the cross-sectional equation (2.2) generalized to pooled data of  $T$  periods can be represented as:

$$y_{it} = \alpha + \beta' x_{it} + u_t + u_{it} \quad (2.3)$$

where  $t = 1, \dots, T$  and  $u_t$  are  $T - 1$  possible common shocks to all regions in each period. The term  $u_{it}$  collects the effects of omitted variables and departures from the assumptions of the theoretical model. In order to study how the coefficients of the  $x_{it}$  explanatory variables change in time, the cross-sectional equation (2.2) can be estimated  $T$  times to obtain a time series of  $\beta$ . The time-varying version of equation (2.3) estimated year by year can be represented as:

$$y_{it} = \alpha_t + \beta_t' x_{it} + \varepsilon_{it} \quad (2.4)$$

For each of the cross-sectional estimations,  $\varepsilon_{it}$  is supposed to be spatially uncorrelated in order to apply OLS. In section 2.7 a Spatial Error Model (SEM) will be calculated to correct the model for residual spatial autocorrelation:

$$\begin{aligned} Y &= X\beta + u \\ u &= \lambda W u + \varepsilon \end{aligned} \quad (2.5)$$

An alternative spatial model is the Spatial Autoregressive (SAR) model:  $Y = \rho W Y + X\beta + u$ . For reasons that will become clear below, the results of a SAR model will not be shown. However, in the context of this paper is particularly relevant because Market Potential is a type of spatial lag of the dependent (or a very related) variable (see Chapter 1). Therefore the impact of the explanatory variables should be calculated through total effects (LeSage and Pace, 2009, chap. 2), even when the model does not include an additional spatial lag of the dependent variable. At the moment, the expression “elasticity” is used here as in standard OLS regressions with variables in logarithms. This issue has been omitted in the previous literature and it is not further investigated in this paper in order to limit its scope. However, the results in section 2.6 will confirm that some problems can appear when two different types of spatial dependence are simultaneously considered in a Spatial Econometrics model including Market Potential.

Closely related to the previous issue is the endogeneity of Market Potential, which has been broadly discussed in the NEG empirical literature. See, for instance, Redding and Venables (2004), Breinlich (2006) or Head and Mayer (2006). Endogeneity is particularly severe if the variable of Market Potential includes a measure of the internal market sizes. The interpretation of possible changes over time of the cross-sectional estimate of Market Potential in a wage equation is affected by this and other issues. Therefore, the effort of the paper is oriented to analyze the robustness of the estimates with respect to different specifications, the consideration of the internal markets, the estimation with instrumental variables and the estimation of spatial models.

### 2.3 Data, measurement issues and samples of regions

The global sample studied in this paper consists of 206 European regions since the year 1995 to the year 2008. Table 2.1 summarizes the pooled means of the main variables (in levels) to be used in the later empirical analysis.

In a similar way to some other NEG empirical research (Redding and Venables, 2004; Brakman *et al.*, 2009a), wages are proxied by per capita income, measured as gross value added per capita (GVA). Breinlich (2006) argues that proxying wages by GVA per worker is innocuous as long as labor’s share in GVA does not vary across locations or at least not in a way systematically related to Market Potential. However, the *per capita* version is preferred here because it provides generality to the discussion. The wage equation has been broadly interpreted in terms of a relationship between Market Potential and the spatial distribution of economic activity (Redding, 2011), instead of the nominal manufacturing wages of Krugman’s (1991) stylized model or later NEG models. The data Appendix provide more details about this issue.

Human capital is proxied by the share of the population who has successfully completed education in Science and Technology (S&T) at the third level and is employed in a S&T occupation. In order to avoid jumps in the time-varying estimates due to different sample composition, miss-



ing data in this variable were imputed with a polynomial of degree 2 on the regional time trend of each region.

The Real Market Potential ( $RMP_{it}$ ) of region  $i$  in time  $t$  is proxied by a Harris's (1954) measure of Market Potential, defined as the inverse distance ( $d_{ij}$ ) weighted sum of the GVA of the regions  $j$  accessible to  $i$ . Given that the calculation is done on areal units, a correction for the size of the internal market of each area (self-potential) is necessary in order to measure the accessibility of its firms to the markets. Therefore, considering the  $R - 1$  possible markets of other  $j$  regions, the Harris's Market Potential ( $HMP_{it}$ ) of region  $i$  can be decomposed into its *Internal* ( $IMP_{it}$ ) and *External* ( $EMP_{it}$ ) components:

$$HMP_{it} = \sum_{j=1}^R \frac{GVA_{jt}}{d_{ij}} = \frac{GVA_{it}}{d_{ii}} + \sum_{j \neq i}^{R-1} \frac{GVA_{jt}}{d_{ij}} = IMP_{it} + EMP_{it} \quad (2.6)$$

where the distance to the own regional market ( $d_{ii}$ ) is measured by within region distances, as it will be discussed below. The calculation of Market Potential includes the regions of Norway and Switzerland though they are excluded from the sample because of lack of capital stock data (see Figure 2.2 below).

Alternatively, Redding and Venables (2004) built a measure of  $RMP_{it}$  (*Market Access*) proxying the NEG competition index ( $S_j$ ) by unobserved importer fixed effects. These effects were estimated using gravity equations for bilateral trade. In order to analyze time-varying effects of Market Potential by subsamples of regions, Harris's index is preferred here because of four reasons. First, Harris's measure keeps the same weighting scheme across time and space while Redding and Venables's approach presents comparability difficulties. For instance, the calculations by these last authors are based on an estimated trade elasticity to distance which is 2.5 times the one estimated by Boulhol and de Serres (2010). Breinlich's (2006) definition of Market Access includes a measure of income absent in Redding and Venables's measure. These issues are crucial when comparing different time periods because they determine what can change in the definition of the variable and the weight of that (possibly time-varying) component.

Second, the method of Redding and Venables (2004) is based on trade data what implies two difficulties. On one hand, the time-varying estimation of a wage equation get mixed with the so-called 'missing globalization puzzle' or 'distance puzzle' (Disdier and Head, 2008). This debate refers to the estimation of a non-decreasing elasticity of trade to distance in spite of globalization. A large trade literature has been following different approaches to solve or qualify the 'puzzle'. The diversity of explanations create problems to interpret the results of a changing cross-sectional estimate of Market Access, while Harris's simple measure can offer useful initial insights. On the other hand, when working with regional data, Redding and Venables's method requires additional simplifying assumptions due to the lack inter-regional trade data (Breinlich, 2006; Head and Mayer, 2006).

Third, in spite of the NEG interpretation of geographical distances as an indicator of trade costs, the meaning of distance is not clear. Physical distances proxy not only trade costs but 'relative' trade costs (Yotov, 2012) and capture non-trade-related barriers (Linders *et al.*, 2008) and regional characteristics, interactions and spillovers (Rodríguez-Pose, 2011) too. Even when working with trade data, the estimation of a wage equation with any measure of Market Potential based on distances is sensitive to these factors. Harris's approach makes it transparent and facilitates to focus on the direct effects of relative location on income.

Fourth, Harris's Market Potential is more parsimonious than other proxies of Real Market Potential. Both Head and Mayer (2006) and Breinlich (2006) obtain similar results for the European regions when comparing the approaches of Redding and Venables (2004) and Harris (1954).

Common to all the empirical methods for proxying  $RMP_{it}$  is the problem of measuring the Internal Market Potential, here defined as  $IMP_{it} = GVA_{it}/d_{ii}$ . Different measures of the internal market size have been proposed in the literature. A standard approach is to assume that regions are circular so the radius of region  $i$  is  $r_i = \sqrt{area_i/\pi}$ . In this paper internal distances are measured following Keeble *et al.* (1982), who chose  $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$  to allow for the likely clustering of economic activity in and around the regional 'centre'. This is similar to the 40% of the radius considered by Cambridge Econometrics (2014). See the data Appendix for more details.

**Table 2.1. Summary statistics by regime: pooled means 1995-2008 and average economic growth**

	<i>All</i>	<i>Rich</i>	<i>Poor</i>	<i>Central</i>	<i>Peripheral</i>
GVA per capita	20,295	24,957	15,632	22,593	17,997
Market Potential	16,814	20,658	12,969	22,502	11,125
External Market Potential	14,159	16,593	11,724	18,807	9,510
Weight of the internal market in Market Potential (%)	13.1	16.5	9.7	13.5	12.6
Capital stock per capita	72,412	87,367	57,457	80,300	64,524
Human capital (core variable of S&T, % of population)	9.0	10.0	7.9	9.5	8.4
Average distance to <i>All</i> the other regions (km)	1,112	972	1,252	854	1,370
Area (km <sup>2</sup> )	15,669	12,417	18,920	9,270	22,067
Growth rate GVA per capita (annual average % 1995-2008)	1.8	1.7	1.9	1.7	2.0

Notes: 206 European regions (*All*) splitted in four subsamples of 103 regions each of them according to the median log of GVA per capita in 1995 (*Rich-Poor*) and the median log of the average regional distance to the other regions (*Central-Peripheral*). The variables in the table are not log transformed. GVA and capital stock per capita are in 2000 year euros. Market Potential is in millions of 2000 euros. Human capital is proxied by the Eurostat's core variable of human resources in Science and Technology (S&T). See the data Appendix for details.

Exceptionally in the NEG empirical literature, Boulhol *et al.* (2008) analyze the weights of the internal component in their variable of Market potential. However, they do not report the absolute values of those weights. Table 2.1 shows the pooled mean of the weight of  $IMP_{it}$  on  $HMP_{it}$  when internal distances are calculating as 1/3 of the radius of circular regions. For the sample of 206 regions (*All*) regions, the average share is 13.1%. However, this number is affected by a few regions with big cities. In the year 2008, the weight of Internal Market Potential in Market Potential is higher than 40% for the regions of Stockholm, Brussels, Berlin, Hamburg, Madrid, Paris, Vienna, Athens and (Inner) London. Therefore, a better indicator of the effects of the chosen methodology to measure the internal markets is the median weight of  $IMP_{it}$  on  $HMP_{it}$ . The pooled median weight of  $IMP_{it}$  is 9.9%. When the internal distances are measures as 2/3 of a circular region, as it is frequently done in the empirical NEG research, that median is 5.2%. The approach of Keeble *et al.* (1982) to measure the internal distances as 1/3 of the radius is preferred here to the 2/3 alternative because it allows a higher differentiation between  $HMP_{it}$  and  $EMP_{it}$ .

The presence of  $IMP_{it}$  in the measurement of Market Potential does not only generate a huge endogeneity problem in the data of those regions (domestic GVA in both sides of the equation), but makes more difficult to interpret the time-varying estimates of Market Potential in terms of location. However, omitting the internal markets introduces measurement error by reducing the access measure of some economically larger locations (Breinlich, 2006; Head and Mayer, 2006). Therefore, the 1/3 approach to internal distances allows establishing a broader range of results

than the 2/3 approach for the robustness analysis of an estimated wage equation with respect to the measurement of the internal markets.

Table 2.1 also shows the average levels of the variables for 4 subsamples of regions. The curse of distance is mainly an issue about the economic development of peripheral regions. Therefore, the sample of 206 European regions in four ‘regimes’ conceived as meaningful groups of regions according to two criteria: economic development and peripherality. On one hand, the sample is splitted into economic regimes depending of having a log of per capita GVA in 1995 over or under the sample median that year: ‘Rich’ or ‘Poor’ regions. On the other hand, it splitted into geographical regimes depending of their log average distance to all the other regions being under or over the median: ‘Central’ or ‘Peripheral’ regions. Given that there is no objective dividing line about richness or peripherality, the medians are preferred over the means in order to obtain the same number of observations in each regime.

As pointed out to the authors by a referee, it can be argued that this division in regimes creates a problem of censored data because the range of variation of the dependent variable is limited with endogenous criteria. Indeed, the initial value of GVA per capita in the economic regimes is endogenous and location is closely related with the endogeneity problems of the Market Potential variable. However, an implicit economic criterion is always present in sample selection, particularly when the research is based on a particular geographical area. Any empirical result is the consequence of decisions about the data aggregation level, variables to study (availability) and singularities to consider (such as islands or possible ‘Nordic’ or ‘Eastern’ European regimes). Here the focus of attention is on comparing the possible different effects of Market Potential on economic development among four specific groups of regions over time. The next section provides details about their spatial structure.

## 2.4 The European spatial core-periphery pattern and regional convergence

The curse of distance is consistent with the core-periphery pattern of the spatial distribution of economic activity in the European regions (see Chapter 1). As the NEG predicts, the data in Table 2.1 confirms that the European Peripheral regions tend to be poorer than then Central ones. For the cross-section of the year 2008, the following figures represent the spatial distribution of the dependent variable in the wage equation under scrutiny, the logarithm of GVA per capita. In Figure 2.1 this variable is plotted against the average distance from each region to all the other regions in the sample. The economically central regions (high log GVA per capita) appear to be geographically central too (low average distance). Therefore, the regression line in the plot is negatively sloped<sup>8</sup>.

The relation between economic centrality and geographic centrality can be observed on a cloropheth map in spite of the visual distortion created by the heterogeneous size of the regions. Figure 2.2 shows the maps of the logarithms of GVA per capita and Market Potential in Europe in the year 2008. Their values are divided in seven quantiles, which helps to visualize their global spatial pattern. Darker colors are associated with higher values of the variables. The left map of Figure 2.2 shows that there are only a few high per capita income regions out of the geographical

<sup>8</sup> In Figure 2.1 the average distance is not log-transformed to facilitate the interpretation of the horizontal axis. The estimate of log average distance on the regression of log GVA per capita is -0.59 (not shown).

center of Europe, particularly those in Nordic countries. The economically central regions are mainly located around the so called *blue banana*, from West England in the North to Milan in the South. Given the spatial structure of GVA in Europe and the construction of Market Potential as a (weighted) sum of GVA, the logarithm of a Harris's measure of Market Potential shows an even more concentrated distribution and a clearer core-periphery pattern. Indeed, Table 2.1 shows that the pooled mean of (External) Market Potential before logs for Peripheral regions is half of the mean for the value Central ones. This characteristic allows Market Potential to capture in a stylized way the global core-periphery pattern of per capita GVA.

**Figure 2.1. Log GVA per capita (year 2008) versus average distance to the other regions**

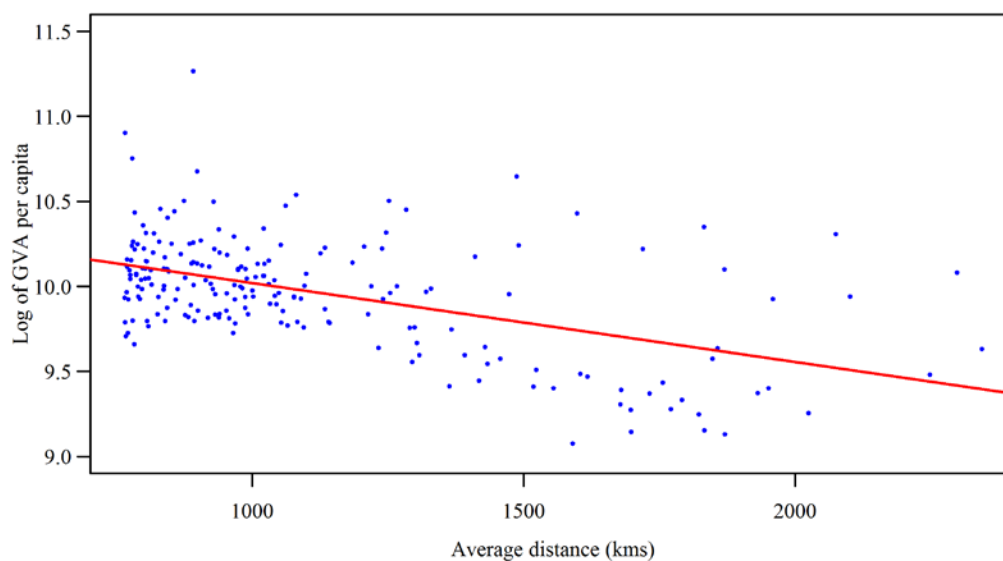


Figure 2.3 shows the values of the log of per capita GVA in the year 2008 for the four regimes. Again, for each regime those values are divided in seven quantiles. The key issue is the general similarity of the maps of the Poor and Peripheral subsamples, in spite of the arbitrary criteria of the medians used to classify the regimes.

Some of the (darker) relatively rich regions in the regime Poor are regions with high economic growth during the sample period. Table 2.1 shows the distribution of the average annual growth rate 1995-2008 of per capita GVA by regimes. Poor regions had higher average economic growth than Rich ones, which implies absolute convergence. Peripheral regions had higher growth than Central ones. This means that Peripheral regions are escaping the curse of distance, though the spatial distribution of economic activity in Europe continued to present a core-periphery pattern in the year 2008.

Both issues, regional convergence and the curse of distance, are closely related in the European case. The time-varying estimation to be presented below allows studying how this process affects the estimation of a European regional wage equation.

Figure 2.2. Choropleth maps of the logs of GVA per capita and Market Potential (year 2008)

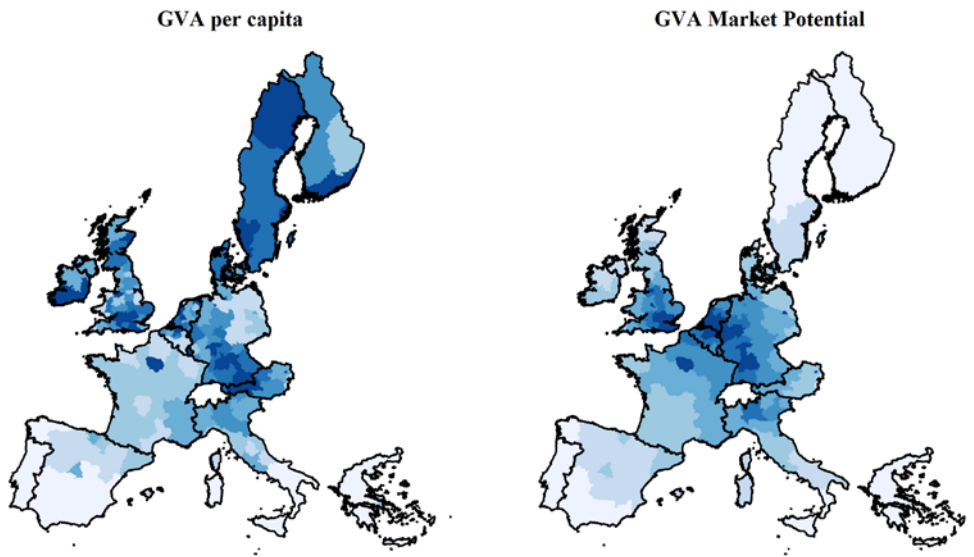
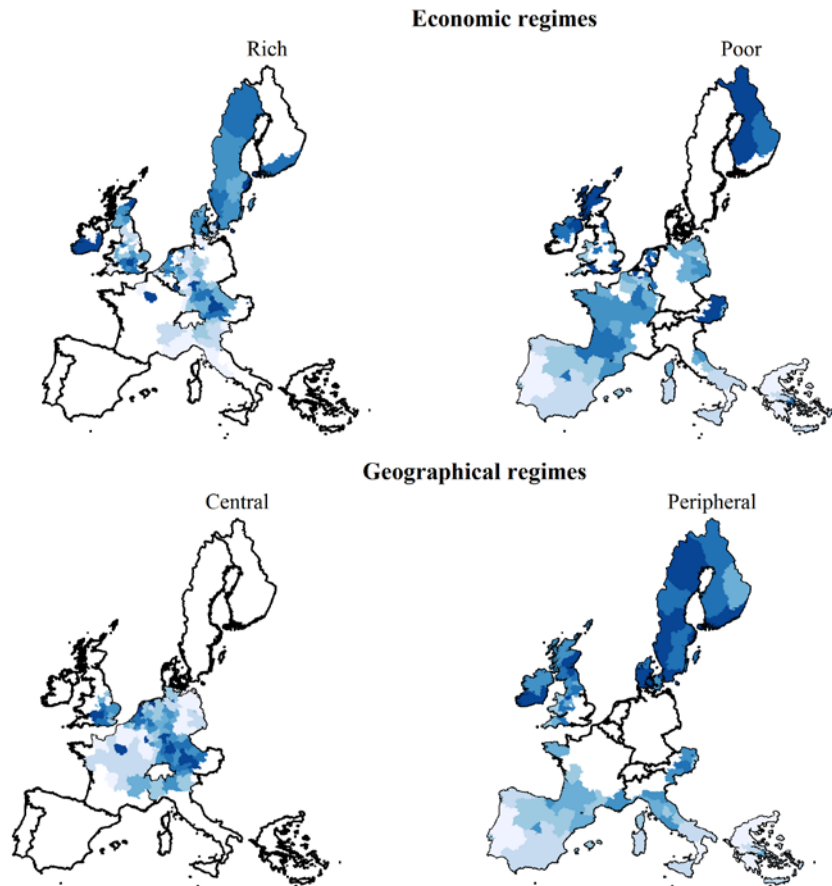


Figure 2.3. Choropleth maps of the log of GVA per capita by regimes (year 2008)

(Rich/Poor by year 1995 values)



## 2.5 Baseline pooled estimation: global sample and regimes

Table 2.2 analyzes the pooled equation (2.3) by parts<sup>9</sup>. Each row reports two standard errors: those estimated by OLS (above) and clustered standard errors (below) that allow for heteroskedasticity and serial correlation of arbitrary form (Arellano, 1987). Columns (1) and (2) of Table 2.2 show that capital stock per capita and Market Potential by themselves produce an adjusted coefficient of determination of 0.73 and 0.42, respectively. If human capital is the only explanatory variable that coefficient is 0.34 (not shown). The estimated elasticity of GVA per capita to Market Potential decreases from 0.42 when the latter is the only explanatory variable to 0.15-0.18 when control variables are considered. The inclusion of time effects is supported by Lagrange Multiplier tests but it does not have great influence on the pooled estimates. Column (7) shows that imputing missing data in the variable of human capital (see the Appendix) does not alter the results. The clustered standard errors in columns (6) and (7) show that the human capital variable loses significance when country dummies are introduced in the regression: the impact of human capital is partially due to country characteristics. However, the estimate of Market Potential of Market Potential is not very sensitive to the inclusion of country dummies. For the baseline model to be presented in Table 2.3, the specification with human capital is preferred.

In columns (5) and (6) of Table 2.2 Market Potential is replaced by its value lagged one period. Using lagged values has been done in the literature as a way of reducing endogeneity problems (Redding and Venables, 2004). However, this simple test with Market Potential lagged one year reveals that the results do not change in spite of losing the year 1995. The reason is that the pooled estimates are dominated by the cross-sectional relative values of the variables in levels, which are similar from one year to another one. The robustness of the results with respect to the inclusion of a proxy for the internal markets in Market Potential will be analyzed in the following sections.

Table 2.3 shows the baseline pooled models that will be the reference for the time-varying estimation below. The estimations by regimes reveal some differences. For instance, human capital in the regime ‘Peripheral’ might be able to collect some North-South differences of per capita GVA. Focusing on Market Potential, the benchmark estimate in the first column of Table 2.3 is 0.16<sup>10</sup>. According to the clustered standard errors Market Potential is not significant in the Rich regime, probably because this regime includes some rich Peripheral regions, which have low Market Potential. For the other three regimes the elasticity of GVA per capita to Market Potential ranges from 0.21 to 0.31. Therefore, considering all the results, it is possible to conclude that a rough pooled OLS estimate of the direct cross-sectional ‘effect’ of Market Potential is around 0.2.

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<sup>9</sup> R’s plm package (Croissant and Millo, 2008) has been used.

<sup>10</sup> As it will be shown in Table 2.6 below, if Table 2.3 is repeated using only the external component of Market Potential, the estimate for the sample with all the regions is 0.14.



**Table 2.2. Pooled OLS estimation of alternative specifications (1995-2008, 206 EU regions)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(Intercept)	0.759 (0.103)*** (0.392)	5.834 (0.087)*** (0.443)***	0.284 (0.095)** (0.334)	1.371 (0.117)*** (0.392)***	1.418 (0.123)*** (0.409)***	-0.088 (0.133) (0.671)	-0.020 (0.115) (0.604)
Capital stock per capita	0.818 (0.009)*** (0.035)***		0.709 (0.010)*** (0.034)***	0.669 (0.011)*** (0.033)***	0.670 (0.011)*** (0.034)***	0.764 (0.011)*** (0.064)***	0.756 (0.010)*** (0.060)***
Human capital				0.162 (0.009)*** (0.030)***	0.171 (0.009)*** (0.030)***	0.085 (0.010)*** (0.034)*	0.075 (0.009)*** (0.029)**
Market Potential		0.420 (0.009)*** (0.045)***	0.183 (0.006)*** (0.027)***	0.158 (0.007)*** (0.026)***	0.154 (0.007)*** (0.026)***	0.174 (0.008)*** (0.052)***	0.175 (0.007)*** (0.051)***
Year dummies?	No	No	Yes	Yes	Yes	Yes	Yes
Country dummies?	No	No	No	No	No	Yes	Yes
R-squared	0.730	0.425	0.798	0.831	0.824	0.929	0.929
Adj. R-squared	0.730	0.424	0.793	0.825	0.819	0.918	0.919
F	7804	2128	754	793	767	1110	1238
Sum sq. errors	88.86	189.53	66.66	52.39	50.38	20.20	23.50
N	2884	2884	2884	2605	2472	2472	2884

Notes: Table displays coefficients and two standard errors between brackets, those estimated by OLS (above) and Arellano's (1987) clustered standard errors (below). The coefficients are \* significant at 10% level; \*\* at 5% level; \*\*\* at 1% level. The variables are in logarithmic form. The dependent variable is gross value added per capita. In columns (5) and (6) Market Potential is replaced by its values lagged one year for each region. In Column (7) missing data in human capital were imputed. See the data Appendix.

**Table 2.3. Baseline pooled OLS estimation by regimes (1995-2008, 206 regions)**

	<i>All</i>	<i>Rich</i>	<i>Poor</i>	<i>Central</i>	<i>Peripheral</i>
(Intercept)	1.523 (0.111)*** (0.404)***	4.212 (0.171)*** (0.855)***	2.079 (0.170)*** (0.690)**	-0.653 (0.174)*** (0.698)	1.789 (0.166)*** (0.539)***
Capital stock per capita	0.648 (0.010)*** (0.032)***	0.488 (0.014)*** (0.053)***	0.538 (0.015)*** (0.061)***	0.675 (0.013)*** (0.051)***	0.583 (0.014)*** (0.042)***
Human capital	0.151 (0.008)*** (0.028)***	0.176 (0.010)*** (0.033)***	0.078 (0.011)*** (0.038)*	0.004 (0.012) (0.036)	0.232 (0.011)*** (0.035)***
Market Potential	0.163 (0.006)*** (0.025)***	0.079 (0.008)*** (0.044)	0.205 (0.008)*** (0.035)***	0.315 (0.013)*** (0.068)***	0.238 (0.010)*** (0.031)***
R-squared	0.820	0.648	0.768	0.778	0.838
Adj. R-squared	0.815	0.641	0.759	0.769	0.829
F	816	164	295	312	462
Sum sq. errors	59.32	23.13	23.50	20.67	30.64
N	2884	1442	1442	1442	1442

Notes: See notes of Table 2.1 and Table 2.2. The specification includes year dummies. The proxy of human capital includes imputed missing values. For the whole sample of regions, column *All* repeats column (7) of Table 2.2 but without country dummies.

## 2.6 Cross-sectional interactions: spatial models and instrumental variables

The time-varying estimations in the next section will be done for the cross-section of each year. Before that, it is convenient to analyze two possible problems in the cross-sections that have been pooled in the models of Table 2.3. First, residual spatial autocorrelation would violate the OLS assumption, calling for the estimation of spatial econometric models. Second, the endogeneity of the Market Potential variable would bias the OLS results. These issues are analyzed in this section for the cross-section of a particular year, 2008.

Table 2.4 and Table 2.5 show the estimation of equation (2.2) by OLS and the estimation of a Spatial Error Model, as in equation (1.5), by maximum likelihood, as well as the second and first stages of three instrumental variables estimations<sup>11</sup>. The first table uses the full variable of Market Potential, including the proxy for the internal markets, while the second one uses the external component.

The significant p-values of Moran's I in column (1) of the tables show that the OLS residuals are spatially autocorrelated. Non-reported Lagrange multiplier tests reveal that the simple versions of the tests for a SEM and a SAR model, including the spatially lagged dependent variable, are significant. Only the robust test for the SEM model is significant, pointing out to an erroneously omitted spatial process in the disturbances. If the true model is a SEM, OLS estimates are not biased and very different OLS and SEM estimates would indicate problems of specification. Column (2) of Table 2.4 shows that the OLS and SEM estimates of Market Potential are similar, 0.16 and 0.18, respectively. On the contrary, the SEM estimate of External Market Potential in Table 2.5 is zero. The Lagrange multiplier tests for the specification with the external component of Market Potential actually select the SAR model. However, the estimation of a SAR model (not show) is not able to correct the model for residual spatial autocorrelation. Additionally, the estimated total effect of External Market Potential in a SAR model is 0.08, which is similar to the estimate of 0.03 in column (2) of Table 2.5.

As it was discussed in section 2.2 these results are due to the simultaneous inclusion of two types of spatial dependence, a short-distance spatial autocorrelation and a core-periphery long-distance spatial pattern in the dependent variable, captured by External Market Potential. The result of the SEM model in Table 2.5 invalidates possible exercise of using OLS to estimate that specification for different years. However, non-reported estimations of the cross-sectional models in Table 2.5 excluding the control variables show that the OLS estimate of External Market Potential is 0.35 while the SEM estimate is 0.26, both of them being significant. Therefore, the results are very sensitive to the inclusion of control variables. The next section will compare the time-varying results when OLS is used for different specifications of the equation

The comparison of results when the internal component of Market Potential is included and omitted is relevant to analyze the issue of endogeneity too. As mentioned in section 2.3, Internal Market Potential introduced strong endogeneity problems. However, similarly to the spatial lag of the dependent variable in SAR models, External Market Potential is endogenous. Therefore columns (3) to (5) of the tables show the second stage of instrumental variables estimations, while the first stage is shown in columns (6) to (8).

Apart from the control variables of physical and human capital, which are considered as 'exogenous', the instruments are the Market Potential variables in the year 1991, the average distance of each region to all the other regions and the regional area. The first instrument uses data lagged 16 years while the other two instruments use purely geographic data. These instruments present shortcomings. The lagged values of Market Potential do not exclude the possibility of endogeneity in a long run relationship. The average distance implicitly determines a European

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<sup>11</sup> The spatial estimations were done with R's `spdep` package (Bivand, 2014) and the instrumental variables estimation with R's `AER` package (Kleiber and Zeileis, 2008).



center (Head and Mayer, 2006), which happens to be located in the European *blue banana* of rich regions<sup>12</sup>.

The regional area can potentially extract from Market Potential the endogenous component of internal markets. Indeed, column (8) of Table 2.4 shows a negative relationship between area and Market Potential. The rationality would be that a bigger area increases internal distances and reduces GVA density, reducing Market Potential. However, the same negative relation appears in column (8) of Table 2.5, which does not consider the internal markets. This is probably due to the fact that peripheral regions tend to have bigger size and lower External Market Potential than central regions (see Table 2.1)<sup>13</sup>. The regional area depends on the average size of the NUTs 2 regions in each country. It tends to be bigger in the geographically peripheral countries. Those countries are less densely populated so the variable area contains information about density, which is an endogenous factor. However, in spite of the shortcomings, this type of instruments have been used in the literature and provide both a first approach to the issue of endogeneity of Market Potential and knowledge about the characteristics of this variable.

Endogeneity tests are sensitive to heteroskedasticity error terms, so the Eicker-White covariance estimator is used in the IV estimations. The weak instrument tests confirm that the instruments are not considered weak. However, as any contextual test, the Wu-Hausman tests for the exogeneity of Market Potential are conditional to the quality of these instruments as exogenous variables. Under the cautionary remarks presented above, in this analysis endogeneity is accepted in columns (3) and (4) of Table 2.4. However, the estimates of Market Potential in columns (1) to (5) of Table 2.4 are very similar, with values around 0.15-0.18 and a slightly lower value of 0.11 in column (4). The endogeneity of External Market Potential tends to be rejected in Table 2.5, so the 0.14 OLS estimate in column (1) would be consistent.

In conclusion, the analysis does not reveal strong endogeneity problems provoking relevant biases in the OLS estimates of the Market Potential variables. The estimation of Spatial Econometrics models confirms Chapter 1's results about the important role of internal markets. If the internal markets are not considered in the estimation, External Market Potential has significance problems when the specification of a spatial model includes control variables. Added to this shortcoming is the general omission in the previous literature of the calculation of total effects when Market Potential is an explanatory variable. At the moment, the strategy followed in this paper is to analyze the robustness of the time-varying estimations with respect to the control variables and the inclusion of the proxy for the internal market size.

<sup>12</sup> In this sample the two NUTS 2 regions with lower average distance to the other regions are Trier, in Germany, and Luxembourg. Extending the sample to 274 regions, the geographical centre of Europe is Darmstadt, in German Hesse state. In this sense, it would be possible to say that a European regional index of Harris's Market Potential captures the peripherality with respect to the seats of the European Central Bank and the German Federal Bank, which are located in Frankfurt, Darmstadt.

<sup>13</sup> The negative effects on the regional area are robust to the simultaneous inclusion of the average distance (not shown). Aside from this, Breinlich (2006) finds a positive significant effect of the region's home country area, which would capture the advantage conferred to large national markets by the trade-reducing effects of national borders. With the data bank used in the present paper, the country size does not produce positive significant effects in different specifications of the Market Potential variables.

**Table 2.4. Cross-sectional estimations with Market Potential (year 2008, 206 regions)**

	OLS	ML-SEM	IV second stage			IV first stage		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	0.900 (0.490)	1.374** (0.520)	0.921 (0.542)	1.006 (0.551)	0.909 (0.562)	1.443*** (0.152)	21.060*** (1.047)	6.638*** (1.362)
Capital stock per capita	0.706*** (0.042)	0.646*** (0.039)	0.711*** (0.043)	0.735*** (0.045)	0.708*** (0.050)	-0.062*** (0.013)	0.001 (0.065)	0.484*** (0.104)
Human capital	0.195*** (0.038)	0.205*** (0.038)	0.196*** (0.039)	0.203*** (0.038)	0.195*** (0.041)	0.097*** (0.012)	0.222*** (0.058)	0.162 (0.099)
Market Potential	0.158*** (0.023)	0.183*** (0.035)	0.150*** (0.027)	0.116*** (0.027)	0.154** (0.051)			
$\lambda$		0.715*** (0.054)						
Market Potential 1991						0.980*** (0.007)		
Average distance (km)							-1.555*** (0.062)	
Area (km <sup>2</sup> )								-0.222*** (0.025)
R-squared	0.806		0.805	0.802	0.805	0.992	0.813	0.445
Adj. R-squared	0.803		0.802	0.799	0.803	0.992	0.810	0.437
Log likelihood	104.14	156.56				343.70	16.83	-95.05
Moran's I residuals	0.534	-0.021						
Moran's I p-value	0.000	0.649						
Weak inst. F test			10252.7	836.7	61.8			
Weak inst. p-value			0.000	0.000	0.000			
Wu-Hausman F test			12.941	7.357	0.012			
Wu-Hausman p-value			0.000	0.007	0.913			
Sum squared errors	4.39	2.35	4.39	4.47	4.39	0.43	10.24	30.35

Note: Table displays coefficients and standard errors. Columns (3) to (5) include Eicker-Huber-White standard errors. Moran's tests use the normality assumption for the residuals. The alternative hypothesis for the p-values is that Moran's I is greater than expected under the null hypothesis of absence of spatial autocorrelation. The weights matrix ( $W$ ) for Moran's test and the SEM estimation is a row-standardized binary matrix to the 5 nearest neighbors. The Stock and Yogo's (2005) critical value for the first-stage F-statistic weak identification test for 1 endogenous regressor, 1 instrumental variable and 10% of desired maximal size of a 5% Wald test is 16.38.

**Table 2.5. Cross-sectional estimations with External Market Potential (year 2008, 206 regions)**

	OLS	ML-SEM	IV second stage			IV first stage		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	0.874 (0.510)	2.311*** (0.595)	0.889 (0.576)	0.953 (0.575)	0.725 (0.615)	1.129*** (0.108)	22.456*** (0.744)	6.546*** (1.394)
Capital stock per capita	0.733*** (0.043)	0.703*** (0.040)	0.735*** (0.044)	0.748*** (0.046)	0.704*** (0.054)	-0.056*** (0.054)	-0.117* (0.046)	0.428*** (0.107)
Human capital	0.215*** (0.039)	0.259*** (0.039)	0.215*** (0.039)	0.217*** (0.039)	0.211*** (0.042)	0.054*** (0.042)	0.107** (0.041)	0.052 (0.101)
External Market Potential	0.136*** (0.024)	0.032 (0.043)	0.132*** (0.027)	0.111*** (0.027)	0.185** (0.065)			
$\lambda$		0.709*** (0.055)						
External Market Pot. 1991						0.995*** (0.005)		
Average distance (km)							-1.622*** (0.044)	
Area (km <sup>2</sup> )								-0.186*** (0.025)
R-squared	0.792		0.792	0.790	0.787	0.996	0.892	0.338
Adj. R-squared	0.788		0.788	0.787	0.784	0.995	0.891	0.328
Log likelihood	97.01	144.18				415.07	87.15	-99.86
Moran's I residuals	0.500	-0.038						
p-value Moran's I	0.000	0.790						
Weak inst. F test			14041.1	2760.2	39.2			
Weak inst. p-value			0.000	0.000	0.000			
Wu-Hausman F test			3.941	2.707	0.957			
Wu-Hausman p-value			0.048	0.101	0.329			
Sum squared errors	4.70	2.65	4.70	4.73	4.80	0.21	5.18	31.80

## 2.7 Time-varying estimations by year

If the possible effects of endogeneity and spatial autocorrelation in the estimated model remain constant over time, any temporal change of the cross-sectional elasticity of income per capita to Market Potential would be attributable to a change of the relative importance of location. Under this framework it is worthy to make the simple exercise of estimating the cross-sectional wage equation for different years.

Figure 2.4 presents the time-varying estimated elasticities of per capita GVA to Market Potential for the specifications in the pooled models of Table 2.3. The estimates remain pretty stable around the values of Table 2.3 for the five samples of regions, close to the 0.2 benchmark estimate. In spite of the convergence process discussed in section 2.4, this is probably due to the fact that the variables are in (log-transformed) levels and their cross-sectional dispersion (coefficient of variation) only had a slight reduction during the sample period. Particularly, when stock variables are used as controls, the estimates of Market Potential are not expected to present a very sloped trend. However, a slight declining trend is present in the lines of Figure 2.4. This is shown in Table 2.6.

**Figure 2.4. Time-varying cross-sectional elasticities of GVA per capita to Market Potential (based on Table 2)**

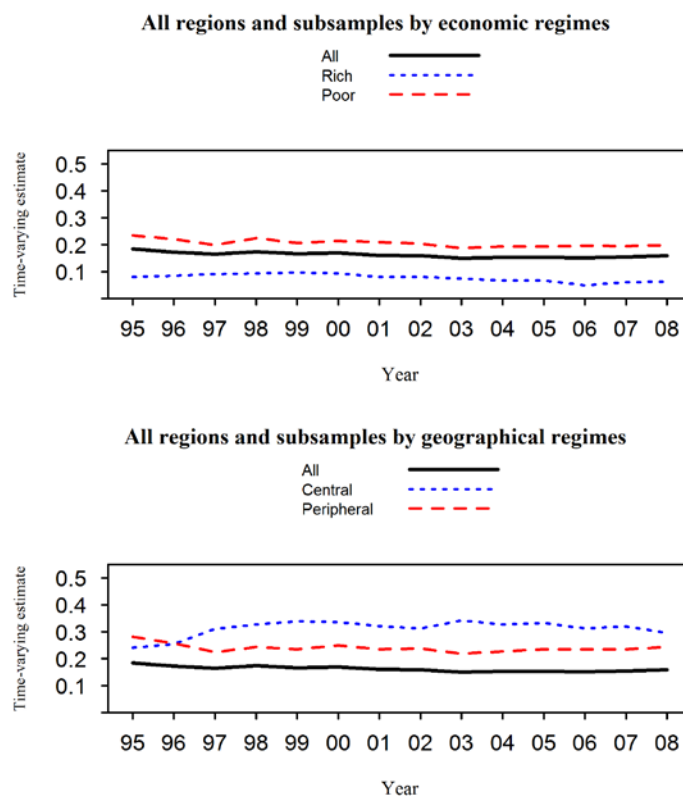


Table 2.6 shows a robustness analysis for different specifications when the control variables and the proxy for internal market size are omitted. The prudent benchmark pooled estimate of 0.2 is preferred in this paper to the 0.4 or 0.5 estimates reported in some columns of Table 2.6. However, the time-varying estimates are calculated for different specifications to check if there are

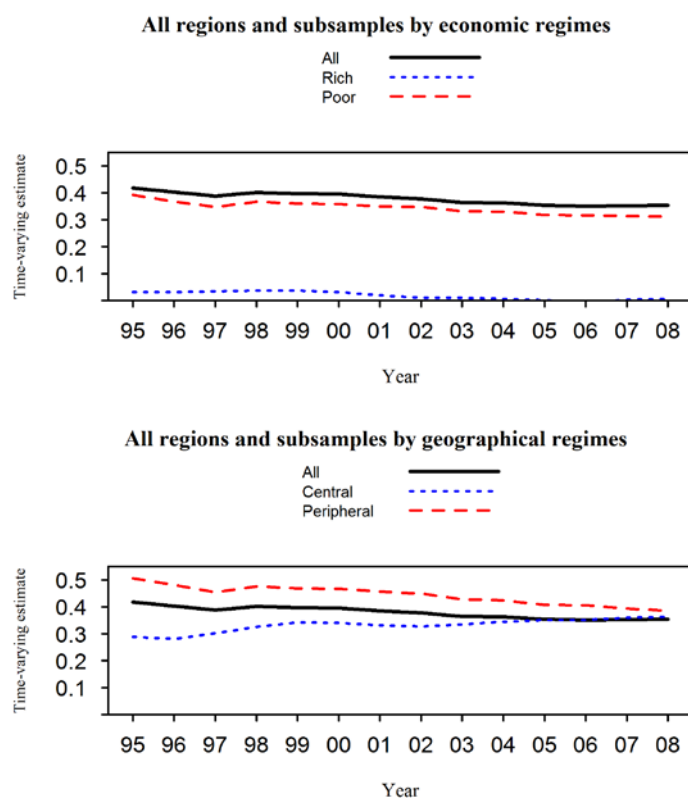
contradictory results. Additionally, Table 2.6 shows the percentage change of the time-varying estimates of the Market Potential variables since the first to the last year of the sample period. Given that the first two or three years sometimes present extreme values, this indicator must be supplemented by the whole series of estimates, as plotted in the accompanying figures.

**Table 2.6. Alternative pooled estimates of Market Potential and their cross-sectional change**

Specification	Indicators	All	Rich	Poor	Central	Peripheral
Market Potential with capital stock per capita and human capital	Estimate	0.163***	0.079	0.205***	0.313***	0.240***
	% change	-14.4	-22.0	-15.4	22.8	-13.5
Market Potential with human capital	Estimate	0.323***	0.112	0.305***	0.522***	0.367***
	% change	-16.9	-29.9	-24.8	-13.9	-19.3
Market Potential	Estimate	0.407***	0.112	0.365***	0.499***	0.461***
	% change	-10.8	-9.1	-16.6	7.0	-16.8
External Market Potential with capital stock per capita and human capital	Estimate	0.138***	0.037	0.182***	0.222**	0.243***
	% change	-19.9	-9.4	-23.5	136.3	-19.1
External Market Potential with human capital	Estimate	0.294***	0.046	0.283***	0.280	0.373***
	% change	-18.8	-39.5	-27.6	-15.9	-19.5
External Market Potential	Estimate	0.379***	0.018	0.344***	0.333	0.443***
	% change	-15.5	-84.0	-20.5	25.4	-24.0

Notes: 'Estimate' is the pooled estimate of Market Potential or External Market Potential when using the explanatory variables in the first column (in log form) and time dummies, as in Table 2.3. '% change' is the percentage of change of the cross-sectional estimates for the years 2008 and 1995. The stars mean significance levels of the pooled estimates using clustered standard errors (see notes of Table 2.2).

**Figure 2.5. Time-varying elasticities of External Market Potential as unique explanatory variable**



Comparing the specifications with the same control variables, the omission of the internal market sizes does not change too much the estimates of Market Potential when the both the full variable and its external component are significant. The pooled effects of External Market Potential in Table 2.6 tend to be more relevant for the regime Peripheral than for the Central one. A possible reason for this is the inverse distance weighting in External Market Potential. The GVA level of the nearest neighbors would be a more discriminatory variable for Peripheral regions than for regions located around the European geographical center, which have more similar values of Market Potential.

The cross-sectional estimate of Market Potential decreases a 14,4% for the sample of *All* regions when the years 1995 and 2008 are compared, though this reduction is not obvious in Figure 2.4. The evidence of Table 2.6 shows that this decreasing trend appears for all the specifications and in all the subsamples except the Central regime.

The time-varying estimates with External Market Potential generally show more pronounced downward trends than their analogous including a measure of internal markets. Figure 2.5 shows the time-varying estimates with more pronounced declining trend for the Peripheral regime, which corresponds to the specification using only External Market Potential (last row of Table 2.6).

In summary, contrary to the distance puzzle in the trade literature, measures of Harris's Market Potential allow to identify signs of a decreasing role of distance in the determination of the cross-regional dispersion of the European per capita production or income. The evidence is not totally conclusive because of the limitations emphasized in the previous sections. However, with the exception of the regime Central, the finding of a negatively sloped trend of the cross-sectional effects of Market Potential on GVA per capita is robust to the alternatives analyzed in Table 2.6. Moreover, the estimates of the variable with a more direct interpretation in terms of location, External Market Potential, seem to present clearer declining trends.

For Peripheral regions this trend implies that their relative GVA per capita tends to be less related with location. This is consistent with the data of economic growth shown in Table 2.1. The nearest neighbors of Peripheral regions tend to be Peripheral too and have relatively low Market Potential. As Peripheral regions converge to the levels of economic development of the geographically Central regions, the GVA level of their nearest neighbors becomes less discriminant to explain their cross-sectional differences of GVA per capita. The results confirm that Peripheral regions are slowly escaping the curse of distance.

## 2.8 Conclusions

This chapter analyzes the evolution of the cross-section elasticity of GVA per capita to Market Potential during the period 1995-2008 in a sample of 2006 European regions and in four subsamples ('regimes') characterized as Poor-Rich and Central-Peripheral regions. This is done under the framework of the NEG wage equation and using a Harris's (1954) measure of Market Potential.

The empirical exercise shares some of the limitations of the previous literature, such as the possible different interpretations of the meaning of distance or ignoring that Market Potential is a closely related with a spatial lag of the dependent variable. However, the exercise is considered useful to study the possible changing effects of distance after several decades of European efforts

on regional and transport policies. The paper focuses on analyzing the robustness of the results for different specifications of the wage equation, the inclusion or exclusion of a proxy for the internal market size, the use of instrumental variables and the estimation of Spatial Econometrics models.

A negatively sloped trend on the cross-sectional estimated effects of Market Potential on gross value added per capita seems to be a pretty robust finding. Moreover, the estimates of the variable with a more direct interpretation in terms of location, External Market Potential, present clearer declining trends. However, the evidence is not totally conclusive because it is highly sensitive to the inclusion of control variables. In particular, the cross-sectional effects of External Market Potential disappear when the estimation is controlled for physical and human capital and for spatial autocorrelation. With other specifications the evidence is more solid towards a decreasing role of location to explain the relative GVA per capita of Peripheral regions. This is consistent with the peripheral regions being slowly escaping the curse of distance.

This research can be extended in several directions. The wage equation has been estimated with unobserved individual effects. Preliminary tests show that this extension requires further discussion and is current research. The exercise can be repeated using measures of Market Potential derived from trade data and considering the alternative explanations to the distance puzzle proposed by the literature. The time-varying models can be estimated with different methods, using other sets of variables or for other samples of European regions and periods.

## **Chapter 3: The observational equivalence of the NEG wage-type equation**

### **Abstract**

In spite of the apparent empirical success of the New Economic Geography (NEG) wage equation, some authors have asserted its observational equivalence, i.e., the consistency of those results with alternative frameworks, such as Urban Economics theories. However, few efforts have been made to empirically test this equivalence. One reason could stem from the lack of commonly accepted approach for that.

This chapter proposes a procedure to show that many empirical wage equations are actually proxying an underlying production function augmented with locational information about the economic scale of the nearest neighbor(-s). The method begins by presenting a NEG setting with capital stock, which encompass several wage equations found in the literature. A baseline wage-type equation is then estimated by redefining the key variables of the model in several ways different from those that are commonly considered by the NEG empirical literature.

Cross-sectional European regional data and a Harris's measure of Market Potential are used to analyze the robustness of the estimation to these alternative specifications. The findings are similar to those of a standard NEG wage equation, which is the essence of the observational equivalence of NEG theory.

#### **Keywords:**

New Economic Geography, wage equation, Market Potential, production function, cross-section, European regions

**JEL codes:** C21, F12, R12





### 3.1 Introduction

The basic form of the so called ‘wage equation’ of the New Economic Geography (NEG) predicts that nominal regional manufacturing wages are a function of an index of regional accessibility to markets called *Market Access* or *Market Potential*. It has been widely studied in the empirical literature, which seems to confirm a ‘causal relationship’ between market access and the spatial distribution of economic activity (Redding, 2011). This apparent success has been questioned. The problem of the observational equivalence of the NEG is that ‘there are a number of other explanations that are consistent with the data and not much yet that strongly points to the explanation offered by NEG’ (Head and Mayer, 2004b). However, it is not obvious how this statement can be empirically tested.

The goal of this chapter is to propose a procedure to empirically check whether wage equations are actually proxying an underlying production function augmented with locational information about the nearest neighbor(-s) economic development.

The initial NEG specifications of the wage equation started from very restrictive assumptions, which were generalized by Robert-Nicoud (2005) and Head and Mayer (2011). However, that generalization does not facilitate to disentangle the channels of agglomeration. The sources of the observational equivalence of the NEG are old and can be discussed in the framework of the basic NEG models. Duranton and Puga (2004) call it *Marshallian equivalence*. The difficulty to discern between alternative theories of location has also been mentioned by Head and Mayer (2004b), Overman (2004), Rosenthal and Strange (2004), Brakman *et al.* (2009b, chap. 5) or Puga (2010). However, few efforts have been made to empirically test such an observational equivalence.

There are not commonly accepted approaches for this test. A possible reason is that the stylized NEG framework offers ambiguous empirical guidelines about a variety of issues: 1) the definition of the sectors; 2) the definition of the immobile inputs in each sector and the type of factor price equalization affecting the mobile ones; 3) the temporal horizon of the model and the proper sample period and estimation technique to capture that temporal process; 4) the alternative sources of agglomeration underlying an estimable relation between measurable variables in a wage equation; 5) the role of technological differences in determining factor prices and the control variables in an empirical wage equation; 6) the role of the distance decay parameter in a measure of Market Potential; and 7) the role of sample heterogeneity when using variables in levels to estimate the equation.

The ambiguous empirical guidelines can be illustrated with an example. The conventional dependent variable of the NEG *wage* equation is the nominal wages of the sector producing under monopolistic competition. However, as it was mentioned above, a frequent interpretation of the equation makes reference to the spatial distribution of economic activity instead of wages (a price). The wage equation is actually a market clearing condition affecting firm’s marginal costs. All the empirical proxies for marginal costs are a measure of productivity, which is assumed to be the same for all regions in the basic NEG model. This is particularly true for wages since they are a measure of productivity (Feldstein, 2008). Moreover, due to lack of data, many empirical estimations of the wage equation frequently proxy the wages of the agglomerating sector with aggregate income or production per capita or per worker, which are considered as proxies for

productivity in different literatures. Some possible proxies that can be used as dependent variable of the NEG *wage* equation are displayed in Table 3.1 to show their cross-sectional correlations for year 2008 in a sample of 206 European regions. The correlations among the variables are reported to be very high. The lower correlations correspond to variables of different sectors, which is not that relevant if sector-specific control variables are included in the estimation of each possible wage-type of equation. The correlations are even higher if a more heterogeneous sample of regions is used by including the Eastern European regions (not shown). These high correlations could be indicating the existence of an underlying production function with different levels of total factor productivity. If so, technology and technology diffusion are a key aspect of the observational equivalence of the wage equation (Krugman, 2011).

**Table 3.1. Alternative dependent variables: correlations year 2008 (206 regions)**

	IGVAp	IGDPp	IGVAw	IREMw	IGVAwem	IREMwem	IGVAwms	IREMwms
IGVAp	1.000	0.994	0.888	0.794	0.733	0.808	0.781	0.738
IGDPp	0.994	1.000	0.890	0.782	0.749	0.796	0.789	0.732
IGVAw	0.888	0.890	1.000	0.910	0.801	0.845	0.915	0.857
IREMw	0.794	0.782	0.910	1.000	0.694	0.860	0.857	0.950
IGVAwem	0.733	0.749	0.801	0.694	1.000	0.812	0.576	0.610
IREMwem	0.808	0.796	0.845	0.860	0.812	1.000	0.683	0.725
IGVAwms	0.781	0.789	0.915	0.857	0.576	0.683	1.000	0.878
IREMwms	0.738	0.732	0.857	0.950	0.610	0.725	0.878	1.000

Note: For the total regional economy the variables are the following (in log form): gross value added per capita (IGVAp), gross domestic product per capita (IGDPp), GVA per worker (IGVAw) and remuneration (compensation) per worker (IREMw). Additionally, GVA per worker and remuneration per worker are presented for two sectors: energy and manufacturing (IGVAwem and IREMwem) and market services (IGVAwms and IREMwms). See Appendix A for details.

The test about the observational equivalence of a theory must distinguish the essential issues to test. Head and Mayer (2004b) ask for estimation methods connected closely to the theory but not dependent on features of models that were included for tractability or clarity of exposition instead of realism. ‘Rather we need to focus on testing the essential distinguishing features of the models that allow one to falsify them or their alternatives’. Therefore, the chapter proposes a method to check if statements *forbidden* by NEG theory may also lead to similar results to those obtained with more conventional NEG specifications. For Sir Karl Popper (1959, p. 95), a theory is falsifiable ‘if there exists at least one non-empty class of homotypic basic statements which are forbidden by it; that is, if the class of its potential falsifiers is not empty’. Head and Mayer’s (2004b) re-state it in terms of the statistical Error Type II when testing a null hypothesis: empirical work should not confirm the validity of NEG based on results that are consistent with NEG but would also be equally consistent with alternative theories. This chapter does not pretend to falsify NEG theory but to show that many of its empirical results can be obtained with variables that are forbidden by NEG.

The problem of identifying the different sides of the observational equivalence is first approached in this chapter by developing a NEG setting that allows emphasizing the similarities between a wage-type equation and an augmented production function. The theoretical approach builds on Redding and Venables’s (2004) model and its subsequent by Head and Mayer (2004b), Breinlich (2006) and Head and Mayer (2006). Focusing on marginal costs, instead on wages, a *wage-type* equation is derived to encompass several wage equations found in the literature. In

order to emphasize the similarity of wage equation to an expanded production function, the derivation of that wage-type equation adds capital stock as explanatory variable, in a similar way to what Head and Mayer (2006) did for human capital. Chapter 2 provided additional arguments in favor of controlling the estimation for physical and human capital.

The second step of the procedure consists on the repeated estimation of a baseline wage-type equation by redefining the key variables of the model in alternative ways from those commonly used by the NEG empirical literature. These exercises are illustrated using cross-sectional regressions for the European regions and a Harris's (1954) definition of *Market Potential*. The augmented wage-type equation allows estimating the empirical direct effects of Market Potential when controlling for human and physical capital stock per capita. The joint analysis of robustness of the estimations to alternative specifications allows concluding that the results found are similar to those of a standard NEG wage equation.

One of these tests shows that a measure of Market Potential mainly collects information about the location and economic scale of the nearest region. That result is robust to the omission of control variables and it cast doubts on the measure of Market Potential as a proxy of the aggregate market size. With the regional data used here, it seems unclear both the difference between urban and regional inequality and the spatial bounds of each type of possible interaction. Therefore, the conclusion of this analysis does not support Combes *et al.*'s (2008, chap. 2) defense of the NEG explanation of interregional inequalities when compared with the theories of urban agglomeration.

The remaining of the chapter is structured as follows. Section 3.2 discusses the NEG theory and derives a generalized form of the wage-type equation. Section 3.3 reviews the econometric approach followed here. Section 3.4 shows the results of testing the wage-type equation under different definitions for both the right hand side and the left hand side of the equation. Section 0 concludes.

## 3.2 Theoretical framework

### 3.2.1 The NEG basic model: the demand side

The NEG model sketched here is mainly based in Redding and Venables's (2004) model as well as in the versions of it by Head and Mayer (2006) and Breinlich (2006). The expression 'generalized' wage equation is used to emphasize that the dependent variable is not wages but marginal costs, as in Head and Mayer's (2004b)<sup>14</sup> interpretation of Redding and Venables's (2004) specification. This emphasis facilitates the derivation of an expression for wages encompassing many of the wage equations previously derived in the literature. The research focus on the observational equivalence of the NEG makes to stress the empirical aspects of the theory of estimable 'wage-type equations'. Additionally, the following presentation highlights the role of prices in NEG's definition of Market Potential in order to justify the later utilization of Harris's (1954) measure of Market Potential in the empirical part of the Chapter.

Redding and Venables's (2004) model include intermediate inputs and the full general equilibrium model is described by Fujita *et al.* (1999, chap. 14). As in Breinlich's (2006) version of their

<sup>14</sup> Too see Combes *et al.* (2008, chap. 12).

model, the intermediate inputs are omitted here, though Appendix B provides some details about this extension. Many variants of the NEG models are isomorphic irrespective of the agglomeration mechanism they assume (Robert-Nicoud, 2005), so the focus here is on the basic NEG model.

The NEG literature distinguishes two sectors: a perfect competitive sector that produces a single homogeneous good under constant returns to scale and a sector producing a large variety of differentiated goods under a market structure of monopolistic competition. The production of each variety in this last sector exhibits internal increasing returns to scale. The final result of the model revised here is an estimable equation for the maximum remuneration that firms can afford to pay to the immobile production factors in the monopolistically competitive sector. The notation used here follows Fingleton's (2006, 2007, 2008) or Fingleton and Fischer's (2010) distinction of a competitive  $C$  sector and a monopolistically competitive  $M$  sector.

The basic NEG model of Fujita *et al.* (1999, chap. 4) calls these two sectors 'agriculture' and 'manufacturing' but these names are not a good guide for empirical work. As Fujita *et al.* (1999, p. 58) point out, '(...) the label 'agriculture' need not always be interpreted literally; the sector's defining characteristic is that it is the 'residual', perfectly competitive sector that is the counterpart to the action taking place in the increasing-returns, imperfectly competitive manufacturing sector'. In this case, 'agriculture' would be a composite of the  $C$ -part of the two broad sectors of it could encompass 'services'. In spite of this, Redding and Venables's (2004) empirical application takes gross domestic product per capita or manufacturing wages as proxies for the price of immobile factors in the  $M$  sector. Contrary, Fingleton and Fischer (2010) argue that the  $M$  sector is properly defined as services and they use this definition to measure the shares of the  $M$  and  $C$  sectors in the workforce<sup>15</sup>. However, they proxy the  $M$  wage with the overall gross value added per worker in each region and a constant across regions  $C$  wage with the mean gross value added per worker in their cross-sectional sample.

Another interpretation about the  $M$  sector is that it is the 'modern' sector, as opposite to a 'traditional'  $C$  sector. Under this view, Ottaviano and Thisse (2004) observe that 'what the two sectors are' changes with the stage of development of the economy as well as with the epoch under consideration. Finally, Baldwin *et al.* (2003, chap. 2) argue that the key distinction in the basic core-periphery model described by Fujita *et al.* (1999) is that the  $C$  sector uses the interregionally immobile factor intensively in its production. However, this distinction cannot be extended to other NEG model arriving to similar predictions about wages. Therefore, it is better to approach the NEG model in terms of the general definition of  $C$  and  $M$  sectors, according to the assumptions about market structure.

The focus of the model presented here is on the  $M$  sector. However, in order to fix notation the model is introduced with the demand side for both sectors. The basic model assumes that every consumer shares the same Cobb-Douglas tastes for the two types of goods. Alternatively, though it is not essential for later arguments, it is useful to assume a different  $0 < \mu_j < 1$  parameter of preferences for each type of good in each region  $j$ . The upper-level step of the problem of the representative consumer in region  $j$  is to divide its total income  $Y_j$  between the consumption of the two aggregated goods:

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<sup>15</sup> Using many of the NEG ingredients, such as space and transport costs, Desmet and Rossi-Hansberg (2012) build a two sector model of manufacturing and services in which services innovate and concentrate in space.

$$\begin{aligned} \max_{M_j, C_j} U_j &= M_j^{\mu_j} C_j^{1-\mu_j} \\ \text{s.t. } G_j^M M_j + P_j^C C_j &= Y_j \end{aligned} \quad (3.1)$$

where  $M$  represents a composite index of the consumption of goods produced under monopolistic competition and  $C$  the consumption of goods produced under a competitive market structure.  $P_j^C$  is the price of the  $C$  good and  $G_j^M$  is a ‘price index’ for the  $M_j$  goods consumed by  $j$ . The reason for a different notation for both types of prices is discussed below. Therefore, the amount of consumption of region  $j$  in  $M$  goods is:

$$M_j = \mu_j Y_j / G_j^M = E_j^M / G_j^M \quad (3.2)$$

$E_j^M$  is the expenditure of region  $j$  in all the varieties of the  $M$  good and  $E_j^C$  is the analogous for  $C$  goods.  $\mu_j$  is the share of total expenditure,  $E_j = E_j^M + E_j^C$ , in  $M$  goods. Total income,  $Y_j$ , is the same than total expenditure in consumption,  $E_j$ , because the model does not include intermediate goods. The double notation is a reminder of the convenient assumption of different preferences in each region ( $\mu_j$ ). Apart from different tastes, different regional  $\mu_j$  can be justified by regional heterogeneity in terms of non-explicit restrictions making agents to demand different bundles of products in different regions<sup>16</sup>. But the main purpose of assuming different regional shares of total expenditure on  $M$  goods is to encompass the full model with backward and forward industry linkages. As it will be shown in Appendix B, equation (B.6), in models with intermediate goods, the total expenditure of each region in the composite good  $M$  is a function of the share of consumer demand of  $M$  goods and the share of producer costs which are purchases of intermediate goods  $M$ . For simplicity here it is assumed that the good produced by the monopolistic competitive sector is used just for consumption. Setting differences in the parameter of preferences  $\mu_j$  allows for what in a model with intermediate goods would be different shares of costs in intermediate goods in different sectors, or different sectorial composition in different regions<sup>17</sup>.

After deciding the optimal consumption of the composite index of  $M$  goods, the representative consumer of region  $j$  decides the quantity of consumption for each  $M$  variety. The demand of  $M$  goods in any region  $j$  is derived from the maximization of a CES subutility function for the consumption  $x(v)_j$  of each  $M$  variety  $v = 1, \dots, V$ , where  $V$  is the number of varieties potentially available for consumption. Given that the utility function  $M_j$  embodies a preference for diversity and there are increasing returns to scale in the  $M$  sector, each firm produces a distinct variety. If the ‘world’ is composed by  $R$  regions, the number of varieties potentially available in region  $j$  is the number of firms and varieties produced in all the  $R$  regions:  $V = \sum_{i=1}^R n_i$ , where  $n_i$  is the number of firms/varieties produced in region  $i = 1, \dots, R$ . In equilibrium all goods produced in each region  $i$  are demanded by region  $j$  in the same quantity. Therefore, the representative consumer in  $j$  solves the following problem:

<sup>16</sup> For instance, Fujita *et al.* (1999, chap. 15) assume that consumers have a minimal ‘subsistence’ level of food consumption. Therefore, in terms of the total income  $Y_j$  of a consumer in region  $j$ , there will be different  $\mu_j$  in different regions. This idea can be extended to general condition related with the level of development.

<sup>17</sup> This makes total income,  $Y_j$ , different from total expenditure in consumption,  $E_j$ . A similar simplification is done by Head and Mayer (2006). The assumption of different regional preferences collected by the  $\mu_j$  parameter is implicit in Combes *et al.* (2008b, chap. 12) too.

$$\begin{aligned} \max_{x_{ij}} M_j &= \left[ \sum_{i=1}^R \sum_{v=1}^{n_i} x(v)_{ij} \frac{\sigma-1}{i_j^\sigma} \right]^{\frac{\sigma}{\sigma-1}} = \left[ \sum_{i=1}^R n_i x_{ij} \frac{\sigma-1}{i_j^\sigma} \right]^{\frac{\sigma}{\sigma-1}} \\ \text{s. t. } \sum_{i=1}^R n_i p_{ij} x_{ij} &= E_j^M \end{aligned} \quad (3.3)$$

where  $\sigma > 1$  is the elasticity of substitution between any pair of varieties,  $E_j^M$  is the expenditure of region  $j$  on  $M$  goods,  $x_{ij}$  is the amount of consumption in  $j$  of the variety produced in  $i$  and  $p_{ij}$  is the delivery price of that variety. The first-order conditions of this problem for a representative variety from region  $i$  and a variety  $g$  produced anywhere, maybe produced in  $i$  too, give equality of marginal rates of substitution to price ratios:

$$\frac{x_{ij} \frac{1}{i_j^\sigma}}{x_{gj} \frac{1}{i_j^\sigma}} = \frac{p_{gj}}{p_{ij}} \quad (3.4)$$

Substituting  $x_{ij} = x_{gj} (p_{gj}/p_{ij})^\sigma$  from this equation into the expenditure constraint and bringing the common  $g$ -terms  $p_{gj}^\sigma x_{gj}$  outside the sum, it is possible to deduce the compensated demand function for the  $g$  variety of the monopolistically competitive  $M$  good. Noting with a  $d$  superscript the optimal consumption level in  $j$ -market for the good produced by a  $g$ -firm:

$$x_{gj}^d = p_{gj}^{-\sigma} \frac{E_j^M}{\sum_{i=1}^R n_i p_{ij}^{1-\sigma}} \quad (3.5)$$

This relation is true for the representative variety from region  $i$  too. Therefore, the notation of the denominator with a sum across  $i$  varieties can be kept if the last equation is rewritten to go back to  $j$ -consumption of a variety produced by a firm in region  $i$ :

$$x_{ij}^d = p_{ij}^{-\sigma} \frac{E_j^M}{\sum_{i=1}^R n_i p_{ij}^{1-\sigma}} = p_{ij}^{-\sigma} \frac{E_j^M}{S_j^M} \quad (3.6)$$

The term with a sum across all the varieties in the world potentially available in region  $j$ ,  $S_j^M = \sum_{i=1}^R n_i p_{ij}^{1-\sigma}$ , is what Redding and Venables (2004) call ‘supplier access’. Here it is called ‘supply index’, following Head and Mayer (2006), or ‘competition index’. Plugging the value in equation (3.6) into the utility function, the optimal utility level is  $M_j = E_j^M S_j^{\frac{1}{\sigma-1}}$ , which can be re-written as  $M_j = E_j^M / G_j^M$  after defining  $G_j^M \equiv S_j^{M/(1-\sigma)}$ . This allows the interpretation of  $G_j^M$  as an aggregate ‘price index’ of the composed  $M$  good, such as  $G_j^M M_j = E_j^M$ . Fujita *et al.* (1999) obtain this index through cost minimization, the dual problem of the restricted maximization of equation (3.3):

$$G_j^M = \left[ \sum_{i=1}^R \sum_{v=1}^{n_i} p(v)_{ij}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = \left[ \sum_{i=1}^R n_i p_{ij}^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \quad (3.7)$$

‘The price index,  $G$ , measures the minimum cost of purchasing a unit of the composite index  $M$  of goods produced under monopolistic competition, so just as  $M$  can be thought of as a utility function,  $G$  can be thought of as an expenditure function’ (Fujita *et al.*, 1999, p. 47).  $G_j^M$  is a ‘price’ because it is the unit cost of utility for the consumer. Brakman *et al.* (2009b, chap. 3) call  $G_j^M$  the consumption-based, or exact, price index. Baldwin *et al.* (2003, chap. 2) call  $G_j^M$  a ‘perfect’ price index and observe that real income defined with  $G_j^M$  is a measure of utility. The original adjective used by Krugman (1992) was ‘true’ price index.



Adapting Head and Mayer's (2004b) definition, the unit cost of utility  $G_j^M$  is a generalized mean of the delivered prices of all the suppliers to location  $j$  that assigns increasing weight to sources that have a large number of suppliers,  $n_i$ . The power of the generalized mean depends on the elasticity of substitution among varieties because  $G_j^M$  gives an exact representation of the utility derived from the consumption of  $M$  goods (Brakman *et al.*, 2009b, chap. 3).

Redding and Venables (2004) calls 'market capacity' to the term  $E_j^M/S_j^M = E_j^M G_j^{M\sigma-1}$ . It gives the position of the demand curve facing each firm in market  $j$ . Equation (3.6) says that the demand of a variety  $i$  in  $j$  market,  $x_{ij}^d$ , is inversely related to the delivery price of that variety,  $p_{ij}$ , and to the supply index,  $S_j^M$ . This index includes the delivery prices in  $j$  of all varieties and those prices have a negative exponent, related with the elasticity of substitution among varieties. The assumption of a CES utility function for  $M$  goods with  $\sigma_i = \sigma > 1$  is crucial. That it is the reason why here it is preferred Head and Mayer's (2006) notation, with  $S_j^M$ , to the conventional notation with  $G_j^M$ . It makes more transparent that the exponent of the  $p_i^{1-\sigma}$  terms in  $S_j^M$  are negative. A location that is served by a large number and low-price sources will have a high supply index and will therefore be a market where it is difficult to obtain a high market share (Head and Mayer, 2006). This is why the supply index  $S_j^M$  measures the level of competition among  $M$  varieties in  $j$  market given the characteristic tastes of consumers. Additionally, the notation with  $S_j^M$  avoids deriving the wage equation in terms of a 'price index' which has not empirical counterpart.

Firms of the same region are assumed to have the same *free-on-board* price. Trade costs are assumed to be borne by consumers, so firms follow a mill pricing policy. If  $p_i$  is the mill price of a good produced in region  $i$ , the delivered price in market  $j$  is assumed to be  $p_{ij} = T_{ij}p_i$ , where  $T_{ij} \geq 1$  are 'iceberg' transport or trade costs<sup>18</sup>: for every unit shipped only  $1/T_{ij}$  units arrive to destiny while the rest melts during transport. Therefore, for every unit consumed in market  $j$  at a price  $p_{ij}$ ,  $T_{ij}$  units must be shipped in region  $i$  with a mill price  $p_i$ . With this at hand, equation (3.6) is used to write an expression for the effective demand to a representative firm in region  $i$ , to satisfy  $x_{ij}^d$  consumption in market  $j$ . When  $i \neq j$ , these sales are the exports from region  $i$  to region  $j$ :

$$x_{ij} = T_{ij}x_{ij}^d = T_{ij}^{1-\sigma} p_i^{-\sigma} \frac{E_j^M}{S_j^M} \quad (3.8)$$

$\phi_{ij} \equiv T_{ij}^{1-\sigma}$  is what Baldwin *et al.* (2003, chap. 2) call 'phi-ness' of trade. This expression is a play on words with the idea of free-ness of trade. As Head and Mayer (2006) emphasize, many results of the Dixit-Stiglitz-Krugman framework depend on  $\phi_{ij}$ . It ranges from  $\phi_{ij} = 0$ , where  $T_{ij}$  and  $\sigma$  are high enough to eliminate all trade (absence of economic integration between regions), to  $\phi_{ij} = 1$ , where trade costs are negligible and there are free trade (full economic integration).

Redding and Venables (2004) aggregate the volume of export from a firm in region  $i$  to region  $j$ , in equation (3.8) across all the varieties produced in region  $i$  expressed in values to get the value of total exports from region  $i$  to  $j$ . The resulting 'trade equation' reflects bilateral trade flows in an Anderson and van Wincoop's (2003) gravity-type of equation:

<sup>18</sup> The assumption of *ad valorem* trade costs is neither neutral nor, in many cases, realistic (Combes *et al.*, 2008, p. 115). See Fingleton and McCann (2007), Alonso-Villar (2007) and Bosker and Garretsen (2010).

$$n_i p_i x_{ij} = \phi_{ij} n_i p_i^{1-\sigma} \frac{E_j^M}{S_j^M} \quad (3.9)$$

where the term  $n_i p_i^{1-\sigma}$  measures the ‘supplier capacity’ of the exporting region.

Given the effective demand from the  $j$ -market in equation (3.8), total demand to a representative firm of the  $M$  sector in region  $i$  will be the sum of what it sells to the world markets:

$$x_i \equiv \sum_j^R x_{ij} = p_i^{-\sigma} \sum_j^R \phi_{ij} \frac{E_j^M}{S_j^M} = p_i^{-\sigma} \sum_j^R T_{ij}^{1-\sigma} E_j^M G_j^{M\sigma-1} = p_i^{-\sigma} RMP_i \quad (3.10)$$

where the term  $RMP_i$  stands for Real Market Potential ( $RMP_i$ ) and it is discussed below.

The derived demand function for each variety has the form of equation (3.10) because of the assumption of an elasticity of substitution among  $M$  varieties,  $\sigma > 1$ , constant across regions. Therefore, in equation (3.10) the elasticity of the aggregate demand for each variety with respect to its mill price,  $p_i$ , is constant and equal to the elasticity of substitution among varieties,  $\sigma$ , regardless of the spatial distribution of consumers. Firms from any region have the same elasticity of demand  $\sigma$  and each firm chooses a mill pricing policy instead of a specific delivered price for each market (Combes *et al.*, 2008, chap. 4)<sup>19</sup>. This practical advantage of the Dixit-Stiglitz-Krugman CES utility function and iceberg trade costs to model monopolistic competition is a weakness of the framework too, as discussed by Baldwin *et al.* (2003, chap. 5)<sup>20</sup>.

By equation (3.10) the total sales of a representative firm in region  $i$  are a linear function of its Real Market Potential ( $RMP_i$ ), which is a weighted sum of the market capacities of all regions. Following the literature and for simplicity, the  $M$  superscript is omitted in the notation but  $RMP_i$  depends on three  $M$  sector specific terms: the supply index of the markets relevant for region  $i$  ( $S_j^M$ ), the  $M$  share of total expenditure in those markets ( $\mu_j = E_j^M / E_j$ ) and the bilateral phi-ness of trade of  $M$  products ( $\phi_{ij}$ ). In summary, using the alternative notations reflecting different concepts, the Real Market Potential of a firm in  $i$ , or of region  $i$ , is:

$$RMP_i = \sum_j^R \phi_{ij} \frac{E_j^M}{S_j^M} = \sum_j^R \mu_j T_{ij}^{1-\sigma} E_j G_j^{M\sigma-1} \quad (3.11)$$

where  $\phi_{ij} = T_{ij}^{1-\sigma} = 1$  for the domestic sales, when  $i = j$ , and the supply index,  $S_j^M$ , is inversely related to the local industry unit cost of utility,  $G_j^M$ :

$$S_j^M = G_j^{M1-\sigma} = \sum_{i=1}^R \phi_{ij} n_i p_i^{1-\sigma} = \sum_{i=1}^R T_{ij}^{1-\sigma} n_i p_i^{1-\sigma} \quad (3.12)$$

Redding and Venables (2004) call ‘Market Access’ to the expression  $\sum_j^R \phi_{ij} E_j^M / S_j^M$  and Head and Mayer (2004a) call it ‘Krugman Market Potential’. Following Head and Mayer (2006), here it is called ‘Real Market Potential’ ( $RMP_i$ ). A Harris’s (1954)-style measure such as  $\sum_j^R \phi_{ij} E_j$  is qualified as ‘nominal’ by Head and Mayer (2006) because it is a pure measure of the size of the

<sup>19</sup> This result is not supported by the empirical evidence. See Hummels (2001), Anderson (2010) or Martin (2012).

<sup>20</sup> The assumption of a CES utility function for  $M$  goods with  $\sigma_i = \sigma > 1$  allows firm’s mill price  $p_i$  to be a constant mark-up over marginal cost, as it will be derived below. Additionally, the unit cost of utility for goods produced under monopolistic competition,  $G_j^M$ , enters the demand equation (3.8) in multiplicative form and with a positive exponent  $(\sigma - 1) > 1$ : a higher local exact price index of the  $M$  varieties in region  $j$  implies a higher demand to region  $i$ . With a quadratic utility function  $G_j^M$  enters the demand function in additive form (Ottaviano *et al.*, 2002), which does not change the argument. See too Melitz and Ottaviano (2008).



available market. This measure will be discussed in section 3.3.1 and used in the empirical part of this paper. Alternatively, a NEG definition of Market Potential is a phi-ness of trade weighted sum of market capacities,  $E_j^M/S_j^M = E_j^M G_j^{M\sigma-1}$ , and Head and Mayer use the adjective ‘real’ to underline the importance of discounting expenditures by the supply index  $S_j^M$ .

The name Market ‘Access’ is more appropriate than ‘Real Market Potential’ to consider the competition effects of  $S_j^M$ , in order to distinguish NEG’s concept from the seminal definition of Market ‘Potential’ by Harris (1954), which is equivalent to assume  $S_j^M = S^M = 1$  in the NEG framework. Head and Mayer’s (2006) adjective ‘real’ is a misleading analogy with the division of nominal monetary values of a magnitude by a price index to get the ‘real’ values of the magnitude, i.e. the values of the magnitude in different periods when prices are assumed to be constant. But the  $p_i^{1-\sigma}$  terms in  $S_j^M$  have a negative exponent, contrary to the prices of individual goods in any price index used in national accounts to deflate nominal magnitudes. Additionally, the word ‘real’ to define  $RMP_i$  becomes more confusing when a variable in ‘real’ monetary units is taken as a proxy of expenditure, as the empirical literature frequently does, using deflated magnitudes.

However the expression ‘Real Market Potential’ has two advantages. On one side, it stresses the continuity from the old-style Regional Science to the NEG, as Fujita *et al.* (1999, chap. 3) discuss. On the other hand, the name Real Market Potential avoids the confusion with WTO definition of market access as the ‘tariff and non-tariff measures, agreed by members for the entry of specific goods into their markets’ (Head and Mayer, 2011). Given that Real Market Potential is still a misleading name, here sometimes it is referred as ‘model derived’ or ‘NEG defined’ Market Potential too.

### 3.2.2 The generalized wage equation

Since Krugman’s (1980) model the standard assumptions for the  $M$  sector are: labor is the only production factor; there are no economies of scope; there are constant returns to scale during production; and production involves a marginal input requirement. Additionally, production involves a fixed input too, so firms of the  $M$  sector have increasing returns to scale. Because of increasing returns to scale, consumer’s preference for variety and the unlimited number of potential varieties, no firm will choose to produce the same variety supplied by another firm. This means that each variety is produced in only one location, by a single specialized firm, so the number of manufacturing firms in operation is the same as the number of available varieties (Fujita *et al.*, 1999, chap. 4).

These basic NEG assumptions are kept here for the compound input  $I_i$  with a few modifications. Extending the traditional NEG model, Redding and Venables (2004) allow technology to vary across regions  $i$ , so the marginal input requirement is noted  $c_i$ . Here, the production function is set up explicitly in order to emphasize the role of technology ( $A_i$ ), though the  $c_i$  notation will be used to derive the generalized wage equation to keep NEG notation. The constant returns to scale part of the production function is  $A_i I_i$ , where  $A_i$  is a Ricardian technology, so the marginal input requirement is  $c_i = 1/A_i$  and the variable production cost is  $q_i c_i = q_i A_i^{-1}$ . Given that technology is allowed to vary across regions,  $f$  is a fixed cost defined in units of output, instead of the conventional definition in units of inputs, so the fixed input requirement,  $f/A_i$ , is allowed to

vary across regions too<sup>21</sup>. Therefore, the production function of a firm producing a  $M$  variety in region  $i$  is:

$$x_i = -f + A_i I_i = A_i \left( -\frac{f}{A_i} + I_i \right) \quad (3.13)$$

Considering  $c_i = 1/A_i$ , the cost of producing  $x_i$  is  $q_i c_i (f + x_i)$ , which is the type of cost function specified by Redding and Venables (2004). Therefore marginal costs can be defined as  $m_i = q_i c_i$  and the wage equation can be derived in terms of marginal costs, as Head and Mayer (2004b) do. To see this last point it is useful to solve firm's problem of cost minimization and pay attention to the relation between the marginal input requirement ( $c_i$ ) and the marginal cost ( $m_i$ ).  $m_i = q_i A_i^{-1}$ , the price of the compound input in efficiency units, is the optimal Lagrangian multiplier of minimizing total costs  $q_i (f A_i^{-1} + I_i)$  under the restriction of satisfying a given level of demand with the production function in equation (3.13). Therefore, when including capital stock ( $K_i$ ), at a price  $r_i$ , and labor ( $L_i$ ), at a price  $w_i$ , in a constant returns to scale Cobb-Douglas form, such as,  $I_i = K_i^{1-\beta} L_i^\beta$  ( $0 \leq \beta \leq 1$ ), the marginal cost is  $m_i = (1 - \beta)^{\beta-1} \beta^{-\beta} r_i^{1-\beta} w_i^\beta A_i^{-1}$ . In order to simplify this expression is convenient to define  $q_i = r_i^{1-\beta} w_i^\beta$  and an index  $A'_i = (1 - \beta)^{1-\beta} \beta^\beta A_i$ .  $q_i$  can continue to be called nominal price of the compound input  $I_i$  and the index  $c_i = 1/A'_i$  marginal input requirement.

Firm's total output is given by the sum of what it sells to the world markets,  $x_i = \sum_j^R x_{ij}$ , and its total income is  $\sum_{j=1}^R p_j x_{ij} = p_i x_i$ . Therefore, firms of the monopolistic competitive  $M$  sector, facing given factor prices in  $m_i$ , maximize the following profit function with respect to their mill prices  $p_i$ :

$$\pi_i = p_i x_i - m_i (f + x_i) \quad (3.14)$$

Total effective demand to firm  $i$  in equation (3.14) is taken from equation (3.10). Assuming that each firm takes the competition index  $S_j^M$  in  $RMP_i$  as given (see the discussion below), profit maximization implies that firms choose price as a mark-up over marginal costs<sup>22</sup>:

$$p_i = \frac{\sigma}{\sigma - 1} m_i \quad (3.15)$$

At the optimum mill prices in equation (3.15), profits in equation (3.14) are:

$$\pi_i = m_i \left( \frac{1}{\sigma - 1} x_i - f \right) \quad (3.16)$$

The demand function in equation (3.10) at optimum prices is:  $x_i = \left( \frac{\sigma}{\sigma - 1} \right)^{-\sigma} m_i^{-\sigma} RMP_i$ . Therefore, the profits of a  $M$ -firm in region  $i$  become a function of its (regional) Real Market Potential:

$$\pi_i = \frac{(\sigma - 1)^{\sigma-1}}{\sigma^\sigma} m_i^{1-\sigma} RMP_i - f m_i \quad (3.17)$$

This 'profit equation', similar to the one in Combes *et al.* (2008, chap. 12), is at the root of the empirical NEG literature. The term of Real Market Potential,  $RMP_i = \sum_j^R T_{ij}^{1-\sigma} E_j^M / S_j^M$ , collects the two typical NEG effects discussed before. On one hand, profits are higher in areas where the demand is higher because of lower trade costs to the biggest markets ( $T_{ij}^{1-\sigma} E_j^M$ ), stimulating the agglomeration of firms. On the other hand, the demand from the markets with higher levels of

<sup>21</sup> For the case of identical technologies across regions, Combes *et al.* (2008, chap. 3) summarize three strategies found in the literature for the definition of the fixed cost, depending on the assumptions about the heterogeneity of labor and the inclusion of capital. Baldwin *et al.* (2003) provide details about many of these models.

<sup>22</sup> A notation to distinguish optimum prices and profits at optimum prices is omitted.

competition, as collected by the supply index  $S_j^M$ , will be lower. This moderating effect on profits is a dispersion force over the spatial distribution of the  $M$  sector.

The wage-type equation re-states the profit equation (3.17) to give a relationship between the spatial distribution of expenditure, as collected by  $RMP_i$ , and the spatial distribution of factor prices. Indeed, Hanson (2005) interprets the wage equation as a spatial labor demand function. The translation of profits into factor prices is done imposing an equilibrium market condition in the monopolistically competitive  $M$  sector of region  $i$ . Free entry and exit in response to profits or losses ensures that the long-run profits are zero. Alternatively, Redding and Venables (2004) do not impose zero profits but calculate the production level at which firms break even and later the (maximum) remuneration that firms afford to paid to factors.

The production level at which profits in equation (3.16) are zero is  $x_i = (\sigma - 1)f = \bar{x}$ . Therefore, from the effective demand equation (3.10), active firms at location  $i$  attain this level of output and break even if and only if the mill price they charge satisfies:

$$p_i^\sigma = \frac{1}{\bar{x}} RMP_i \quad (3.18)$$

Focusing on costs, through the mark-up pricing rule (3.15), equation (3.18) can be expressed with marginal cost as the dependent variable:

$$m_i = \frac{\sigma - 1}{\sigma} \left( \frac{1}{\bar{x}} RMP_i \right)^{\frac{1}{\sigma}} = \frac{\sigma - 1}{\sigma} \left( \frac{1}{\bar{x}} \sum_j^R \mu_j T_{ij}^{1-\sigma} \frac{E_j}{S_j^M} \right)^{\frac{1}{\sigma}} \quad (3.19)$$

This expression is called here ‘generalized wage equation’. As a result, in the Dixit-Stiglitz model all scale effects work through changes in the variety of goods. Firms do not take advantage of the extent of the market by producing at larger scale because the nonstrategic behavior implied by the assumption that they take the competition indexes,  $S_j^M$ , to be constant as they solve the maximization of profits in equation (3.14). As discussed by Fujita *et al.* (1999, chap. 4), when adopting a specific form of oligopolistic interaction, such as Cournot or Bertrand competition<sup>23</sup>, an increase in market size has a procompetitive effect. It causes entry of firms, which reduces price-cost margins and means that firms must operate at larger scale (and lower average cost) to break even. The procompetitive effect is a second force operating in the same direction and makes the model more intractable. Therefore, the constant price-cost markups and firm scale is a useful device to derive a relation between  $RMP_i$  and  $m_i$ , with  $\bar{x}$  on the right hand side of equation (3.19).

$RMP_i$  captures proximity to market demand. As summarized by Redding (2011), increasing returns to scale imply that firms want to concentrate production while transport costs imply that they want to concentrate production close to a large market. This is called ‘home market effect’ and provides a ‘backward linkage’: firms want to locate proximate to large markets for  $M$  goods. Therefore, firms close to large markets can pay a higher remuneration to production factors because they can charge higher *free-on-board* prices and still sell enough units of output to cover fixed production costs and make zero equilibrium profits.

Under factor immobility, the home market effect is the only force promoting the agglomeration of the  $M$  sector. The counteracting force promoting its dispersion is the ‘market crowding’ or ‘competition’ effect derived from discounting expenditures by the supply index  $S_j^M$ . The supply

<sup>23</sup> See Combes *et al.* (2008, chap. 9) for further discussion.

index  $S_j^M$  is the sum of supply capacities weighted by trade costs and measures the degree of competition faced in market  $j$  by firms producing  $M$  varieties under monopolistic competition in their original regions at mill prices  $p_i$ . The competition adjustment collected by  $S_j^M$  can help explain why other-wise identical firms would not all select the same location. As more firms choose one region, the market there becomes more crowded, lowering the Real Market Potential, until another region is more profitable (Head and Mayer, 2004a).  $S_j^M$  captures a dispersion force moderating the spatial concentration of the  $M$  sector because an increase in the number of competitors located in a given destination generates a more fragmented demand and reduces  $RMP_i$  (Combes *et al.*, 2008, chap. 12).

Head and Mayer (2004a) note that this is not the only mechanism causing dispersion. Firms are not identical and will therefore differ in their views of the prospective profitability of each region. This heterogeneity is analogous to matching in labor markets and can be thought of as firm-specific variation in regional productivity ( $A_i$ ). As summarized by Head and Mayer (2011) in a supplementary document, it is possible to derive a gravity equation and a wage equation from a model with comparative advantages based in heterogeneous industries. But the interpretation of the terms in this wage equation is not the same than in NEG theory<sup>24</sup>. This point is relevant for the observational equivalence of NEG theory. However, the approach followed in this paper to discuss this observational equivalence stresses how capital stock immobility affect regional factor productivity and, therefore, marginal costs and wages.

Equation (3.19) is a relation between Real Market Potential and the maximum marginal cost that a firm can afford to pay. The expression ‘generalized wage equation’ follows the name ‘wage equation’ used by Fujita *et al.*’s (1999, chap. 4). Head and Mayer (2004b) trace the first published derivation of the wage-potential equation back to the 1991 NBER working paper version of Krugman (1993). There, Krugman discusses the similarity of the right hand side variable with the index of ‘Market Potential’ used by geographers, which here it is called Harris’s Market Potential or Nominal Market Potential and it will be reviewed in section 3.3.1<sup>25</sup>. The generalized wage equation comes from equation (3.18) and  $p_i^g \bar{x} = RMP_i$  is a market clearing condition in which firms have zero profits. Indeed, Baldwin *et al.* (2003, chap. 2) prefer the expression ‘market-clearing condition’ to the expression ‘wage equation’. However, following Krugman’s (1980) set-up, the main NEG models assume that  $M$  goods are produced using just labor and that technology is the same across regions, therefore, the left hand side of the equation becomes wages. Even when labor is not the only production factor, as in Redding and Venables’s (2004) model, the assumptions about factor mobility determine which factor prices are not equalized across regions, so the left hand side variable of equation (3.19) becomes the price of immobile factors and labor is interpreted to be the main immobile factor.

Head and Mayer (2006) discuss two paths to equilibrium. Spatial equilibrium requires that markets clear and no mobile agent has a unilateral incentive to relocate. In a spatial equilibrium firms has the same profits in all regions, so any shock in the demand  $E_i$  of a region will be fol-

<sup>24</sup> A recent new approach to international trade is based on firm heterogeneity in differentiated product markets. See Melitz (2003), Melitz and Redding (2012) or Helpman *et al.* (2012). Bernard *et al.* (2012) survey the empirical findings. Ottaviano (2011) argues that this ‘new’ New Trade Theory can be an inspiration for a ‘new’ New Economic Geography.

<sup>25</sup> The following NBER working paper of Krugman (1992) derives the text book wage equation more explicitly and discusses again Harris’s Market Potential.

lowed by an adjustment in their use of factors and/or by an adjustment in the price of factors. For factors perfectly mobile among regions, spatial equilibrium also requires real factor price equalization. Therefore, the relative magnitudes of price or quantity adjustment to cross-regional variation in demand depend chiefly on the mobility of factors between sectors and between regions. One strand of the literature makes the polar assumption of factor price equalization. This has been associated to the long run equilibrium, where wages are invariant to demand and employment adjustment is the only mechanism for equalizing profits.

Redding and Venables (2004) pioneer what Head and Mayer (2006) call the second polar path towards spatial equilibrium, that loads all the response to demand differences into wages. This has been associated with short run equilibrium but Redding and Venables do not put it in that way. The full general equilibrium explored in Fujita *et al.* (1999) involves specifying factor endowments and hence factor market clearing to determine income and expenditure ( $E_i$ ), the output levels of each country's manufacturing (the values of  $n_i$ ), output in other sectors (primary and non-tradable), and payments balance. Alternatively, Redding and Venables '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?'. Therefore, under this empirical framework, Real Market Potential in equation (3.19) is considered exogenous.

Redding and Venables's (2004) remark that their 'wage' equation is more accurately an equation for the price of the composite immobile factor of production. The generalized wage equation (3.19) can be transformed to emphasize this point in a way that can encompass the wage equation derived in other models. In order to do this, it is useful to assume that there are two types of inputs, combined in a Cobb–Douglas technology with constant returns to scale. Breinlich's (2006) version of Redding and Venables's (2004) model assumes that  $q_i$  is the price of an interregionally immobile factor which has input share  $\theta$ , while  $z_i$  is the price of a mobile factor which has an input share  $\psi$ . In the original model of Redding and Venables's (2004),  $\psi = 1 - \theta$ . Alternatively,  $\theta$  and  $\psi$  can be considered as parameters describing the interregionally mobility of the underlying compound production factors, so these factors are not necessarily primary inputs, as defined by Redding and Venables (2004). In this way,  $\theta$  and  $\psi$  reflect the time horizon of the model, and not so much technological parameters of the production function. Similarly to Breinlich's (2006) specification, marginal costs are:

$$m_i = q_i^\theta z_i^\psi c_i \quad (3.20)$$

Therefore, the generalized wage equation takes the form:

$$q_i = \left[ \frac{\sigma - 1}{\sigma} \frac{1}{\bar{x}^{1/\sigma}} RMP_i^{1/\sigma} \frac{1}{z_i^\psi c_i} \right]^{1/\theta} \quad (3.21)$$

Equation (3.21) is what Redding and Venables (2004) define as an equation for the price of the composite immobile factor of production, though their equation has an additional term, as it will be shown below. They make two additional considerations. First, the immobile factor is interpreted as labor, so the dependent variable of equation (3.21) becomes wages:  $q_i = w_i$ . Second, given that  $z_i$  is the price of a mobile factor, they assume that it is equalized across regions, so  $z_i = z$ . Redding and Venables seem to be thinking of the Footloose Capital (FC) model. Under the FC model each  $M$  firm requires just one unit of mobile capital and its remuneration is repatriated. Therefore capital owners care about nominal remuneration. In a long-run spatial equilibrium

there are no incentives for capital migration, so the nominal remuneration of capital is equalized across regions. An alternative assumption is discussed in the next section.

Redding and Venables estimate the basic equation assuming a common technology for all regions  $c_i = c$ , but additionally the control for exogenous determinants of levels of technical efficiency. In doing this, they concern is with fundamental determinants of levels of per capita income (such as physical geography and institutions) rather than proximate sources of income differences (such as human and physical capital which are ultimately endogenous. Considering  $c_i$  as proportional to an index of total factor productivity, as discussed after equation (3.13), and simplifying  $c_i = A_i^{-1}$ , after taking logarithms the empirical cross-sectional wage equation becomes:

$$\ln w_i = C + \frac{1}{\theta\sigma} \ln RMP_i + \frac{1}{\theta} \ln A_i + u_i \quad (3.22)$$

Three issues must be noted about this equation. One, the estimated parameter of  $\ln RMP_i$  cannot be interpreted as an estimate of  $1/\sigma$  anymore. It would be necessary to measure  $A_i$  in order to estimate equation (3.22) and deduce from the results an estimate for  $\sigma$ . Two, Redding and Venables's (2004) assumption  $z_i = z$  is a long-term consideration about factor price equilibrium under interregionally mobility. Actually, this implies that factor owners care about nominal remuneration so they spend their income locally. This can be appropriate for investment, but it is more difficult to defend that the user cost of capital stock is the same across regions. Third, Redding and Venables (2004) proxy wages with GDP per capita, but alternatively wages can be considered as a proxy of GDP per capita too, so the dependent variable becomes the typical one in the estimation of production functions and a key issue in this latter literature is the specification of factor endowments and technology.

Head and Mayer (2004b) provide an alternative interpretation of equation (3.22). Without the assumption  $z_i = z$ , the dependent variable changes. Adapting their specification to the discussion here, the 'wage-type equation' takes the form:

$$\theta \ln w_i + \psi \ln z_i = C + \frac{1}{\sigma} \ln RMP_i + \ln A_i + u_i \quad (3.23)$$

The left hand side of this equation is a cost-share weighted sum of logged primary factor prices. Head and Mayer (2004b) interpret that a natural proxy for this dependent variable is the log of GDP per capita. Therefore GDP per capita is proxying a different theoretical variable than when  $z_i$  is assumed to be constant across regions. With this last trick, again the estimated coefficient of  $\ln RMP_i$  in a regression could be interpreted in terms of  $\sigma$ . However, it seems that the structural interpretation of the estimates sometimes goes too far, considering the high number of unrealistic theoretical assumptions, the use of proxy variables, and other problems, such as the measurement of the internal market, which will be discussed in section 3.3.1. As mentioned in section 1.1, Leamer and Levinsohn (1995) could say that this is to take 'theory too seriously'.

Table 3.2 summarizes how some NEG models can be interpreted under the specification of marginal costs in equation (3.20). Appendix B gives details about each specification. The table takes the 1999 book of Fujita, Krugman and Venables as the main reference and omits many contributions that have been relevant too. The models in Table 3.2 have different emphasis in theory and in econometrics and were built for different purposes. Their order in the table follows a more or less arbitrary criterion of similarity. The goal of the table is just to show that the framework presented here is useful to encompass a variety of models and to improve the understanding of the role played by each element. With this at hand, the last row of the table introduces for first



time a theoretical specification of a testable wage-type of equation controlling by per capita capital stock, which will be derived in the next section.

The production function is the one in equation (3.13) though, as it was discussed, if there are several production factors Table 3.2 does not distinguish the constant terms when translating the technological parameter  $c_i$  into the total factor productivity parameter  $A_i$ . Now  $q_i$  is not the price of the compound factor  $I_i$ , but the price of some of the factors included in that factor index  $I_i$ . The distinction about what is noted as  $q_i^\theta$  and  $z_i^\psi$  in Table 3.2 should correspond with the prices of the factors in the production function of the  $M$  sector, as in Redding and Venables's (2004) specification. However, as it will become clear in the next section, when thinking about the role of capital stock as an immobile factor, it would be possible to disaggregate  $q_i$  such as  $q_i = r_i^\alpha w_i^\beta$ , with  $r_i$  being the user cost of capital in region  $i$ . Therefore, if this last price is not equalized across regions, and being difficult to obtain data about it, the dependent variable of the generalized wage equation would become  $q_i$  and the testable wage equation would adopt a form similar to Head and Mayer's (2004b) specification in equation (3.23). This ambiguity about the dependent variable of a 'wage equation' justifies a name such as 'generalized wage-type equation'. At the end, what is considered as  $q_i$  or  $z_i$  in Table 3.2 is a matter of convenience to encompass several models into the same notation and to discuss about issues such as factor mobility and price equalization, intermediate inputs or the definition of the dependent variable in the wage-type equation.

**Table 3.2. Adaptation of several NEG models to the generalized wage equation**

$$m_i = q_i^\theta z_i^\psi c_i \Rightarrow \text{Generalized wage-type of equation if } q_i = w_i: w_i = \left[ \frac{\sigma-1}{\sigma} \frac{1}{\bar{x}^{1/\sigma}} RMP_i^{1/\sigma} \frac{1}{z_i^\psi} \frac{1}{c_i} \right]^{1/\theta}$$

Authors, model	$\theta$	$z_i^\psi$	$1/c_i$
Fujita <i>et al.</i> (1999, chap. 4)	1	1	$A$
Fujita <i>et al.</i> (1999, chap. 15)	1	1	$A_t$
Fujita <i>et al.</i> (1999, chap. 14); Puga (1999)	$\theta$	$G_i^{M^{1-\theta}}$	$A$
Redding and Venables (2004)	$\theta$	$u^\gamma G_i^{M^{1-\theta-\gamma}}$	$A_i$
Head and Mayer (2004a)	$\theta$	$z_i^{1-\theta}$	$A_i$
Breinlich (2006)	$\theta$	$z^\psi$	$A_i$
Head and Mayer (2006)	1	1	$A \exp(\beta h_i)$
Fingleton (2006, 2008); Fingleton and Fischer (2010)	1	1	$A_i: h_i^\beta$
Redding and Schott (2003) simplified, $w_i^u = w_i / h_i$	1	1	$h_i^\beta$
Bruna (2014)	$\theta$	$z^\psi$	$(A k_i^\alpha h_i^\beta)^\theta$

In order to keep the same traditional dependent variable as wages, the criterion for Table 3.2 was to extend Head and Mayer's (2006) version of the model and to include per capita capital stock in a similar way that they do with (per capita) human capital. Therefore, Table 3.2 includes human capital and capital stock under the column of the technological parameter  $c_i$ . The  $\theta$  and  $z^\psi$  parameter could be omitted in the last row of Table 3.2, as in Head and Mayer's (2006) specification. But they are retained as a reminder of the role of factor mobility and the difficulty of interpreting in terms of  $\sigma$  an estimated coefficient of  $\ln RMP_i$  in equation (3.22), even when

$z_i = z$  is assumed. The  $\alpha$  and  $\beta$  notation is reserved for the exponents of per capita capital stock and human capital to stress the similarity of an empirical wage-type equation with the estimation of a conventional production function.

The last column of Table 3.2 translates  $c_i$  to the parameters of factor productivity in the production function of the  $M$  sector. A few models in the table consider an empirical wage equation with control variables proxying for  $A_i$ . However, the emphasis here is only on human and physical capital. Breinlich's (2006) estimation is the only previous work with a robustness check controlling for these two variables. However, his test tries to measure the importance of the direct trade cost advantage when Real Market Potential has a positive impact on physical and human capital accumulation and the three variables increase regional income. Those considerations are omitted in his version of Redding and Venables's (2004) model and, hence, in Table 3.2.

Brakman *et al.* (2009) assume that the production process use only labor marginal costs are  $m_i = w_i^\theta c_i$ . They note that 'using other inputs is straightforward and adds other costs factors'. However, no other inputs have been modeled in the literature of the wage equation apart from human capital probably for reasons of complexity and/or endogeneity. However, Redding and Venables's (2004) framework allows a wage-type-equation such as the one in equation (3.21) to be obtained from a production function with capital stock.

### 3.2.3 The generalized wage-type equation with human and physical capital

A tractable model with endogenous capital formation has been developed by Baldwin (1999). It is called the constructed capital (CC) model by Baldwin *et al.* (2003, chap. 6). Capital is immobile so it is constructed in the attractive regions and depreciated in the less attractive ones. As the capital stock changes total expenditure rises in the attractive regions and declines in the other ones. It is natural to ask about the interpretation of Redding and Venables's (2004) wage equation when capital adopts the form of capital stock, as in the CC model or in Li's (2012) model.

In the international trade literature, it is possible to reconcile the assumption of internationally immobile capital stock with the fact that investment is mobile. In this case, investment is internationally mobile as a produced commodity subject to international trade. Once installed as an addition to the capital stock becomes immobile. If capital is considered as mobile *ex-ante*, in some degree or another, but capital stock is considered (inter-regionally) immobile *ex-post*, then past decisions about the location of capital goods are going to condition firm's productivity during long time horizons.

The time horizon of the model is a key issue and therefore, the econometric techniques and samples for an empirical estimation. However, under Redding and Venables's empirical approach, total expenditure is considered exogenous to focus in the remuneration of factors that firms in a given location afford to pay. Therefore, their framework allows adding the construction of immobile capital stock and the mobility of investment goods without the complexity of a general equilibrium model. Here capital stock is considered immobile and exogenous, the same than human capital in Head and Mayer's (2006). This allows controlling for a key determinant of labor productivity, which it is a healthy exercise of development accounting even if capital accumulation is endogenous in the long term. Additionally, it shows the similarities of the estimation of a wage equation and an expanded production function. However, the introduction of capital



stock in the wage equation is not a key element for some of the conclusions of the later empirical tests.

As mentioned when presenting Table 3.2 in the previous section, the user cost of capital stock,  $r_i$ , could be considered as part of  $q_i$  or  $z_i$ . However this creates an empirical problem: it is not easy to have data about the user cost of capital stock. One alternative is to consider that the dependent variable of the wage-type of equation is an index of factor prices,  $w_i^\theta \tau_i^\psi$ , for instance, as in equation (3.22). Then, Head and Mayer (2004b) consider that income per capita is a natural proxy for this index, which means that introducing physical capital stock would have no impact on the empirical wage equation. Under this approach, it does not matter what immobile factors are considered. The standard NEG approach is built on labor producing  $M$  goods and this extension makes wages to be replaced by an index of factor prices proxied by the same empirical variable. Therefore, under this framework it is not relevant if income per capita and wages are a proxy for productivity too... This does not seem a very useful path to enlighten the observational equivalence of the wage equation. As discussed in section 1.1, at the root of this discussion is the problem that wages and income per capita are a proxy of productivity, so the wage equation is about productivity. Or, at least, the key empirical issue is to disentangle the sources of productivity. That is why measuring  $A_i$  on the right hand side of the wage equation is so important.

If this is not done, an empirical wage equation is estimating a relation between  $A_i$  on the left hand side of the equation and Market Potential on the right hand side. It could be said that panel data with fixed effects solves this problem, because it allows for the estimation of a different intercept for each region. As it will be mentioned in section 3.3.2 this is not the approach followed here. The proposal of this paper starts recovering capital stock as a determinant of labor productivity. This is done treating per capita capital stock as a regional (firm) productivity characteristic of labor, the same than per capita human capital. It could be argued that human capital is embodied in people and capital stock is not. The approach taken here considers capital stock as embodied in firms and regions and per capita capital stock as embodied in the immobile people consuming in those regions and working in those firms.

The proposal of this paper is to extend the production function in equation (3.13) to consider an specification similar to the one by Jones (1997), in equation (B.9):

$$x_i = -f + K_i^\alpha (B_i H_i)^\beta = -f + K_i^\alpha (B_i h_i L_i)^\beta \quad (3.24)$$

Assuming constant returns to scale in the variable part of this production function, as it is standard in NEG theory,  $\beta = 1 - \alpha$ . Then, if physical capital stock per worker is noted as  $k_i$ , firm's production function becomes:

$$x_i = -f + B_i^{1-\alpha} k_i^\alpha h_i^{1-\alpha} L_i = -f + A_i k_i^\alpha h_i^{1-\alpha} L_i \quad (3.25)$$

where  $A_i = B_i^{1-\alpha} = A$  is the marginal labor requirement in 'effective' labor units,  $L_i/k_i^\alpha h_i^{1-\alpha}$ , and can be considered constant across regions. This last solution does not solve the problem of measuring regional differences of total factor productivity. But at least it allows the estimation of a wage-type equation controlling for capital stock per worker, a variable that has been largely ignored by NEG theory. Therefore, similarly to Head and Mayer's (2006) specification for human capital per worker but letting aside the Mincerian regressions, marginal costs take the form  $m_i = w_i^\theta z_i^\psi c_i = w_i c_i = w_i / A k_i^\alpha h_i^{1-\alpha}$ , with  $z_i = 1$  and  $\theta = \psi = 1$ .

It should be noted that allowing for increasing returns to scale ( $\alpha + \beta > 1$ ) into the variable part of the production function gives the following version:

$$x_i = Ak_i^\alpha h_i^\beta L_i^{\alpha+\beta-1} \left( -\frac{f}{Ak_i^\alpha h_i^\beta L_i^{\alpha+\beta-1}} + L_i \right) \quad (3.26)$$

In this case, there would be a scale effect reducing marginal costs in locations with a large work force<sup>26</sup>. Apart from its theoretical implications in the NEG model, non-reported cross-sectional estimations do not seem to be consistent with a scale effect such as this. Therefore, the assumption of constant returns to scale is kept here.

However, even if the variables of physical and human capital per worker are considered as determinants of the productivity of labor, the possible presence of other production factors makes relevant the parameter  $\theta$ . As mentioned when presenting Table 3.2 the last row of the table includes the  $\theta$  and  $z_i^\psi = z^\psi$  terms as a reminder of the degree of factor mobility and the possible presence of other inputs, maybe intermediate goods. The following three examples show why this issue is relevant in order to interpret the results.

The first case is the one summarized in the last row of Table 3.2. The Jones (1997)-style production function is a generalization of equations (3.24) and (3.25), such as:

$$x_i = -f + [AK_i^\alpha (h_i L_i)^{1-\alpha}]^\theta Z_i^\psi = -f + [Ak_i^\alpha h_i^{1-\alpha} L_i]^\theta Z_i^\psi \quad (3.27)$$

where  $Z_i$  is a factor with price  $z_i$ , and  $z_i = z$ . Therefore, from this production function, the last row of Table 3.2 shows the proposed version of equation (3.21). The generalized wage-type equation now has the form:

$$w_i = A \left( \frac{\sigma-1}{\sigma} \bar{x}^{-1/\sigma} z^{-\psi} \right)^{1/\theta} RMP_i^{1/\theta\sigma} k_i^\alpha h_i^\beta \quad (3.28)$$

which it is supposed to verify  $\alpha + \beta = 1$ . It is not empirically relevant if  $\theta + \psi = 1$  or not, because of the assumption  $z_i = z$ .

In the production function of equation (3.27)  $h_i$  is the average level of human capital of the labor force. An example of an alternative production function is based in Mankiw-Romer-Weil's (1992) specification of equation (B.8). Let's assume that production needs physical capital, human capital and raw labor. Human capital is considered to be  $h_i$  times more productive than raw labor. The production function can be the following:

$$x_i = -f + AK_i^\alpha H_i^\beta L_i^{1-\alpha-\beta} = -f + AK_i^\alpha (h_i L_i)^\beta L_i^{1-\alpha-\beta} = -f + Ak_i^\alpha h_i^\beta L_i \quad (3.29)$$

A wage equation derived from here has the form:

$$w_i = A \frac{\sigma-1}{\sigma} \bar{x}^{-1/\sigma} RMP_i^{1/\sigma} k_i^\alpha h_i^\beta \quad (3.30)$$

but now  $\alpha + \beta < 1$ .

Of course, the concepts underlying  $h_i$  are different in equations (3.28) and (3.30). The empirical variables to measure them should be different too. However, the whole debate is about proxying wages with per capita income and controlling for regional technological differences. The empirical representation of human capital should not be our major concern. The same happens with wages. In equation (3.30) wages represent the price of raw labor though raw labor takes advantage of the contribution to production from the workers with human capital. However, nothing of this is important if wages are proxied by income per capita.

Anyway, the point of this discussion is to show how sensitive is the structural interpretation of an estimated wage equation to basic assumptions in the underlying production function. The

<sup>26</sup> A scale effect has been debated by Jones (1999) and others in the context of the endogenous growth theory.

$\theta = 1$  assumption underlying equation (3.30) changes the expected size of the parameter of Market Potential in a cross-sectional regression and because of the different specification of human capital, the expected value of  $\alpha + \beta$  changes too. This discussion shows the general difficulties of interpreting the estimation in terms of structural NEG parameters. This problem is one of the sides of the observational equivalence of the wage equation.

A last example gets out of the NEG framework, just to illustrate again the observational equivalence. The story starts with a neoclassical production function with constant returns to scale ( $\alpha + \beta = 1$ ), in per capita units:

$$y_i = A_i k_i^\alpha h_i^\beta \quad (3.31)$$

However,  $A_i$  creates aggregate increasing returns to scale. If the productivity parameter is proportional to Real Market Potential:

$$A_i = A RMP_i^\chi \quad (3.32)$$

the estimable cross-sectional wage equation is identical to (3.28). Of course, there are no micro-fundamentals here. However, this type of formulation has been used before. For instance, Dekle and Eaton (1999) assume agglomeration economies taking a technological form in which the production function has a neutral shift term that depends on nearby economic activity. Their term is a variant of Harris's Market Potential that assumes an exponential distance decay function.

Too Vanhoudt (1999) assumed this type of production function to test for scale effects in the European average labor productivity growth process. His production function is  $y_i = A_i k_i^\alpha s_i^\chi$ , where  $y_i$  is income per worker,  $k_i$  is capital per worker,  $A_i = B_i^{1-\alpha}$  is a technological index and  $s_i$  is a scale variable. Clemente *et al.* (2009) extend Vanhoudt's work by using a measure of Market Potential as scale variable and focusing on the successive enlargements of the European Union. They find that the enlargement in the market potential is capable of explaining between 15% and 40% of the economic growth of countries after joining the EU. Holl (2012) follows a similar approach to study the contribution to firm-level productivity of a measure of population-based market potential which takes into account the real transport network. Alternatively, Combes *et al.* (2010) study the impact on firm-level wages and productivity of a measure of Market Potential built with data of workers per squared kilometer.

In a neoclassical setting, Koch (2008) and Ertur and Koch (2007) make  $A_i$  to depend on the productivity index of the neighbors and on capital per worker. The human capital term is added by Fischer (2011). That produces a neoclassical production function similar in spirit to the NEG models with spillovers discussed by Baldwin *et al.* (2003, chap. 7). Koch (2008) provides a number of theoretical and empirical arguments for this specification and a justification for using spatial econometrics techniques when estimating a wage-type-equation.

These examples just show different choices. The wage-type equation derived from equations (3.31) and (3.32) is a production function in per capita terms with a parameter of scale related with Market Potential or, more specifically, with variables of the neighboring regions. Of course, in the NEG definition of Market Potential there is a competition index, which could be the key variable to solve the observational equivalence of the equation, as noted by Head and Mayer (2004b). However, this is the weakest empirical aspect of the NEG. Without this index, the tests presented later in this paper show results that are consistent with the hypothesis that the estimation of a NEG wage-type equation is very similar to the estimation of a production function collecting an ambiguous influence of the nearest neighbors.

### 3.3 Econometric specification

#### 3.3.1 Harris's (1954) Market Potential and the NEG

The New Economic Geography provided the micro-economic foundations for a concept of Market Potential' (*MP*) originally developed by Chauncy Harris (1954). Harris's approach has been widely used in Regional Economics. One reason is that it offers a way of capturing Tobler's (1970)<sup>27</sup> first law of Geography, which would be much quoted later by the Spatial Econometrics literature: 'Everything is related to everything else, but near things are more related than distant things'.

The market potential of a point (region *i*) is defined as the summation of markets (*M*) accessible to *i* divided by their 'distances' to that point *i*. Considering the  $R - 1$  possible markets of other *j* regions, Harris's Market Potential (*HMP*) is defined as:

$$HMP_i = \sum_{j=1}^R \frac{M_j}{T_{ij}} = \frac{M_i}{T_{ii}} + \sum_{j \neq i}^{R-1} \frac{M_j}{T_{ij}} = IMP_i + EMP_i \quad (3.33)$$

where  $T_{ij}$  are transport costs between market *i* and the market *j* and the Internal Market Potential (*IMP*) is distinguished from the External Market Potential (*EMP*) of region *i*. In the following discussion it will be assumed  $T_{ij} = d_{ij}$ , being  $d_{ij}$  the physical distance between any two markets *i* and *j*.<sup>28</sup>

In order to measure distances when working with areal data it is necessary to summarize the data of each region in a point, the capital city, the regional centroid, which it is its geographical center, or similar references. Therefore, for the evaluation of the domestic market's size it became crucial to measure the internal distances to the own market, and this is an issue that has not been properly solved until now. The problem is common to both the NEG derived approach to Market Potential and to the traditional Regional Science approach using Harris's measure.

The standard approach is to assume that regions are circular so the radius of region *i* is  $r_i = \sqrt{area_i/\pi}$ . Then some correction is considered for the likely clustering of economic activity in and around the 'center'. Keeble *et al.* (1982) chose  $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$  to allow for the likely clustering of economic activity in and around the 'center'. Head and Mayer (2000)-Thisse provide a different argument: If all production concentrates in the centre of a disk and consumers are randomly distributed throughout the rest of the area, the average distance between a producer and a consumer is  $d_{ii} = 2/3 \cdot r_i = 0.376\sqrt{area_i}$ . But 'estimating the average intrazonal trip length is still an ongoing challenge in spatial models' (Kordi *et al.*, 2012). Though below there are some tests with Head and Mayer (2000)-Thisse's measure, this paper measure internal distances following the approach of Keeble *et al.* (1982), similar to the 40% of the radius considered by Cambridge Econometrics (2014) to calculate internal distances. These methods are

<sup>27</sup> See the discussion in Annals of the Association of American Geographers (2004).

<sup>28</sup> Harris (1954) or Clark *et al.* (1969) estimated total transport cost carefully. However, data restrictions usually force to proxy trade costs with physical distances. An apparently improvement is to use travel times. But with European regional data Breinlich (2006) or Ahlfeldt and Feddersen (2008) obtain similar results using travel times or geographical distances. See Boulhol *et al.* (2008) for the construction of an aggregate index of transportation costs for a sample of OECD countries.

*ad hoc* and problematic. The literature usually does not discuss their empirical implications<sup>29</sup>. With a broad sample of 274 European regions in the year 2008, the median share of  $IMP_i$  in  $HMP_i$  is 8,1% when 1/3 of the radius is taken for internal distances, while it is just a 4.2% when 2/3 is used. But with the 1/3 measure this share is higher than 45% for Madrid, Vienna, Paris, Athens and Inner London. For the same calculation of  $IMP_i$ , these numbers depend on the sample and on the methodology for calculating the external component of Market Potential. Therefore, the argument about the distribution of consumers in a circular region does not add anything to explain the role of internal markets for firms, especially when considering coastal regions or countries. See the Appendix A for further discussion. Excluding the own regional market in  $HMP_i$  introduces measurement error by reducing the access measure of some economically larger locations (Breinlich, 2006; Head and Mayer, 2006), as the capital cities tend to be. But including it aggravates the general endogeneity problem of Market Potential. Therefore both the full measure  $HMP_i$  and its external component,  $EMP_i$ , will be used in later empirical tests.

The present work uses a Harris's measure of Market Potential instead of the measure derived from the NEG model. See Appendix A for a list of recent works using this measure. To compare Harris's definition in equation (1.1) with the NEG measure in equation (3.11) it is useful to make some transformations. First, the abstract measure of market size ( $M_j$ ) is replaced in Harris's definition by a measure of expenditure ( $E_j$ ) or income in each region. Additionally, Real Market Potential is disaggregated into its internal and external component:

$$HMP_i = \sum_{j=1}^R \frac{E_j}{T_{ij}} = \frac{E_i}{T_{ii}} + \sum_{j \neq i}^{R-1} \frac{E_j}{T_{ij}} = IMP_i + EMP_i \quad (3.34)$$

$$RMP_i = \sum_j^R T_{ij}^{1-\sigma} \frac{E_j^M}{S_j^M} = \sum_j^R \mu_j T_{ij}^{1-\sigma} \frac{E_j}{S_j^M} = \mu_i \frac{T_{ii}^{1-\sigma} E_i}{S_i^M} + \sum_{j \neq i}^{R-1} \mu_j \frac{T_{ij}^{1-\sigma} E_j}{S_j^M} \quad (3.35)$$

NEG theory can assume that the phi-ness of trade  $\phi_{ii} = T_{ii}^{1-\sigma} = 1$  for the domestic sales in order to get that all the firms from the same region have the same mill prices. However, given that Market Potential is a summation, NEG empirical work needs to proxy  $T_{ii}$  the same than when using a Harris's measure. Assuming that the share of income spent on manufacturing goods is the same in all regions ( $\mu_j = \mu = 1$ ), as Fujita *et al.* (1999, chap. 4) do<sup>30</sup>, and proxying trade costs with distances, the main difference between  $RMP_i$  and  $HMP_i$  is that the latter is not corrected by the NEG's competition index  $S_j$ , which is not directly measurable. Combes *et al.* (2008, p. 305) conclude that 'Harris's market potential is at best a rough approximation of the  $RMP$ '.

NEG empirical work has proxied the supply index in several ways<sup>31</sup>. Redding and Venables (2004) use the bilateral trade equation (3.9) to get a value for the elasticity of trade flows to distance and to the other trade determinants. These estimations can be used to construct the External Real Market Potential of each region (no data is considered for intra-regional trade). In this gravity equation, import and export dummies try to capture  $S_j^M$  and control for the 'multilateral resistance' term of Anderson and van Wincoop (2003). This term reflects average trade barriers to

<sup>29</sup> The discussion about this by Redding and Venables (2004) and Bouhol *et al.* (2008) are an exception.

<sup>30</sup> See the discussion after equation (B.6) in Appendix B.

<sup>31</sup> Head and Mayer (2004b) survey these methods. The method of Hanson (2005) to estimate Helpman's (1998) model is not considered here. Too see Fingleton and Fischer (2010).

$i$ : the more resistant to trade with all others a region is, the more it is pushed to trade with a given bilateral partner.

Redding and Venables (2004), or Head and Mayer (2006), construct Market Potential proxying market capacities,  $E_j^M/S_i^M$ , with the estimated coefficient of an importing region dummy in the gravity equation. This means that the whole theoretical NEG theoretical framework is reduced to a fixed effect for the importing region estimated in an equation of bilateral aggregate trade. Alternatively, Breinlich (2006) get closer to the measure proposed by Harris. The estimated coefficient of a dummy variable for the importing region in a gravity equation is proxying  $1/S_i^M$  for Breinlich (2006) and  $E_j^M/S_i^M$  for Redding and Venables (2004). Even when controlling the estimation of the gravity equation by effects such as border or common languages, the importer fixed effects will be collecting a number of other issues different from the competition effects. Given that these estimations focus on the role of Market Potential in a wage equation, the authors do not discuss the estimated size and distribution of their proxies. Therefore, it is not possible to check if the estimated competition effect provides economic sense to the NEG estimation. Additionally they use different dependent variables for the trade equation (3.9) and it is necessary to make additional assumptions when working with regional data.

Alternatively, Harris's approach presents four advantages for the tests presented in this paper. First, the competition index is not directly measurable and its omission in Harris's definition of Market Potential allows making a first exam of the most obvious parts of the measure. The present work goes back to the basics by checking what happens in a wage-type equation when the old definition of Harris's Market Potential is altered. Therefore, using the vocabulary of section 1.1, the estimation omits an 'essential distinguishing feature' of the model, which is a weakness of the strategy. However, the strength of this approach is that is both transparent and general. Though the competition or the 'price' indexes are a theoretically essential feature of NEG, its empirical definition is a fragile aspect of the theory in terms of generality or realism, because it is based in assumptions about the consumer's utility function. Using Harris's formulation to test the wage equation allows isolating the analysis of other elements of NEG definition of Market Potential. With some support in the recommendations of Leamer and Levinsohn (1995) and Head and Mayer (2004b), an intellectually healthy initial exercise is to make a robustness analysis of the wage-type equation without this term. A continuation of this paper could check if the conclusions of the empirical tests presented later could change under alternative empirical approaches to the competition index.

Second, Harris's Market Potential provides comparability to the results. In the tests presented later only one aspect is changed each time, the definition of the scale variable or the number of neighbors, keeping constant the structure of the measure of Market Potential. This would imply a number of difficulties when using a model derived measure of Market Potential.

Third, the estimates of the elasticities of trade to distance obtained in the literature of gravity equations are similar to the exponent of distance in Harris's definition of Market Potential, -1. Head and Mayer's (2013) expand Disdier and Head's (2008) meta-analysis to study 2508 estimates of the trade elasticity to distance. They confirm a mean distance elasticity of -0.9. Taking just the estimations using country fixed effects or ratio-type methods, the mean elasticity is -1.1. Contrary to the estimation with gravity equations, this distance decay parameter is not sample dependent in Harris's measure, what gives comparability to the results.



Fourth, using European regional data, the same as here, both Breinlich (2006) and Head and Mayer (2006) find similar results with a Harris's definition of Market Potential than with a model derived measure. The last authors observe that when estimating with Harris's definition, the coefficient of this variable does not retain the structural NEG interpretation. However, they note that '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'. The following argument provides a hypothesis to explain this similarity.

With equations (3.11) and (3.12) at hand, when the main markets of  $M$  firms in region  $i$  have low market capacity,  $E_j^M/S_j^M$ , the Real Market Potential of those firms is low so they receive a low demand and have a low production. The definition of the main  $j$ -markets of  $i$  is given by the  $T_{ij}^{1-\sigma}$  term in  $RMP_i$ , while this same term in  $S_j^M$  gives the location of those  $j$ -markets with respect to the world markets. Abstracting now from the values of expenditure, if trade or transport costs ( $T_{ij}$ ) increase with geographical distance and assuming  $\sigma = 2$  for simplicity<sup>32</sup>, the  $T_{ij}^{1-\sigma}$  term in  $RMP_i$  express the geographical peripherality of region  $i$ , as measured by inverse distances to the rest of the regions: peripheral regions have higher distances to the world markets and lower Market Potential. This is the agglomeration force. But the nearest markets of region  $i$  tends to be peripheral too so their term  $T_{ij}^{1-\sigma}$  in  $S_j^M$  is low. Therefore, they will tend to have low  $S_j^M$  and high market capacity for a given  $E_j^M$ . This is the dispersion force. However, if a NEG derived measure of Market Potential is built with the term  $T_{ij}^{1-\sigma}$  close to  $d_{ij}^{-1}$  the estimate of this variable in an empirical wage-type of equation collects the net effect of both forces for the average region in a particular sample. A sample of European regions is characterized by a spatial distribution of economic activity following a core-periphery pattern (see Chapter 1), with the economic center of Europe around the 'blue banana' (see Figure 3.1 in section 3.3.2). This might mean that the trade agglomeration forces have dominated at some point in history and their effects are persistent today. Therefore the global spatial distribution of a measure of  $E_j^M$  or  $w_i$  is approximately captured by a Harris's (1954) variable of Market Potential: peripheral regions tend to have lower Market Potential. A NEG derived measure can collect this spatial pattern too, producing similar results in the estimation of a wage equation. The distance decay close to 1 mainly weights the nearest neighbors of each region and any measure with a core-periphery distribution in Europe could do the job. Even more, fixed importer effects from gravity equations could play the role of  $E_j^M$  because big economies tend to be big importers. Some of these issues will be explored below.

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<sup>32</sup> Head and Mayer (2004b) report estimates of  $\sigma$  in the literature ranging between 4.9 and 7.6, which in equation (3.15) correspond to an equilibrium markup of prices over marginal costs,  $\sigma/(\sigma - 1)$ , between 1.15 and 1.25. These estimates have been used to calculate  $G_j^M$  and build a measure of  $RMP_i$ . For instance, Fingleton (2006) assumes  $\sigma = 6.25$ , the mid-point of Head and Mayer's (2004b) range. Fingleton and Fischer (2010) assume the similar  $\sigma = 6.5$  with a *post hoc* rationalization based on their preferred model estimates. However, many of these estimations assume  $\theta = 1$  in equation (3.20).  $\sigma = 2$  implies a demand rather inelastic but, letting aside the structural interpretation of  $\sigma$ , a -1 distance decay is consistent with Head and Mayer's (2013) evidence about the trade elasticity to distance.

### 3.3.2 Benchmark specification of the cross-sectional wage-type equation and data

Taking logarithms to the wage-type of equation (3.28) and proxying  $RMP_i$  with  $HMP_i$ , the econometric specification considered in this paper for a cross-sectional regression is:

$$\ln w_i = C + \alpha \ln k_i + \beta \ln h_i + \frac{1}{\theta\sigma} \ln HMP_i + u_i \quad (3.36)$$

which is observationally equivalent to the logarithm of equation (3.30) but they have different underlying assumptions about the values of  $\alpha + \beta$ . This is one of the issues that will be studied in the next sections. Though when using  $HMP_i$  it is not possible a structural NEG interpretation of the parameters the notation is kept as a reference.

The benchmark specification in this work proxy wages with per capita income, as it is frequent in the NEG literature (Redding and Venables, 2004; Brakman *et al.*, 2009a). Here it is represented by per capita gross value added (GVA). The research focus on the observational equivalence of the NEG makes to try alternative measures for the dependent variable in section 3.4.2. The benchmark Market Potential variable is built with GVA too. Alternative measures are tried in section 3.4.3. The estimations are controlled by per capita capital stock and by a proxy of human capital. The variable chosen to proxy human capital is the share of the population who has successfully completed education in Science and Technology (S&T) at the third level and is employed in a S&T occupation<sup>33</sup>. Details about the variables and the sample are provided in Appendix A. The sample exclude the regions of Norway and Switzerland because of lack of data on capital stock but those regions are included to calculate the Market Potential variables of the 206 NUTS 2 regions studied here. Table 3.1 and Appendix C show correlations among different variables used in the next sections.

The term  $u_i$  is supposed to collect the effects of omitted variables and departures from the assumptions of the theoretical model, which are assumed to be randomly distributed under OLS estimation. Actually, all the estimations presented in this paper present spatially autocorrelated residuals. However, the models of Spatial Econometrics are avoided to discuss the observational equivalence of the NEG because they provide alternative interpretations and/or channels of interaction, through spillovers or the other motivations of spatial specifications discussed by LeSage and Pace (2009, chap. 2). Some partial results of the following empirical exercises change when estimating spatial models but the main message about the observational equivalence of the NEG remains the same than using simple OLS regressions.

Market Potential is not instrumented here, contrary to the frequent instrumentation of this variable in the NEG empirical literature. Instrumental variables estimation of a wage-type equation involves a number of issues that are out of the scope of this paper. The same can be said about the estimation with panel data and fixed regional effects. However, given the previous discussion about the important role of regional productivity differences it is worthy saying a few words about this.

Panel estimation with fixed individual effects follows a procedure of time-demeaning to produce estimates of the average effects of the variations of the right hand variables on the variations of the dependent variable (within estimator). The procedure can reduce measurement errors in the levels of the Market Potential variable but the resulting estimates are not comparable with those

<sup>33</sup> Though this variable is not frequently used in the literature, Niebuhr (2006), Bivand and Brunstad (2006), Artis *et al.* (2011) or Dreger *et al.* (2011) have worked with variants of it.

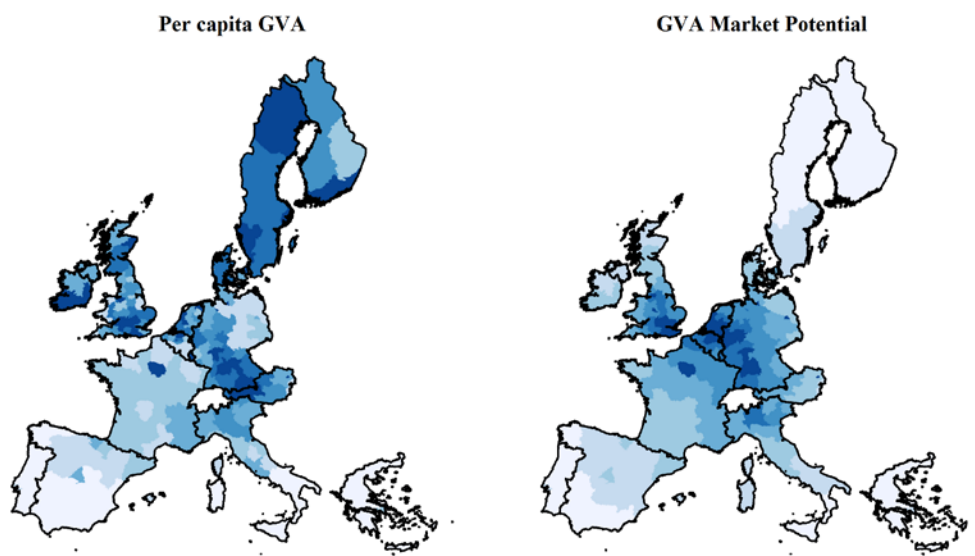


of cross-sectional or pooled estimations (Acemoglu *et al.*, 2008). For instance, estimating with fixed effects human capital tends to be insignificant because of the smooth changes of this variable in Europe. Additionally, given that panel estimation with fixed effects just eliminates the time invariant individual factors, the results are going to dependent on the variations of the variables omitted from the regression and related with changes in  $A_i$ . If capital stock is not included in the estimation, the results are sensitive to the omitted short-term variations of capital stock.

Again the time horizon of the theoretical model to be estimated is the key issue and therefore, the econometric techniques and samples to be used in the estimation. This paper does not analyzes how trade interactions are able to explain short term effects on the income of a region after variations of variables in the neighboring regions. The strategy of this paper is to keep the estimation procedure simple, cross-sectional OLS, and control the estimation for capital stock, though some of the tests exclude this variable. This strategy allows the discussion about one of the sides of the NEG observational equivalence: cross-sectional estimations of wage-type equations are driven by general characteristics of the variables in levels. Therefore, the definition of the sample is crucial both because of the geographical location of the observations and because their relative wealth.

The following figures make this last point clearer. First, Figure 3.1 provides a first intuition about the role of a Market Potential variable on a wage-type equation. It shows quantile maps of the logarithms of per capita gross value added and Market Potential in the year 2008. The values of are divided in seven quantiles and darker colors are associated with higher values of the variables. In spite of the visual limitations of choropleth maps, Figure 3.1 is enough to distinguish the core-periphery spatial pattern of the logarithm of per capita GVA, with just a few high per capita income regions out of the geographical center of Europe, particularly those in Nordic countries. Given the spatial structure of GVA in Europe, the logarithm of a Harris's measure of Market Potential built with GVA shows an even more concentrated distribution and a clearer core-periphery pattern. Therefore, in the context of a wage equation a variable of Market Potential is able to collect the global core-periphery pattern of per capita GVA.

**Figure 3.1. Choropleth maps of the logs of per capita GVA and Market Potential (year 2008)**



**Figure 3.2. Log of per capita GVA in year 2008: Countries and regions**

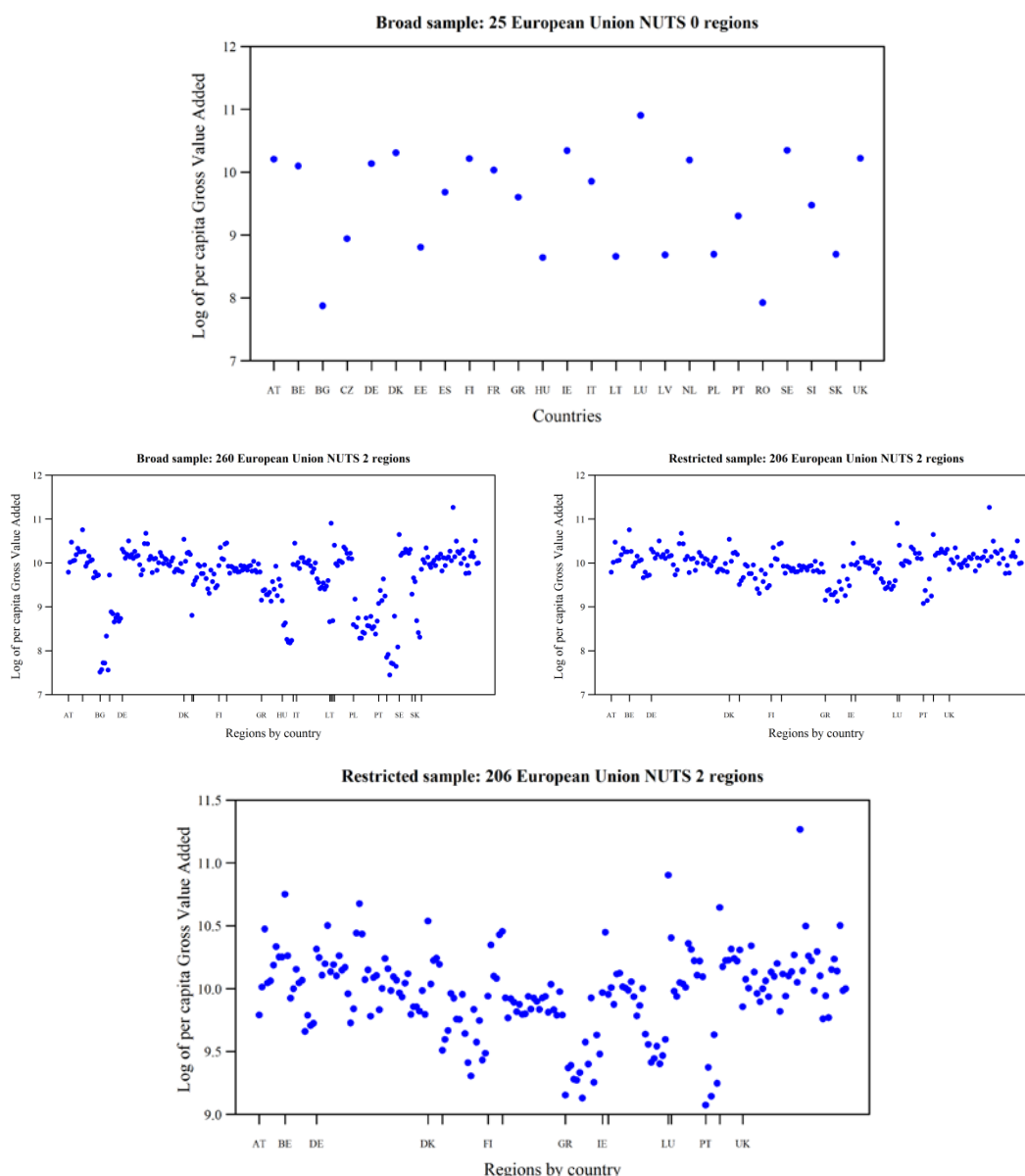


Figure 3.2 compares from a different perspective the levels of the benchmark dependent variable, the logarithm of per capita GVA on two samples of countries at two different NUTS disaggregation levels (see details in Appendix A). The top plot of Figure 3.2 shows the variable for 25 countries of the European Union (excluded Malta and Cyprus). The left central plot shows 260 regions from this broad sample. The points in the lower band of this last plot are the regions from the Eastern European countries, which are relatively poor. Those 54 regions are suppressed in the right central plot. The omission of this 20% of the observations of the broad sample reduces to coefficient of variation of the cross-sectional log of per capita GVA from 7.5 % to 3.3%. However, because of the higher heterogeneity of the sample with the Eastern European regions all the correlations shown in Table 3.1 are higher than 0.9 for the broad sample: the variables collect approximately in the same way the dispersion of per capita income in a sample including the

Eastern regions. The tests presented in this paper were repeated for the broad sample and are available upon request. The main conclusions about the observational equivalence do not change so the results presented later will use the restricted sample of 206 regions.

The broad sample is shown in Figure 3.2 to illustrate the role of sample heterogeneity. Many regional variables can collect the heterogeneous levels of income of a sample including the Eastern European regions. If a variable of Market Potential is included in the regression the issue of the relative wealth of the Eastern European regions get mixed with their particular location, some of them relatively close to the economic center of Europe. Too this mix of explanation affects the restricted sample, as shown in the bottom plot of Figure 3.2, which just zooms the right central plot. Now the lower band of points mainly represents regions from the following Mediterranean countries: Spain (ES), Greece (GR), Italy (IT) and Portugal (PT). Of course, the NEG explanation is that these countries have lower income and physical and human capital due to their lower Market Potential. However, the results presented later show that the main explanatory variable is capital stock. Therefore it is necessary to translate the NEG explanation of wages to an explanation of capital accumulation what take us to the same type of conclusion discussed before. At the end all is about explaining differences of total factor productivity. What it is studied here is the role of Market Potential to explain the cross-sectional dispersion of per capita income after controlling the estimation for the effects of human and physical capital stocks on factor productivity. However, some conclusions do not depend on the inclusion of control variables.

### 3.4 The OLS cross-sectional wage-type equation in EU NUTS 2 regions: results

#### 3.4.1 The cross-sectional benchmark equation for year 2008

This section presents the benchmark empirical cross-sectional equation studied in this research and starts to show the robustness tests that will continue along the next three sections.

Table 3.3 shows the role of different explanatory variables to select that equation, which is shown in column (6). The variable chosen in this work to measure Market Potential is a Harris's (1954) measure (IMP2GVA), calculating internal distances in Internal Market Potential as  $1/3$  of the radius of a circular region (Keeble *et al.*, 1982). Too the table presents the equation estimated with a different calculation of internal distances or using only the external component of Market Potential. The results are similar. Table C.1 in Appendix C shows the correlation among the variables used in Table 3.3.

As it can be seen in column (1), capital stock is the main explanatory variable of the model. Total factor productivity might exert a powerful indirect effect on income differences through its impact on capital accumulation (Hsieh and Klenow, 2010), which it is related with the previous discussion about total factor productivity and the wage equation. But this issue is not explored here. The inclusion of a variable of human capital or different measures of Harris's style Market Potential does not add too much explanatory power to the regression, as shown by the comparison of the adjusted R-squared.

Market Potential explains by itself around 40 % of the cross-sectional dispersion of per capita GVA - column (3) -. However, its contribution to the explanatory power of the regression mainly comes from the External Market Potential component (IEMPGVA) - column (5) -. That it is why

the results of columns (5) and (6), using different methodologies to calculate Internal Market Potential, are similar too.

The benchmark equation in column (6)<sup>34</sup> of Table 3.3 is comparable to Breinlich's (2006) analysis to disentangle the channels of influence of a model-derived measure of Market Access. In his estimation, the elasticity of GVA per worker to Market Access drops from 0.26 to 0.08 when controlling for per capita capital stock and proxies of human capital. In Table 3.3 the elasticity of per capita GVA to Harris's Market Potential drops from 0.39 in column (3) to 0.16 in column (6). These regressions with variables in levels tend to have endogeneity problems. However, omitting other dependent variables to reduce these problems has the cost of a severe upward bias in the estimated elasticity of the dependent variable with respect to Market Potential, as shown by the statistical significance of all the dependent variables in the full benchmark specification. This bias is commented by Fingleton (2006) too, though he does not control by capital stock.

**Table 3.3. Benchmark cross-sectional equation for the year 2008 (206 regions)**

	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	-0.519 (0.454)	1.295* (0.542)	6.200*** (0.349)	0.874 (0.510)	0.877 (0.498)	0.900 (0.490)
IKSp	0.928*** (0.040)	0.813*** (0.043)		0.733*** (0.043)	0.715*** (0.042)	0.706*** (0.042)
lhrstc_pop		0.226*** (0.042)		0.215*** (0.039)	0.203*** (0.038)	0.195*** (0.038)
IMP2GVA			0.387*** (0.036)			0.158*** (0.023)
IEMPGVA				0.136*** (0.024)		
IMP1GVA					0.153*** (0.023)	
R-squared	0.724	0.758	0.364	0.792	0.800	0.806
Adj. R-squared	0.722	0.756	0.361	0.788	0.797	0.803
Log likelihood	67.91	81.78	-17.95	97.01	101.45	104.14
Sum squared errors	6.24	5.45	14.36	4.70	4.50	4.39

Notes: Table displays coefficients: \* significant at 10% level; \*\* at 5% level; \*\*\* at 1% level. Standard errors are in brackets. The variables are in logarithmic form. The dependent variable is per capita Gross Value Added. Column (1) shows per capita capital stock (IKSp) as independent variable while column (2) adds the share of population who has successfully completed education at the third level in Science and Technology (S&T) fields and is employed in a S&T occupation (lhrstc\_pop). The independent variable in column (3) is Market Potential (IMP2GVA) calculating internal distances in Internal Market Potential as 1/3 of the radius of a circular region (Keeble *et al.*, 1982). Column (4) adds External Market Potential to the specification of column (2) while column (5) replaces it by Market Potential (IMP1GVA) calculating internal distances as 2/3 of the radius of a circular region (Head and Mayer, 2000). The benchmark equation is shown in column (6), adding IMP2GVA to the specification in column (2).

<sup>34</sup> The estimated benchmark equation is similar when using gross domestic product (GDP) per capita as dependent variable and Market Potential is measured with GDP too, what it is confirmed by Ahlfeldt and Feddersen (2008). The results in column (6) are robust to the inclusion of country dummies (not-shown). In this case, the elasticities of per capita GVA to per capita capital stock and Market Potential are very similar but the elasticity to the proxy of human capital decreases until 0.13 and this variable is only significant at 5% level.

The evidence presented here is consistent with the hypothesis presented at the end of section 3.2.3: the estimation of a wage-type of equation is similar to the estimation of an aggregate production function including a variable of scale.

### 3.4.2 The benchmark equation with alternative dependent variables

Following the discussion in sections 1.1 and 3.2.1, the next test analyzes the sensitivity of the regional wage-type equation to alternative measures of the dependent variable.

Table 3.4 studies the specification of the equation in per worker terms instead of per capita terms for two dependent variables in logarithms: gross value added per worker, in columns (1), (3) and (5), and nominal remuneration per worker, in columns (2), (4) and (6). The first variable has been used many times in the literature of growth or development as a proxy of regional labor productivity. Too it has been used in the NEG literature of the wage equation as a proxy of wages. The second variable is a direct measure of regional wages. Additionally, Table 3.4 studies the empirical definition of  $C$  and  $M$  sectors in the NEG theory. The sectorial labels in the first row of Table 3.4 are a reference to what it is tried to capture in each estimation. Columns (1) and (2) estimate the equation for the aggregate regional economy, columns (3) and (4) for the sector of energy and manufacturing and columns (5) and (6) for the sector of market services. As mentioned in Appendix A, the sectorial disaggregation for capital stock data is lower than for GVA, remuneration and employment. The necessary adjustments are explained in the note of Table 3.4. There is not available data by sector about the proxy of human capital, as a share of active population this time, and Market Potential for the total economy is used in all the estimations too.

**Table 3.4. Estimation with alternative dependent variables (206 regions)**

	<i>Total economy</i>		<i>Manufacturing</i>		<i>Services</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
(Intercept)	3.000*** (0.531)	2.413*** (0.575)	2.010* (0.853)	2.455*** (0.657)	5.275*** (0.606)	3.944*** (0.761)
IKSw	0.533*** (0.044)	0.570*** (0.048)	0.619*** (0.062)	0.399*** (0.048)	0.378*** (0.048)	0.452*** (0.061)
lhrstc_act	0.203*** (0.037)	0.321*** (0.040)	0.285*** (0.074)	0.298*** (0.057)	0.287*** (0.044)	0.490*** (0.055)
IMP2GVA	0.174*** (0.020)	0.162*** (0.021)	0.234*** (0.038)	0.402*** (0.029)	0.160*** (0.024)	0.169*** (0.030)
R-squared	0.723	0.735	0.545	0.687	0.561	0.581
Adj. R-squared	0.719	0.731	0.538	0.682	0.554	0.575
Log likelihood	126.60	110.30	-17.95	35.72	81.57	34.65
Sum squared errors	3.53	4.13	14.36	8.53	5.46	8.62

Notes: Cross-sectional OLS estimation for the year 2008. Table displays coefficients: \* significant at 10% level; \*\* at 5% level; \*\*\* at 1% level. Standard errors are in brackets. Variables are in logarithmic form. The dependent variables in columns (1), (3) and (5) are GVA per worker for: (1) the aggregate regional economy; (3) the sector of energy and manufacturing; and (5) the sector of market services. Columns (2), (4) and (6) are the analogous for remuneration per worker (compensation per employee). As independent variable, capital stock per worker (IKSw) is defined in each column for: (1) and (2), the aggregate economy; (3) and (4), the sector of energy, manufacturing and construction; and (5) and (6), the sector of market and not market services. In all the columns the other two independent variables are defined for the total economy: the variable of human resources in S&T used before, but as a share of active population (lhrstc\_act); and Harris's Market Potential (IMP2GVA).

The results of all specifications show good linear fit and significant explanatory variables. Column (1), for GVA per worker, is directly comparable to column (6) in Table 3.3 for GVA per capita and presents a slightly lower R-squared. The equations regressing the log of GVA per worker, in columns (1), (3) and (5), always have lower R-squared than the respective equations using the log of remuneration per worker as dependent variable, in columns (2), (4) and (6). However, with the exception of columns (3) and (4), the differences are small. A similar conclusion is obtained when comparing the specifications for the two big sectors using the same dependent variable: columns (3)-(5) and columns (4)-(6). As expected, the estimates of human capital are higher and present lower standard deviations when the dependent variable is wages that when regressing GVA per person.

The regression diagnostics are better for the aggregate regional economy in columns (1) and (2) than for the sectorial estimates in columns (3) to (6). They are approximately the same for both dependent variables in the total economy. A higher R-squared for aggregate variables is not surprising given that particular shocks in more disaggregated variables get diffused and compensated. However, this statistical effect is not related with NEG theory about the *C* and *M* sectors.

The estimated elasticity of each dependent variable to Market Potential shows a surprising stability. If in column (6) of Table 3.3 this elasticity was 0.16 in Table 3.4 is around 0.16-0.17 with the exception of columns (3) and (4) for energy and manufacturing, with estimates of 0.23 and 0.40 respectively. A possible reason for these last results is the need of including the subsector of construction to measure capital stock per worker<sup>35</sup>.

In spite of the data limitations, the main conclusion of this exercise is that “everything works”. The differences of results among specifications are not enough to draw clear conclusions in terms of NEG specific variables and channels of interaction. As discussed before, this does not seem to be due to the use of a Harris’s type of Market Potential instead of model derived measured.

What this analysis of the observational equivalence of the NEG is emphasizing is the similarity of wage-type equations estimated with different dependent variables to an estimated production function and the uncertain role of total factor productivity in both cases.

### 3.4.3 Harris’s Market Potential as a scale variable

An empirical test about the trade channels of interaction in NEG theory would have to prove that the variable of Market Potential defined in terms of market size has significantly higher explanatory power than alternative measures based on other variables. Under the caveat of using a Harris’s measure, the following exercise is a first attempt to address this issue.

Table 3.5 shows the results of estimating the benchmark equation with “Market Potential” built on alternative variables. In Appendix C Table C.2 presents the correlations among the logs of the variables used to build different types of “Internal Market Potential”. Table C.3 contains the correlations among the logs of measures of “External Market Potential” built with those variables. Both the internal and the external components are added and logged to build the logs of

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<sup>35</sup> In columns (5) and (6) the sector of non-market services is included too in capital stock per worker to explain a dependent variable of market services. However capital stock is expected to have less influence on the services sector than in manufacturing and the inclusion of public capital stock might be more reasonable to explain variables of market services when compared with construction to explain variables of the energy and manufacturing.



Harris's type of measures of "Market Potential" used in Table 3.5 as explanatory variables of the log of gross value added per capita. The variables are explained in the note of the table<sup>36</sup>.

**Table 3.5. Estimation with alternative "Market Potential" (206 regions)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	0.900 (0.490)	0.972 (0.502)	1.129* (0.482)	0.397 (0.487)	1.085* (0.508)	1.393** (0.480)	1.906*** (0.476)	2.320*** (0.552)
IKSp	0.706*** (0.042)	0.758*** (0.041)	0.677*** (0.043)	0.736*** (0.039)	0.745*** (0.042)	0.744*** (0.039)	0.684*** (0.041)	0.754*** (0.043)
lhrstc_pop	0.195*** (0.038)	0.218*** (0.039)	0.194*** (0.037)	0.159*** (0.038)	0.211*** (0.039)	0.167*** (0.038)	0.183*** (0.037)	0.140** (0.043)
IMP2GVA	0.158*** (0.023)							
IMP2GVAhr		0.154*** (0.025)						
IMP2GVAp			0.180*** (0.024)					
IMP2GVAd				0.104*** (0.013)				
IMP2POP					0.144*** (0.026)			
IMP2POPd						0.107*** (0.014)		
IMP2TFP							0.089*** (0.011)	
IMP2hrstc_pop								0.064*** (0.013)
R-squared	0.806	0.796	0.810	0.816	0.790	0.811	0.819	0.785
Adj. R-squared	0.803	0.793	0.807	0.813	0.787	0.808	0.816	0.782
Log likelihood	104.14	99.16	106.47	109.92	96.21	107.05	111.57	93.70
Sum squared errors	4.39	4.61	4.29	4.15	4.74	4.27	4.08	4.86

Notes: Cross-sectional OLS estimation for the year 2008. Table displays coefficients: \* significant at 10% level; \*\* at 5% level; \*\*\* at 1% level. Standard errors are in brackets. Variables are in logarithmic form. The dependent variable is GVA per capita (IGVAp). The independent variables common to all the regressions are capital stock per capita (IKSp) and the share of population who has successfully completed education at the third level in S&T fields and is employed in a S&T occupation (lhrstc\_pop). The additional independent variable in each column is "Market Potential" built with: (1) gross value added (IMP2GVA); (2) GVA of the sector of hotels and restaurants (IMP2GVAhr); (3) GVA per capita (IMP2GVAp), which is the dependent variable in the benchmark equation; (4) GVA density (IMP2GVAd), built with GVA and the regional area; (5) population (IMP2POP); (6) population density (IMP2POPd); (7) total factor productivity (IMP2TFP), built as a Solow's residual by discounting 1/3 of the logarithm of capital stock per capita to IGVAp; (8) the same variable of human resources in S&T mentioned above (IMP2hrstc\_pop).

Given that, by construction, for the average region the main component of Market Potential is External Market Potential (*EMP*), the high correlation of the *EMP* variables shown in Table C.3 makes all the "Market Potential" variables to provide similar results in Table 3.5. All of them are significant at 1% level and the elasticity of GVA per capita to these variables is in the range 0.1-0.2 found in the previous tables. The exceptions are columns (7) and (8), with elasticities to "Market Potential" lower than 0.1. In these cases, "Market Potential" is built with proxies of total

<sup>36</sup> The variable in column (2), GVA of the sector of hotels and restaurants, might be surprising. This variable was chosen for a test of "Market Potential" because the share of this sector in GVA has a particular distribution. While in Finland or Denmark this sector is 1% of the 2008 GVA in Spain is 7% and in Greece 10%. However, the level of the variable is used in the Table.

factor productivity and human capital respectively, can be considered as “forbidden” by NEG theory, in the sense discussed in section 1.1. However, the variable is equally significant. Though the R-squared of the regressions are always similar, column (7) happens to present the highest one of all the estimations analyzed until now.

When the distance decay parameter is close to -1, the weight of the neighboring regions in Market Potential is very high. The selection of the neighbors dominates the estimated effects of Market Potential. The main message from Table 3.5 is that a Harris’s-type of variable collecting information about the economic scale of the neighboring regions has a significant positive effect in the regression no matter what variable be used to build it. The results are supportive of the hypothesis that the empirical estimation of wage-type equations is driven by general differences among the levels of variables. The channel of interaction could be given by market size, productivity, density of people and ideas...

It can be argued that the role of market size is already captured by the endogenous capital stock per capita, which is the main explanatory power of these wage-type equations. Therefore, the next exercise studies the role of the neighboring regions considering both the equation with the two control variables and an equation without them.

#### **3.4.4 External Market Potential as a measure of the nearest neighbor’s scale**

The literature of gravity equations finds a trade elasticity to distance around -1, the same than the distance decay parameter in Harris-type of measures when trade costs are proxied with geographical distance. The -1 exponent of distance implies a practical low number of neighbors contributing to the measure, though this issue is usually not tested in the empirical literature<sup>37</sup>. Therefore, probably for first time<sup>38</sup>, the following exercise tests the empirical effects of changing the number of neighbors when building a Harris’s measure of External Market Potential. If the concept of Market Potential represents regional accessibility to the potentially *relevant* markets, how many of those markets are empirically relevant? In other words, the research question is: how many of the nearest neighbors do collect the statistically relevant spatial information to compute the size of the “potential markets” of each region? The main idea behind these questions is that any measure based on distance exponents close to -1 overweights the nearest neighbors, especially in peripheral regions. The median first nearest neighbor in the sample is at a distance of 80 kilometers while the median fifth nearest neighbor is at a double distance. Therefore their weights in External Market Potential are 0.012 and 0.006 respectively. But the levels of GVA are spatially autocorrelated and tend to vary smoothly over the European space. Therefore, in general, regions inside a range of distance of 160 kilometers do not have too different GVA levels. At distances of 500 kilometers the distribution of GVA levels tends to vary more but the weight of those regions is only 0.002. Peripheral regions are by definition located at the geographic borders of the sample and have a lower number of neighbors at distances of 500 kilometers than regions located close to the center of the European Union. Therefore, how many nearest neighbors are actually contributing with significant information to the wage equation?

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<sup>37</sup> See Negreiros (2009) for an exception in the Spatial Econometrics literature.

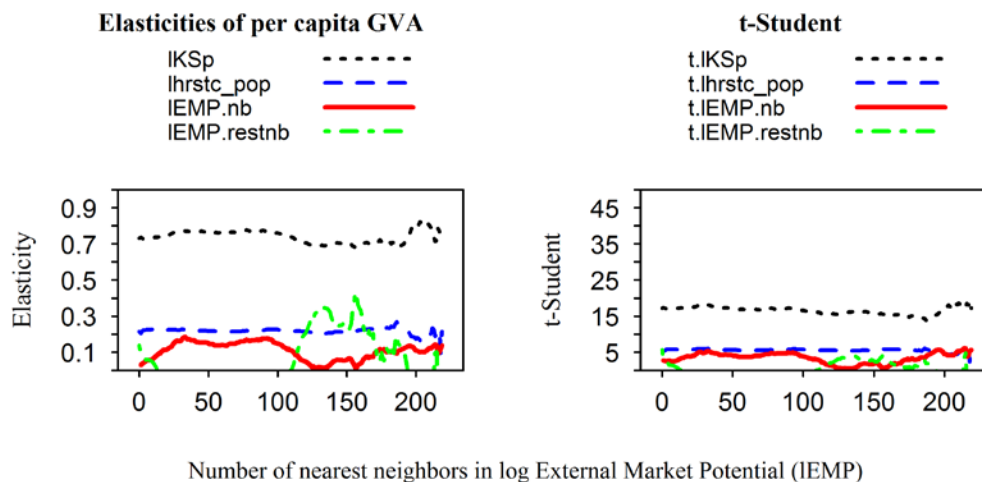
<sup>38</sup> The author is very grateful to a conversation with James LeSage for his inspiration to do this exercise. See LeSage and Pace (2011, 2012) for similar exercises and for a discussion in the context of Spatial Econometrics.



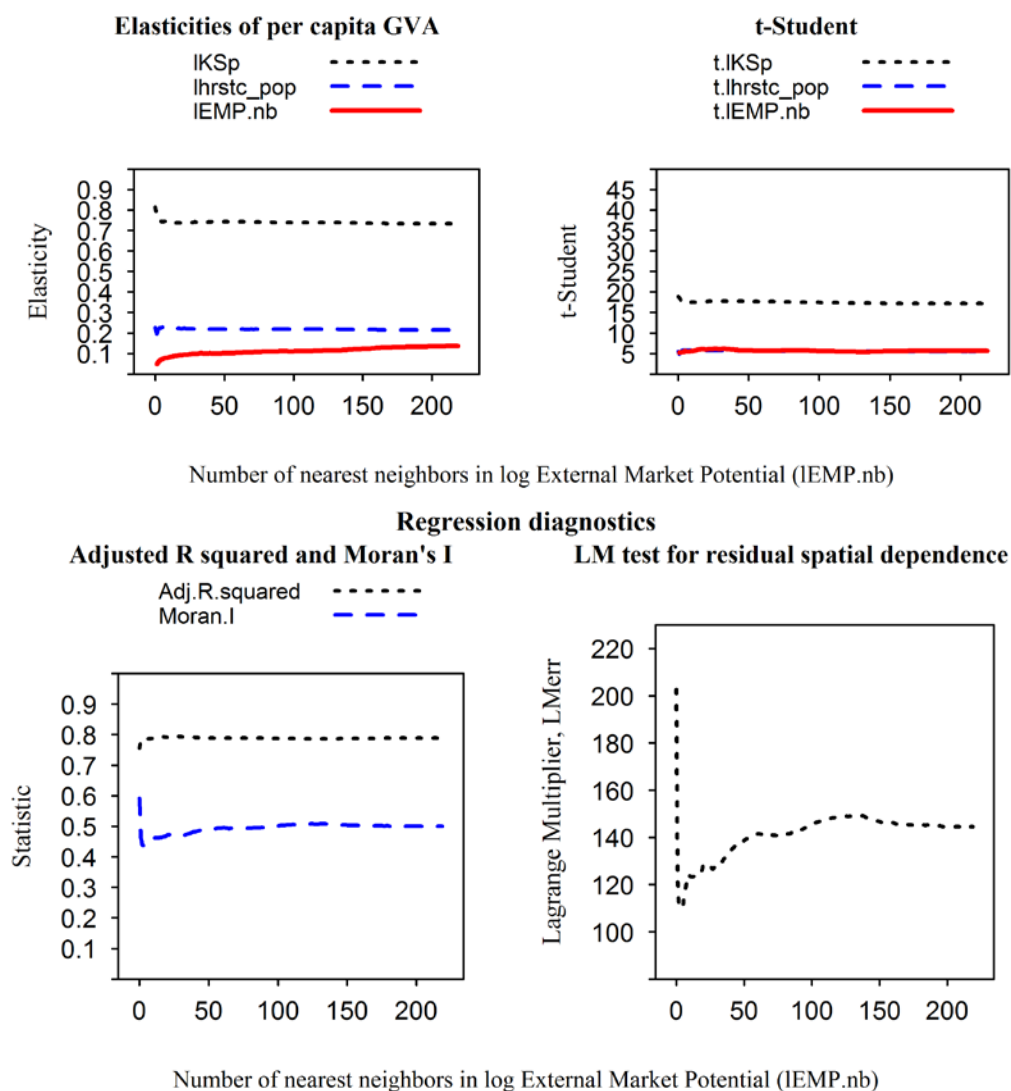
The following estimations are based on the benchmark equation but only with GVA External Market Potential (EMP), without the internal component. However, the standard IEMPGVA used until now is re-defined in different variables IEMP.nb for each number of nearest neighbors: first for the nearest neighbor, then for the two nearest neighbors, and so on. As it is explained in Appendix A, the sample has 206 regions but 220 regions are considered to calculate Market Potential. Therefore, 220 new variables are created and used to estimate 220 regressions of the wage-type equation. The tests are repeated twice for the equation with control variables of capita physical and human capital stocks and omitting these control variables.

In the first exercise each equation includes an additional variable, IEMP.restnb, calculating another “External Market Potential” built with the rest of neighbors, i.e., those not included in IEMP.nb. Therefore, when IEMP.nb is built with zero neighbors and it is omitted in the regression, IEMP.restnb is built with all the 219 neighbors of each region and it is the logarithm of Harris’s External Market Potential. Contrary, if IEMP.nb is built with all the neighbors, IEMP.restnb is omitted. The specific research question of this first exercise is the following: If “External Market Potential” is built with just a few neighbors, do all the other neighbors add significant effects to the benchmark equation? The results in Figure 3.3 offer a negative answer to this question. Once the information of the first neighbors is captured with IEMP.nb, the variable IEMP.restnb collecting the rest of the neighbors becomes insignificant. In Figure 3.3 the plots of the estimates and t-Students of these two variables are not clear when the number of neighbors considered in IEMP.nb is high. Contrary, if 54 Eastern European regions are added to the sample (not shown), once IEMP.nb is included in the regression with just the nearest neighbor the coefficient of IEMP.restnb becomes negative and not significant and this result keeps the same if more neighbors are added to IEMP.nb. In this extended sample all the other neighbors do not add any useful information to the regression when the information of the nearest neighbor is considered in the definition of “External Market Potential”.

**Figure 3.3. 220 benchmark regressions with two EMP variables by number of neighbors**  
**OLS cross-sectional estimations by number of nearest neighbors in IEMP.nb**  
**(IEMP.restnb also included in the regression with the rest of neighbors)**



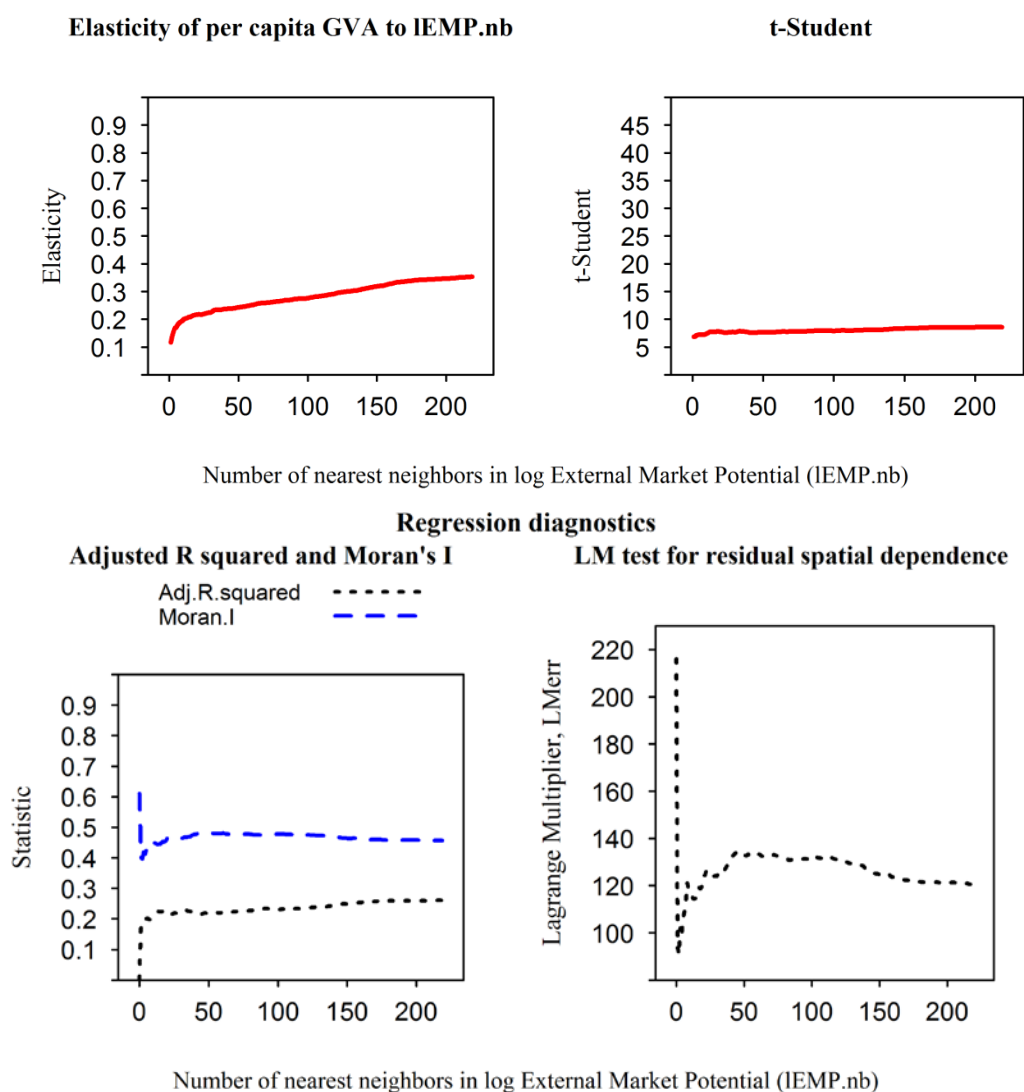
**Figure 3.4. 220 benchmark regressions with EMP by number of neighbors**  
**OLS cross-sectional estimations by number of nearest neighbors in IEMP.nb**  
**(Estimation without log EMP when the number of neighbors is 0)**



Given that the set of variables IEMP.nb and IEMP.restnb tend to be highly correlated, Figure 3.4 presents a second exercise omitting the latter variable in the regressions. On the other hand, though it is not a central issue for the current discussion about observational equivalence, all the OLS estimations shown in this paper present spatially autocorrelation residuals, as commented in section 3.3.2. Figure 3.4 includes two measures of spatial dependence for the residuals of each regression. Together with the adjusted R-squared of each regression, these statistics allow answering two questions: does the inclusion of more neighbors in the definition of “External Market Potential” improve the explanatory power of this variable? Does it reduce the spatial autocorrelation of the residuals? The answer to both questions is again negative. Harris’s Market Potential is significant in these cross-sectional regressions because it captures information about the location of each region. This information can be captured with just one neighbor too. Given that the estimated equation is controlled for capital stocks the R-squared has just a slight improvement

when the “External Market Potential” variable for the nearest neighbor is added (with 1 neighbor). Adding more regions does not improve the linear fit of the regressions. However, the relevance of the locational information can be seen on the jump of the Moran’s I and the LM statistics comparing the estimation without IEMP.nb (0 neighbors) or with IEMP.nb built with one neighbor. The minimum of these two statistics is in the regression using the three nearest neighbors and all of these regressions continue to present spatially autocorrelated residuals (zero p-values of the tests, not shown in the figure). The locational information is relevant, but it does not avoid local clustering of residuals.

**Figure 3.5. 220 regressions with only EMP by number of neighbors as explanatory variable**  
**OLS cross-sectional estimations by number of nearest neighbors in IEMP.nb**  
**(Estimation without log EMP when the number of neighbors is 0)**



The third exercise excludes per capita physical and human capital from the regressions. The research question is: are the previous results due to per capita capital stock being dependent on Market Potential, so the market size effects of all the other regions are present through capital

stock? The answer is negative too. Figure 3.5 shows the same analysis but when the log of per capita GVA is regressed only on the “External Market Potential” variables. Therefore, in the case of zero neighbors this variable is excluded and the regression just includes an intercept. Comparing the extreme estimations when IEMP.nb is defined with the nearest neighbors or with all the 219 neighbors (Harris’s measure), the elasticity of GVA per capita to “Market Potential” goes from 0.12 to 0.35. But the additional information does not reduce the standard deviation of the estimate so the improvement of the t-Student is low: it goes from 6.8 to 8.6. The adjusted R-squared goes from 0.18 to 0.26 but in the regression with the 5 nearest neighbors the adjusted R-squared is already 0.20. Therefore, adding all the other regions from the 6<sup>th</sup> nearest region to the most distant one in the sample just improves the adjusted R-squared 0.06 points. Again the conclusion is that the effects of adding more than the first nearest neighbor(-s) to the definition of External Market Potential are marginal.

### 3.5 Conclusions

There are many mentions in the literature to the observational (or Marshallian) equivalence of the NEG wage equation. However, there are not commonly accepted approaches to empirically test such equivalence. The goal of this chapter is to propose a procedure to empirically check whether wage equations are actually proxying an underlying production function augmented with locational information about the nearest neighbor(-s) economic development.

This procedure has two steps. The first one is to derive a *wage-type* equation with emphasis on marginal costs, instead on wages, and encompass several wage equations found in the literature. In order to highlight the similarity of wage equation to an expanded production function, the derivation of that wage-type equation adds capital stock as explanatory variable, in a similar way to what Head and Mayer (2006) did for human capital. The second step of the procedure consists on the repeated estimation of a baseline wage-type equation by redefining the key variables of the model in alternative ways from those commonly used by the NEG empirical literature.

These latter exercises are illustrated using cross-sectional regressions for the European regions and a Harris’s (1954) definition of *Market Potential*. First, the cross-sectional benchmark equation is analyzed by parts to check that it has an appropriate specification. Second, the equation is estimated for alternative dependent variables, including income per person and wages in the aggregate regional economy and the analogous for the sectors of manufacturing and services. Third, the equation is estimated replacing a conventional measure of Market Potential based on gross value added by alternative measures with the same structure but based on different variables, such as productivity, population or density variables. Four, alternative specifications of the equation are estimated 220 times with External Market Potential re-defined to include just the nearest neighbor, the two nearest neighbors, the three nearest ones... and so on.

The conclusions of these tests are: 1) the cross-sectional estimation of a wage-type equation is similar to the estimation of production function expanded with a factor of scale; 2) the results are similar when the calculation are based on interactions ‘forbidden’ by NEG theory; 3) those results are driven by general characteristics of the variables in levels; and, 4) a variable of Market Potential with a distance decay parameter close to -1 does not clearly collect the information that it is supposed to collect. The estimation of a wage equation produce similar results to those obtained with an aggregate production function expanded to include a variable with information

about the location and economic scale of the nearest region. These findings are compatible with the NEG as well with alternative explanations which it is the essence of the observational equivalence of NEG theory.

More research is needed to test the NEG theory. There are many possible extensions of this chapter, using alternative samples and econometric techniques and using alternative measures of Market Potential.



## **Conclusions and contributions**





## I Conclusions of the doctoral thesis

Chapter 1 shows that the combination in Harris's (1954) indicator of a sum for all the regions in the sample with a weighting scheme based on absolute distances is what allows Market Potential to capture the core-periphery pattern (global spatial trend) of the spatial distribution of economic activity. However, the smoothing effects of the sum make the residuals of an estimated wage equation to be spatially autocorrelated at short ranges. These features are common to other empirical measures of Market Potential used in the literature, though they are not studied here.

The comparison of Harris's measure of Market Potential with other spatial lags frequently used in Spatial Econometrics reveals four differences: the number of neighbors considered in the sum; the standardization of the weights; the reference to the dependent variable in SAR models (instead of market size); and the 'lag of log' versus 'log of lag' issue. The analysis shows that the achievement of simultaneously capturing two different types of spatial dependence in a simple equation comes with a number of caveats. The Market Potential variable induces endogeneity problems similar to those of a spatial lag of the dependent variable, affecting the calculation of total effects. Multicollinearity is sensitive to the selection of the spatial weights matrix. The problematic consideration of the internal markets can be critical when estimating spatial models. The results might be sample dependent and sensitive to the inclusion of country dummies. These challenges have been only partially addressed in the literature and do not obscure the important achievement of capturing a global spatial trend and an average local pattern of spatial dependence in an empirical wage equation.

A negatively sloped trend on the cross-sectional estimated effects of Market Potential on gross value added per capita seems to be a pretty robust finding of Chapter 2. Moreover, the estimates of the variable with a more direct interpretation in terms of location, External Market Potential, present clearer declining trends. However, the evidence is not totally conclusive because it is highly sensitive to the inclusion of control variables. In particular, confirming findings of Chapter 1, the cross-sectional effects of External Market Potential disappear when the estimation is controlled for physical and human capital and for spatial autocorrelation. With other specifications the evidence is more solid towards a decreasing role of location to explain the relative GVA per capita of Peripheral regions. This is consistent with the peripheral regions being slowly escaping the curse of distance.

The conclusions of the empirical test in Chapter 3 are the following: 1) the cross-sectional estimation of a wage-type equation is similar to the estimation of production function expanded with a factor of scale; 2) the results are similar when the calculation are based on interactions 'forbidden' by NEG theory; 3) those results are driven by general characteristics of the variables in levels; and, 4) a variable of Market Potential with a distance decay parameter close to -1 does not clearly collect the information that it is supposed to collect. The estimation of a wage equation produce similar results to those obtained with an aggregate production function expanded to include a variable with information about the location and economic scale of the nearest region. These findings are compatible with the NEG as well with alternative explanations, which it is the essence of the observational equivalence of NEG theory.

The research presented in this thesis can be extended in multiple ways. The empirical analysis in these chapters does not include unobserved individual effects. Preliminary tests show that this extension requires further discussion. The estimations can be repeated using alternative measures

of Market Potential, different estimation methods and samples. The three chapters show some caveats in the previous literature that are suggestive for further research.

## II Contributions of the doctoral thesis

### Seminar presentations

#### Chapter 1

1. *Spatial structure of the European regional wages: Market Potential, spillovers and the distance puzzle*, I Doctoral Seminar. Chair: Frank Van Oort (Utrecht University). University of A Coruña, Faculty of Economics and Business. January 23<sup>rd</sup>, 2012.

#### Chapter 2

2. *Market Potential and the curse of distance in the European regions*, III Doctoral Seminar. Chair: Frank Van Oort (Utrecht University). University of A Coruña, Faculty of Economics and Business. November 20<sup>th</sup>, 2013.

#### Chapter 3

3. *The observational equivalence of the NEG wage-type equation*, Department of Economic Theory, Autonomous University of Madrid (UAM), January 29<sup>th</sup>, 2013.

### Conference presentations

#### Chapter 1: *Market Potential and Spatial Autocorrelation in the European Regions*

1. XV Applied Economics Meeting, Asociación Libre de Economía (ALdE). University of A Coruña. June 8<sup>th</sup>, 2012.
2. XIII Conference on International Economics, Spanish Association of International Economics and Finance (AEEFI). University of Granada, June 22<sup>nd</sup>, 2012.
3. VI World Conference of the Spatial Econometrics Association (SEA). Salvador, Brazil, July 13<sup>rd</sup>, 2012.

#### Chapter 2: *Market Potential and the curse of distance in the European regions*

4. XXXVIII Conference on Regional Studies, Spanish Association of Regional Science (AEER). University of Deusto, Bilbao, November 23<sup>rd</sup>, 2012.

#### Chapter 3: *The observational equivalence of the NEG wage-type equation*

5. XV Conference on International Economics, Spanish Association of International Economics and Finance (AEEFI). University of Salamanca, June 26-26<sup>th</sup>, 2014 (accepted).

### Publications

#### Chapter 1

1. Market Potential and Spatial Autocorrelation in the European Regions (with Andrés Faíña and Jesus Lopez-Rodriguez), *Funcas working paper 714*, April-2013.
2. Market Potential and spatial dependencies in the European Regions (with Jesus Lopez-Rodriguez and Andrés Faíña). Revised and resubmitted to *Regional Studies*.

## Chapter 2

3. Market Potential and the curse of distance in European regions (with Andrés Faíña and Jesus Lopez-Rodriguez). Submitted to *Munich Personal RePEc Archive* (MPRA).



**Long summaries in Spanish and Galician languages**



## I Resumen largo

### Marco de investigación y objetivos

La conocida como *ecuación de salarios* (Krugman, 1992, 1993) de la Nueva Geografía Económica (NEG) predice que los salarios regionales son una función del tamaño de los mercados accesibles a cada región. Esta condición de equilibrio de mercado (Baldwin et al., 2003) predice que el ingreso regional es una función positiva del acceso regional a los principales mercados internacionales, capturado por una variable de *Acceso* o *Potencial de Mercado*. Esta variable es una suma ponderada del tamaño de mercado de las otras regiones. La interacción regional clave en este marco depende de los costes comerciales, que son generalmente aproximados por distancias geográficas. La ecuación de salario ha sido considerada como de gran éxito para confirmar una relación entre el acceso al mercado y la distribución espacial de la actividad (Redding, 2011).

La presente tesis tiene tres objetivos: 1) proporcionar una nueva forma de interpretar la ecuación de salarios; 2) estudiar si los efectos de la distancia sobre el ingreso per cápita regional europeo han estado disminuyendo durante los pasados años; y 3) proponer un procedimiento para examinar la equivalencia observacional de la ecuación de salario, es decir, la existencia de explicaciones alternativas que son compatibles con los datos.

El Capítulo 1 propone distinguir dos tipos diferentes de dependencias espaciales estudiadas en las literaturas de la NEG y de la Econometría Espacial. Por una parte, como en Geoestadística, una estructura espacial centro-periferia es vista aquí como una *tendencia espacial “global”* o “regional”, en la cual los valores de la variable cambian sistemáticamente con las coordenadas del espacio geográfico. Esta es la dependencia espacial global capturada por el Potencial de Mercado de la NEG. Por otra parte, la mayor parte de las técnicas de Econometría Espacial están diseñadas para capturar *pautas espaciales locales* o de corta distancia. El capítulo estudia las características que permiten considerar ambos tipos de pautas espaciales cuando se estima una ecuación de salarios para las regiones europeas. Se acentúa que el Potencial de Mercado puede ser visto como un retardo espacial de la variable endógena y se analizan sus semejanzas y diferencias con otros tipos de retardos espaciales.

La ecuación NEG de salarios predice que las regiones periféricas tienden a tener un menor ingreso debido a su menor Potencial de Mercado. El Capítulo 2 analiza esta “*maldición de la distancia*” en el tiempo. Este objetivo es especialmente relevante debido a la puesta en práctica de políticas regionales y de transporte activas durante las pasadas décadas, que deberían reducir las consecuencias de la periféricidad. El foco del capítulo está en el análisis de la robustez de una ecuación de salario con respecto a distintas especificaciones, submuestras diferentes de regiones, la inclusión o exclusión de una medida aproximada del tamaño interno de mercado, el empleo de variables instrumentales y la estimación de modelos estándar de Econometría Espacial.

La línea de investigación final de esta tesis vuelve a las raíces de la ecuación de salarios para cuestionar su interpretación empírica. La *equivalencia observacional* (o *Marshalliana*) de la ecuación NEG de salarios ha sido mencionada por diferentes autores. Sin embargo, no hay enfoques generalmente aceptados para examinar empíricamente tal equivalencia. Se puede explicar la razón para esto a través de una intuición simple. Si el número 4 es observable, pero la operación que generó este número no lo es, existe una imposibilidad cognitiva para determinar empíricamente si el 4 fue generado por la “teoría” 1+3 o por la “teoría alternativa” 2+2. Sin embargo, la

literatura empírica NEG con frecuencia interpreta sus resultados como corroboraciones de uno de los marcos teóricos posibles. Head y Mayer (2004) lo asemejan a el Error Estadístico Tipo II cuando se analiza una hipótesis nula: la literatura empírica no debería confirmar la validez de la NEG basándose en resultados que también son consistentes con otros marcos. Por tanto, el Capítulo 3 aborda el problema de la equivalencia observacional, tanto desde el punto de vista teórico como empírico.

Se propone un procedimiento en dos pasos para comprobar empíricamente si muchas ecuaciones de salario están en realidad estimando una función de producción subyacente aumentada con información de localización sobre el nivel de desarrollo del (de los) vecino(-s) más cercano(-s). El primer paso consiste en derivar una ecuación tipo-salarios que enfatiza los costes marginales, en vez de los salarios, y que permite abarcar varias ecuaciones de salarios propuestas previamente en la literatura. Para destacar la semejanza de la ecuación de salarios a una función de producción aumentada, la derivación de la ecuación tipo-salarios añade el stock de capital como variable explicativa. El segundo paso consiste en repetir la estimación de una ecuación tipo-salarios de referencia tras redefinir las variables claves del modelo de formas alternativas a aquellas comúnmente usadas por la literatura empírica NEG.

### **Marco teórico**

La base teórica de esta tesis yace en la Nueva Geografía Económica y en la Econometría Espacial. La NEG ofrece una explicación sobre los efectos de la ubicación geográfica sobre los gradientes de ingreso. La Econometría Espacial proporciona una caja de herramientas para corregir los efectos la autocorrelación espacial en los residuos de un modelo de regresión. El Capítulo 1 supone una contribución a dos tipos de literatura: la que analiza los efectos de la perifericidad en el desarrollo económico y la que usa técnicas de Econometría Espacial para estimar una ecuación que incluye una variable de Potencial de Mercado. Este capítulo emplea extensamente los conceptos de ambos enfoques para distinguir las dependencias espaciales a distancias largas y cortas capturadas generalmente por cada enfoque. Esto conduce a revelar algunas deficiencias que podrían aparecer cuando ambos tipos de dependencias espaciales son capturadas simultáneamente en una ecuación de salarios empírica.

El Capítulo 2 sigue usando el marco NEG pero se orienta más hacia cuestiones de medida. Los modelos de Econometría Espacial se consideran como parte del análisis de robustez de la ecuación de salarios empírica que se usa para estudiar la evolución en el tiempo de los efectos del Potencial de Mercado en un corte transversal de datos regionales europeos. Adicionalmente, la estimación de una ecuación de salarios para distintos períodos de tiempo se relaciona con otras dos vertientes de la literatura empírica, el “*rompecabezas de la distancia*”, en comercio internacional, y la *convergencia*, en la literatura de crecimiento. En este Capítulo se aborda también una discusión metodológica sobre la medida del Potencial de Mercado, que continúa en el Capítulo 3 y en el Apéndice de Datos.

La primera mitad del Capítulo 3 es puramente teórica. El problema de la equivalencia observacional de la NEG es que los resultados empíricos pueden también ser explicados por teorías alternativas. A pesar de que esto ha sido señalado en distintas ocasiones por la literatura previa, este capítulo aborda el primer estudio específico sobre esta cuestión. Inspirado por la falsabilidad de Karl Popper, el capítulo enfatiza la ambigüedad teórica de la NEG como guía empírica y ofre-



ce una nueva derivación de una ecuación tipo-salarios. La especificación final de la ecuación incluye capital humano y, como novedad, el stock de capital físico. Esta última variable se tiene en cuenta en el Capítulo 2 para estimar los efectos directos del Potencial de Mercado, recoger los efectos exógenos de las políticas regionales y de transporte europeas y obtener un rango de estimaciones de los efectos del Potencial de Mercado cuando el análisis se repite omitiendo las variables de control. En el Capítulo 3 la inclusión del stock de capital en la ecuación de salarios se deriva de fundamentos microeconómicos a efectos de comparar la ecuación tipo-salarios con una función de producción como la que se usa frecuentemente en ejercicios de contabilidad del desarrollo.

### **Marco empírico**

Dado que la ecuación de salario hace una predicción a largo plazo sobre la distribución espacial del ingreso, el análisis empírico de esta tesis se basa en datos de corte transversal, usando datos de Cambridge Econometrics y Eurostat (la variable de capital humano) para una muestra de regiones europeas.

El Capítulo 1 analiza una muestra de 220 regiones de 17 países europeos para el año 2008. En los Capítulos 2 y 3 se reduce la muestra a 206 regiones debido a la falta de datos de stock de capital para Noruega y Suiza pero sus 14 regiones son incluidas en el cálculo del Potencial de Mercado. El período muestral considerado en el Capítulo 2 es el de los años 1995-2008. Para completar la información sobre este período, los datos de capital humano que faltaban se imputaron con un polinomio de grado 2 sobre la tendencia temporal de cada región. El capítulo 3 vuelve a enfocar la atención en el corte transversal para año 2008.

La variable dependiente en las ecuaciones de salarios analizadas aquí es el logaritmo del valor añadido bruto (Gross Value Added, GVA) per cápita. El Potencial de Mercado se aproxima con el indicador de Harris (1954), definido como la suma ponderada con distancias inversas del GVA de todas las demás regiones de la muestra. Dado que la medida del tamaño interno de mercado es una cuestión problemática, los tres capítulos de la tesis analizan la robustez de resultados a la inclusión de una medida aproximada del componente interno del Potencial de Mercado, en vez de considerar el *Potencial Externo de Mercado*. El capital humano se mide por aproximación con la proporción de la población que ha completado satisfactoriamente educación terciaria en Ciencia y Tecnología (Science & Technology, S&T) y está empleada en una ocupación de S&T. El Apéndice de datos ofrece discusión adicional sobre estas variables.

Se estimaron Modelos de Error Espacial (SEM) y Modelos Espaciales Autoregresivos (SAR) para el análisis de corte transversal de los Capítulos 1 y 2. El Capítulo 2 compara la serie de estimaciones transversales para cada uno de los años desde 1995 hasta 2008 con la estimación de un modelo que agrupa todos los datos de este período. Adicionalmente se usan variables instrumentales para analizar las posibles consecuencias de la endogeneidad en los efectos estimados del Potencial de Mercado. Una contribución original del Capítulo 2 es el análisis de la evolución en el tiempo de los efectos de corte transversal del Potencial de Mercado para una muestra de 206 regiones y para cuatro 'regímenes' de regiones definidas como Pobres-Ricas y Centrales-Periféricas.

La atención del Capítulo 3 se orienta a la metodología de ciencia. Simples estimaciones por MCO son suficientes para ilustrar empíricamente los argumentos de este capítulo. El Capítulo 3

muestra cuatro tipos de ejercicios empíricos distintos. Primero, la ecuación de corte transversal de referencia se analiza por partes para comprobar que su especificación es apropiada. Segundo, se estima la ecuación para variables dependientes alternativas, incluyendo el ingreso por persona y los salarios en la economía agregada regional y sus análogos para los sectores de manufacturas y servicios. Tercero, se estima la ecuación substituyendo una medida convencional de Potencial de Mercado basada en el valor añadido bruto por medidas alternativas con la misma estructura pero basadas en variables diferentes, como la productividad, la población o variables de densidad. Cuarto, se estiman 220 veces especificaciones alternativas de la ecuación con el Potencial Externo de Mercado redefinido para incluir solamente al vecino más cercano, los dos vecinos más cercanos, los tres más cercanos ... etcétera. En línea, con los dos capítulos previos, los análisis se repiten de distintas formas para estudiar la robustez de las conclusiones.

## Conclusiones

El Capítulo 1 muestra que la combinación en el indicador de Harris (1954) de una suma para todas las regiones en la muestra con un esquema de pesos basado en distancias absolutas es lo que permite al Potencial de Mercado capturar la pauta centro-periferia (la tendencia global espacial) de la distribución espacial de actividad económica. Sin embargo, los efectos de suavizado del sumatorio hacen que los residuos de una ecuación de salario estimada estén espacialmente autocorrelacionados a rangos cortos de distancia. Se muestra que estas características son comunes a otras medidas empíricas del Potencial de Mercado utilizadas en la literatura, aunque no sean estudiadas aquí. De esta forma, la tesis gana generalidad aunque se restringe el análisis a la medida específica del Potencial de Mercado propuesta por Harris.

La comparación de la medida de Harris de Potencial de Mercado con otros retardos espaciales frecuentemente usados en Econometría Espacial revela cuatro diferencias: el número de vecinos considerados en la suma; la estandarización de los pesos; la referencia a la variable dependiente en los modelos SAR (en vez de al tamaño de mercado); y la cuestión del “retardo del logaritmo” frente al “logaritmo del retardo”. El análisis muestra que el logro de capturar simultáneamente dos tipos diferentes de dependencias espaciales en una ecuación simple viene acompañado de varias advertencias. La variable Potencial de Mercado induce problemas endogeneidad similares a los de un retardo espacial de la variable dependiente, lo que afecta al cálculo de efectos totales. La multicolinealidad es sensible a la selección de la matriz de pesos espacial. La problemática consideración de los mercados internos puede ser crítica cuando se estiman modelos espaciales. Los resultados pueden depender de la muestra y ser sensibles a la inclusión de variables ficticias por país. Estos desafíos sólo se han abordado parcialmente en la literatura y no oscurecen el importante logro de capturar una tendencia global espacial y una pauta media de dependencia espacial local en una ecuación de salario empírica.

Contrariamente al “rompecabezas de la distancia” en la literatura de comercio internacional, medidas de Potencial de Mercado a lo Harris permiten identificar en el Capítulo 2 una tendencia decreciente en los efectos de corte transversal del Potencial de Mercado en el valor añadido bruto per cápita. Además, las estimaciones de la variable con una interpretación más directa en términos de localización, el Potencial Externo de Mercado, presentan tendencias decrecientes más claras. Sin embargo, la evidencia no es totalmente concluyente ya que es muy sensible a la inclusión de variables de control. En particular, confirmando las conclusiones del Capítulo 1, los efec-

tos del Potencial Externo de Mercado en un corte transversal de regiones Europeas desaparecen cuando se controla la estimación con variables de capital físico y humano y por autocorrelación espacial. Con otras especificaciones la evidencia es más sólida hacia un papel decreciente de la localización para explicar el valor añadido per cápita de las regiones Periféricas. Este resultado es consistente con que las regiones periféricas estén lentamente escapando de la maldición de la distancia.

El Capítulo 3 realiza cuatro tipos de principales contribuciones:

- El debate sobre la equivalencia observacional de la teoría NEG.
- La discusión sobre los costes marginales y la Tabla 3.2 abarcando en un único marco muchas ecuaciones de salarios previamente derivadas en la literatura.
- La adición del stock de capital a la ecuación de salarios.
- Los análisis empíricos, y especialmente los de la sección 3.4, que muestran que cualquier medida del mercado potencial con exponentes de la distancia cercanos a -1 recoge principalmente los efectos del primer vecino, al menos utilizando datos regionales europeos.

Las conclusiones de los análisis empíricos en el Capítulo 3 son las siguientes: 1) la estimación en corte transversal de una ecuación tipo-salarios es similar a la estimación de una función de producción expandida con un factor de escala; 2) los resultados son similares cuando los cálculos se basan en interacciones “prohibidas” por la teoría NEG; 3) estos resultados están provocados por características de las variables en niveles; y, 4) una variable de Potencial de Mercado con un parámetro de decaimiento de la distancia cercano a -1 no recoge claramente la información que se supone que debería recoger. La estimación de una ecuación de salarios produce resultados similares a los obtenidos con una función de producción agregada ampliada para incluir una variable con información sobre la ubicación y escala económica de la región más cercana. Estas conclusiones son compatibles con la NEG tanto como con explicaciones alternativas, lo cual constituye la esencia de la equivalencia observacional de la teoría NEG.

Los tres capítulos realizan algunas advertencias sobre la literatura anterior que incitan a continuar la investigación. En particular, se pone de relieve el inadecuado tratamiento que la literatura previa ha realizado para calcular los efectos del Potencial de Mercado, habida cuenta de que esa variable se puede interpretar como un retardo espacial de la variable dependiente.

También se enfatiza la sensibilidad de los resultados a la elección de la matriz de pesos para estimar modelos de Econometría Espacial, así como la posible multicolinealidad que puede surgir cuando se capturan simultáneamente pautas globales y locales de dependencia espacial. Adicionalmente se enfatiza la sensibilidad de los resultados a la posible inclusión de variables que aproximen el tamaño interno de los mercados, las cuales carecen de una base teórica sólida. Finalmente se muestra que las estimaciones previas de la ecuación de salarios pueden no tener las implicaciones confirmatorias de la NEG que algunos autores les atribuyen. Los resultados empíricos son muy semejantes cuando la ecuación a estimar se altera de formas que se alejan del marco NEG. Específicamente, los resultados son prácticamente iguales cuando la ecuación se estima definiendo el Potencial de Mercado con los datos de toda la muestra, como predice la NEG para medir la accesibilidad a los mercados, o cuando se define con uno o unos pocos vecinos más cercanos. Con datos regionales, en este último caso los resultados se interpretarían mejor bajo el marco de las teorías urbanas que bajo el marco NEG.

El proceso de investigación desde el Capítulo 1 al 3 ha ido llevando desde cimentar el abordaje sobre la NEG a volverse a mirar críticamente sus supuestos y la vulnerabilidad de sus resultados.

La tesis deja un número de cuestiones abiertas que podrán ser exploradas en futuras etapas de investigación.

La investigación presentada en esta tesis se puede ampliar de múltiples modos. El análisis empírico en estos capítulos no incluye efectos individuales inobservables. Análisis preliminares muestran que esta extensión requiere una discusión más amplia. Las estimaciones se pueden repetir usando medidas alternativas del Potencial de Mercado y diferentes métodos de estimación y muestras.

## II Resumen longo

### Marco de investigación e obxectivos

A coñecida como *ecuación de salarios* (Krugman, 1992, 1993) da Nova Xeografía Económica (NEG) predí que os salarios rexionais son unha función do tamaño dos mercados accesibles a cada rexión. Esta condición de equilibrio de mercado (Baldwin et al., 2003) predí que o ingreso rexional é unha función positiva do acceso rexional aos principais mercados internacionais, capturado por unha variable de *Acceso ou Potencial de Mercado*. Esta variable é unha suma ponderada do tamaño de mercado das outras rexións. A interacción rexional crave neste marco depende dos custos comerciais, que son xeralmente aproximados por distancias xeográficas. A ecuación de salario foi considerada como de grande éxito para confirmar unha relación entre o acceso ao mercado e a distribución espacial da actividade (Redding, 2011).

A presente tese ten tres obxectivos: 1) proporcionar un novo xeito de interpretar a ecuación de salarios; 2) estudar se os efectos da distancia sobre o ingreso per cápita rexional europeo estiveron a diminuír durante os pasados anos; e 3) propoñer un procedemento para examinar a equivalencia observacional da ecuación de salario, é dicir, a existencia de explicacións alternativas que son compatibles cos datos.

O Capítulo 1 propón distinguir dous tipos diferentes de dependencias espaciais estudadas nas literaturas da NEG e da Econometría Espacial. Por unha parte, como en Xeoestatística, unha estrutura espacial centro-periferia é vista aquí como *unha tendencia espacial “global”* ou *“rexional”*, na cal os valores da variable cambian sistematicamente coas coordenadas do espazo xeográfico. Esta é a dependencia espacial global capturada polo Potencial de Mercado da NEG. Por outra parte, a maior parte das técnicas de Econometría Espacial están deseñadas para capturar *pautas espaciais locais* ou de curta distancia. O capítulo estuda as características que permiten considerar ambos os dous tipos de pautas espaciais cando se estima unha ecuación de salarios para as rexións europeas. Acentúase que o Potencial de Mercado pode ser visto como un retardo espacial da variable endóxena e se analizan as súas semellanzas e diferenzas con outros tipos de retardos espaciais.

A ecuación NEG de salarios predí que as rexións periféricas tenden a ter un menor ingreso debido ao seu menor Potencial de Mercado. O Capítulo 2 analiza esta *“maldición da distancia”* no tempo. Este obxectivo é especialmente relevante debido á posta en práctica de políticas rexionais e de transporte activas durante as pasadas décadas, que deberían reducir as consecuencias da perifricidade. O foco do capítulo está na análise da robustez dunha ecuación de salario con respecto a distintas especificacións, submostras diferentes de rexións, a inclusión ou exclusión dunha medi-

da aproximada do tamaño interno de mercado, o emprego de variables instrumentais e a estimación de modelos estándar de Econometría Espacial.

A liña de investigación final desta tese volve ás raíces da ecuación de salarios para cuestionar a súa interpretación empírica. A *equivalencia observacional* (ou *Marshalliana*) da ecuación NEG de salarios ten sido mencionada por diferentes autores. Non obstante, non hai enfoques xeralmente aceptados para examinar empiricamente tal equivalencia. Pódese explicar a razón para isto a través dunha intuición simple. Se o número 4 é observable, pero a operación que xerou este número non o é, existe unha imposibilidade cognitiva para determinar empiricamente se o 4 foi xerado pola “teoría”  $1 + 3$  ou pola “teoría alternativa”  $2 + 2$ . Non obstante, a literatura empírica NEG con frecuencia interpreta os seus resultados como corroboracións dun dos marcos teóricos posibles. Head e Mayer (2004) aseméllano ao Erro Estatístico Tipo II cando se analiza unha hipótese nula: a literatura empírica non debería confirmar a validez da NEG baseándose en resultados que tamén son consistentes con outros marcos. Polo tanto, o Capítulo 3 aborda o problema da equivalencia observacional, tanto dende o punto de vista teórico como empírico.

Propónse un procedemento en dous pasos para comprobar empiricamente se moitas ecuacións de salario están en realidade a estimar unha función de produción subxacente aumentada con información de localización sobre o nivel de desenvolvemento do(dos) veciño(-s) máis cercano(-s). O primeiro paso consiste en derivar unha ecuación tipo-salarios que resalta os custos marxinais, en vez dos salarios, e que permite abranguer varias ecuacións de salarios propostas previamente na literatura. Para destacar a semellanza da ecuación de salarios a unha función de produción aumentada, a derivación da ecuación tipo-salarios engade o stock de capital como variable explicativa. O segundo paso consiste en repetir a estimación dunha ecuación tipo-salarios de referencia tras redefinir as variables claves do modelo de formas alternativas a aquelas xeralmente usadas pola literatura empírica NEG.

### **Marco teórico**

A base teórica desta tese xace na Nova Xeografía Económica e na Econometría Espacial. A NEG ofrece unha explicación sobre os efectos da situación xeográfica sobre os gradientes de ingreso. A Econometría Espacial proporciona unha caixa de ferramentas para corrixir os efectos a autocorrelación espacial nos residuos dun modelo de regresión. O Capítulo 1 supón unha contribución a dous tipos de literatura: a que analiza os efectos da periferidade no desenvolvemento económico e a que usa técnicas de Econometría Espacial para estimar unha ecuación que inclúe unha variable de Potencial de Mercado. Este capítulo emprega extensamente os conceptos de ambos os dous enfoques para distinguir as dependencias espaciais a distancias longas e curtas capturadas xeralmente por cada enfoque. Isto conduce a revelar algunhas deficiencias que poderían aparecer cando ambos os dous tipos de dependencias espaciais son capturadas simultaneamente nunha ecuación de salarios empírica.

O Capítulo 2 segue usando o marco NEG pero se orienta máis cara a cuestións de medida. Os modelos de Econometría Espacial considéranse como parte da análise de robustez da ecuación de salarios empírica que se usa para estudar a evolución no tempo dos efectos do Potencial de Mercado nun corte transversal de datos rexionais europeos. Adicionalmente, a estimación dunha ecuación de salarios para distintos períodos de tempo relaciónase con outras dúas vertentes da literatura empírica, o “*crebacabezas da distancia*”, en comercio internacional, e a *converxencia*,

na literatura de crecemento. Neste Capítulo abórdase tamén unha discusión metodolóxica sobre a medida do Potencial de Mercado, que continúa no Capítulo 3 e no Apéndice de Datos.

A primeira metade do Capítulo 3 é puramente teórica. O problema da equivalencia observacional da NEG é que os resultados empíricos poden tamén ser explicados por teorías alternativas. A pesar de que isto foi sinalado en distintas ocasións pola literatura previa, este capítulo aborda o primeiro estudo específico sobre esta cuestión. Inspirado pola falsabilidade de Karl Popper, o capítulo resalta a ambigüidade teórica da NEG como guía empírica e ofrece unha nova derivación dunha ecuación tipo-salarios. A especificación final da ecuación inclúe capital humano e, como novidade, o stock de capital físico. Esta última variable tense en conta no Capítulo 2 para estimar os efectos directos do Potencial de Mercado, recoller os efectos exógenos das políticas rexionais e de transporte europeas e obter un rango de estimacións dos efectos do Potencial de Mercado cando a análise se repite omitindo as variables de control. No Capítulo 3 a inclusión do stock de capital na ecuación de salarios derívase de fundamentos microeconómicos cara a comparar a ecuación tipo-salarios cunha función de produción como a que se usa frecuentemente en exercicios de contabilidade do desenvolvemento.

### **Marco empírico**

Dado que a ecuación de salario fai unha predición a longo prazo sobre a distribución espacial do ingreso, a análise empírica desta tese baséase en datos de corte transversal, usando datos de Cambridge Econometrics e Eurostat (a variable de capital humano) para unha mostra de rexións europeas.

O Capítulo 1 analiza unha mostra de 220 rexións de 17 países europeos para o ano 2008. Nos Capítulos 2 e 3 redúcese a mostra a 206 rexións debido á falta de datos de stock de capital para Noruega e Suíza pero as súas 14 rexións son incluídas no cálculo do Potencial de Mercado. O período mostral considerado no Capítulo 2 é o dos anos 1995-2008. Para completar a información sobre este período, os datos de capital humano que faltaban imputáronse cun polinomio de grao 2 sobre a tendencia temporal de cada rexión. O capítulo 3 volve enfocar a atención no corte transversal para ano 2008.

A variable dependente nas ecuacións de salarios analizadas aquí é o logaritmo do valor engadido bruto (Gross Value Added, GVA) per cápita. O Potencial de Mercado aproxímase co indicador de Harris (1954), definido como a suma ponderada con distancias inversas do GVA de todas as demais rexións da mostra. Dado que a medida do tamaño interno de mercado é unha cuestión problemática, os tres capítulos da tese analizan a robustez de resultados á inclusión dunha medida aproximada do compoñente interno do Potencial de Mercado, en vez de considerar o Potencial Externo de Mercado. O capital humano mídese por aproximación coa proporción da poboación que completou satisfactoriamente educación terciaria en Ciencia e Tecnoloxía (Science & Technology, S&T) e está empregada nunha ocupación de S&T. O Apéndice de datos ofrece discusión adicional sobre estas variables.

Estimáronse Modelos de Erro Espacial (SEM) e Modelos Espaciais Autoregresivos (SAR) para a análise de corte transversal dos Capítulos 1 e 2. O Capítulo 2 compara a serie de estimacións transversais para cada un dos anos dende 1995 ata 2008 coa estimación dun modelo que agrupa todos os datos deste período. Adicionalmente úsanse variables instrumentais para analizar as posibles consecuencias da endoxeneidade nos efectos estimados do Potencial de Mercado. Unha

contribución orixinal do Capítulo 2 é a análise da evolución no tempo dos efectos de corte transversal do Potencial de Mercado para unha mostra de 206 rexións e para catro “réximes” de rexións definidas como Pobres-Ricas e Centrais-Periféricas.

A atención do Capítulo 3 oriéntase á metodoloxía de ciencia. Simples estimacións por MCO son suficientes para ilustrar empiricamente os argumentos deste capítulo. O Capítulo 3 mostra catro tipos de exercicios empíricos distintos. Primeiro, a ecuación de corte transversal de referencia analizase por partes para comprobar que a súa especificación é apropiada. Segundo, estímase a ecuación para variables dependentes alternativas, incluíndo o ingreso por persoa e os salarios na economía agregada rexional e os seus análogos para os sectores de manufacturas e servizos. Terceiro, estímase a ecuación substituíndo unha medida convencional de Potencial de Mercado baseada no valor engadido bruto por medidas alternativas coa mesma estrutura pero baseadas en variables diferentes, como a produtividade, a poboación ou variables de densidade. Cuarto, estímase 220 veces especificacións alternativas da ecuación co Potencial Externo de Mercado redefinido para incluír soamente o veciño máis próximo, os dous veciños máis próximos, os tres máis próximos... etcétera. En liña, cos dous capítulos previos, as análises repítese de distintas formas para estudar a robustez das conclusións.

## **Conclusiones**

O Capítulo 1 mostra que a combinación no indicador de Harris (1954) dunha suma para todas as rexións na mostra cun esquema de pesos baseado en distancias absolutas é o que permite ao Potencial de Mercado capturar a pauta centro-periferia (a tendencia global espacial) da distribución espacial de actividade económica. Non obstante, os efectos de suavizado do sumatorio fan que os residuos dunha ecuación de salario estimada estean espacialmente autocorrelacionados a rangos curtos de distancia. Móstrase que estas características son comúns a outras medidas empíricas do Potencial de Mercado utilizadas na literatura, aínda que non sexan estudadas aquí. Desta forma, a tese gaña xeneralidade aínda que se restrinxe a análise á medida específica do Potencial de Mercado proposta por Harris.

A comparación da medida de Harris de Potencial de Mercado con outros retardos espaciais frecuentemente usados en Econometría Espacial revela catro diferenzas: o número de veciños considerados na suma; a estandarización dos pesos; a referencia á variable dependente nos modelos SAR (en vez de ao tamaño de mercado); e a cuestión do "retardo do logaritmo" fronte ao "logaritmo do retardo". A análise mostra que o logro de capturar simultaneamente dous tipos diferentes de dependencias espaciais nunha ecuación simple vén acompañado de varias advertencias. A variable Potencial de Mercado induce problemas endoxeneidad e similares aos dun retardo espacial da variable dependente, o que afecta ao cálculo de efectos totais. A multicolinealidade é sensible á selección da matriz de pesos espacial. A problemática consideración dos mercados internos pode ser crítica cando se estiman modelos espaciais. Os resultados poden depender da mostra e ser sensibles á inclusión de variables ficticias por país. Estes desafíos só se abordaron parcialmente na literatura e non escurecen o importante logro de capturar unha tendencia global espacial e unha pauta media de dependencia espacial local nunha ecuación de salario empírica.

Contrariamente ao “crebacabezas da distancia” na literatura de comercio internacional, medidas de Potencial de Mercado ao Harris permiten identificar no Capítulo 2 unha tendencia decrecente nos efectos de corte transversal do Potencial de Mercado no valor engadido bruto per cápiti-

ta. Ademais, as estimacións da variable cunha interpretación máis directa en termos de localización, o Potencial Externo de Mercado, presentan tendencias decrecentes máis claras. Non obstante, a evidencia non é totalmente concluínte xa que é moi sensible á inclusión de variables de control. En particular, confirmando as conclusións do Capítulo 1, os efectos do Potencial Externo de Mercado nun corte transversal de rexións Europeas desaparecen cando se controla a estimación con variables de capital físico e humano e por autocorrelación espacial. Con outras especificacións a evidencia é máis sólida cara a un papel decrecente da localización para explicar o valor engadido per cápita das rexións Periféricas. Este resultado é consistente con que as rexións periféricas estean lentamente escapando da maldición da distancia.

O Capítulo 3 realiza catro tipos de principais contribucións:

- O debate sobre a equivalencia observacional da teoría NEG.
- A discusión sobre os custos marxinais e a Táboa 3.2 abranguendo nun único marco moitas ecuacións de salarios previamente derivadas na literatura.
- A adición do stock de capital á ecuación de salarios.
- As análises empíricas, e especialmente os da sección 3.4, que mostran que calquera medida do mercado potencial con expoñentes da distancia próximos a -1 recolle principalmente os efectos do primeiro veciño, polo menos utilizando datos rexionais europeos.

As conclusións das análises empíricas no Capítulo 3 son as seguintes: 1) a estimación en corte transversal dunha ecuación tipo-salarios é semellante á estimación dunha función de produción expandida cun factor de escala; 2) os resultados son similares cando os cálculos se basean en interaccións “prohibidas” pola teoría NEG; 3) estes resultados están provocados por características das variables en niveis; e, 4) unha variable de Potencial de Mercado cun parámetro de decaemento da distancia próximo a -1 non recolle claramente a información que se supón que debería recoller. A estimación dunha ecuación de salarios produce resultados similares aos obtidos cunha función de produción agregada ampliada para incluír unha variable con información sobre a situación e escala económica da rexión máis próxima. Estas conclusións son compatibles coa NEG tanto como con explicacións alternativas, o cal constitúe a esencia da equivalencia observacional da teoría NEG.

Os tres capítulos realizan algunhas advertencias sobre a literatura anterior que incitan a continuar a investigación. En particular, ponse de relevo o inadecuado tratamento que a literatura previa realizou para calcular os efectos do Potencial de Mercado, tendo en conta que esa variable se pode interpretar como un retardo espacial da variable dependente.

Tamén se resalta a sensibilidade dos resultados á elección da matriz de pesos para estimar modelos de Econometría Espacial, así como a posible multicolinealidade que pode xurdir cando se capturan simultaneamente pautas globais e locais de dependencia espacial. Adicionalmente resáltase a sensibilidade dos resultados á posible inclusión de variables que aproximen o tamaño interno dos mercados, as cales carecen dunha base teórica sólida. Finalmente móstrase que as estimacións previas da ecuación de salarios poden non ter as implicacións confirmatorias da NEG que algúns autores lles atribúen. Os resultados empíricos son moi semellantes cando a ecuación a estimar se altera de xeitos que se afastan do marco NEG. Especificamente, os resultados son practicamente iguais cando a ecuación se estima definindo o Potencial de Mercado cos datos de toda a mostra, como predí a NEG para medir a accesibilidade aos mercados, ou cando se define con un ou uns poucos veciños máis próximos. Con datos rexionais, neste último caso os resultados interpretaríanse mellor baixo o marco das teorías urbanas que baixo o marco NEG.



O proceso de investigación dende o Capítulo 1 ao 3 foi levando dende cimentar a abordaxe sobre a NEG a volverse a ollar criticamente os seus supostos e a vulnerabilidade dos seus resultados. A tese deixa un número de cuestións abertas que poderán ser exploradas en futuras etapas de investigación.

A investigación presentada nesta tese pódese ampliar de múltiples modos. A análise empírica nestes capítulos non inclúe efectos individuais inobservables. Análises preliminares mostran que esta extensión require unha discusión máis ampla. As estimacións pódense repetir usando medidas alternativas do Potencial de Mercado e diferentes métodos de estimación e mostran.



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## **Annexes**



## Appendix A. Data description

### A.1 Sample

The disaggregation level for the regional data is NUTS 2 (2006 version), which involves the basic regions for the application of regional policies. The following NUTS 2 regions are excluded: the Atlantic islands (the Spanish Canary Islands and the Portuguese Madeira and the Azores), the Spanish Ceuta and Melilla in the North African coast and the French Departments Guadeloupe, Guiana, Martinique and Reunion. Oil related regions are not excluded. The regions of Greece are kept in the sample in spite of the particular geographic and economic characteristics of this country (Bivand and Brunstad, 2006).

Chapter 1 analyzes a cross-sectional sample of 220 regions from 17 European countries. In Chapters 2 and 3, the sample is reduced to 206 regions because of the lack of capital stock data for Norway and Switzerland but their 14 regions are included to compute Market Potential. The 15 countries of the European Union considered in Chapters 2 and 3 are: Austria (AT), Belgium (BE), Spain (ES), Finland (FI), France (FR), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Sweden (SE) and United Kingdom (UK).

Figure 3.2 shows data about additional 54 Eastern European regions from the following countries: Bulgaria (BG), Czech Republic (CZ), Estonia (EE), Hungary (HU), Lithuania (LT), Latvia (LV), Poland (PL), Romania (RO), Slovenia (SI) and Slovakia (SK).

The sample period for Chapters 1 and 3 is the year 2008 while for Chapter 2 is 1995-2008..

### A.2 Variables

All the variables used in the models are in logarithmic form. Cambridge Econometrics data is used for gross value added (GVA), capital stock (Chapters 2 and 3) and population. GVA and capital stock per capita are in 2000 year euros. Market Potential is built with GVA and it is in millions of 2000 euros. Cambridge Econometrics's deflators are regional in the sense that are based on the sectorial deflators published in the Annual Macro-economic Database of the European Commission (AMECO), so deflators vary according to the size of the respective sectors in each region. Cambridge Econometrics scales these estimates of real variables to the national estimates.

GVA excludes value added taxes but includes subsidies linked to production. Eurostat calculates regional gross domestic product on the basis of GVA, using approximations to distribute national tax income to regions. Thus GVA is the more direct indicator of regional economic activity (Breinlich, 2006). Proxying wages by GVA per worker is innocuous as long as labor's share in GVA does not vary across locations or at least not in a way systematically related to Market Potential (Breinlich, 2006). However, the *per capita* version is preferred here because it provides generality to the discussion. The wage equation has been broadly interpreted in terms of a relationship between Market Potential and the spatial distribution of economic activity (Redding, 2011), instead of the nominal manufacturing wages of Krugman's (1991) stylized model or later NEG models<sup>39</sup>.

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<sup>39</sup> Additionally, as in many other empirical wage equations, here Market Potential is built with deflated data. Moreover, a variable of compensation of employees is more sensitive to inflation and labor market differences and it presents comparability problems (Head and Mayer, 2006), while GVA data is more reli-

Human capital stock ( $H_{it}$ ) is proxied by the following Eurostat variable: share of the population who has successfully completed education in Science and Technology (S&T) at the third level and is employed in a S&T occupation<sup>40</sup>. 9.7% of the observations 1995-2008 were missing and imputed for Chapter 2 using R's Amelia II package (Honaker *et al.*, 2011). The imputed data is the average of 5 multiple imputations with a small ridge prior predicting with a polynomial of degree 2 on the time trend of each region and including lags and leads:  $H_{it} = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 H_{it-1} + \beta_4 H_{it+1}$ . This method allows imputing this control variable in mainly seven regions with high degree of missingness.

Additionally, Chapter 3 uses Cambridge Econometrics's data of employment and compensation per employee and data disaggregated by sectors. Capital stock is calculated by Cambridge Econometrics for the total regional economy and for three sectors. GVA, employment and compensation per employee is available for 15 sectors. Therefore, some adjustments were necessary to estimate Table 3.4.

Geographical distances ( $d_{ij}$ ) are measured as great circle distances among regional centroids calculated using GISCO's shape files (© EuroGeographics for the administrative boundaries). Regional areas and internal regional distances are calculated from these files after an EPSG 3035 projection.

This thesis uses a Harris's (1954) measure of Market Potential. Some recent examples using Harris's Market Potential are: Faïña and López-Rodríguez (2006), Bouhold *et al.* (2008), Clemente *et al.* (2009), Brakman *et al.* (2009a), López Rodríguez *et al.* (2011), López Rodríguez *et al.* (2011), Fallah *et al.* (2011), Tokunaga and Jin (2011), Karahasan and López-Bazo (2013) or López-Rodríguez and Acevedo-Villalobos (2013). Baldwin and Harrigan (2011) use Harris's Market Potential to proxy 'remoteness' in a gravity equation for bilateral trade volumes.

The External Market Potential of region  $i = 1, \dots, R$  is defined as the inverse distance ( $d_{ij}$ ) weighted sum of the GVA of all the other regions in the sample (time subscripts are omitted for simplicity):

$$EMP_i = \sum_{j \neq i}^{R-1} \frac{GVA_j}{d_{ij}}$$

An apparent improvement is to use travel times instead of physical distances. However, Breinlich (2006) or Ahlfeldt and Feddersen (2008) obtain similar results using travel times or geographical distances with European regional data.

The full variable of Harris's (1954) Market Potential is calculated correcting this last measure by a proxy of the internal market size:  $HMP_i = IMP_i + EMP_i$ . The Internal Market Potential is defined here as:  $IMP_i = GVA_i/d_{ii}$ . The empirical measurement of the internal market potential has been discussed since the work of Stewart (1947). Different alternatives have been proposed by Bonsall (1975)-Head and Mayer (2000)-Thisse ('BHMT's method'), Rich (1980), Bröcker (1989), Wilson (1990), Redding and Venables (2004) or Dijkstra *et al.* (2011), among others. For Kordi *et al.* (2012) this issue is still an ongoing challenge.

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able. However, preliminary tests using compensation data show that many qualitative results are similar to those obtained with income per head. In the context of the present research, the cross-sectional disparities of economic development tend to dominate the relative regional levels of both types of variables.

<sup>40</sup> Niebuhr (2006), Bivand and Brunstad (2006) or Artis *et al.* (2011) have proxied human capital by variants of this variable. See Dreger *et al.* (2011) for an analysis of its characteristics.

A standard method is to assume that regions are circular so the radius of region  $i$  is  $r_i = \sqrt{\text{area}_i/\pi}$ . In this research internal distances are measured following Keeble *et al.* (1982), who chose  $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{\text{area}_i}$  to allow for the likely clustering of economic activity in and around the regional ‘centre’. This is similar to the 40% of the radius considered by Cambridge Econometrics (2014). The calculation of internal distances as 1/3 of the radius increases the role of the internal market when compared with the 2/3 used under the BHMT’s method on the basis of geometrical arguments about the distribution of consumers in a circular region. The 1/3 ratio was preferred in order to compare possible differences of results when using  $HMP_i$  or  $EMP_i$ .

The challenge of measuring the internal market size is worth consideration. The area-based approximation can lead to problems of interpretation because its relationship with the measurement of density (Head and Mayer, 2006). Unlike grid based methodologies, the most used geometrical methods do not consider the fact that the main city of coastal regions is not generally located at the geographical center of the region. The coastal NUTS 3 regions account for 40% of the population and territory of the 27 members of the European Union (Collet and Engelbert, 2013). The expectation is that the economic ‘center’ of the NUTS 2 coastal regions will be close to the sea. Their consumers would not be agglomerated around the geographical regional center of those regions.

The authors proposing alternative proxies for the internal market size under a NEG framework do not usually compare the results of their estimated domestic market with the available (but limited) evidence about domestic (intra-regional) and foreign (external) trade. See Redding (2012) for an analysis of this issue at the country level. Comparing the 2/3 and 1/3 ratios that have been used to measure the internal distances with respect to the radius of a circular region, the median weight of  $IMP_i$  on  $HMP_i$  increases from around 5 to 10% in the regional sample of 206 NUTS 2 units. Both 5 and 10% seem to be underestimations of the role of domestic trade in total trade. Redding and Venables (2004) allowed the internal trade costs to be lower than the international ones, but their empirical criterion is as arbitrary as the criteria of one or two thirds of the radius.

Moreover, in any empirical proxy for the NEG Real Market Potential, the external component of the variable is built as a (weighted) sum of values for all the other observations in the sample. The resulting weight of the internal market in Market Potential depends on the number of observations included in that sum. Possible geometrical arguments about the distribution of consumers in a circular region do not affect the fact that the criterion to measure internal distances is *ad hoc* and its effects are sample dependent (data aggregation level and focus of attention).

Therefore, more than an abstract discussion about the geometry of the circle, what it is considered useful in this research is to check the robustness of the results obtained with  $EMP_i$  to the inclusion of a particular measure of  $IMP_i$ . This measure is a technical correction to capture the presence of big cities, at the cost of huge endogeneity problems for the estimated wage equation. In the sample of 206 European regions, using 1/3 of the radius to measure internal distances, the weight of  $IMP_i$  on  $HMP_i$  in the year 2008 is between 41 and 59% for the regions of Stockholm, Brussels, Berlin, Hamburg, Madrid, Paris, Vienna, Athens and (Inner) London. Using the 2/3 ratio, those weights are between 25 and 42%. The 1/3 criterion chosen in the present research stresses the possible influence of capital cities, emphasized by Urban Economics, in order to create a range of results when a variable of Market Potential includes or omits a proxy for the inter-

nal market size. Alternatively, the calculation of internal distances as 2/3 of circular regions reduces the role of big cities and the problems of endogeneity. However, it does not reduce its arbitrariness.

### Appendix B. Chapter 3: Adaptation of different wage equations to Table 3.2

It is easy to see the relation of equation (3.19) with the basic NEG wage equation in Fujita *et al.* (1999, chap. 4). Adapting their notation and extending the basic model to allow for technological differences among regions, if labor is the only factor of production of  $M$  goods, the price of the compound input in production function (3.13) is wages ( $q_i = w_i$ ) so marginal costs are  $m_i = w_i c_i$ , where  $c_i = A_i^{-1}$  is the marginal input requirement. Considering a share of expenditure in  $M$  goods common in all regions,  $\mu_j = \mu$ , the wage equation of the basic NEG model becomes:

$$w_i = \frac{\sigma - 1}{\sigma} \left( \frac{\mu}{\bar{x}} \sum_j^R T_{ij}^{1-\sigma} \frac{E_j}{S_j^M} \right)^{1/\sigma} \frac{1}{c_i} = \frac{\sigma - 1}{\sigma} \left( \frac{\mu}{\bar{x}} \right)^{1/\sigma} RMP_i^{1/\sigma} A_i \quad (\text{B.1})$$

where this time  $RMP_i$  is defined excluding the constant  $\mu_j$  terms. Fujita *et al.* (1999, chap. 4) simplify the right hand side of this equation to  $RMP_i^{1/\sigma}$  by considering  $c_i = c$  and choosing convenient units for  $\bar{x}$ . This simplification is what can be estimated in a cross-sectional empirical equation based on equation (B.1), after taking logarithms of variables representing  $w_i$  and  $RMP_i$ . If technology is assumed to be constant across regions ( $A_i = A$ ), the basic empirical cross-sectional wage equation is:

$$\ln w_i = C + \frac{1}{\sigma} \ln RMP_i + u_i \quad (\text{B.2})$$

where the intercept collects the constant terms,  $C = [(\sigma - 1)/\sigma](\mu/\bar{x})^{1/\sigma} A$ , and the disturbance  $u_i$  is supposed to collect the random differences between the estimate of the mean  $C$  and the individual values of the terms included in  $C$ .

Redding and Venables's (2004) specification has been the base for some of the later models studied here. They consider three types of inputs, combined in a Cobb-Douglas technology with constant returns to scale ( $\theta + \gamma + \vartheta = 1$ ). The first one is an interregionally immobile composite primary factor interpreted as labor, with price  $w_i$ . The second is a composite intermediate good with price  $G_i^M$  and the third one is an interregionally mobile primary factor with price  $u_i$ . Therefore, adapting notation to their model, the generalized marginal cost in equation (3.20) is:

$$m_i = q_i^\theta z_i^\psi c_i = w_i^\theta u_i^\gamma G_i^{M^\vartheta} c_i \quad (\text{B.3})$$

And the generalized wage equation (3.21) will be:

$$w_i = \left( \frac{\sigma - 1}{\sigma} \bar{x}^{-1/\sigma} u_i^{-\gamma} \right)^{1/\theta} RMP_i^{1/\theta\sigma} G_i^{M^{-\vartheta/\theta}} c_i^{-1/\theta} \quad (\text{B.4})$$

where, using the vocabulary of Head and Mayer (2006), Real Market Potential is a trade-cost-weighted sum of market capacities  $E_j^M/S_j^M$  of all regions importing from region  $i$ , and the supply index of region  $i$  is the analogous sum of supplier capacities  $n_j p_j^{1-\sigma}$  of regions  $j$  exporting intermediates to  $i$ . Similarly to equation (3.12), the supply index or a firm in region  $i$  is  $S_i^M = G_i^{M^{1-\sigma}} = \sum_{j=1}^R \phi_{ji} n_j p_j^{1-\sigma}$ . Therefore,  $G_i^M = S_i^{M^{1/(1-\sigma)}}$ . Additionally, Redding and Venables's distinction between the two primary production factors is very useful. Given that they



wonder about the magnitude of  $w_i$  that firms in each location afford to pay given the locations of expenditure, Redding and Venables assume that the price of the mobile factor is equalized across regions. This means  $u_i = u$ . Therefore, the generalized wage equation (3.21) takes the form:

$$w_i = \left( \frac{\sigma - 1}{\sigma} \bar{x}^{-1/\sigma} u^{-\gamma} \right)^{1/\theta} RMP_i^{1/\theta\sigma} S_i^M{}^{\theta/(\theta(\sigma-1))} c_i^{-1/\theta} \quad (\text{B.5})$$

As in equation (3.22), the logarithm of the first bracket of the right hand side of equation (B.5) can be considered as the intercept  $C$  of an empirical estimation in logs. Therefore, when assuming factor price equalization for the mobile factors, the deviations from this condition are considered to be captured by the error term of the econometric equation.

Through  $S_j^M$  in  $RMP_i = \sum_j^R \phi_{ij} E_j^M / S_j^M$  the number of competitors and their prices in all the  $j$ -markets of firm (region)  $i$  determine firm's sales and profits and, therefore, the wages that it affords to pay (forward linkage). Simultaneously, through  $S_i^M$  the number of firms competing in the world to deliver intermediate goods to  $i$  and their prices determine  $i$ -costs and, therefore, the affordable wages for the firm too (backward linkage).

To see the role of trade costs in each component, it is easier to think of trade costs,  $T_{ij}$ , as proportional to geographical distances. In this case, the phi-ness of trade,  $\phi_{ij} \equiv T_{ij}^{1-\sigma} < 1$ , will be low for the geographically peripheral regions because they are far from their markets  $E_j^M / S_j^M$ .  $\phi_{ij}$  appears in  $S_j^M$  too, which is in the denominator of  $RMP_i$  (Redding and Venables's Market Access). However,  $S_j^M$  is the supply index of each of the  $j$  markets of  $i$  and  $\phi_{ij}$  is referred there to the trade costs of each  $j$ -region imports from the world. Therefore, taking distance by trade costs, the set of  $\phi_{ij}$  parameters in each  $S_j^M$  measures the geographic 'centrality' of each of the markets of region  $i$  and it is independent of the region  $i$  degree of peripherality. In summary, the weights  $\phi_{ij}$  in  $RMP_i$  measure the peripherality of  $i$  with respect to the markets of 'real' size  $E_j^M / S_j^M$ , with  $\phi_{ij}$  inside  $S_j^M$  correcting the 'nominal' (potential) size  $E_j^M$  by the centrality of that market. Simultaneously,  $\phi_{ji}$  in the supply index  $S_i^M$  (Redding and Venables's Supplier Access, SA) measures again the peripherality of region  $i$ , this time with respect to its suppliers. Low  $\phi_{ji}$  in  $S_i^M$  collect the higher costs in peripheral regions  $i$  because of transporting imported intermediate inputs over long distances. Therefore, geographically peripheral regions will tend to have a lower Real Market Potential and a lower supply index than the central ones. Hence, their firms will tend to afford lower wages. From an empirical perspective, both Redding and Venables (2004) and Bouhol *et al.* (2008) find that their measures of Real Market Potential and supply index are very correlated for aggregated data of countries<sup>41</sup>. That is the reason why intermediate goods are not considered here, so the generalized marginal cost adopts the form in equation (3.20) for  $q_i = w_i$ , as in Breinlich (2006) version of Redding and Venables's model.

The demand side of the model presented in section 3.2.1 had not intermediate inputs. However, in order to close Redding and Venables's model and to encompass the model with intermediates into the framework presented here, equation (3.2) was defined for different regional shares of total expenditure in  $M$  goods,  $\mu_j$ , derived there from different regional preferences. The same that Fujita *et al.* (1999) choose units of output, to adapt this framework to a model with labor and intermediates, notation can be forced to redefine the  $\mu_j$  term as:

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<sup>41</sup> The empirical role of  $S_i^M$  probably becomes more relevant when working with sectorial data. See Lu and Tokunaga (2009) or Fally *et al.* (2010).

$$\mu_j = \mu + \vartheta \frac{n_j p_j \bar{x}}{Y_j} \quad (\text{B.6})$$

so  $\mu$  is the common share of income  $Y_j$  spent in the consumption of  $M$  goods and  $\vartheta$  is the share of intermediates in the production function. As in Fujita *et al.* (1999, chap. 14), at the zero-profit equilibrium with sales  $\bar{x}$ , the total costs of location  $i$  firms equal the total value of their production,  $n_j p_j \bar{x}$ . Therefore, the sectorial composition of the  $j$  markets affects their demand of intermediates from location  $i$  and the Real Market Potential of region  $i$ . This role of  $\mu_j$  in the definition of  $RMP_i$  in equation (3.11) is one of the differences mentioned by Combes *et al.* (2008, chap. 12) between  $RMP_i$  and Harris's definition of Market Potential, as it is mentioned in section 3.3.1. The sectorial composition of each region has relevant empirical implication (Karahasan and López-Bazo, 2013), though this issue is out of the scope of this paper.

Now the specifications of the technological  $c_i$  parameter in Table 3.2 are studied, reminding that the discussion of this paper uses the notation  $A_i$  for the index of total factor productivity in the  $M$  sector, which is assumed to be the same than in the  $C$  sector.

Fingleton (2006) distinguishes between efficiency wages (earnings per efficiency unit) and earnings per worker and claims that 'recognizing this distinction opens the door to some additional variables'. He considers a wage equation similar to the one in equation (B.2) but with an additional  $A_i$  term:

$$w_i = RMP_i^{1/\sigma} A_i \quad (\text{B.7})$$

Actually this is not an extension of the basic NEG wage equation. Though the previous literature was using the  $c_i$  notation, instead of  $A_i$ , the unit input requirement was already in the wage equation (B.1). When production uses only labor,  $L_i$ , the production function (3.13) is  $x_i = -f + A_i L_i$ , where  $A_i$  is a regional Ricardian technology. Therefore, the marginal input requirement is  $c_i = 1/A_i$ . Indeed, Fujita *et al.* (1999, chap. 15) already define the wage equation in efficiency units of labor. Though with a different notation, they introduce exogenous technical change in the basic wage equation (B.1). This is equivalent to redefine the left hand side of the equation with time subscripts, such as  $w_{it}/A_t$ , what it is summarized in Table 3.2 as  $c_i = 1/A_t$ . However, Fingleton's (2006) empirical specification emphasizes the determinants of  $A_i$ . He assumes that technology is homogeneous across areas but differences exist in terms of the ability to apply that technology in production: efficiency depends on local levels of schooling and on workplace acquired skills, what it summarized in Table 3.2 as human capital per worker,  $h_i$ . Incorporating commuting, Fingleton obtains a spatial econometric specification.

As noted by Head and Mayer (2006), introducing regional differences of efficiency implies a revised version of the  $S_j^M$  term in the definition of  $RMP_i$  given by equation (3.11). Namely, the supply index should be re-expressed in terms of industry employment instead of the number of varieties. The reason is that if output per firm,  $\bar{x}$ , does not vary across locations, when there are regional differences in the productivity of labor, human capital abundant areas have lower employment per firm so employment is not strictly proportional to the number of firms. Therefore, the supply index, the term that discounts expenditures in the  $RMP_i$  summation, is increasing in the amount of education-adjusted employment that has good access to the market in question. In the empirical part of this paper,  $S_j^M$  is not considered so this issue is not discussed further.

Head and Mayer's (2006) paper was published in the same year than Fingleton's one. It contains a more formal derivation of a wage equation with human capital. Though they do not make the following derivation, it is useful to review their model starting with Mankiw-Romer-Weil's

(1992) production function, that uses physical capital ( $K_i$ ), human capital ( $H_i$ ) and raw labor ( $L_i$ ) as primary inputs:

$$x_i = K_i^\alpha H_i^\beta (B_i L_i)^{1-\alpha-\beta} \quad (\text{B.8})$$

where  $B_i$  is a labor-augmenting (Harrod-neutral) technological index. Jones (1997) modifies Mankiw-Romer-Weil's production function to the following::

$$x_i = K_i^\alpha (B_i H_i)^{1-\alpha} = K_i^\alpha [B_i \exp(\beta S_i) L_i]^{1-\alpha} \quad (\text{B.9})$$

Following Lucas (1988), in Jones's specification for  $H_i$  the variable  $S_i$  is time devoted to skill accumulation by a representative member of the labor force. When interpreting  $S_i$  as years of schooling,  $\beta$  is the Mincerian rate of return to a year of schooling<sup>42</sup>. That is the logic of Head and Mayer's (2006) specification in Table 3.2. Assuming  $\alpha = 0$ ,  $B_i = B$  and calling  $h_i$  to the average years of schooling ( $S_i$ ), the translation of their underlying production function to equation (B.9) in the form of equation (3.13) is:

$$x_i = -f + B \exp(\beta h_i) \quad L_i = B \exp(\beta h_i) \left[ -\frac{f}{B \exp(\beta h_i)} + L_i \right] \quad (\text{B.10})$$

where  $B$  is the marginal labor requirement in 'effective' (education-adjusted) labor units,  $L_i/\exp(\beta h_i)$ , and it is considered constant across regions. That means that Head and Mayer's marginal cost in table Table 3.2 takes the form  $m_i = w_i^\theta z_i^\psi c_i = w_i c_i = w_i/B \exp(\beta h_i)$ , with  $z_i = 1$  and  $\theta = \psi = 1$ . In the table  $1/c_i$  appears as  $A \exp(\beta h_i)$  for comparability, to indicate that  $\exp(\beta h_i)$  comes with a common technological parameter for all regions. Here the  $B$  notation distinguishes this parameter from a Hicks-neutral index of total factor productivity,  $B_i^{1-\alpha}$  in equation (B.9), in order to stress its role in Mankiw-Romer-Weil-Jones's specification if there would be technical change ( $B_{it}$ ).

Table 3.2 does not distinguish between human capital and particular measures of schooling or on-the-job learning. However, the argument about the Mincerian rate of return works only through years of education. Given that this last empirical variable enters exponentially in Head and Mayer's (2006) wage equation, it appears in levels in the logarithmic econometric wage equation. Therefore, Head and Mayer's (2006) version of equation (3.22) for  $\theta = 1$  is :

$$\ln w_i = C + \frac{1}{\sigma} \ln RMP_i + \beta h_i + u_i \quad (\text{B.11})$$

The case considered by Fingleton and Fischer (2010) is similar to equation (B.9) when  $\alpha = 0$  and  $B_i \exp(\beta S_i)$  is subsumed into a  $h_i$  term collecting the efficient level of the labor force. In their specification marginal costs take the form  $m_i = w_i c_i = w_i/h_i$ , though in Table 3.2 appears  $c_i = h_i^{-\beta}$  to consider that their empirical specification proxy human capital with the level of educational attainment of the population. This same framework can encompass a simple version of Redding and Schott's (2003) specification. They introduce endogenous human capital accumulation in a model with a constant returns to scale production function including skilled and unskilled labor, paid  $w_i^s$  and  $w_i^u$  respectively. Their marginal cost is  $m_i = q_i^\theta z_i^\psi c_i = w_i^{s\theta} w_i^{u\beta} G_i^{M^\vartheta} c_i$ , with  $\theta + \beta + \vartheta = 1$ . To make compatible the wage equation with the exponents of the variables in Table 3.2, it is only necessary to simplify marginal costs to  $m_i = w_i^{s1-\beta} w_i^{u\beta}$ , as in the versions of this model by López-Rodríguez *et al.* (2007) or Fallah *et al.* (2011). Then, the assumption  $w_i^u = w_i^s/h_i$  produces a wage equation for  $w_i = w_i^s$  similar to

<sup>42</sup> Too Klenow and Rodríguez-Claré (1997) add a Mincerian specification of human capital into the Mankiw-Romer-Weil production function.

the ones showed in the previous paragraphs. Instead of this, Fallah *et al.* (2011) estimate the following wage equation (omitting here the constant term):

$$w_i^{s^{1-\beta}} w_i^{u\beta} = RMP_i^{1/\sigma} A_i \quad (\text{B.12})$$

Their empirical dependent variable is  $\log w_i^s - \log w_i^u$  across different skill groups. Therefore, implicitly they would be estimating:

$$\frac{w_i^s}{w_i^u} = \left( RMP_i^{1/\sigma} \frac{A_i}{w_i^u} \right)^{1/(1-\beta)} \quad (\text{B.13})$$

so in the regression of the dependent variable on Market Potential, their control variables, educational attainment, industry shares, exogenous amenities and other economic and demographic variables, would play the role of proxies for  $A_i/w_i^u$ . However, given that educational attainment is part of those control variables, actually they are implicitly assuming something like  $w_i^u = w_i^s/h_i$ , and the other control variables are proxies for  $A_i$ . Therefore, Fallah *et al.*'s (2011) specification can be included in Table 3.2 under the re-interpretation of Redding and Schott's (2003) wage equation. The generalized version of the logarithmic econometric wage equation (3.22) encompassing the specifications of human capital by Redding and Schott or Fingleton is:

$$\ln w_i = C + \frac{1}{\theta\sigma} \ln RMP_i + \frac{\beta}{\theta} \ln h_i + u_i \quad (\text{B.14})$$

## Appendix C. Chapter 3: Correlations among variables in logs for the year 2008

**Table C.1. Variables included in Table 3.3: correlations year 2008 (206 regions)**

	IGVAp	IKSp	lhrstc_pop	IEMPGVA	IMP1GVA	IMP2GVA
IGVAp	1.000	0.851	0.580	0.515	0.574	0.603
IKSp	0.851	1.000	0.491	0.399	0.441	0.461
lhrstc_pop	0.580	0.491	1.000	0.238	0.289	0.319
IEMPGVA	0.515	0.399	0.238	1.000	0.984	0.956
IMP1GVA	0.574	0.441	0.289	0.984	1.000	0.993
IMP2GVA	0.603	0.461	0.319	0.956	0.993	1.000

**Table C.2. Alternative variables to build IMP for Table 3.4: correlations year 2008 (206 regions)**

	IGVA	IGVAhr	IGVAp	IGVAd	IPOP	IPOPd	ITFP	lhrstc_pop
IGVA	1.000	0.776	0.445	0.593	0.937	0.551	0.470	0.316
IGVAhr	0.776	1.000	0.137	0.445	0.809	0.466	0.172	0.011
IGVAp	0.445	0.137	1.000	0.575	0.105	0.382	0.977	0.580
IGVAd	0.593	0.445	0.575	1.000	0.435	0.976	0.594	0.347
IPOP	0.937	0.809	0.105	0.435	1.000	0.463	0.141	0.125
IPOPd	0.551	0.466	0.382	0.976	0.463	1.000	0.410	0.237
ITFP	0.470	0.172	0.977	0.594	0.141	0.410	1.000	0.568
lhrstc_pop	0.316	0.011	0.580	0.347	0.125	0.237	0.568	1.000

Notes: Cross-sectional correlations among the logarithm of variables tested as measures of Internal 'Market Potential'.

**Table C.3. Alternative variables to build EMP for Table 3.4: correlations year 2008 (206 regions)**

	IEGVA	IEGVAhr	IEGVAp	IEGVAd	IEPOP	IEPOPd	IETFP	IEhrstc_pop
IEGVA	1.000	0.952	0.986	0.929	0.990	0.944	0.983	0.975
IEGVAhr	0.952	1.000	0.902	0.886	0.960	0.900	0.911	0.897
IEGVAp	0.986	0.902	1.000	0.927	0.969	0.944	0.995	0.989
IEGVAd	0.929	0.886	0.927	1.000	0.891	0.994	0.941	0.936
IEPOP	0.990	0.960	0.969	0.891	1.000	0.916	0.970	0.965
IEPOPd	0.944	0.900	0.944	0.994	0.916	1.000	0.960	0.956
IETFP	0.983	0.911	0.995	0.941	0.970	0.960	1.000	0.995
IEhrstc_pop	0.975	0.897	0.989	0.936	0.965	0.956	0.995	1.000

Notes: Cross-sectional correlations among the logarithm of Harris's measures of External 'Market Potential' (IE) built with the variables in Table C.2.

