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The Effects of Economic Geography on Education in Romania*

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Abstract. *This paper evaluates the role that geography plays in determining the distribution of educational attainment levels among Romanian counties. We provide evidence that, in Romania, educational levels are higher in those counties with greater market access. This finding corroborates the theoretical predictions of the Redding and Schott´s (2003) model and proves that remoteness is a penalty for the economic development and convergence of the Romanian counties.*

Keywords: Economic Geography; Education Attainment Levels; Romania.

JEL Codes: R11, R13, R14, F12, F23.
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1. Introduction

There is a wide scholarly agreement of the impact of Human capital on economic growth, however there is little consensus on the exact contributions of the different measures and indicators of human capital to economic development (Levine and Renelt, 1992, Rodriguez-Pose and Vilalta-Buffi, 2005). However, the relationship between human capital and economic geography and its implications for economic development is far less studied. Redding and Schott's (2003) pioneering paper extend a standard two-sector New Economic Geography model to demonstrate that being located on the economic periphery can reduce the return to skills, thereby reducing incentives for investment in human capital accumulation. Lopez-Rodriguez et al. (2007) applied Redding and Schott´s (2003) model to estimate the relationship between educational attainment levels and market access for a cross regional sample of NUTS 2 regions in Europe, showing that the model´s predictions hold in the case of Europe. The literature of New Economic Geography lacks this type of empirical studies and to the best of our knowledge there are not studies at the country level on the Redding and Schott's (2003) model.

In this paper we derive the structural equations which relate human capital endowments and geographical location of Redding and Schott's (2003) model and estimate them for a sample of 42 Romanian regions in the year 2006. The results of the estimations give validity to the forces put at work in Redding and Schott's (2003) model for the case of Romania and show that there is a spatial structure of educational attainment levels across Romanian counties. The results show the importance of market access in explaining Romanian human capital levels. In fact between 45% and 59% human capital levels is explained by the region's market access.

The rest of the paper is structured as follows: Section 2 briefly describes the model. Section 3 shows the approximation to the empirical estimation and describes the data used in the analysis. Section 4 contains the results of the econometric estimations. Finally, Section 5 has the conclusions and the main policy implications.

2. The model

The theoretical framework presented in this paper is a short version of the Redding and Schott (2003) New Economic Geography model.

We consider a world in which we have R locations and each location have a mass of consumers L_i. We assume that consumers are endowed with one unit of labour which is offered inelastically with zero disutility and that consumers

choose endogenously whether to invest or not in becoming skilled. In the decision of becoming skilled a worker has to compare the costs of education to acquire those skills with the future benefits of been skilled, which for the purposes of this paper can be summarized in the higher wages skilled workers perceive.

Therefore, the decision of an individual (z) at location $i \in \{1,...,R\}$ to become a skilled worker would be given by the wage differential between the two options, difference of wages of a qualified worker versus an unskilled one, and the costs associated with educate himself.

In this paper we skip the modelling of the demand side which is no necessary for the theoretical premises of our empirical investigation. Therefore, we focus on the agriculture and manufacturing equilibrium conditions (supply side), to characterize endogenously the relationship between geographical location and human capital accumulation.

The profit function of a typical firm at location i can be given by the following expression:

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

where: P_{ij}^M is the price at location j of one unit produced at location i, w_i^S is the wage of skilled workers with a share (α) in the total costs, w_i^U is the wage of unskilled workers with a share $(1-\alpha)$ in the total costs, c_i is a marginal input specific to each location representing a technology index. F is a fixed cost of production and $x_i = \sum_{j=1}^{R} x_{ij}$ is the total output produced by the company for all markets it serves.

Once we solve for the first order conditions of profit maximization, the expression in the manufacturing sector implies:

$$(w_i^S)^{\alpha} (w_i^U)^{1-\alpha} = \xi c_i^{-1} (MA_i)^{\frac{1}{\sigma}}, \qquad (2)$$

where: $\xi = \frac{\sigma - 1}{\sigma}$ is a constant, c_i is the parameter that reflects differences in technology between locations, $MA_i = \sum_{j=1}^{R} (T_{ij}^M)^{1-\sigma} E_j G_j^{\sigma-1}$ is the market access at

location i and σ the elasticity of substitution between varieties of manufactured goods.

The equation (2) gives us the equilibrium value for the wages of skilled and unskilled workers.

Therefore, this new equilibrium implies a higher critical level for the skill parameter (a_i^*) above which individuals prefer to invest in education and become skilled and thus we will have a lower supply of skilled workers. In this derivation we assume that the number of individuals with higher and higher levels of skills decreases as we move further away from those thresholds.

We can express the derivative of the wage of unskilled workers as follows:

$$\frac{dw_i^U}{w_i^U} = -\frac{\phi}{(1-\phi)}\frac{dw_i^S}{w_i^S}. \tag{3}$$

This intuitive explanation is based on the fact that a decrease in market access modifies the initial equilibrium conditions in the manufacturing sector, which experience a decrease in size. This decrease in size, frees more skilled labour than the ones that are initially demand in the agricultural sector.

So to re-establish the equilibrium, the nominal wage paid to skilled workers must decrease and that nominal wages paid to unskilled workers must increase in relative terms. Therefore as the wages of skilled workers decrease this reduces the incentives to invest in becoming skilled.

3. Data and Econometric Specifications

The equation (2) in last section relates for the manufacturing sector wages of skilled and unskilled workers with locations´ market access. This equation can be translated quite easily into a regression equation by applying logs and considering the different educational attainment levels as the dependent variable. Therefore we can estimate the following equation:

$$Ln(E_i) = \beta_0 + \beta_1 \ln(MA_i) + \upsilon_i, \tag{4}$$

where: E_i represents the educational attainment level in region i, MA_i represents the market access for region i and υ_i represents the disturbance term. Equation (4) is going to be our benchmark estimation and checks for the relationship between secondary and tertiary educational attainment levels and market access.
Educational attainment levels for the benchmark estimations are defined based on the percentage of each Romanian region's population that has attained secondary and tertiary education which will be labelled in the econometric

estimations as *log Higher Education* and in the percentage of each Romanian region's population that has attained primary education which will be labelled in the estimations as *log Lower Education*. The Romanian institute for National Statistics (INSSE) provides us with these data for the year 2006. We have also carried out an alternative estimation to the one show in equation (4) based on a different definition of the dependent variable. The alternative will consist of ranking educational attainment levels accordingly with the level of education achieved in the counties, i.e., we assign the value 1 when low educational attainment levels are the most predominant, 2, if medium and high educational attainment levels are the most predominant and then estimate an ordered probit model.

The dependent variable in the regression equation is the logarithm of educational attainment levels. We define two different types of educational attainment levels. In first place we consider the percentage of each Romanian region's population that has attained secondary and tertiary education which will be labelled in the econometric estimations as *log Higher Education.* In second place we define a new educational attainment level variable which takes in the percentage of each Romanian region's population that has attained primary education which is labelled in the estimations as *log Lower Education*. Both higher and lower educational attainment levels data are taken from the Romanian National Statistical Institute (INSSE) and refer to the year 2006.

Regarding to the main independent variable in expression (4) it is the regions' market access. We built this variable for each Romanian county as a weighted sum of regional GDPs in the surrounding locations where the weighted scheme is the distance measured in Kms between the capital cities of each Romanian region. GDP data is taken from the Romanian office for National Statistics (INSSE) and the data on bilateral distances comes from the website www.travelworld.ro**.** Regions internal distance is modelled proportional to the square root of the regions´area following the expression $0.66\sqrt{\frac{Area}{\pi}}$ where "*Area*" represents the size of the region expressed in km^2 (see Crozet 2004, Head and Mayer, 2000, and Nitsch, 2000) for a discussion of this measure of internal distance).

4. Economic Geography and Educational Attainment Levels: Estimation results

Table 1 provides us with 2006 data on the percentage of individuals in each Romanian region that has attained primary education (labelled as lower education) or secondary and tertiary education (labelled as higher education). The highest percentages of individuals with higher education are reach in the so called

economic centers of Romania; Bucharest, Iaşi, Timişoara, Cluj-Napoca, Constanța, Braşov and Craiova where also the country's main universities are. The percentages figures on higher education in these regions are well above the country's average (8.55%) being Bucharest the region which ranks at the top (18.19%). On the other site, the Romanian regions located far from the above poles of growth in the so called *Romanian economic periphery* such as Piatra-Neamț Târgu Mureş, Tulcea, Satu Mare, Botoşani, Vaslui, Olt, Teleorman have figures on higher education below the country's average (6.97%).

Table 1

Educational Attainment Levels in Romania (2006)

Region/County	Lower Education	Higher Education	Region/County	Lower Education	Higher Education
Bacău	10.07	5.95	Mehedinți	8.75	6.43
Botoşani	10.44	4.77	Olt	9.28	4.88
Iaşi	9.91	12.74	Vâlcea	8.85	5.97
Neamț	9.50	1.97	Arad	8.48	7.87
Suceava	11.25	6.79	Caraş-Severin	8.68	8.37
Vaslui	10.66	6.12	Hunedoara	8.59	7.19
Brăila	8.00	5.32	Timiş	8.25	12.17
Buzău	8.62	4.67	Bihor	9.12	9.43
Constanța	8.55	9.97	Bistrița-Năsăud	9.93	5.40
Galați	9.12	7.81	Cluj	7.46	14.67
Tulcea	4.45	4.40	Maramureş	8.80	6.49
Vrancea	8.69	4.24	Satu Mare	9.68	5.32
Argeş	4.58	7.98	Sălaj	9.25	5.21
Călăraşi	9.09	4.46	Alba	8.58	6.88
Dâmbovița	9.32	6.19	Braşov	7.76	10.41
Giurgiu	8.92	2.80	Covasna	8.97	5.59
Ialomița	9.22	5.25	Harghita	8.95	6.01
Prahova	7.99	6.10	Mureş	8.85	3.95
Teleorman	8.10	4.22	Sibiu	9.06	10.63
Dolj	8.46	8.91	Ilfov	0.90	3.02
Gorj	9.95	8.03	Bucureşti	5.91	18.19
	Computations including Bucureşti			**Computations excluding Bucureşti**	
Average Ed. A.	8.55	6.97	Average Ed. A.	8.61	6.70
Minimum Ed. A.	0.90	1.97	Minimum Ed. A.	0.90	1.97
Maximun Ed. A.	11.25	18.19	Maximun Ed. A.	11.25	14.67
Ratio max/av	1.32	2.61	Ratio max/av	1.31	2.19
Ratio max/min	12.49	9.23	Ratio max/min	12.49	7.44

Source: author's elaboration based on INSSE data.

Table 2

Market Access and Educational Levels: Baseline Estimations Romania (2006)

Dep. Variable	*log Higher Education*			*Log Lower Education*		*Ei,j*
Regress.	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Constant	1.09* (0.16)	1.20** (0.16)	2.14** (0.16)	4.49** (0.07)	4.54** (0.09)	1.57** (0.10)
MAGDP06	0.25** (0.03)	0.22** (0.04)		-0.15** (0.02)	-0.17** (0.02)	0.11** (0.02)
Dist.Timisoara			-0.0007 (0.000)			
$D_{i,j}$						0.20** (0.06)
Est.	OLS	IV	OLS	OLS	IV	OLS
Inst. variables						
First stage R2		0.62			0.62	
R2	0.59	0.58	0.09	0.59	0.59	0.27
J-Statistic						
Prob (F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
N.obs.	42	42	42	42	42	84

Note: Table displays coefficients and Huber-White heteroscedasticity robust standard errors in parenthesis, ** indicates coefficient significant at 0.01 level, "First stage" R2 is the R2 from regressing market access on the instruments set, Instruments: Distance to Timişoara and region size.

Source: author's elaboration.

Table 2 presents the results of estimating equation (4) on the sample of 42 regions in Romania for the year 2006. In Column 1 we regress Log Higher Education on market access for the set of 42 Romanian regions. The results of the OLS estimation show that the coefficient of market access has the expected sign and is statistically significant at the 1% level. The results also show that doubling regions'market access would increase secondary and tertiary education attainment levels by 25%. The null hypothesis that the coefficient on market access is equal to zero is easily rejected at conventional significance levels using a standard F-test, and the model explains over 59% of the cross-regional variation in secondary and tertiary educational levels.

In column 4 we summarize the results of regressing the percentage of population with primary education (labelled as *Log Lower Education* in the table) against market access. The results of the OLS estimation indicate that an increase in regional market access is negatively correlated with the percentage of population who has primary education. This result constitutes an indirect way of checking the theoretical predictions of the model.

A potential shortcoming of the previous analysis is the one 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 Romanian regions and therefore cause inconsistent and biased estimates. To avoid problems of endogeneity between human capital levels and regional market access, the paper presents instrumental variables estimates in columns 2 and 5. These estimations are based on the existence of a set of instruments that are strongly correlated with the original endogenous variables but asymptotically uncorrelated with the error term. 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. Once these instruments are identified, they are used to build a proxy for the explanatory endogenous variables which consists of their predicted values in a regression on both the instruments and the exogenous variables(2).

In this paper we propose to use mainly accessibility variables as instruments, since they are highly correlated with our market access variable but also non contemporary correlated with the errors. We instrument market access with distance from Timişoara and with the region size in a similar vein as Breinlich (2006). The first instrument capture market access advantages of regions close to the geographic centre of Romania. The second instrument captures the advantage of large regional markets in the composition of domestic market access.

Columns 2 and 5 present the results for the corresponding instrumental variables estimation. Instruments are highly statistically significant and have the expected signs in the first stage. Distance to Timişoara and regions size explains 62% of regional market access. Since the instruments represent quite a distinct source of information and are uncorrelated, we can trust them to be reliable instruments. In the second-stage estimation we again find positive and highly statistically significant effects of market access on educational attainment levels although its effects are lower than in the OLS estimations. The market access coefficients change from 0.25 to 0.22 in the regression of log higher education against market access (column 2) and from –0.15 to –0.17 in the regression of log lower education against market access (column 5).

For comparison purposes, column 3 reports the result of regressing log higher education against distances from Timişoara instead of using market access. The result provides evidence of the negative correlation between secondary and tertiary educational attainment levels and regions distance from Timişoara and therefore back our results.

5. Conclusions and Policy Lessons

This paper provides and empirical estimation of the Redding and Schott (2003) model in a national setting such as Romania. The results obtained in the econometric estimations allow us to corroborate the main forces at work in the Redding and Schott (2003) model showing that market access plays an important role in the configuration of the spatial structure of educational attainment levels across Romanian counties.

Our investigation on the effects of economic geography on educational attainment levels in Romania delivers a message for policy-markers and for policy action in general. We have proved that being located in the economic periphery of the country implies that human capital levels in those areas will be hampered, therefore in order to solve the problem these areas are facing (lack of human capital investment) and to put them back on truck policy measures should be designed to cope with this lack of incentives to invest in human capital .Perhaps one of the most important policy action that can be carried out is to improve infrastructures (e.g. roads, ports, etc.) which will bring closer together the economic periphery and the economic center of the country and which in the case of Romania are still very much lagging behind.

Notes

(1) By first nature geography we refer to the physical geography of a country (natural endowments, climate conditions, access to ports, airports, navigable rivers and so). Second nature geography refers to the economic geography, i.e. how far a country or region is from its consumer markets and from its input suppliers.

(2) The statistic reported in ordered probit models to check the significance of the estimated coefficient is z-statistic instead of t-statistic from OLS.

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