New Economic Geography And Educational Attainment Levels In The European Union

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ABSTRACT

In this paper a New Economic Geography model is used to analyse the distribution of educational attainment levels in the European Union. The results show that educational attainment levels decrease with distance to large consumer markets, proving that the theoretical predictions of the model are verified empirically.

INTRODUCTION

New Economic Geography (NEG) has reached a theoretical consolidation as a theory that explains the emergence of a heterogeneous economic space[1]. In NEG models agglomeration of economic activities and population bases on increasing returns to scale and transport costs. Firms that are far from large consumer markets pay greater transport costs and have less value added available to remunerate domestic factors of production. Although it is well documented the theoretical bases of NEG models, authors such as Neary (2001), Ottaviano (2002) and Head and Mayer (2003) pointed out that empirical research on NEG is lagging behind.

The development of NEG meant that the theoretical pitfalls concerning concepts such us market potential or market access have been remedied. An important block of studies that investigate the empirical significance of the market potential focuses on tests of corresponding NEG models. Hanson (1998, 2000) conducted the leadoff analysis of this kind for US counties. He estimated the structural parameters of Krugman (1991) economic geography model and also a reduced form of it which approximates the Harris' (1954) market-potential function. His findings indicate how fare demand linkages extend across space and how shocks to income in one location affect wages an employment in other locations. The regression analysis point to strong and growing over time demand linkages between regions but they are highly localized. Regional wages decline with increasing distance to consumer markets. According to the results, suggest that a 10% fall in regional income for a region size Illinois reduces employment by 6-6.4% in countries that are 100 Km in distance, with effects declining to zero for countries more than 800 Km in distance. Brakman et al.(2000) estimate the market potential function for German districts finding a strong confirmation of the significance of a spatial wage structure in Germany. Regional wages are affected by economic activity and demand in neighbouring regions. Again, the effects of the demand are highly localized, i.e., distance matters a lot for interregional demand linkages.

The analysis of Roos (2001) corroborates the works of Hanson (2000) and Brakman et al. (2000). A positive relationship between regional wage and purchasing power in neighbouring locations marks the analysed cross section of West German NUTS3 regions. Mion (2003) also-analysing Italian NUTS3 regions- found his results consistent with the NEG hypothesis that demand linkages affect the spatial structure of economic activities. Studies with higher geographical scope are those of Lopez-Rodriguez (2002), Faiña and Lopez-Rodriguez (2004, 2005). The results of their study suggest the importance of geography in determining the spatial distribution of EU cross-region income. They found that market access measure could explain at the beginning of eighties near 60% of the spatial variation in the EU income and by 1997 this figure fell down to 44%. These results also show that within the European Union space, the geography of access to markets is vanishing over time, i.e. the penalty of distance is less important in the

[1]See Krugman, 1991, 1992

nineties than at the beginning of eighties. Redding and Venables (2004) estimated an structural model of economic geography using world cross-country data on per capita income, bilateral trade and price of manufacturing goods. They found that over 70% of the spatial variation in per capita income could be explained by the geography of access to markets and sources of supply of intermediate inputs.To sum up, the findings of current empirical investigations are in line with specific implications of NEG models.

The aim of the paper is to add to the empirical evidence on NEG. We investigate whether there is a positive correlation between regional levels of educational attainment and distance from large consumer markets.

Our study departs from an extension of the standard two sector (agriculture and manufacturing) Fujita et al. (1999) economic geography model carried out by Redding and Schott (2003). It differs from them in geographical focus (European Union regions rather than World countries) and in the fact that we use and *ad hoc* measure of market access instead of using the theory-based measure.
The rest of the paper is structured as follows: Section 2 contains the theoretical model. Section 3 contains the data and methodology used in our estimations. The results of the regression analysis are presented in section 4. Finally, section 5 contains the main concluding remarks.

THE THEORETICAL MODEL

In NEG models, the interaction of transport costs and increasing returns to scale generates demand linkages and serves as explanation for agglomeration. Agglomeration is caused by a circular relationship in which the spatial concentration of manufacturing both creates and follows market access. In krugman's (1991a) words, *circular causation a la Myrdal* is present because these two effects reinforce each other: "manufactures production will tend to concentrate where there is a large market, but the market will be large where manufactures of production is concentrated". These forces that are at work in any multiregional economy can be studied within a relatively simple general equilibrium model of monopolistic competition developed by Krugman (1991b), which has come to be known as the *core-periphery model*[5]. Krugman's theoretical research on NEG has triggered a plethora of contributions[6], which have been surveyed by Ottaviano and Puga (1998). Most recently a synthesis of the existing theoretical research on NEG can be found in Fujita et al. (1999) and Fujita and Thisse (2002).

The present analysis is based on an extension of the standard two sector (agriculture and manufacturing) Fujita et al. (1999) economic geography model carried out by Redding and Schott (2003) by introducing human capital accumulation. The structure of Redding and Schott's model is as follows. The economic space is made of $i \in \{1,....,R\}$ countries. Each country is endowed with L_i consumers. Consumers have one unit of labour which is supplied inelastically with zero disutility and consumers choose endogenously whether or not to invest in becoming skilled. Preferences are identical across all consumers and described by a Cobb-Douglas utility function,

$$U_j = A_j^{1-\mu} M_j^{\mu}, \qquad 0 \prec \mu \prec 1 \tag{1}$$

Where μ is the share of expenditure on manufactures, A is the quantity of agricultural good consumed and M is a composite of symmetric product varieties given by:

$$M_j = \left[\sum_{i=1}^{R} \int_0^{n_i} m_{i,j}^C(z)^{(\sigma-1)/\sigma} dz \right]^{\sigma/(\sigma-1)} = \left[\sum_{i=1}^{R} n_i \left(m_{i,j}^C \right)^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \tag{2}$$

[5] An earlier analysis that anticipated several aspects of Krugman's work was developed by Faini (1984). Ideas close to economic geography have already appeared in Krugman (1979) but were not fully worked out.
[6] See Krugman and Venables (1995), Venables (1996), Redding a Venables (2004) among others

We use j to denote a country that is demanding or importing a good and i to denote a country that is producing or exporting a good. σ is the constant elasticity of substitution between any pair of varieties (consumers have love for variety, with increasing σ, the substitutability among varieties rises, thus the desire to spread consumption over manufactured goods declines), n_i denotes the number of varieties produced in country i and $m_{i,j}^{C}$ denotes the amount of each variety produced in country i for final consumption in country j. The second equation exploits the fact that, in equilibrium all the products produced in country i are demanded by country j in the same quantity, so we can remove the index z and rewrite the integral as a product.

Dual to manufacturing goods consumption index (M_j) is a price index (G_j) defined over the prices of individual varieties produced in i and sold in j (i.e) $P_{i,j}$.

$$G_j = \left[\sum_i^R \int_0^{n_i} P_{i,j}(z)^{1-\sigma} dz\right]^{1/1-\sigma} = \left[\sum_i^R n_i (P_{i,j})^{1-\sigma}\right]^{1/1-\sigma} = \left[SA_j\right]^{\frac{1}{1-\sigma}} \quad (3)$$

Equation (3) can also be interpreted as a measure of the country's overall access to sources of supply-supplier access (SA_j).

The agricultural sector produces a homogeneous good under constant returns to scale.

$$Y_i = \theta_i^Y (S_i^Y)^{\phi} (L_i^Y)^{1-\phi}, \qquad 0 \prec \phi \prec 1 \quad (4)$$

Y_i denotes the output in the agricultural sector which is endowed with L_i unskilled workers and with S_i skilled workers. θ_i stands for agricultural productivity. Here, we assume that the output of the agricultural sector is costlessly traded between any two countries[7].

The manufacturing sector produces a differentiated good according to an increasing returns to scale technology such as the production of each variety requires primary factors of production (skilled and unskilled labour) and goods from the manufacturing sector (intermediate inputs). The costs that a firm in country i incurs to produce the differentiated good can be given by:

$$\Gamma_i = (w_i^S)^{\alpha} (w_i^U)^{\beta} G_i^{(1-\alpha-\beta)} c_i \left[F + x_i\right], \quad (5)$$

where w_i^S is the wage of skilled workers (input share α), w_i^U is the wage of unskilled workers (input share β), G_i is the price index for manufactures (input share $1-\alpha-\beta$), c_i is a constant marginal input requirement, F is a fixed input requirement and $x_i = \sum_{j=1}^{R} x_{ij}$ is the total output of the firm produced for all markets.

Manufactured goods are trade among countries incurring iceberg costs, i.e. a fraction of any good shipped from location i to location j melts away so in order to arrive at location j with one unit of good $T_{ij}^M \succ 1$ units must be shipped.

[7] Redding and Schott (2003) also relax this assumption considering the possibility of trade costs involved in shipped the agricultural good.

In order to introduce endogenous human capital accumulation in the model, Redding and Schott (2003) assume that one unit of unskilled labour in country i (z_i) can be converted in one unit of skilled labour by incurring in a fixed cost of education $\Omega_i(z) = \frac{h_i}{a(z)}$ units of unskilled labour where h_i is an inverse measure of the extend of public provision education and $a(z)$ is the individual ability that has an upper and lower bounds determined by human biology $[\underline{a}, \bar{a}]$. Associated with this distribution of ability we can define a probability density function $\lambda(a)$ and a cumulative distribution of ability[8] $\Lambda(a) = \int_{\underline{a}}^{a} \lambda(a) da$. Taking into account the features above mentioned the decision to become educated will be given by:

$$w_i^s - w_i^u \geq \frac{h_i}{a(z)} w_i^u \tag{6}$$

This expression tells us that there is incentives to invest in education when the differential wage between skilled workers and unskilled ones exceed the educational costs. Moreover from equation (6) it can be obtained the equilibrium supply of skills, i.e., the critical value for a (a_i^*) such that if $a(z) \geq a_i^*(z^*)$ all individuals choose to become skilled:

$$a_i^* = \frac{h_i}{\left(w_i^S / w_i^U - 1 \right)} \tag{7}$$

The worker with ability (a_i^*) is indifferent between becoming skilled and remaining unskilled, so this equation is called *skill indifference condition (S)*.

The equilibrium conditions on the consumer's side are obtained by maximizing their utility subject to their budget constraint.

If we denote by E_j^C total consumer expenditure on manufacturing goods in country j, its demand for each product is (Applying Shephard's lema on the price index[9]).

$$m_{ij}^C = (P_{ij}^M)^{-\sigma} E_j^C G_j^{\sigma-1} \tag{8}$$

The term $E_j^C G_j^{\sigma-1}$ is a measure of demand in the importing country j termed *market capacity* ($m_j^C = E_j^C G_j^{\sigma-1}$) and comprised of total expenditure on manufacturing goods in market j (E_j^C) as well as the number of competing firms and the prices they charge as summarized in the manufacturing price index (G_j).

With respect to the producers' equilibrium, in the agricultural sector profit maximization imply that price equals unit costs of production:

[8] For a rigorous analysis see Redding and Schott (2003)
[9] See also Dixit and Stiglitz (1977)

$$P_i^Y = 1 = \frac{1}{\theta_i^Y}(w_i^S)^{\phi}(w_i^U)^{1-\phi} \tag{9}$$

where the output of the agricultural good is chosen as the numeraire, and thus $P_i^Y = 1$ for all i. In the manufacturing sector, the profit function of a representative country i firm is:

$$\prod_i = \sum_{j=1}^{R} \frac{P_{ij}^M x_{ij}}{T_{ij}^M} - (w_i^S)^{\alpha}(w_i^U)^{\beta} G_i^{1-\alpha-\beta} c_i (F + x_i) \tag{10}$$

Because varieties are equally weighed in the utility function, the equilibrium price is the same across all firms located in region i. Solving the first order condition yields the common equilibrium price:

$$P_i^M = (\frac{\sigma}{\sigma - 1})(w_i^S)^{\alpha}(w_i^U)^{\beta} G_i^{1-\alpha-\beta} c_i \tag{11}$$

This means that the firm uses a relative mark-up over marginal costs. Substituting (11) into the profit function leads to:

$$\prod_i = \left(\frac{P_i^M}{\sigma}\right)\left[x_i - (\sigma - 1)F\right] \tag{12}$$

Under free entry, profits are zero, and thus equilibrium output of a firm is a constant given by:

$$\bar{x} = \frac{\sigma - 1}{F} \tag{13}$$

The price needed to sell this many units satisfies[10] (using demand function (4))

$$(P_i^M)^{\sigma} = \frac{1}{\bar{x}} \sum_{j=1}^{R} E_j G_j^{\sigma-1} (T_{ij}^M)^{1-\sigma} \tag{14}$$

Introducing the equilibrium prices (11) in equation (14) we obtain the following zero-profit condition:

$$\left[\left(\frac{\sigma}{\sigma - 1}\right)(w_i^S)^{\alpha}(w_i^U)^{\beta} G_i^{(1-\alpha-\beta)} c_i\right]^{\sigma} = \frac{1}{\bar{x}} \sum_{j=1}^{R} E_j G_j^{\sigma-1} (T_{ij}^M)^{1-\sigma} \tag{15}$$

This is the so-called nominal wage equation which is point of departure of most studies that investigate the existence of a spatial wage structure for different cross sections. According to equation (15), the nominal wage level in region i depends on a weighted sum of purchasing power in all accessible regions j, whereby the weighting scheme is a function declining with increasing distance between locations i and j. This sum we will refer to as the

[10] The transport cost term ($T_{i,j}$) enters with the exponent ($1-\sigma$) and not σ because total shipments to market j are $T_{i,j}$ times quantities consumed

"*market access"* of country i (MA_i). As Hanson (2000) notes, equation (15) can be thought of as a spatial labour demand function in an economy with perfect labour mobility. Labour demand and wages increase with income of neighbouring regions and decline with rising transport costs to these locations. The nominal wage equation represents one of the main propositions emerging from NEG models mentioned by Head and Mayer (2003): access advantages raise local factor prices. More precisely, production sites with good access to major markets because of relatively low trade costs tend to reward their production factors with higher wage and land rentals. Moreover, the equation resembles the market potential concept introduced by Harris (1954). The market potential concept states that the attractiveness of a region as a production site depends on its access to markets.
The nominal wage equation can be rewritten as:

$$(w_i^S)^{\alpha}(w_i^U)^{\beta} = \xi \frac{1}{c_i}(MA_i)^{\frac{1}{\sigma}} G_i^{(\alpha+\beta-1)} \tag{16}$$

By making use of equation (3) we can express the skilled and unskilled wages as a function of the market access and supplier access.

$$(w_i^S)^{\alpha}(w_i^U)^{\beta} = \xi \frac{1}{c_i}(MA_i)^{\frac{1}{\sigma}} (SA_i)^{\frac{(1-\alpha-\beta)}{(\sigma-1)}} \tag{17}$$

Where the constant ξ on the right-hand side combines constants from the equation (15).

Equations (9) and (17) combined together give us the equilibrium wages for skilled and unskilled workers. Taking logs and differentiating equations (9) and (17) and combining them with the skill indifference condition-equation (7)-, it is obtained the equilibrium relationship between geographical location and endogenous human capital investments.

$$0 = \phi \frac{dw_i^S}{w_i^S} + (1-\phi)\frac{dw_i^U}{w_i^U} \tag{18}$$

$$\alpha \frac{dw_i^S}{w_i^S} + \beta \frac{dw_i^U}{w_i^U} = \frac{1}{\sigma}\frac{dMA_i}{MA_i} + \frac{(1-\alpha-\beta)}{(\sigma-1)}\frac{dSA_i}{SA_i} \tag{19}$$

Taking into account equations (18) and (19) it can be shown that if the equilibrium market access (MA_i) and supplier access (SA_i) fall and if the manufacturing sector is skill-intensive relative to the agricultural sector and the country remains incompletely specialized (this will occur for relatively high values of trade costs), the new equilibrium must be characterized by a lower relative wage of skilled workers and therefore by using the skill indifference condition this new equilibrium implies a higher critical level of ability (a_i^*) above which individuals become skilled and a reduced (increased) supply of skilled (unskilled) workers.

The intuitive explanation is based on that the fall in the market and supplier access modifies the initial equilibrium conditions in the manufacturing sector which experiences a fall in size. This reduction in size releases more skilled labour than is demanded initially in the agricultural sector. To go back to the equilibrium point, the nominal skilled wage has to be lower and the nominal unskilled wage higher and therefore the relative wage of skilled workers is lower. Taking into account equation (7), a lower relative wage of skilled workers reduces the incentive to invest in education. Therefore, there is a positive (negative) correlation between market access and number of skilled (unskilled) workers.

DATA AND METHODOLOGY

The results that are obtained from the theoretical model can be tested by using the following regression equation:

$$Ln(EA_i) = \alpha_0 + \alpha_1 \ln(MA_i) + \varepsilon_i \tag{20}$$

Equation (20) allows us to check whether there is a positive correlation between medium and high levels of educational attainment and distance from large consumer markets.

The dependent variable is the log of educational attainment $\ln EA_i$. The corresponding data were taken from the Eurostat Region databank -first and second intermediate reports on economic and social cohesion and the third report on economic and social cohesion. The educational attainment is a three-level measure defined as persons aged 25-59 (as a % of total) with low, medium or high levels of education. The dependent variable is given for 203 European Union NUTS2 regions. The right-hand side of the equation contains the market access variable, a constant and the random disturbance. With respect to the market access measure (MA_i), we built the so called *population potential.*

Definition And Methodology Used To Compute Population Potentials

The concept of *population potential* must be understood as the force or attraction which the population centre i would exert on one inhabitant located at location j in geographical space and conditioned according to the distance between them, T_{ij}. Therefore, this measure shows the influence each place exerts on all other places and in this sense it measures the proximity of a place to other places. There is a natural link with Lösch's (1954) concept of demand cones and the market potential concept proposed by Harris (1954). *Population potentials* at a given location represent an index of the aggregate market potential from the whole structure of population weighing the number of inhabitants by their distance to this location.

In order to compute de *population potentials* for the European Union we have to say that it is not possible to consider all the possible points within a given space (i.e, there are infinite points in a given space). This is why the practical computation of the population potentials is carried out by using a dot or grid "net". This net, which is placed over the European space, defines a finite and manageable set of nodes for the calculations. The potential indices are calculated by going through each node on the net and assigning to it a corresponding "potential" value, that is, the value of its own population plus the population of each and every other node divided by the distance separating them to the original node.

Mathematically, the expression we use to compute the market potential values for each node is the following one:

$$MA_i = Po_i + \frac{Po_1}{D_{i,1}} + ... + \frac{Po_n}{D_{i,n}} = Po_i + \sum_{j \neq i,\, j=1}^{n} \frac{Po_j}{D_{i,j}} \tag{12}$$

Where MA_i represents the market potential at the 'i' node, Po_i represents the population of the 'i' node and $D_{i,j}$ measures the distance between 'i' node and 'j'node.

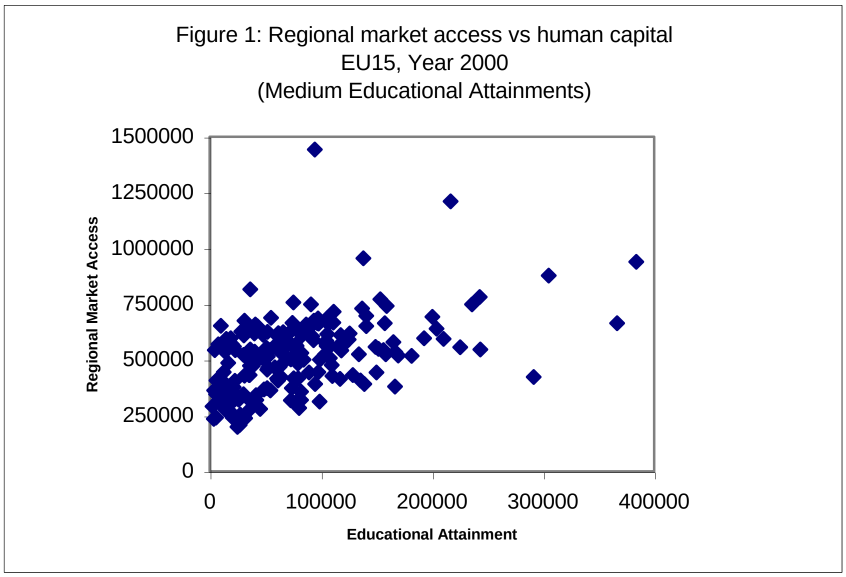
To carry out the computations, we use a Geographic Information System (Arc/Info software from ESRI) that allows us to design an algorithm which goes through the whole nodes of the net (i) and compile the values.

The population data take in all the urban centers with twenty thousand or more inhabitants. These data have been obtained from the statistics information service of the European Commission (Eurostat) and the cartographic data from Gisco.

GEOGRAPHY OF EDUCATIONAL ATTAINMENT LEVELS IN EUROPE: EMPIRICAL RESULTS

In this section we test econometrically expression (20), i.e. whether there is a positive correlation between human capital investments and distance from large consumer markets. Consistent with the model, we provide evidence that educational attainment is higher in those regions that have greater market access.

Figures 1, 2 and 3 plot medium, high and medium+high educational attainments against market access for year 2000. It is clear from these figures that the relationship between regional levels of medium, high and medium+high educational attainments and regional market access are in line with the predictions of the model. The relationship is robust and is not due to the influence of a few individual regions.



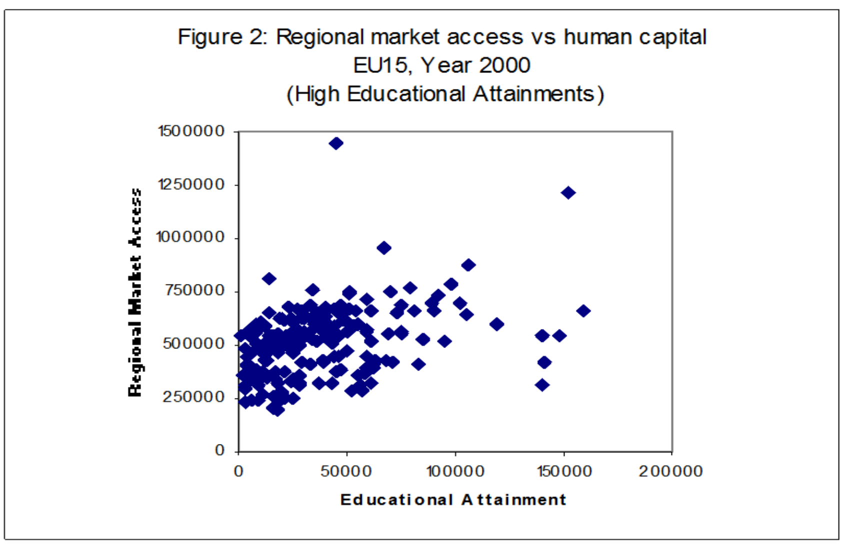
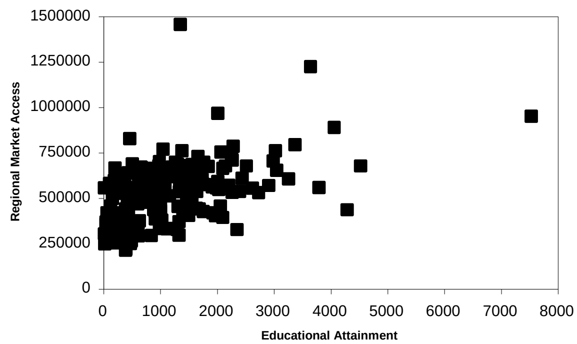


Figure 3: Regional market access vs human capital
EU15, Year 2000
(Medium+High Educational Attainments)



Tables 1-3 present the results of our econometric estimations for 203 EU NUTS2 regions. We regress log medium educational attainment, log high educational attainment and log medium+high educational attainment on log ad hoc measure of market access using Ordinary Least Squares (OLS). The coefficients on market access are significant and the signs correspond with theoretical expectations.

These results show that almost 20% of the variation in regional levels of secondary and tertiary education is explained by market access.

According to the results, market access has a positive effect on the educational attainment levels of the European Union regions. Our results are in line with those obtained by Redding and Schott (2003) for a world sample of countries. In their estimations market access itself explained 23% of the variation in educational attainment (105 countries) and excluding from the sample OECD countries, US, Japan and Belgium (66 countries) the explanatory power of the regression raised to 26%.

These results shed new light to the pioneering work initiated by Redding and Schott (2003), showing that at the EU level there is a positive correlation between countries' human capital investments and market access. As Redding and Schott (2003) pointed out fruitful avenues for future research include the analysis of the relationship between changes in educational attainment and changes in market access within countries and the exploitation of exogenous changes in market access associated with changes in policy regimes.

CONCLUSIONS

In this paper, we test empirically a NEG model analyzing the relationship between market access (Population potential) and the levels of educational attainment in the European Union regions for the year 2000. Consistent with the predictions of the theoretical model, we provide empirical evidence of a spatial educational attainment structure in the EU, i.e. a positive correlation between regional medium and high levels of educational attainment and distance from large consumer markets.   These results suggest that the EU should make bigger efforts to improve the quality of their infrastructures trying to reduce distance to the main centres of economic activity and to improve the levels of human capital in the outskirt locations. An important role in this sense has been played by the European Union Regional Policy since its institutionalization (1989), devoting an important part of its resources to objective 1 regions (most of them in the outskirts of the EU and so facing the penalty of the remoteness) throughout its three programming periods (Delors I and II packages and Agenda 2000). The majority of resources where channelled to improvements in infrastructure, human capital and aids to production sectors.

Table 1: OLS Regression Of Medium Educational Attainment On Regional Market Access, Year 2000
Dependent Variable: Log Medium Educacional Attainment
Included Observations: 203 After Adjusting Endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.809588	1.887801	-3.607154	0.0004
Log (MA)	0.998549	0.143535	6.956853	0.0000
R-squared	0.194059	Mean dependent var		6.316829
Adjusted R-squared	0.190049	S.D. dependent var		0.956941
S.E. of regression	0.861221	Akaike info criterion		2.548873
Sum squared resid	149.0821	Schwarz criterion		2.581515
Log likelihood	-256.7106	F-statistic		48.39781
		Prob(F-statistic)		0.000000

Table 2: OLS Regression Of High Educational Attainment On Regional Market Access, Year 2000
Dependent Variable: Log High Educational Attainment
Included Observations: 203 After Adjusting Endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.262878	1.921406	-3.259529	0.0013
LN (MA)	0.903618	0.146090	6.185365	0.0000
R-squared	0.159905	Mean dependent var		5.615624
Adjusted R-squared	0.155726	S.D. dependent var		0.953973
S.E. of regression	0.876552	Akaike info criterion		2.584162
Sum squared resid	154.4370	Schwarz criterion		2.616804
Log likelihood	-260.2924	F-statistic		38.25875
		Prob(F-statistic)		0.000000

Table 3 OLS Regression of Medium+High Educational Attainment on Regional Market Access, Year 2000
Dependent Variable: Log Medim+High Educational Attainment
Included observations: 203 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.913805	1.806912	-3.272879	0.0013
LN (MA)	0.963220	0.137384	7.011127	0.0000
R-squared	0.196501	Mean dependent var		6.748192
Adjusted R-squared	0.192504	S.D. dependent var		0.917330
S.E. of regression	0.824320	Akaike info criterion		2.461287
Sum squared resid	136.5801	Schwarz criterion		2.493929
Log likelihood	-247.8206	F-statistic		49.15591
		Prob(F-statistic)		0.000000

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