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Jesús López-Rodríguez, *University of A Coruna*

Andrés Faiña, *University of A Coruna*

José López Rodríguez, *University of A Coruna*



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Human Capital Accumulation and Geography: Empirical Evidence from the European Union

JESÚS LÓPEZ-RODRÍGUEZ, J. ANDRÉS FAÍÑA and JOSÉ LÓPEZ-RODRÍGUEZ

Department of Economic Analysis and Business Administration, University of A. Coruña, A. Coruña, E-15.071 Campus de Elviña s/n, Spain. Emails: jelopez@udc.es, fai@udc.es and jolopez@udc.es

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LÓPEZ-RODRÍGUEZ J., FAÍÑA J. A. and LÓPEZ-RODRÍGUEZ J. (2007) Human capital accumulation and geography: empirical evidence from the European Union. *Regional Studies* **41**, 217–234. This paper evaluates the role that geography plays in determining the spatial distribution of educational attainment levels among European Union regions, based on an extension of the standard two-sector (agriculture and manufacturing) Fujita *et al.* (1999) economic geography model. The present paper provides evidence that, in the European Union, educational attainment levels are higher in those regions with greater market access. This finding corroborates the theoretical predictions of the model and proves that remoteness is a penalty for the economic development and convergence of the European Union regions.

Economic development Economic geography Spatial structure Human capital Market access

LÓPEZ-RODRÍGUEZ J., FAÍÑA J. A. et LÓPEZ-RODRÍGUEZ J. (2007) L'accroissement du capital humain et la géographie: des preuves empiriques de l'Union européenne. *Regional Studies* **41**, 217–234. A partir d'une extension du modèle économique-géographique type à deux secteurs (à savoir l'agriculture et l'industrie manufacturière) d'après Fujita *et al.* (1999), cet article cherche à évaluer le rôle que joue la géographie dans la détermination de la distribution géographique du niveau scolaire à travers les régions de l'Union européenne. Il en résulte que, au sein de l'Union européenne, le niveau scolaire est supérieur dans les régions où l'accès au marché est plus facile. Ces résultats confirment les prévisions théoriques du modèle et prouvent que l'isolement pénalise le développement économique et la convergence des régions de l'Union européenne.

Développement économique Géographie économique Structure géographique Capital humain Accès au marché

LÓPEZ-RODRÍGUEZ J., FAÍÑA J. A. und LÓPEZ-RODRÍGUEZ J. (2007) Konzentration von Humankapital und Geografie: empirische Belege in der Europäischen Union. *Regional Studies* **41**, 217–234. In diesem Beitrag wird untersucht, welche Rolle die Geografie bei der Prägung der räumlichen Verteilung hinsichtlich der Erzielung von Bildungsabschlüssen innerhalb der Regionen der Europäischen Union spielt, ausgehend von einer Erweiterung des wirtschaftsgeografischen Standardmodells mit zwei Sektoren (Landwirtschaft und Produktion) nach Fujita *et al.* (1999). Wir liefern Belege dafür, dass das Niveau der Bildungsabschlüsse innerhalb der Europäischen Union in Regionen mit stärkerem Marktzugang höher ausfällt. Dieses Ergebnis bestätigt die theoretischen Prognosen des Modells und beweist, dass eine abgelegene Lage ein Hindernis bei der wirtschaftlichen Entwicklung und Konvergenz der EU-Regionen darstellt.

Wirtschaftsentwicklung Wirtschaftsgeografie Räumliche Struktur Humankapital Marktzugang

LÓPEZ-RODRÍGUEZ J., FAÍÑA J. A. y LÓPEZ-RODRÍGUEZ J. (2007) La acumulación de capital humano y la geografía: prueba empírica en la Unión Europea. *Regional Studies* **41**, 217–234. En este ensayo analizamos el papel que desempeña la geografía a la hora de determinar la distribución espacial de los niveles de educación entre las regiones de la Unión Europea, basándonos en una extensión del modelo estándar de una geografía económica de dos sectores (agricultura y fabricación) según Fujita *et al.* (1999). Demostramos que en la Unión Europea, los niveles educativos son superiores en las regiones con un mayor acceso al mercado. Estos resultados corroboran las predicciones teóricas del modelo y demuestran que la distancia es un obstáculo para el desarrollo económico y la convergencia de las regiones de la Unión Europea.

Desarrollo económico Geografía económica Estructura espacial Capital humano Acceso al mercado

JEL classifications: F12, F14, O10

INTRODUCTION

In January 2003 the release of the second intermediate report on economic and social cohesion showed that regional disparities in the European Union (EU) are still very large and that there has been little improvement since 1990. The figures given in the report for the year 2000 reflect that at the tenth percentile the ratio between the regions with the highest gross domestic product (GDP) per head and those with the lowest GDP per head was about 2.6 (2.8 in 1990). The persistence of such differences is surprising in light of the successive steps taken by the EU towards higher levels of integration and the number of policies¹ established to level out income differences and to allow the catching up of the peripheral regions. There are a number of reasons that may prevent convergence of income levels such as slow technology diffusion, endowment disadvantages² and remoteness.³

Recently, the so-called New Economic Geography (NEG) has reached a theoretical consolidation about a theory that explains how remoteness (distance to consumer markets and sources of inputs) may prevent convergence of income levels and, therefore, provoke the emergence of a heterogeneous economic space. Although the theoretical bases of NEG models are well documented, evidence on their empirical relevance is still scarce. FUJITA *et al.* (1999) stated 'we clearly need much more such [empirical] works, as closely tied to the theoretical models as possible ...' (p. 347). NEARY (2001), OTTAVIANO (2002), and HEAD and MAYER (2004) also point out that empirical research on NEG is lagging behind.

The present paper applies the NEG framework in an empirical investigation analysing the importance of economic geography in explaining the spatial structure of educational attainment levels in the EU. It is, to the authors' knowledge, the first paper, at the EU level, to use the theoretical tools of the NEG to analyse the impact of distance from markets in the levels of human capital. Methodologically, it builds on the approach developed by REDDING and SCHOTT (2003), who extend the standard two-sector (agriculture and manufacturing) NEG model by FUJITA *et al.* (1999) to allow unskilled workers to choose endogenously whether to invest in education. The basic idea is that an increase in remoteness causes higher transport costs to firms in selling their products, which has the same effect as a reduction in the relative price of the manufactured good. Therefore, if manufacturing goods are relatively skill-intensive, firms have less value added available to remunerate their skilled workers and the incentives to educate decreases. They examine the validity of the predictions of their model estimating it for different samples of world countries,⁴ confirming that countries located far from centres of world economic activity are characterized by relatively low levels of educational attainment.

The paper uses, approximately, the same NEG model in an analysis of the regional educational attainment structure in the EU. When applying the model to the European reality, two comments are worth making. The first refers to the model assumption of the immobility of human capital. Although the REDDING and SCHOTT (2003) model refers to countries and assumes immobility of human capital, the model is the most appropriate for the research topic in question.⁵ In general, labour mobility is very low both between and within countries in the EU. For example, BARRO and SALA-I-MARTIN (1995) estimate the impact of income differences on regional migration for several European Countries,⁶ concluding that on average a 10% increase in local real GDP per capita leads, *ceteris paribus*, to a yearly population inflow rate of less than 0.1%. In a similar vein but with a different research agenda, CROZET (2004)⁷ observes very important migration costs reflecting that European workers have a very low degree of geographical mobility, which explains the small scale of interregional migration flows. The second comment refers to the market access variable used in the empirical part of the paper. At an international level, it is possible to compute a theory-based measure of market access. However, at the regional level the present authors have to build it in an alternative way due to the lack of regional prices and interregional trade flows. This problem is circumvented by computing the market potential function, originally defined by HARRIS (1954) and ISAARD (1954), which is a fairly good approximation of the theory-based measure.⁸

The paper contributes, from a methodological point of view, to the growing literature that aims at testing formally models of the NEG and to the still very scarce empirical relevance of the consequences of economic geography for human capital levels, by adapting and estimating the theoretical framework developed by REDDING and SCHOTT (2003) for a different set of data. The model is estimated for a sample of 203 EU Nomenclature of Territorial Units for Statistics (NUTS)2 regions for the year 2000,⁹ finding an important role for market access in explaining educational attainment levels in the EU. Consistent with the predictions of the model regions with higher market access are higher levels of educational attainment. The results show that remoteness is an additional penalty for convergence of income levels and development in the EU by hampering the accumulation of human capital. From a policy point of view these results can help to orientate the nature and extent of the EU's efforts to promote growth and development of peripheral regions.

The paper is structured as follows. The second section contains a brief description of the theoretical model that constitutes the theoretical framework of the empirical analysis. The third section contains the

empirical framework, data and regional system use in the estimations. The results of the regression analysis are presented in the fourth section. Finally, the fifth section has final remarks and conclusions.

THEORETICAL BACKGROUND

The theoretical framework underlying the empirical analysis carried out in this paper is a reduced version of REDDING and SCHOTT's (2003) NEG model (also KRUGMAN, 1991, 1992; KRUGMAN and VENABLES, 1995; VENABLES, 1996). Its difference¹⁰ with the standard two-sector FUJITA *et al.* (1999) (agriculture and manufacturing) NEG model is that it introduces endogenous human capital accumulation. In order to take into consideration this extension, a world is assumed with R locations where each location is endowed with L_i consumers. Consumers have 1 unit of labour that is supplied inelastically with zero disutility, and consumers choose endogenously whether or not to invest in becoming skilled. The decision of any individual (z) of location $i \in \{1, \dots, R\}$ to become skilled is given by the wage differential between skilled and unskilled workers and by the costs of education.

Mathematically, this condition can be expressed as follows:

$$w_i^s - w_i^u \geq \Omega_i(z)w_i^u \quad (1)$$

where $\Omega_i(z) = h_i/a(z)$ is the cost of education in terms of units of unskilled labour needed for 1 unit of it to become skilled. This cost function depends of two components: h_i , which can be thought of an inverse measure of the extent of public provision education; and $a(z)$, which is the individual's ability.¹¹ From equation (1) the critical value for a (a_i^*) can be obtained such that if $a(z) \geq a_i^*(z^*)$, all individuals choose to become skilled:

$$a_i^* = \frac{h_i}{(w_i^s/w_i^u - 1)} \quad (2)$$

The worker with ability (a_i^*) is indifferent between becoming skilled and remaining unskilled, so this equation, in the words of REDDING and SCHOTT (2003), can be termed as 'skill indifference condition (S)'.

Like in standard NEG models, this model assumes homothetic and identical preferences for consumers that are defined over a consumption of a homogenous agricultural good and a variety of differentiated manufacturing goods.¹²

Hereinafter, the present paper is going to focus on the supply side, agricultural and manufacturing sector, to characterize the equilibrium relationship between

geographical location and endogenous human capital investments.

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

$$Y_i = \theta_i^Y (S_i^Y)^\phi (L_i^Y)^{1-\phi}, \quad 0 < \phi < 1 \quad (3)$$

where Y_i is the output in the agricultural sector that is endowed with L_i unskilled workers and with S_i skilled workers; and θ_i is agricultural productivity.

The manufacturing sector produces a differentiated good according to an increasing returns-to-scale technology, such as the production of each variety requires only primary factors of production (skilled and unskilled labour). The profit function of a representative country i firm is:

$$\Pi_i = \sum_{j=1}^R \frac{P_{ij}^M x_{ij}}{T_{ij}^M} - (w_i^S)^\alpha (w_i^U)^{1-\alpha} C_i (F + x_i) \quad (4)$$

where P_{ij}^M is the price in location j of 1 unit produced in i ; w_i^S is the wage of skilled workers (input share α); w_i^U is the wage of unskilled workers (input share $1 - \alpha$); 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 traded 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 1 unit of good, $T_{ij}^M > 1$ units must be shipped.

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

$$P_i^Y = 1 = \frac{1}{\theta_i^Y} (w_i^S)^\phi (w_i^U)^{1-\phi} \quad (5)$$

where the output of the agricultural good is chosen as the numeraire, and thus $P_i^Y = 1$ for all i .

After solving the first-order conditions, profit maximization in the manufacturing sector implies:¹³

$$(w_i^S)^\alpha (w_i^U)^{1-\alpha} = \xi_i^{-1} (MA_i)^{\frac{1}{\sigma}} \quad (6)$$

where $\xi = (\sigma - 1)/\sigma$ is a constant; c_i is the constant marginal input requirement; $MA_i = \sum_{j=1}^R (T_{ij}^M)^{1-\sigma} E_j G_j^{\sigma-1}$ is market access of region i (where E_j is the total expenditure on manufacturing goods in region j ; and G_j is the price index for them); and σ is the elasticity of substitution among manufacturing varieties.

Equations (4) and (5) combined together give the equilibrium wages for skilled and unskilled workers. Taking logs and differentiating equations (4) and (5) and combining them with the skill indifference condition-equation (2), the equilibrium relationship between geographical location and endogenous

human capital investments is obtained:

$$0 = \phi \frac{dw_i^S}{w_i^S} + (1 - \phi) \frac{dw_i^U}{w_i^U} \quad (7)$$

$$\alpha \frac{dw_i^S}{w_i^S} + (1 - \alpha) \frac{dw_i^U}{w_i^U} = \frac{1}{\sigma} \frac{dMA_i}{MA_i} \quad (8)$$

By taking into account equations (7) and (8), it is shown that if the equilibrium market access (MA_i) decreases and if the manufacturing sector is skill-intensive relative to the agricultural sector, the new equilibrium must be characterized by a lower relative wage of skilled workers. Therefore, by using the skill indifference condition, this new equilibrium implies a higher critical level of ability (a_i^*) above which individuals become skilled¹⁴ and there is a reduced supply of skilled workers.¹⁵

This intuitive explanation is because the decrease in the market access modifies the initial equilibrium conditions in the manufacturing sector, which experiences a decrease 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, which reduces the incentives to invest in education.

EMPIRICAL FRAMEWORK, DATA AND REGIONAL SYSTEM

Econometric specification

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

$$\ln(EA_i) = \alpha_0 + \alpha_1 \ln(MA_i) + \varepsilon_i \quad (9)$$

where EA_i is the level of educational attainment; and MA_i for regions market access and ε_i is the disturbance term. Equation (9) allows one to check if there is a spatial educational attainment structure in the EU, i.e. whether there is a positive correlation between medium and high levels of educational attainment and distance from large consumer markets, i.e. if high market access locations have relatively high levels of education. In this specification the error term captures differences in technology across regions, c_i . To begin, these are consigned to the error term and how much of the variation in cross-regional wages can be explained when only including information on market access is examined. This provides the basis for the baseline estimation where it is assumed that the error term is uncorrelated with the explanatory variables. Considering that this assumption can be violated and, therefore, the coefficient estimates be biased and inconsistent, estimates using instrumental variables regression are also presented.

In order to control for the effects of outlying observations, this alternative specification is also estimated:

$$\ln(EA_i) = \alpha_0 + \alpha_1 \ln MA_i + \sum_{n=1}^N \gamma_n X_{i,n} + \varepsilon_i \quad (10)$$

where X_{in} is a control variable; and γ_{in} is the correspondent coefficient.

To complement the estimations of different equations for different educational attainment levels, the results of two alternative estimations based on transformations in the definition of the dependent variable are also reported. The first transformation of the dependent variable consists of ranking EU regions given the values 1 if low educational attainment is the highest share educational attainment, 2 if it is medium, and 3 if it is high, and then estimate and order the probit model. The second transformation consists of estimating a single equation where the dependent variable is regional average years of schooling instead of educational attainments.

Data and regional system

The dependent variable in the regression analysis is the log educational attainment defined as the percentage of persons aged 25–64 years with low, medium or high levels of education.

Data on educational attainment come from the EU Labour Force Survey (LFS). Classification is based on the highest level of education attained (educational attainment) as well as on recent or current participation of the population in education and training. Data on education collected through the LFS includes three levels of educational attainment:¹⁶ a low level: at best lower secondary education level (ISCED97¹⁷ = levels 0–2); a medium level: upper secondary education level (ISCED97 = levels 3 and 4); and a high level: higher education qualification (ISCED97 = levels 5 and 6).

In the present analysis data on regional educational attainment refer to the year 2000 for a sample of 203 NUTS2 EU-15 regions.

The variables in the right-hand-side of the equation are as follows. Market access (MA), which is a proxy for access to sources of expenditure. In this study, the theory-based measure of market access cannot be computed since at the regional level in Europe there are no data on regional prices and interregional trade flows. Market access is computed as a distance-weighted sum of regional GDPs. Technically, the expression used to compute market access is:

$$MA_i = \sum_{j=1}^n \frac{M_j}{T_{i,j}}$$

where M_j is a measure of the volume of economic activity of region j ; T_{ij} is a measure of the distance between i and j ; and n is the number of regions

considered. For market access computations, taking into account that one is measuring access to sources of expenditure and to avoid underestimation of market access of more peripheral EU regions, the measure are built up for all EU-27 NUTS2 regions, with the exceptions of French dominions (Guadeloupe, Martinique, Reunion and Guyane), Portuguese islands (the Azores and Madeira) and the Spanish islands of the Canaries. A total of 259 EU-27 NUTS2 regions were included. As a measure of economic activity (M_i), regional gross domestic product was taken, and with respect to distance between regions (T_{ij}) they are great circle distances (km) between the main cities of the regions. These distances are derived from the latitude and longitude coordinates of each region's main city. Distance from a region i to itself, T_{ii} is modelled as being proportional to the square-root of the region's area. The expression used to compute it is:

$$0.66\sqrt{\frac{Area}{\pi}}$$

where $Area$ is the size (km^2) of region i . This formula gives the average distance between two points in a circular location (for a discussion of this measure for internal distance, see HEAD and MAYER, 2000; and

CROZET, 2004). Market access computations were carried out using a geographic information system (Arc Info and Arc Map 8.2 software). The results of regional market access computations for the year 2000 are shown in Fig. 1.¹⁸ The value of the market access measure is reflected in the relative shade used,¹⁹ i.e. the darker the shade, the higher the value of market access and vice versa. The spatial pattern of the market potential resembles accessibility measures and peripherality indices calculated by KEEBLE *et al.* (1982) or SHURMANN and TALAAT (2000). Regions marked by low market potentials are located in the geographic periphery, comprising, in particular, Finland, the northern part of the UK, Portugal, the western and southern parts of Spain, and the south-eastern part of Greece. In contrast, high accessibility and market potentials are estimated for the regions in the north-east of Europe, covering the area commonly known as the Golden triangle between Greater Manchester–London–Paris and the Rhur Valley.

ECONOMIC GEOGRAPHY AND EDUCATIONAL ATTAINMENT LEVELS: EMPIRICAL RESULTS

The educational attainment of the European population varies greatly. Table 1 shows the share of labour force

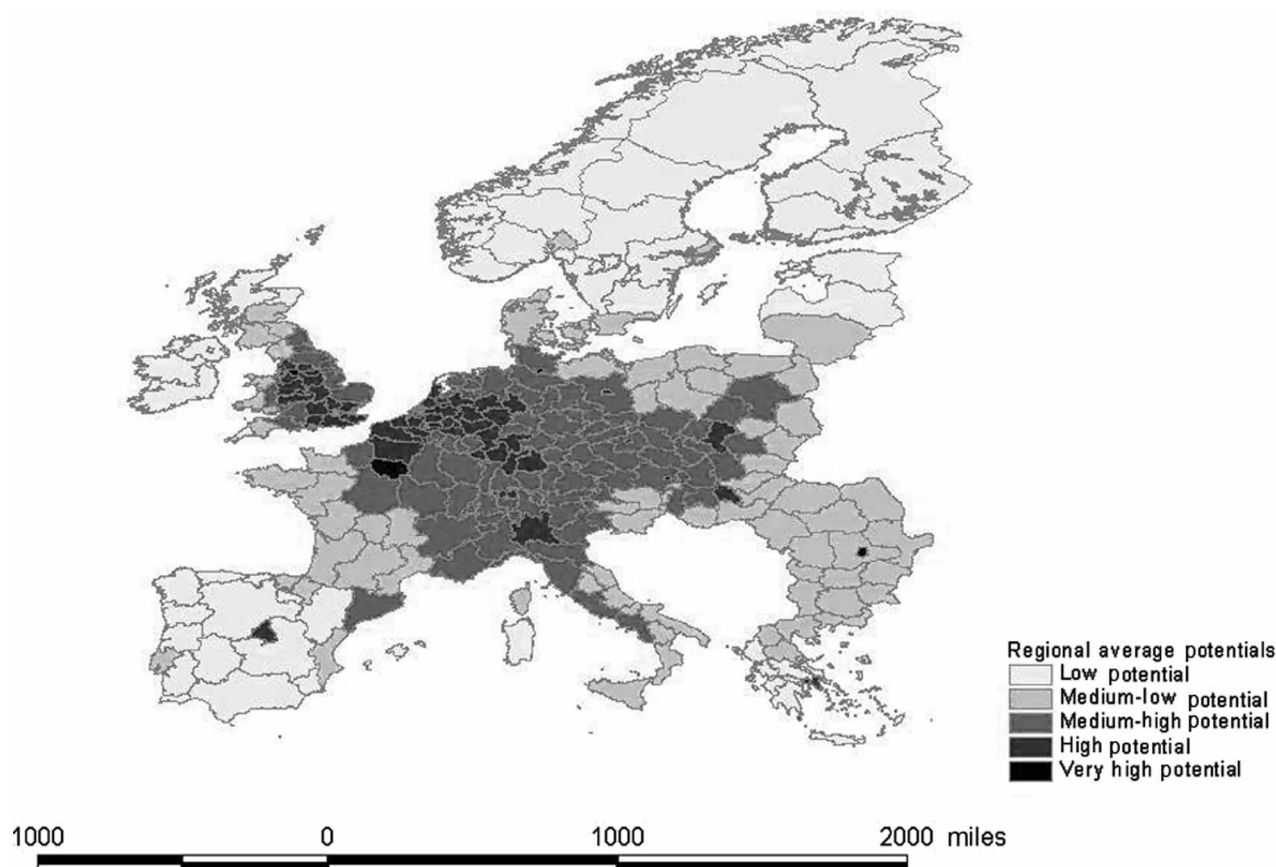


Fig. 1. Estimated market potential by region (EU-27)
Source: Authors' own elaboration using Arc View 8.1.

Table 1. Percentage of the population aged 25–64 years with low, medium and high educational levels, 2000

European Union/countries	Low	Medium	High
EU-15	35	43	22
Belgium	39	32	29
Denmark	19	55	27
Germany	17	58	25
Greece	45	37	18
Spain	60	17	23
France	36	42	23
Ireland	49	28	23
Italy	52	38	10
Luxembourg	37	44	19
Netherlands	33	42	25
Austria	22	63	15
Portugal	78	12	10
Finland	24	42	34
Sweden	21	49	31
UK	19	53	29

Source: Authors' own elaboration based on the Labour Force Survey 2000.

with low, medium and high educational levels. As shown, a large percentage of the labour force in South EU countries and Ireland (the so-called cohesion countries) – Portugal (78%), Spain (60%), Italy (52%), Ireland (49%) and Greece (45%) – have an education at the lower secondary level, well above the EU-15 average (35%). However, in the North and most Central EU countries – Germany (83%), Denmark (82%), the UK (82%) and Sweden (80%) – more than 80% of the labour force population has schooling to at least a higher secondary level, well above the EU-15 average (65%).

Table 2 shows the figures on educational attainment at the regional level for the 62 regions with the highest upper secondary and tertiary education and for the 62 regions with the highest primary and lower secondary education. Among the regions with the highest levels of educational attainment are those located in the so-called *blue banana* (Greater Manchester, Inner London, Outer London, and Köln). The lowest educational attainment levels are in those regions located on the EU periphery.

Therefore, the figures on the spatial distribution of educational attainment at the EU level show a core–periphery gradient, a pattern that is commonly observed when one refers to the spatial distribution of EU income (poor regions predominantly found on the European periphery). Fig. 2 illustrates this fact by plotting high educational levels in 2000 against distance from Luxembourg, which is the approximate geographical centre of the EU.

This core–periphery pattern of EU educational attainment levels can also be analysed by testing econometrically expression (9), which specifically tests for the correlation between human capital investments and

market access.²⁰ Consistent with the model, evidence is provided that educational attainment is higher in those regions that have greater market access.

Figs 3–5 plot low, medium and high educational attainment levels against market access for 2000. It is clear that the relationship between regional levels of educational attainments and regional market access are in line with the predictions made by the model. The relationship is robust and not due to the influence of a few individual regions.

Columns 1, 3, 6 and 9 of Table 3 show the results of the econometric estimations for a sample of 203 EU NUTS2 regions. Column 1 shows the results of regressing the percentage of population with primary education (labelled ‘low’ educational level) against market access. The results indicate that an increase in regional market access is negatively correlated with the percentage of the population that has primary education. Considering that only figures of educated people (the population that has attained primary, secondary or tertiary education) are being dealt with, therefore the share of the population with primary education is 1 minus the share of population with secondary and tertiary education. This result constitutes an indirect way of checking the theoretical predictions of the model. Columns 3, 6 and 9 report the results of regressing the share of population with medium, high and medium plus high educational levels²¹ against market access using ordinary least-squares (OLS) and as such it is a direct way of testing the predictions of the model. The coefficients on market access are significant and the signs correspond with theoretical expectations. Doubling market access would increase medium educational levels by 27% and high educational levels by 26%. These results show that between 16 and 19% of the variation in regional levels of secondary and tertiary education are explained by market access.

The estimation of three different equations for the different levels of educational attainment (medium, high and medium plus high) is because the coefficient estimates are significantly different for the three equations. In order to check this fact, this alternative regression is run:

$$\ln(EA_{ij}) = \alpha_0 + \alpha_1 \ln(MA_{ij}) + \alpha_2 D_{ij} + \varepsilon_{ij}$$

where $i = 1, 2, \dots, 203$ is the 203 NUTS2 EU-15 regions of the sample, $j = \{0, 1\}$ is the level of educational attainment, where 0 is secondary and 1 tertiary education. Therefore, $EA_{1,0}$ is the proportion of the population in region 1 that has secondary education; and $EA_{1,1}$ is the proportion of the population in region 1 that has tertiary education. $MA_{ij} = MA_i$ for all $j = \{0, 1\}$ is the market access of region $i = 1, 2, \dots, 203$; and $D_{ij} = \{0, 1\}$ is a variable that takes the value of zero if $j = \{1\}$ and 1 if $j = \{0\}$; and ε_{ij} is an error term.

Table 2. Regional disparities in educational attainment level across EU-15 regions, 2000

European Union regions with the highest higher secondary and tertiary education (%)		European Union regions with the highest primary and lower secondary education (%)					
Chemnitz	96	Hannover	83	Açores	86	Ellada	57
Dresden	94	Kassel	82	Madeira	84	Cataluña	56
Halle	94	East Wales	82	Norte	82	Makedonia	56
Brandenburg	94	Oberbayern	82	Algarve	82	Thessalia	56
Leipzig	94	Wien	82	Centro	80	Basilicata	55
Magdeburg	92	Hamburg	82	Alentejo	77	Kriti	54
Thüringen	91	Highlands and Islands	82	Lisboa	71	Veneto	54
Dessau	91	Kärnten	82	Castilla-la Mancha	70	Navarra	54
Mecklenburg-Vorpommern	89	Herefordshire, Worcestershire and Warwickshire	82	Extremadura	69	Calabria	54
Berkshire, Buckinghamshire and Oxfordshire	89	Darmstadt	82	Galicia	67	Peloponnisos	53
Surrey, East and West Sussex	89	East Anglia	81	Andalucía	67	Valle d'Aosta	53
Bedfordshire and Hertfordshire	89	Danmark	81	Islas Baleares	64	Voreio Aigaio	53
Gloucestershire, Wiltshire and North Somerset	87	Weser-Ems	81	Comunidad Valenciana	63	Toscana	52
Cumbria	87	Inner London	81	Canarias	63	Piemonte	52
North Eastern Scotland	86	Eastern Scotland	81	Murcia	62	Marche	52
Hampshire and Isle of Wight	86	Münster	81	Notio Aigaio	61	Southern and Eastern	52
North Yorkshire	86	Essex	81	Corse	61	Molise	51
Devon	86	Detmold	81	Asturias	60	Liguria	50
Dorset and Somerset	85	Gießen	81	La Rioja	60	Friuli-Venezia Giulia	50
Kent	85	Lincolnshire	81	Sardegna	59	Abruzzo	50
Stockholm	84	West Yorkshire	81	Anatoliki Makedonia	59	Lombardia	50
Övre Norrland	84	Trier	80	Puglia	59	Madrid	49
Braunschweig	84	Saarland	80	Aragón	59	Pais Vasco	49
Berlin	84	Salzburg	80	Castilla y León	59	Emilia-Romagna	49
Schleswig-Holstein	83	Arnsberg	80	Ceuta y Melilla	59	Kentriki Makedonia	47
Lüneburg	83	Leicestershire, Rutland and Northamptonshire	80	Stereia Ellada	58	Border, Midland and Western	46
Cheshire	83	Karlsruhe	80	Sicilia	58	Liège	46
Cornwall and Isles of Scilly	83	Köln	80	Ipeiros	58	Hainaut	46
Schwaben	83	Oberfranken	80	Ionia Nisia	58	Picardie	46
Outer London	83	Derbyshire and Nottinghamshire	80	Cantabria	57	Nord-Pas-de-Calais	45
Lancashire	83	Greater Manchester	80	Campania	57	Umbria	44

Source: Authors' own elaboration based on the Labour Force Survey 2000.

In this alternative specification, the main parameter of interest is α_2 , such that if α_2 is statistically different from zero, one can reject that the estimated coefficient α_1 is equal for the different equations estimated, and thus it confirms the present approach to the problem. The results reported in column 12 of Table 3 show that α_2 is significantly different from zero, thus justifying the estimation of three different equations for the different levels of educational attainments.

A potential shortcoming of the previous analysis, as in almost all papers in the literature, is that referring to the endogeneity of the market access measure, i.e. good market access, can be correlated with other determinants of the level of educational attainment of the region. This endogeneity problem can cause inconsistent and biased estimates. To avoid problems of endogeneity between human capital levels and regional market access, the paper presents instrumental variables estimates.

Determining a causal effect of market access on educational attainment levels depends on the availability of instruments. These need to be variables that are determinants of market access but exogenous with respect to human capital levels. Furthermore, they should also be variables that are not driven by an unobservable third variable the authors suspect might be jointly affecting market access and human capital levels.

Geographic variables seem to be the most adequate candidates for such an instrumental variables estimation. Similar to REDDING and VENABLES (2004) and BREINLICH (2005), market access is instrumented with distance from Luxembourg and with the size of a region's home country. The first instrument captures the market access advantages of regions close to the geographic centre of the EU. The second instrument captures the advantage of large national markets in the composition of domestic market access.

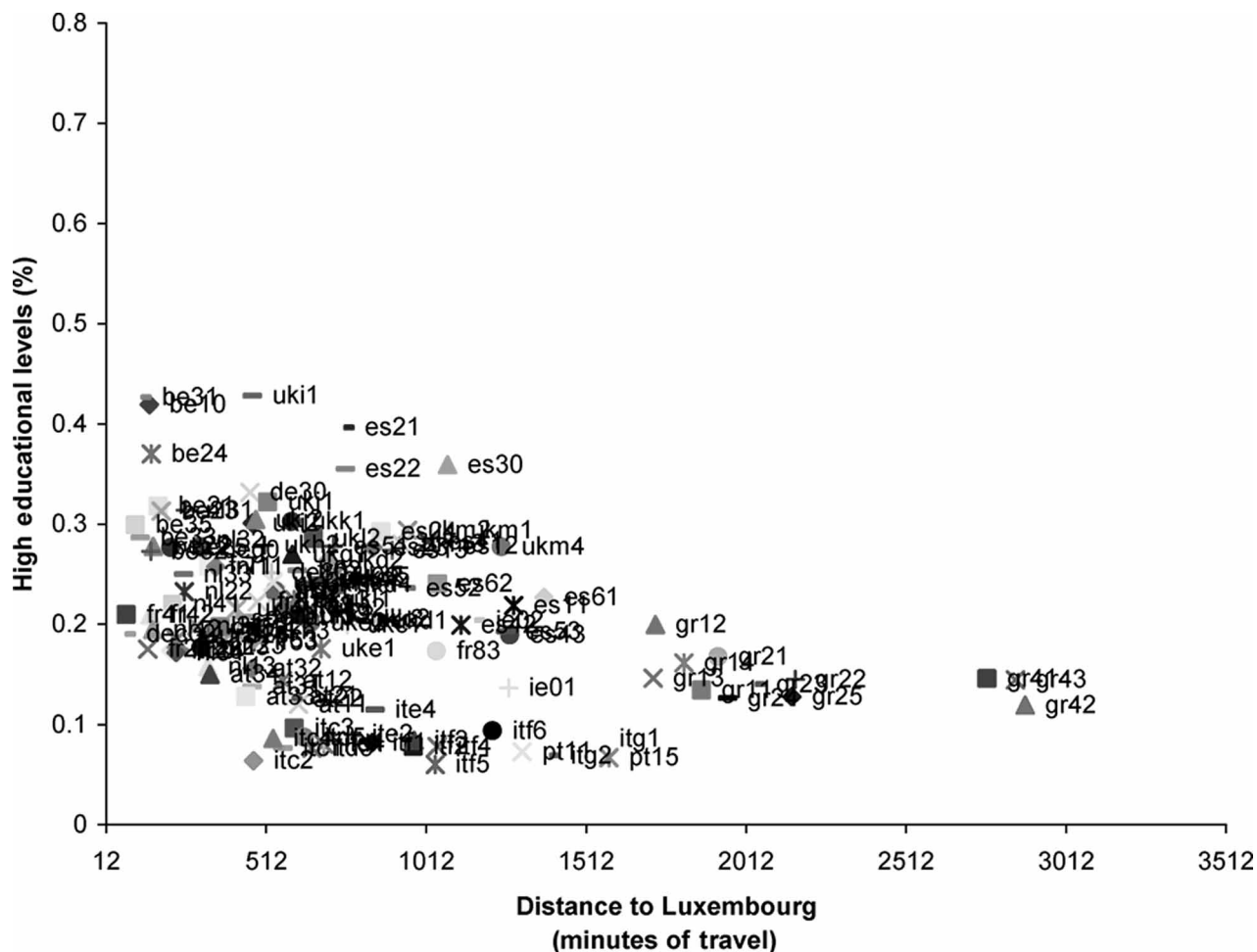


Fig. 2. High educational levels and distance from Luxembourg, EU-15, 2000

Columns 4, 7 and 10 present the results for the corresponding instrumental variables estimation. Both instruments are highly statistically significant and have the expected signs in the first stage. Distance to Luxembourg and the size of a region's home country explains about 57% of regional market access. Since the instruments represent quite a distinct source of information and are uncorrelated, one can trust them to be reliable instruments.

In the second-stage estimation, positive and highly statistically significant effects of market access is again found. The effects of market access on educational attainment levels are even reinforced. The market access coefficient changes from the interval 0.26–0.27 to 0.28–0.35.

For comparison purposes, columns 2, 5, 8 and 11 of Table 3 report results of regressing educational attainment levels against distances from the geographic centre of Europe (approximately Luxembourg) in place of market access. The results provide evidence of the negative correlation between regional medium and high educational attainment levels and regions' distance from Luxembourg, and a positive correlation with low educational attainment levels.

However, the models given in Table 3 are marked by outlying observations. The outlying regions do not correspond with the spatial educational attainment structure determined by the majority of observations. Outliers will seriously affect the coefficient estimates if they are influential leverage points, i.e. outlying observations with regard to the present measure of market access. In order to control for effects of outlying observations, dummy variables for the outliers are introduced. The most significant outliers²² are the Austrian regions of Wien (AT13), Kärnten (AT21) and Steiermark (AT22), the Belgium region of Brussels (BE10), and the British regions of Inner London (UKI1) and Outer London (UKI2).

Columns 1, 3 and 5 of Table 4 report the results including dummies for outlying regions. The results show that the effects of market access on educational attainment levels are reinforced; doubling market access would increase medium educational levels by 47% and high educational levels by 30%. Moreover, the fit of the regressions improves considerably (by 56–57%). The models in Table 4 explain between 25 and 30% of the spatial variation in the educational attainment levels in the EU. Columns 2, 4 and 6

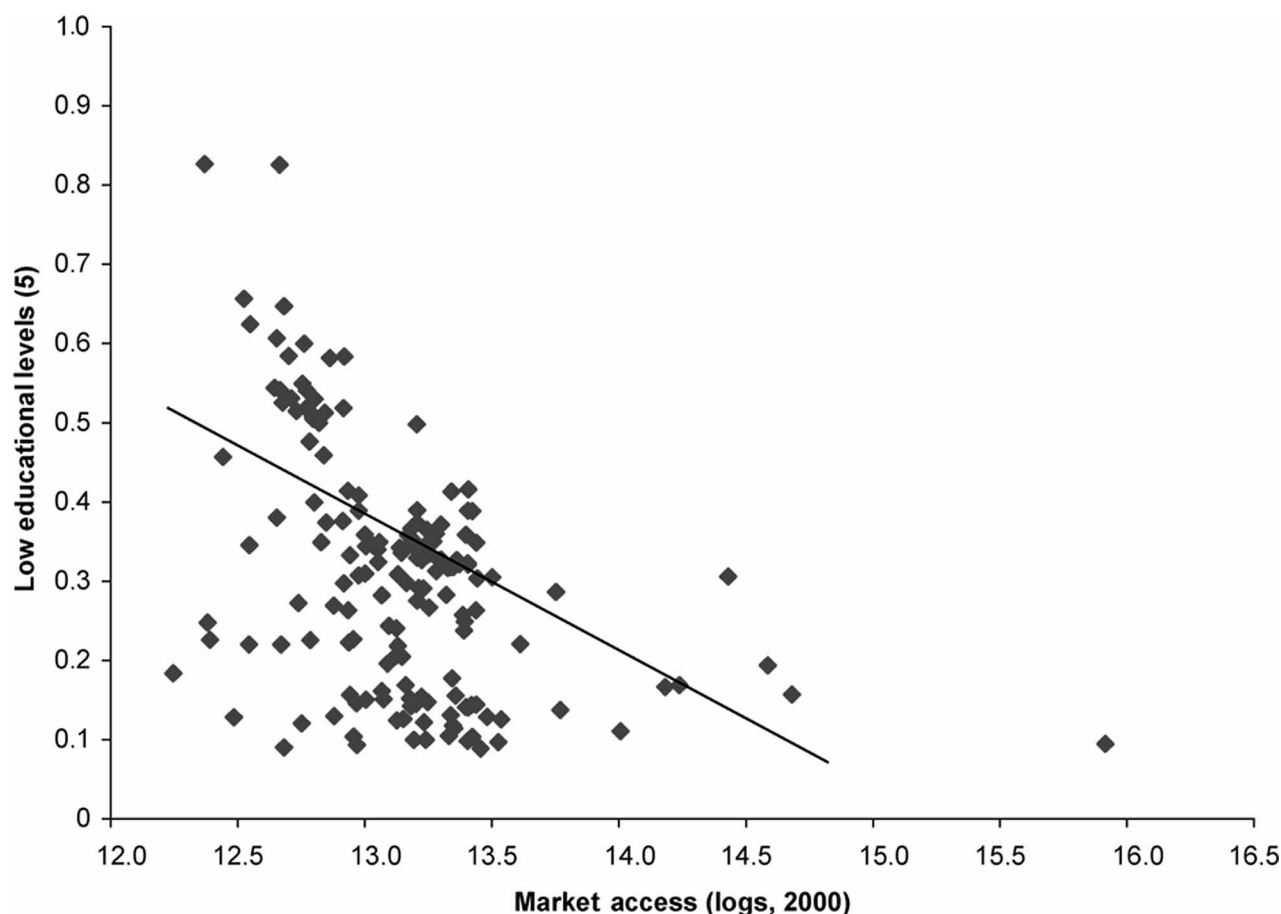


Fig. 3. Low educational levels and market access, EU-15, 2000

investigate the potential endogeneity problem of market access. The instruments are again distance to Luxembourg and the size of a region's home country. In the second stage one again finds positive and statistically significant effects with the instrumental variable (IV) estimate. Again, the effect of market access on educational attainment levels is reinforced when an IV estimation is carried out.

To complement the estimations of different equations for different educational attainment levels, columns 7 and 8 of Table 4 report the results of two alternative estimations based on transformations in the definition of the dependent variable. In column 7 regional educational attainment levels are transformed into average years of schooling and then a single equation is estimated using average years of schooling as the dependent variable.²³ To do the transformation of educational levels into average years of education, the regional information on the proportion of the workforce with primary, secondary and tertiary education from the Labour Force Survey is used and the following assumptions are made:

- Primary education (low educational attainment) consists, on average, of 8 years of education; students generally begin primary education between the ages of 5 and 7 years and end at 13–15 years.

- Secondary education (medium educational attainment) consists on average of 4 years of education; students generally begin secondary education between 13 and 15 years of age and finish between 17 and 18 years of age.
- Tertiary education (high educational attainment) consists of 4 years of education.²⁴

The coefficient on market access is positive and statistically significant at the usual critical values, showing that an increase in a region's market access increases the average years of education of its population.

Column 8 reports the estimates of an ordered probit model where the dependent variable was transformed given to it the values 1, 2 or 3 according to the relative importance of the proportion of the population that has low, medium or high educational levels. Therefore, a region with the highest proportion of the population with primary education is ranked 1; if the highest proportion is secondary education it is ranked 2; and if the highest proportion is tertiary it is ranked 3. In ordered probit models the sign of the coefficient shows the direction of the change in the probability of falling in the endpoint rankings, in the present case (educational attainment level 1 – primary education; or educational attainment level 3 – tertiary education) when market

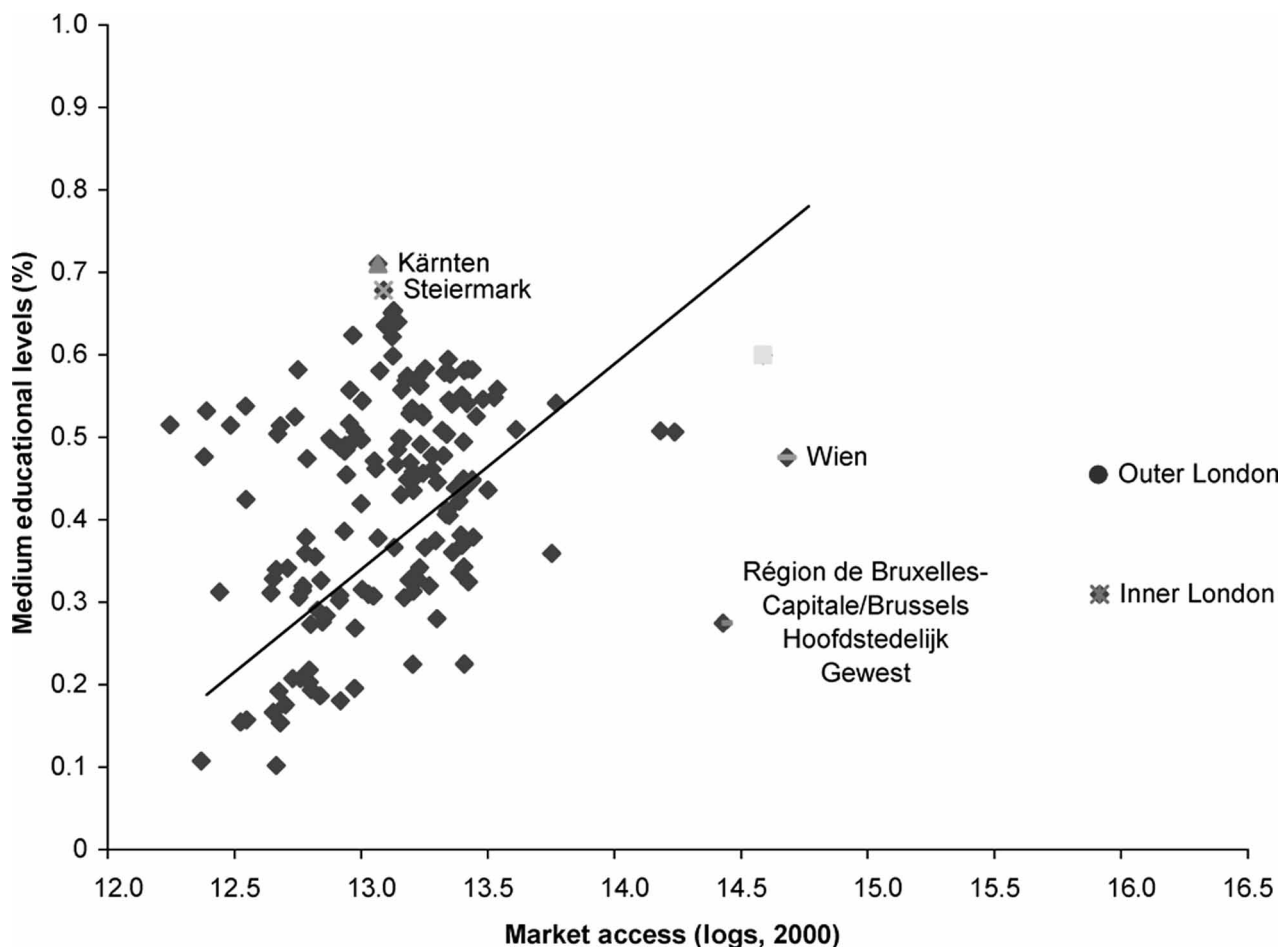


Fig. 4. Medium educational levels and market access, EU-15, 2000

access changes. The probability of educational attainment level 1 changes in the opposite direction of the sign of the estimated coefficient; and the probability of educational attainment level 3 changes in the same direction. The coefficient reported in column 8 of Table 4 is positive, showing that the probability of having higher educational levels is higher in regions with high market access. Moreover, the sign of the coefficient informs that the probability of having low educational attainment decreases with increases in a region's market access. The estimated coefficient is statistically significant at the conventional critical values.²⁵

Therefore, the results reported in columns 7 and 8 of Table 4 can be taken as additional proof that geographical location matters when determining educational levels across EU regions.

The 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 levels (105 countries), and when excluding from the sample Organization for Economic Co-operation and Development (OECD) countries, the USA, Japan and Belgium (66 countries), the explanatory power of the regression raised to 26%.

These results shed new light on the pioneering work initiated by REDDING and SCHOTT (2003), showing that at the EU level geographical location matters for incentives to invest in human capital, i.e. there is a positive correlation between higher educational attainment levels and market access. Fruitful avenues for future research can be exploited through the analysis of the relationship between changes in educational attainment levels and changes in market access for the EU regions, and by looking for a similar relationship across regions within countries.

CONCLUSIONS

This paper analyses the relationship between market access and the levels of educational attainment in the EU regions for the year 2000. Consistent with the predictions of the theoretical model, it provides 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 market access. The inclusion of dummy variables alters the coefficient of market access considerably, changing it from 0.26–0.27 to the interval 0.30–0.47. Moreover, the fits of the regressions also increase

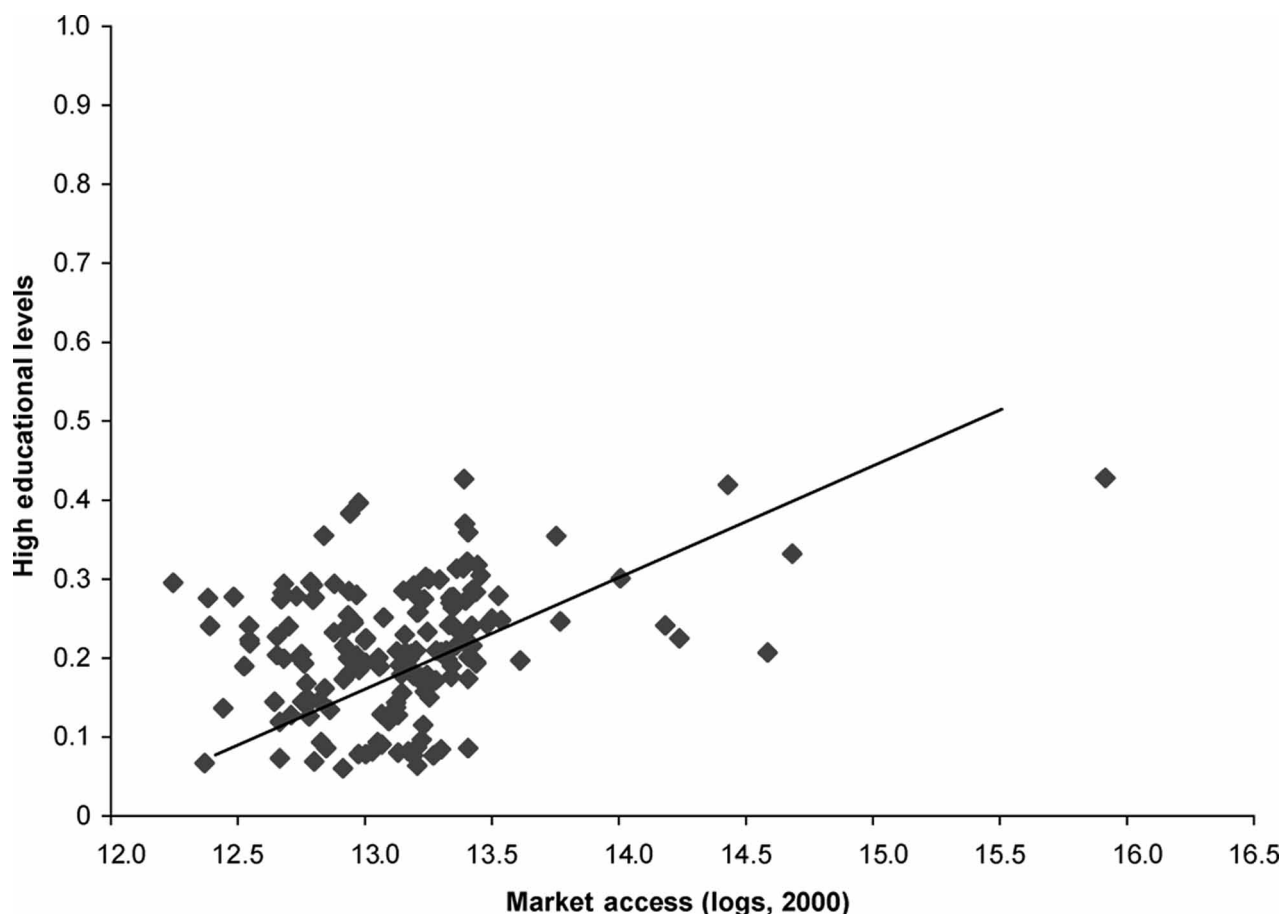


Fig. 5. High educational levels and market access, EU-15, 2000

substantially and the augmented models explain around 30% of the spatial variation in the educational attainment levels in the EU regions.

Alternative estimations using single equations for the dependent variable, years of schooling and an ordered probit model corroborate the results previously found. There is a positive correlation between market access and years of schooling, and there is also a positive correlation between the probability of having higher educational levels and a region's market access.

Taking into account that human capital accumulation is a key factor for regional development and to promote convergence among EU regions and that the results of this analysis show that in the EU there is a penalty of remoteness for human capital accumulation, one obvious policy implication is that the outlying regions in the EU should make bigger efforts to improve the quality of their infrastructures by trying to reduce distance to the main centres of economic activity. An important role in this sense has been played by EU regional policy since its institutionalization in 1989 by 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 were channelled to improvements in infrastructure, human capital and as aids to production sectors.

One potential shortcoming of this analysis could be the clarification of whether the spatial educational structure observed in Europe (high educational levels in the geographical centre of Europe) is a result of skilled workers' incentives to migrate to such regions and, therefore, the present empirical evidence would also be consistent with quite a different NEG model, where skilled workers migrate within each country.²⁶ The question that then emerges is if migration to high-market-access regions within each country, based on the fact that industries agglomerate within a country in regions with good market access, generates an incentive for skilled workers to migrate to such regions. This aspect was studied by CROZET (2004) for a sample of five EU countries²⁷ using data on internal annual migration flows. Crozet concludes that interregional migration flows are very weak because centripetal forces are limited in geographic scope and barriers to migration are high enough to balance the centripetal forces. He observes very important migration costs reflecting the fact that European workers have a very low degree of geographical mobility which explain the small extent of interregional

Table 3. Market access and educational levels: baseline estimation (EU-15, 2000)

Dependent variable	Low	Medium	Medium	Medium	High	High	High	Medium and high	Medium and high	Medium and high	$EA_{i,j}$	
<i>Regressors</i>												
Constant	5.23** (1.23)	-2.55** (0.27)	-4.45** (0.80)	-4.62** (1.23)	0.30 (0.20)	-5.05** (0.76)	-6.23** (1.03)	-0.72** (0.19)	-3.9** (0.81)	-4.41** (0.85)	0.59** (0.15)	-5.74** (0.88)
Market access	-0.54** (0.00)		0.27** (0.06)	0.28** (0.09)		0.26** (0.05)	0.35** (0.07)		0.26** (0.06)	0.30** (0.06)		0.31** (0.06)
ln (Distance to Luxembourg)		0.18** (0.04)			-0.18** (0.03)			-0.14** (0.03)			-0.16** (0.02)	
$D_{i,j}$												0.75** (0.04)
Estimation	OLS	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS
R^2	0.18	0.08	0.19	0.18	0.14	0.16	0.15	0.07	0.19	0.18	0.17	0.50
Probability (F -statistic)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jarque-Bera	4.23		0.79			3.75			1.73			
Probability (Jarque-Bera)	0.12		0.67			0.15			0.42			
Number of observations	203	203	203	203	203	203	203	203	203	203	203	406

Note: Coefficients and Huber-White heterocedasticity robust standard errors (in parentheses) are shown.

**Coefficient significant at the 0.01 level, *significant at the 0.05 level.

Table 4. Market access, regional dummies and educational levels (EU-15, 2000)

Dependent variable log (educational attainment levels)	Medium	Medium	High	High	Medium and high	Medium and high	Educational level	Average years of education
<i>Regressors</i>								
Constant	-7.00** (1.35)	-6.9** (1.29)	-4.79** (1.04)	-6.5** (1.36)	-5.36** (1.02)	-5.87** (1.05)		1.62** (0.25)
Market access	0.47** (0.10)	0.46** (0.09)	0.30** (0.07)	0.37** (0.10)	0.37** (0.07)	0.41** (0.07)	1.19** (0.25)	0.060** (0.01)
Dummy Wien	-0.33** (0.14)	-0.30** (0.13)	-0.34** (0.10)	-0.48** (0.14)	-0.30** (0.10)	-0.35** (0.11)		
Dummy Karnten	0.55** (0.02)	0.55** (0.02)	-0.41** (0.03)	-0.40** (0.03)	0.30** (0.02)	0.30** (0.01)		
Dummy Steiemark	0.50** (0.02)	0.49** (0.02)	-0.44** (0.03)	-0.42** (0.03)	0.25** (0.02)	0.25** (0.02)		
Dummy Brussels	-1.03** (0.12)	-1.02** (0.12)	0.43** (0.10)	0.27** (0.12)	-0.39** (0.09)	-0.44** (0.09)		
Dummy Inner London	-1.62** (0.17)	-1.60** (0.26)	0.09** (0.2)	-0.25** (0.27)	-0.88** (0.20)	-0.99** (0.21)		
Dummy Outer London	-0.33** (0.08)	-0.32** (0.08)	0.20** (0.06)	0.10** (0.08)	-0.14** (0.06)	-0.18** (0.06)		
Estimation	OLS	IV	OLS	IV	OLS	IV	Ordered probit	OLS
R ²	0.30	0.31	0.25	0.26	0.28	0.29	0.10	0.10
Probability (<i>F</i> -statistic)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jarque–Bera	0.70		3.65		1.60		1.59	
Probability (Jarque–Bera)	0.69		0.16		0.45		0.45	
Number of observations	203	203	203	203	203	203	203	203

Note: Coefficients and Huber–White heteroscedasticity robust standard errors (in parentheses) are shown.

**Coefficient significant at the 0.01 level, *significant at the 0.05 level.

migration flows. In CROZET's (2004) words 'it seems very unlikely that a catastrophic core-periphery pattern will emerge within European Countries, or a fortiori on a greater scale' (p. 457). Taking into consideration Crozet's findings, one can admit that migration has little influence on the configuration of the spatial educational attainment structure in the EU.

APPENDIX A

From the zero profit condition (ZPC) in the agricultural sector (equation 5), one can express the derivative of unskilled wages as follows:

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

Substituting this expression into the ZPC of manufacturing sector, one obtains the following expression (note that $(1-\alpha) = \beta$):

$$\left(\alpha - \frac{\beta\phi}{1-\phi}\right) \frac{dw_i^S}{w_i^S} = -\left[\frac{1}{\sigma}\right] \gamma$$

Taking into account that:

$$\left(\alpha - \frac{\beta\phi}{1-\phi}\right) > 0 \quad \frac{\alpha}{\beta} > \frac{\phi}{1-\phi}$$

therefore:

$$\frac{dw_i^U}{w_i^U} > 0 \quad \frac{dw_i^S}{w_i^S} < 0 \quad \frac{d(w_i^S/w_i^U)}{w_i^S/w_i^U} < 0$$

APPENDIX B

List of regions

Codes and names of the EU-203 NUTS2 regions included in the analysis:

(AT) Austria (nine regions): (AT11) Burgenland, (AT12) Niederösterreich, (AT13) Wien, (AT21) Kärnten, (AT22) Steiermark, (AT31) Oberösterreich, (AT32) Salzburg, (AT33) Tirol, (AT34) Vorarlberg.

(BE) Belgium (11 regions): (BE1) Bruxelles, (BE21) Antwerpen, (BE22) Limburg, (BE23) Oost-Vlaanderen, (BE24) Vlaams Brabant, (BE25) West-Vlaanderen, (BE3) Région Wallonne, (BE31) Brabant Wallon, (BE32) Hainaut, (BE33) Liège, (BE34) Luxembourg, (BE35) Namur.

(DE) Germany (40 regions): (DE11) Stuttgart, (DE12) Karlsruhe, (DE13) Freiburg, (DE14) Tübingen, (DE21) Oberbayern, (DE22) Niederbayern, (DE23) Oberpfalz, (DE24) Oberfranken, (DE25) Mittelfranken, (DE26) Unterfranken, (DE27) Schwaben, (DE3)

Berlin, (DE4) Brandenburg, (DE5) Bremen, (DE6) Hamburg, (DE71) Darmstadt, (DE72) Gießen, (DE73) Kassel, (DE8) Mecklenburg-Vorpommern, (DE91) Braunschweig, (DE92) Hannover, (DE93) Lüneburg, (DE94) Weser-Ems, (DEA1) Dusseldorf, (DEA2) Köln, (DEA3) Münster, (DEA4) Detmold, (DEA5) Arnsberg, (DEB1) Koblenz, (DEB2) Trier, (DEB3) Rheinhessen-Pfalz, (DEC) Saarland, Chemnitz, (DED2) Dresden, (DED3) Leipzig, (DEE1) Dessau, (DEE2) Halle, (DEE3) Magdeburg, (DEF) Schleswig-Holstein, (DEG) Thüringen.

(DK) Denmark (one region): (DK) Danmark.

(ES) Spain (17 regions): (ES11) Galicia, (ES12) Principado de Asturias, (ES13) Cantabria, (ES21) Pais Vasco, (ES22) Comunidad Foral de Navarra, (ES23) La Rioja, (ES24) Aragón, (ES3) Comunidad de Madrid, (ES41) Castilla y León, (ES42) Castilla-la Mancha, (ES43) Extremadura, (ES51) Cataluña, (ES52) Comunidad Valenciana, (ES53) Islas Baleares, (ES61) Andalucía, (ES62) Región de Murcia, (ES63) Ceuta y Melilla.

(FI) Finland (six regions): (FI13) Itä-Suomi, (FI14) Väli-Suomi, (FI15) Pohjois-Suomi, (FI16) Uusimaa (Suuralue), (FI17) Etelä-Suomi, (FI2) Åland.

(FR) France (22 regions): (FR1) Île de France, (FR21) Champagne-Ardenne, (FR22) Picardie, (FR23) Haute-Normandie, (FR24) Centre, (FR25) Basse-Normandie, (FR26) Bourgogne, (FR3) Nord-Pas-de-Calais, (FR41) Lorraine, (FR42) Alsace, (FR43) Franche-Comté, (FR51) Pays de la Loire, (FR52) Bretagne, (FR53) Poitou-Charentes, (FR61) Aquitaine, (FR62) Midi-Pyrénées, (FR63) Limousin, (FR71) Rhône-Alpes, (FR72) Auvergne, (FR81) Languedoc-Roussillon, (FR82) Provence-Alpes-Côte d'Azur, (FR83) Corse.

(GR) Greece (13 regions): (GR11) Anatoliki Makedonia, (GR12) Kentriki Makedonia, (GR13) Dytiki Makedonia, (GR14) Thessalia, (GR21) Ipeiros, (GR22) Ionia Nisia, (GR23) Dytiki Ellada, (GR24) Sterea Ellada, (GR25) Peloponnisos, (GR3) Attiki, (GR41) Voreio Aigaio, (GR42) Notio Aigaio, (GR43) Kriti.

(IE) Ireland (two regions): (IE01) Border, Midland and Western, (IE02) Southern and Eastern.

(IT) Italy (20 regions): (IT11) Piemonte, (IT12) Valle d'Aosta, (IT13) Liguria, (IT2) Lombardia, (IT31) Trentino-Alto Adige, (IT32) Veneto, (IT33) Friuli-Venezia Giulia, (IT4) Emilia-Romagna, (IT51) Toscana, (IT52) Umbria, (IT53) Marche, (IT6) Lazio, (IT71) Abruzzo, (IT72) Molise, (IT8) Campania, (IT91) Puglia, (IT92) Basilicata, (IT93) Calabria, (ITA) Sicilia, (ITB) Sardegna.

(LU) Luxembourg (one region): (LU) Luxembourg (Grand-Duché).

(NL) Netherlands (11 regions): (NL11) Groningen, (NL12) Friesland, (NL13) Drenthe, (NL21) Overijssel, (NL22) Gelderland, (NL23) Flevoland, (NL31) Utrecht, (NL32) Noord-Holland, (NL33) Zuid-Holland, (NL34) Zeeland, (NL41) Noord-Brabant.

(PT) Portugal (five regions): (PT11) Norte, (PT12) Centro, (PT13) Lisboa e Vale do Tejo, (PT14) Alentejo, (PT15) Algarve.

(SE) Sweden (eight regions): (SE01) Stockholm, (SE02) Östra Mellansverige, (SE04) Sydsverige, (SE06) Norra Mellansverige, (SE07) Mellersta Norrland, (SE08) Övre Norrland, (SE09) Småland med Öarna, (SE0A) Västsverige.

(UK) United Kingdom (37 regions): (UKC1) Tees Valley and Durham, (UKC2) Northumberland and Tyne and Wear, (UKD1) Cumbria, (UKD2) Cheshire, (UKD3) Greater Manchester, (UKD4) Lancashire, (UKD5) Merseyside, (UKE1) East Riding and North Lincolnshire, (UKE2) North Yorkshire, (UKE3) South Yorkshire, (UKE4) West Yorkshire, (UKF1) Derbyshire and Nottinghamshire, (UKF2) Leicestershire, Rutland and Northamptonshire, (UKF3) Lincolnshire, (UKG1) Herefordshire, Worcestershire and Warwickshire, (UKG2) Shropshire and Staffordshire, (UKG3) West Midlands, (UKH1) East Anglia, (UKH2) Bedfordshire and Hertfordshire, (UKH3) Essex, (UKI1) Inner London, (UKI2) Outer London, (UKJ1) Berkshire, Buckinghamshire and Oxfordshire, (UKJ2) Surrey, East and West Sussex, (UKJ3) Hampshire and Isle of Wight, (UKJ4) Kent, (UKK1) Gloucestershire, Wiltshire and North Somerset, (UKK2) Dorset and Somerset, (UKK3) Cornwall and Isles of Scilly, (UKK4) Devon, (UKL1) West Wales and the Valleys, (UKL2) East Wales, (UKM1) North Eastern Scotland, (UKM2) Eastern Scotland, (UKM3) South Western Scotland, (UKM4) Highlands and Islands, (UKN) Northern Ireland.

Codes and names of Central and Eastern European countries NUTS2 regions included in the Market Access Computations (which also include the regions listed in part A of this Appendix):

(BG) Bulgaria (six regions): (BG01) Severozapaden, (BG02) Severen Tsentralen, (BG03) Severoiztochen, (BG04) Yugozapaden, (BG05) Yuzhen Tsentralen, (BG06) Yugoiztochen.

(CH) Cyprus (one region).

(CZ) Check Republic (eight regions): (CZ01) Praha, (CZ02) Strední Cechy, (CZ03) Jihozápad, (CZ04) Severozápad, (CZ05) Severovýchod, (CZ06) Jihovýchod, (CZ07) Strední Morava, (CZ08) Moravskoslezsko.

(HU) Hungary (seven regions): (HU01) Közép-Magyarország, (HU02) Közép-Dunántúl, (HU03) Nyugat-Dunántúl, (HU04) Dél-Dunántúl, (HU05) Észak-Magyarország, (HU06) Észak-Alföld, (HU07) Dél-Alföld, (HUN) Eesti (one region).

(LT) Lithuania (one region).

(LV) Latvia (one region).

Malta (one region).

(PL) Poland (16 regions): (PL01) Dolnoslaskie, (PL02) Kujawsko-Pomorskie, (PL03) Lubelskie,

(PL04) Lubuskie, (PL05) Łódzkie, (PL06) Malopolskie, (PL07) Mazowieckie, (PL08) Opolskie, (PL09) Podkarpackie, (PL0A) Podlaskie, (PL0B) Pomorskie, (PL0C) Slaskie, (PL0D) Swietokrzyskie, (PL0E) Warminsko-Mazurskie, (PL0F) Wielkopolskie, (PL0G) Zachodniopomorskie.

(RO) Romania (eight regions): (RO01) Nord-Est, (RO02) Sud-Est, (RO03) Sud, (RO04) Sud-Vest, (RO05) Vest, (RO06) Nord-Vest, (RO07) Centru, (RO08) Bucuresti.

(SK) Slovakia (four regions): (SK01) Bratislavský, (SK02) Západné Slovensko, (SK03) Stredné Slovensko, (SK04) Východné Slovensko.

(SL) Slovenia (one region).

NOTES

1. One of the most important policies in fostering growth in backward regions is the European Union Regional Policy. With respect to its effectiveness, the opinions of scholars are divergent (BASILE *et al.*, 2001; BOLDRIN and CANOVA, 2001; FAÍÑA and LÓPEZ-RODRÍGUEZ, 2001, 2004; RODRÍGUEZ-POSE and FRATESI, 2004).
2. Studies examining the link between human capital and growth include BENHABIB and SPIEGEL (1994), BILS and KLENOW (2000), EICHER and GARCIA-PENALOSA (2001), GALOR and MOUNTFORD (2002), and MANKIW *et al.* (1992).
3. For recent empirical contributions, see BRAKMAN *et al.* (2004), BREINLICH (2005), LÓPEZ-RODRÍGUEZ and FAÍÑA (2004), HANSON (2005), LÓPEZ-RODRÍGUEZ *et al.* (2005), MION (2003), NIEBUHR (2004), REDDING and VENABLES (2004), and ROOS (2001). For two recent empirical surveys in geography and trade, see OVERMAN *et al.* (2003) and HEAD and MAYER (2004). For early contributions of geography and income, see GALLUP *et al.* (1998, 2000), HUMMELS (1999), LEAMER (1997), and RADELET and SACHS (1998).
4. REDDING and SHOTT (2003) use three samples of world countries depending on the availability of the data for the regressions they carry out. The largest contains 105 countries; the intermediate 66; and the smallest 49. In all cases the theoretical predictions of the model are confirmed.
5. BREINLICH (2005) also applies an NEG model based on the assumption of immobile labour for the analysis of the spatial wage structure in the European Union regions.
6. The countries they consider in their analysis are Germany, Italy, France, Spain and the UK; the period of observation is 1950–90.
7. CROZET (2004) deals with the analyses of the effects of market potential on migration flows within five European Union Countries: Germany, Italy, Spain, the Netherlands and the UK.
8. The results are not distorted by this adaptation. Works carried out at an international level using both the theory-based measure and the alternative market potential function reach very similar results (REDDING and VENABLES, 2004). For other studies dealing with regional analysis that have used measures of market

- access similar to the present paper, see NIEBUHR (2004) and HANSON (2005).
9. NUTS is a Eurostat classification that provides a single uniform breakdown of territorial units for the production of regional statistics for the European Union. The present NUTS nomenclature valid from 11 July 2003 onwards and extended to cover the EU-25 on 1 May 2004 subdivides the economic territory of the European Union (EU-25) into 89 regions at the NUTS1 level, 254 regions at NUTS2 level and 1214 regions at the NUTS3 level. For the list of NUTS2 regions included in this analysis, see Appendix B.
 10. The difference with REDDING and SHOTT (2003) model is that in the present model manufacturing production does not use intermediate goods in the production of final output.
 11. Individual ability is determined by human biology. The probability of finding individuals with a particular level of ability can be assumed to be the same across all locations.
 12. The analysis of the demand side of the model (consumer side), which is similar to standard New Economic Geography models, is skipped. For more details, see BREINLICH (2005), FUJITA *et al.* (1999), REDDING and SCHOTT (2003), and REDDING and VENABLES (2004).
 13. This is another version of the so-called nominal wage equation. For full details about the derivation, see LÓPEZ-RODRÍGUEZ and FAÍÑA (2004), REDDING and SCHOTT (2003), REDDING and VENABLES (2004), and BREINLICH (2005).
 14. It is a natural assumption that as one considers increasingly higher levels of ability, there will be fewer individuals more able than this level.
 15. See the proof in Appendix A.
 16. The three levels of educational attainment defined here as low, medium and high can also be alternatively defined as primary, secondary and tertiary education. Primary education would correspond to ISCED levels 1 and 2. Students generally begin primary education between the ages of 5 and 7 years and end at 13–15 years. Secondary education consists of ISCED levels 3 (designated ‘upper secondary education’) and 4 (designated ‘post-secondary non-tertiary education’), and students generally begin between 13 and 15 years of age and finish between 17 and 18 years of age. Tertiary education corresponds to ISCED levels 5 and 6.
 17. The International Standard Classification of Education is an instrument used for assembling, compiling and presenting statistics of education. Eurostat provides data based on the 1976 and 1997 versions of ISCED. For further details about ISCED, see UNESCO (1998).
 18. For a comprehensive analysis of the Spatial Structure of Europe, see FAÍÑA *et al.* (2001).
 19. Representation of regional market access computations in Fig. 1 is based on a five-interval classification of market access values depicted in graduated tones. The lowest interval (the first is represented by the lightest tone) comprises all regions whose market access value is $\leq 200\ 000$; the second interval comprises regions with market access values $\leq 600\ 000$ but $> 200\ 000$; the third interval comprises regions with market access values $\leq 800\ 000$ but $> 600\ 000$; the fourth interval comprises regions with market access values $\leq 1\ 200\ 000$ but $> 800\ 000$; and the fifth interval (the highest interval represented with the darkest tone) comprises regions with market access $> 1\ 200\ 000$.
 20. Market access is negatively correlated with distance to Luxembourg.
 21. REDDING and SHOTT (2003) define ‘higher education’ as those who have surpassed primary education. However, they also mention that the results are robust for different definitions of higher education (e.g. only considering secondary education attainment).
 22. Outliers are identified as those observations for which Cook’s distance > 1 .
 23. This synthetic indicator for human capital levels has been used in many empirical studies (BENHABIB and SPIEGEL, 1994; TEMPLE, 1999; KRUEGER and LINDAHL, 1999; DE LA FUENTE and DOMENÉCH, 2001).
 24. With respect to tertiary education it is difficult to give a standard figure in terms of the number of years of education since university systems vary across countries. For a comprehensive analyses, see DE LA FUENTE and DOMENÉCH (2002).
 25. The statistic reported in ordered probit models to check the significance of the estimated coefficient is the z -statistic instead of the t -statistic from OLS.
 26. The authors thank an anonymous referee for pointing out this possible shortcoming of their analysis.
 27. The countries included in the analysis are Germany, Italy, Spain, the Netherlands and the UK.

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