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Geographical Economics and Income Disparities Across Ecuadorian Regions: Analysis for the period 2007-2014

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Abstract:

This paper focuses on the analysis of the role played by market potential in the spatial income structure observed in Ecuador over the period 2007-2014.

Based on the geographical economics theory we derive the so called nominal wage equation which establishes a relationship between nominal wages and a distance weighted sum of the volume of economic activities in surrounding locations which is usually known as market potential.

The estimation of this equation using Ecuadorian provincial data over the period 2007-2014 reveals that market potential plays a crucial role in explanation of the spatial distribution of per capita income. The results of our estimations are robust to the potential endogeneity problems of market potential which have been dealt with by using historical values of market potential and instrumental variables.

Finally, we have also discovered a potential channel that could be affecting the spatial structure of per capita income in Ecuador, which is human capital.

Keywords: *Provincial Disparities, Spatial Structure of Income, Market Potential, Ecuador.*

JEL code: *R11, R12, R13, R14, F12, F23.*

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1. Introduction

Differences in the levels of development across regions within countries is almost a natural feature. In the case of Europe, differences in regional income levels within countries is quite sizeable in many of them: for instance in Italy (Northern regions versus Southern regions), Spain (Northeastern regions versus South and East regions), Portugal (North versus South) and in most Central and Eastern European countries the Western regions of these countries are more developed than the Eastern ones. These patterns have raised considerable concerns in popular debates as well as in policy circles and have led to the establishment of policies aimed at levelling out of income differences and at allowing a catch-up of peripheral regions.

In the case of Ecuador a phenomena similar to the one described for the European countries is at work[3]. Per capita income levels differ by significant amounts across the Ecuadorian provinces. In the year 2014, the ratio between the per capita income of Sucumbios (Oil-producing province) and the average per capita income across the Ecuadorian provinces was 1.51 or in other words, the per capita GDP of Sucumbios was 150% higher than the average per capita GDP in Ecuador. If we exclude the oil-producing provinces (Sucumbios, Orellana and Pastaza) the 2014 difference between Pichincha's per capita income and the average per capita income in Ecuador was 8151.80$ (per capita income in Quito is 110% higher than the country's average) . Even if we discard Pichincha, the ratio between the second wealthiest province in Ecuador (Guayas) and the average per capita income of the country is 0.62, which is a quite sizeable difference.

There are different approaches taken by the economic theory to explain these income differences. On the one hand we can resort to the economic growth theory to deliver potential explanations for these facts which go from differences in saving rates, investment rates to problems of technology diffusion (see Barro and Sala-i-Martin, 1991, 1995 among others). On the other hand we can deliver other messages based on traditional development theories which put the emphasis on first nature geography characteristics of the locations, hours of sunshine, endowments of hydrocarbons, access to navigable rivers, etc. (see for instance Hall and Jones, (1999)). This paper takes a different approach to the analysis of the differences in income levels across the Ecuadorian provinces. The so-called New Economic Geography (NEG) or Geographical Economics (GE) (Krugman 1991, 1992) has provided another conceptual framework within which the geographical structure of production and income levels can be analyzed explicitly. This field has experienced rapid advances in the last two decades both from and theoretical as well as empirical side.

[3] *A very comprehensive analysis of income disparities in Ecuador over the period 2007-2014 can be found in Sotomayor-Pereira PhD Thesis (2019, forthcoming).*

This paper applies the geographical economics framework in an exhaustive empirical investigation of the income structure at the level of provinces in Ecuador. Therefore it is part of the growing literature that uses the theoretical tools from the Geographical Economics to analyze the impact of distance from markets on income levels. In a more technical way, what we will do in this paper is to test one of the main predictions of these models, the so called nominal wage equation, for the case of the Ecuadorian provinces over the period 2007-2014. The basic idea is that in a world where regions or countries specialize in certain goods and export them, firms in locations which are further away from main consumer markets or input suppliers will have to pay more for shipping their goods and buy their intermediate inputs and therefore the value added left to remunerate their local factors of production, among them workers will be lower.

The paper finds widely support to the theoretical predictions related to the nominal wage equation of the Geographical Economics literature, i.e, the elasticity of per capita income with regard to market potential is positive, statistically significant and economic important across the different estimations carried out in the paper. Therefore, distance from markets matters and seems when looking at differences in income per capita across Ecuadorian provinces. Another important contribution of this paper lies in disentangling the channels through which market potential affects the levels of economic development in Ecuador. In particular we have include as additional control to the baseline estimation human capital, to capture the potential indirect effects of economic geography. The results of the estimations show that human capital could be important driver of per capita income levels.

The remaining of the paper is structured as follows: First in the second section, we study the dispersion of the economic development levels among provinces of Ecuador, using per capita income as a proxy for the economic development levels. The results of the spatial descriptive analysis will confirm the existence of sizeable regional disparities and strong spatial dependence in the distribution of per capita income. Next we estimate the coefficient of a simple specification, which reveals the positive and significant effect of market potential on per capita income levels. The theoretical economic rationale from the geographical economics literature that support these empirical results is outlined in the third section. In the fourth section we carry out the estimation of the nominal wage equation (baseline model) from the provincial panel data we have built for the period 2007-2014. In the fifth section several robustness checks to the baseline estimation are taken on board. On the one hand we control for potential endogeneity problems related to market potential and on the other we try to disentangle the effects of market potential on the Ecuadorian per capita income differences by controlling for regional differences in human capita. Finally, the sixth section presents the main conclusions of the paper.

2. The geography of income disparities across provinces in Ecuador

The levels of per capita income in the Ecuadorian provinces differ by significant amounts (Legarda, 2016). Excluding from the sample the oil-producing provinces the per capita income in Quito is well above the per capita income of any other Ecuadorian province. The economic evidence provided in this section of the paper was obtained from the Ecuadorian Central Bank and the Ecuadorian National Institute for Statistics using data for the twenty-three provinces of Ecuador over the period 2007-2014. We use the per capita income of each province as the standard measure of the level of economic development.

Table 1 shows the data of the nominal per capita income across Ecuadorian provinces for the years 2007, 2010 and 2014. The bottom part of the table provides some basic ratios which allow us to see how per capita income differences have evolved over the course of these years. If we pool the data for the periods (2007-2010) and (2011-2014) as it is shown in Table 1 the results show sizeable differences in terms of development levels across the Ecuadorian provinces. The computed ratios for the period 2007-2010 (Max1/Average1=5.67, Min1/Average1=0.35; Max2/Average2=1.99, Min2/Average2=0.56) show that the situation has been worsened as we move along in time. The ratios for the period 2011-2014 are (Max1/Average1=6.97, Min1/Average1=0.27; Max2/Average2=2.07, Min2/Average2=0.44). Pooling these data show that overall, we assist to a process of widening the gap in terms of per capita income across Ecuadorian provinces. Figure 1 depicts the political division of Ecuador

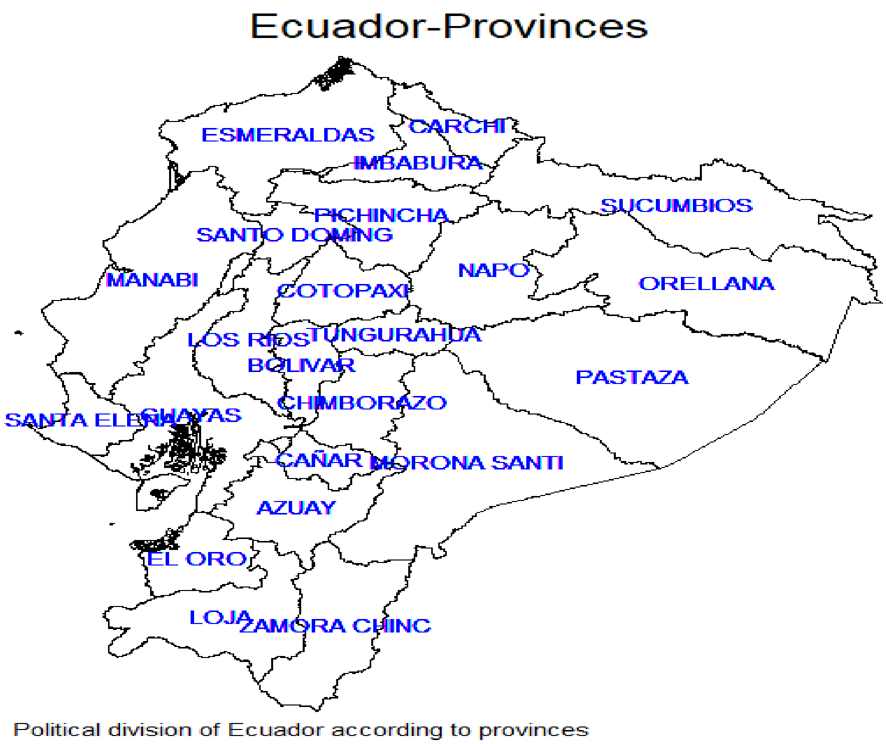
Table 1: *Per capita income across Ecuadorian provinces (2007-2010, 2011-2014)*

PROVINCES	**2007-2010**	**2011-2014**
Azuay	8.509,33	9.922,05
Bolívar	7.877,82	**3.012,85**
Cañar	4.301,05	6.366,16
Carchi	3.954,83	5.636,30
Cotopaxi	3.860,89	5.693,13
Chimborazo	3.457,17	5.075,06
El Oro	4.944,90	7.747,41
Esmeraldas	7.396,26	8.607,11
Guayas	8.306,36	10.114,29
Imbabura	4.172,85	6.841,17
Loja	4.019,71	5.532,16
Los Ríos	4.143,07	5.609,26
Manabí	4.367,56	6.095,79
Morona Santiago	3.367,27	3.850,88
Napo	4.958,15	4.317,02

Pastaza	11.443,72	15.954,44
Pichincha	11.219,11	14.009,25
Tungurahua	5.972,04	7.777,89
Zamora Chinchipe	**3.183,73**	3.969,67
Sucumbíos	31.424,38	26.941,61
Orellana	**50.875,39**	**77.610,15**
Santo Domingo	5.856,38	6.835,80
Santa Elena	8.470,65	8.240,40
Average1	8.960,11	11.119,99
Max1	50.875,39	77.610,15
Min1	3.183,73	3.012,85
Average2	5.616,96	6.762,68
Max2	11.219,11	14.009,25
Min2	3.183,73	3.012,85

Source: *Own elaboration; 1 means all provinces, 2 means excluding oil-producing provinces.*

Figure 1. *Equador Provinces*



The prediction of the core-periphery geographical economics models is that a big deal of the spatial pattern in the distribution of per capita income levels across different spatial settings has to do with the relative access to markets that the different units in the particular setting under consideration enjoy (Brakman *et al.*, 2004; 2009; Breinlich, 2006; Bruna *et al.*, 2015; Faiña and Lopez-Rodriguez, 2005; Fingleton, 2006; Hanson, 2005; Head and Meyer, 2006; 2011; Lopez-Rodriguez and Acevedo, 2013; López-Rodríguez and Faíña, 2006; Lopez-Rodriguez *et al.*, 2011; Niebuhr, 2006; Overman *et al.*, 2003). This relative access to markets, or alternatively, relative remoteness, can be proxied by the so-called market potential measure suggested initially by Harris (1954)[4]

2.1 Market potential: construction and summary statistics

Harris (1954) market potential (MP) of a Ecuadorian province i is defined as the summation of markets accessible to that province divided by the distance between province i and the remaining ones[5] . Therefore, the market potential of a province will be positively associated with the purchasing power of the remaining provinces but negatively related with the distance between each other. Mathematically, it adopts the following expression:

$$MP_{it} = \sum_{j=1}^{n} M_{jt} g(d_{ij}) \qquad (1)$$

Where MPit represents the Harris (1954) market potential function for province i in period t, Mjt is a measure of the purchasing power of province j in period t (usually approximated by its income level, gross value added or population), dij is a measure of the distance between two generic provinces i and j, g (·) is a decreasing function of the distance between two generic provinces i and j and n is the number of provinces considered. Additionally, the market potential of a given province i can be broken down into a domestic or internal component, market potential created by the province itself, (DMPit) and an external or foreign one, market potentials for that province of all remaining provinces in the area under consideration, (FMPit). Aproximating g (·) by the inverse of the distance between province i and j, (1/dij), and considering the two components of the market potential, the mathematical expression (1) can be easily expanded to this one:

$$MP_{it} = \sum_{j=1}^{n} \frac{M_{jt}}{d_{ij}} = \frac{M_{it}}{d_{ii}} + \sum_{j \neq i}^{n-1} \frac{M_{jt}}{d_{ij}} = DMP_{it} + FMP_{it} \qquad (2)$$

[4] The concept is analogous to that of population potential as proposed and mapped by Stewart (1947, 1948, 1952). It is an abstract index of the intensity of possible contact with markets. The concept is derived ultimately from physics, in which similar formulas are used in calculating the strength of a field, whether electrical, magnetic, or gravitational.
[5] The microeconomics grounds for the Harris (1954) market potential concept was first derived in the early nineties in the very influential Krugman's 1991 and 1992 papers on core-periphery geographical economics models.

In making the calculations of the internal distance (dii) the standard methodology assumes that provinces are circular, and the internal distance is approximated by a function that is proportional to the radius of the province. The radius of a circular-shaped province "i" of size equal to "areai" is $r_i = \sqrt{area_i / \pi}$. In this paper and following the work of Keeble et al. (1982), we will use $d_{ii} = 1/3 r_i = 0.188\sqrt{area_i}$ as the first option. On the other hand, following other authors such as Crozet (2004), Head and Mayer, (2000), and Nitsch (2000) we will use $d_{ii} = 2/3 r_i = 0.376\sqrt{area_i}$ as the second option. Both formulas have been frequently used in the literature and give the average distance in a circular location under the assumption that production takes place in the centre and consumers are spread evenly across space. With regards to the variable Mjt we will use GDP, Gross Valued added (GVA) and population of each province as proxies. Finally, distances will be measure both in kms between the capital cities of each province and in lorry travel times. Therefore, we will build six different measures of market potential for distances measured in Kms. and other six for distances measured in Lorry travel times. The market potential measures that use distances expressed in Kms. will be labelled as PMYA (market potential based on GDP, physical distances and dii = 1/3), PM3YA (market potential based on GDP, physical distances and dii = 2/3) , PMVYA (market potential based on GVA, physical distances and dii = 1/3), PM3VYA (market potential based on GVA, physical distances and dii = 2/3), PMP (market potential based on population, physical distances and dii = 1/3) y PM3P (market potential based on population, physical distances and dii = 2/3). The market potential measures that use distances expressed in lorry travel times will be labelled as PMYAT (market potential based on GDP, lorry tavel times and dii = 1/3), PM3YAT (market potential based on GDP, lorry tavel times and dii = 2/3) , PMVYAT (market potential based on GVA, lorry tavel times and dii = 1/3), PM3VYAT (market potential based on GVA, lorry tavel times and dii = 2/3), PMPT (market potential based on population, lorry tavel times and dii = 1/3) y PM3PT (market potential based on population, lorry tavel times and dii = 2/3).

Tables 2 and 3 provide some information on the average composition of market potential for the years 2007 and 2014 to evaluate how it has changed over time. We calculate these access measures separately for the first and the last year of our panel data set to check if significant changes in the composition of market potential have taken place. The total market potential has been broken down according to expression (2) into a domestic component and a foreign component and according to a weighting scheme based on a distance matrix expressed in kms (Table 2) and a distance matrix expressed in minutes of lorry travel times (Table 3). The first conclusion that can been obtained from Tables 2 and 3 is that both the average shares of market potential derived from own provinces (Domestic component) and from the rest of provinces (Foreign component) are kept roughly constant. Of course, these average shares vary quite substantially depending on the variable used to proxy the economic activity when computing market potential. When the variable that proxies, economic activity is GDP the domestic share of market potential represents around 25% of total market potential versus 75% represented by the foreign component no matter how we define internal distances. However internal distances play a role in the distribution of domestic and foreign shares of market potential when we use GVA and Population as proxies for economic activity. When we proxy economic activity by GVA or population and measure internal distances by $d_{ii} = 2/3r_i = 0.376\sqrt{area_i}$ the domestic and foreign shares are respectively 25% and 75%. However, measuring internal distances as $d_{ii} = 1/3r_i = 0.188\sqrt{area_i}$ and proxying economic activity by GVA or population we get a more balanced distribution (40% domestic component versus 60% foreign one).

Table 2. *Summary statistics on Market Potential (distance matrix expressed in kms)*

	2007	2014
Average fraction of Market Potential derived from own province (PM3YA)	24.77(%)	24.88(%)
Average fraction of Market Potential derived from rest of provinces (PM3YA)	75.23(%)	75.17(%)
Average fraction of Market Potential derived from own province (PMVYA)	39.83(%)	39.71(%)
Average fraction of Market Potential derived from rest of provinces (PMVYA)	60.17(%)	60.29(%)
Average fraction of Market Potential derived from own province (PM3VYA)	24.86(%)	24.78(%)
Average fraction of Market Potential derived from rest of provinces (PM3VYA)	75.14(%)	75.22(%)
Average fraction of Market Potential derived from own province (PMP)	40.98%	40.87%
Average fraction of Market Potential derived from rest of provinces (PMP)	59.02%	59.13%
Average fraction of Market Potential derived from own province (PM3P)	25.77%	25.68%
Average fraction of Market Potential derived from	74.23%	74.32%

rest of provinces (PM3P)

Source: *Own elaboration based on market potential computations*.

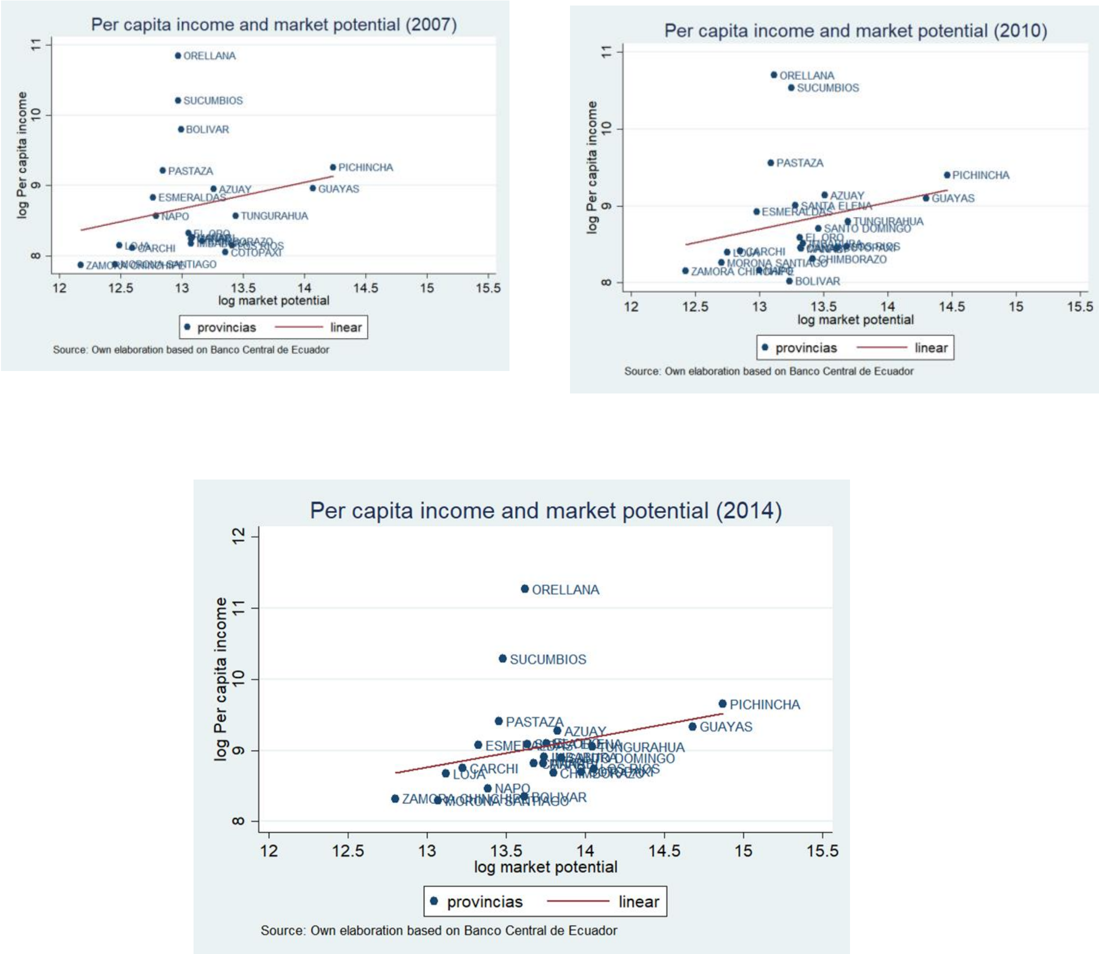
Table 3. *Summary statistics on Market Potential (distance matrix expressed in minutes of travel*

	2007	2014
Average fraction of Market Potential derived from own province (PM3YA)	24.85(%)	24.91(%)
Average fraction of Market Potential derived from rest of provinces (PM3YA)	75.15(%)	75.09(%)
Average fraction of Market Potential derived from own province (PMVYA)	39.92 (%)	39.81(%)
Average fraction of Market Potential derived from rest of provinces (PMVYA)	60.08(%)	60.19(%)
Average fraction of Market Potential derived from own province (PM3VYA)	24.94(%)	24.85(%)
Average fraction of Market Potential derived from rest of provinces (PM3VYA)	75.06(%)	75.15(%)
Average fraction of Market Potential derived from own province (PMP)	41.14%	41.01%
Average fraction of Market Potential derived from rest of provinces (PMP)	89.86%	58.99%
Average fraction of Market Potential derived from own province (PM3P)	25.83%	25.80%
Average fraction of Market Potential derived from rest of provinces (PM3P)	74.17%	74.20%

Source: *Own elaboration based on market potential computations*

As for the relationship between the spatial distribution of per capita income and that of market potential Figure 2 reveals a connection between the two magnitudes although it is far from perfect. In general, high market potential provinces are also provinces with high per capita income levels. However, figures for some provinces contradict this general statement. It can be observed that there are provinces with fairly low values of market potential (for instance the oil producing provinces of Sucumbios and Orellana) but with high per capita income levels due to oil revenues.

Figure 2. *Income and market potential in the Ecuadorian provinces. Source: Banco Central de Ecuador and authors' own calculations*



3. Geographical economics explanation: Income and Geography

The theoretical framework is a reduced version of a standard geographical economics model (multi-regional version of Krugman, 1991). We consider a regional setting composed of R locations and we focus on the analysis of the manufacturing sector. In this sector, firms produce a great number of varieties of a homogenous differentiated good (D) under increasing returns to scale and monopolistic competition. Firms face transport costs in an iceberg form in order to receive one unit of the differentiated good at location j from location i $, T_{i,j} > 1$ units must be shipped from i, so $T_{i,j} - 1$ measures the fraction of good that is melted in transit from i to j. The manufacturing sector can produce the differentiated good in different locations.

On the demand side, the final demand in location j can be obtained via utility maximization of the corresponding CES utility function:

$$Max_{mi,j(z)}\ D_j = \left[\sum_{i=1}^{R}\int_0^{n_i} m_{i,j}(z)^{\sigma-1/\sigma} dz\right]^{\sigma/\sigma-1} \quad \text{s.t.} \quad \sum_{i=1}^{R} n_i x_{ij}^D p_{ij} = E_j \qquad (3)$$

where D_j represents the consumption of the differentiated good in location j . D is an aggregate of industrial varieties where $m_{i,j}(z)$ means the consumption of the each available variety z in location j and produce in location i and n_i is the number of varieties produced in location i . σ represents the elasticity of substitution among the varieties of the differentiated good where $\sigma > 1$, p_{ij} ($p_{ij} = p_i T_{ij}$), is the price of varieties produced in location i and sold in j and E_j represents the total income in location j . The consumer's problem solution gives the final demand in location j for each variety produce in location i.

$$x_{ij}^D = p_{ij}^{-\sigma}\left[\sum_{n=1}^{R} n_n p_{nj}^{1-\sigma}\right]^{-1} Y_j \qquad (4)$$

If we define a price index for the differentiated goods[6] as $P_j \equiv \left[\sum_{n=1}^{R} n_n p_{nj}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$, final demand in location j can be written as $x_{ij}^{consD} = p_{ij}^{-\sigma} P_j^{\sigma-1} E_j$. However, in order for x_{ij}^{consD} units of consumption to arrive at location j , $T_{i,j} x_{ij}^{consD}$ must be shipped. So, the effective demand a firm in location i faces from a consumer in location j is given by:

$$x_{ij}^D = T_{ij} p_{ij}^{-\sigma} P_j^{\sigma-1} E_j = p_i^{-\sigma} T_{ij}^{1-\sigma} P_j^{\sigma-1} E_j \qquad (5)$$

On the supply side a typical firm in location i maximizes the following profit function:

$$\Pi_i = \sum_{j=1}^{R} \frac{p_{ij} x_{ij}^D}{T_{i,j}} - w_i^D (F + c x_i^D) \qquad (6)$$

Technology in the increasing returns to scale manufacturing sector is given by the usual linear cost function: $l_{Dij} = F + c x_{ij}^D$, where l_{Dij}, represents the industrial workers used for the production of a variety in location i and sold in location j ,

[6] *This Industrial Price Index in location j measures the minimum costs of purchasing a unit of the composed index of manufacturing goods D so it can be interpreted as an expenditure function.*

F, represents a fixed cost of production, c, is the variable unit cost and x_{ij}^D is the amount of the differentiated good demanded in location j and produced in location i ($x_i^D \equiv \sum_j x_{ij}^D$ represents the total amount of output produced by the firm in location i and sold in the different j locations) and w_i^D is the nominal wage paid to the manufacturing workers in location i. First order conditions for profit maximization give the standard result that prices are set at a markup $\frac{\sigma}{\sigma-1}$ over marginal costs. At this price profits will be $\prod_i = \left(w_i^D\right)\left[\frac{cx_i^D}{\sigma-1} - F\right]$. Free of entry assures that in the long run firms break even, implying that $x_i^D = \bar{x} = \frac{F(\sigma-1)}{c}$ .The price that is needed to sell this amount of output is $P_i^\sigma = \frac{1}{\bar{x}}\sum_{j=1}^{R} E_j P_j^{\sigma-1} T_{i,j}^{1-\sigma}$. If we combine this expression with the fact that in equilibrium prices are a constant markup over marginal costs, the following zero-profit condition can be obtained:

$$w_i^D = \left(\frac{\sigma-1}{\sigma c}\right)\left[\frac{1}{\bar{x}}\sum_{j=1}^{R} E_j P_j^{\sigma-1} T_{i,j}^{1-\sigma}\right]^{1/\sigma} \tag{7}$$

This equation is the so-called *nominal wage equation* in the Geographical economics literature. Equation (6) shows that the nominal wage level at location i depends on a weighted sum of the purchasing power of the surrounding locations where the weighted scheme is a distance function that decreases as the distance between i and j increases. If we normalize output production choosing our units in such a way that $c = \frac{(\sigma-1)}{\sigma}$, and we set the fixed input requirement as $F = \frac{1}{\sigma}$, and define market potential in location i as $MP_i = \sum_{j=1}^{R} E_j P_j^{\sigma-1} T_{i,j}^{1-\sigma}$, we can rewrite the *nominal wage equation* as:

$$w_i^D = \left[MP_i\right]^{1/\sigma} \tag{8}$$

The meaning of this equation is that those firms in locations that have a good access to big markets (high market potential) will tend to remunerate their local factors of production (workers) with better salaries due to their savings in transportation costs.

4. Estimation of the Baseline Model

4.1 Panel data

As a first step in our study of the robustness of the estimated impact of MP on the spatial distribution of income, we estimate a simple specification of equation 8 that will be used as a benchmark:

$$\ln Yrpc_{it} = \alpha_t + \beta_1 \ln MP_{it} + \varepsilon_{it} \tag{9}$$

where Yrpc denotes the column vector with the per capita income values of the Ecuadorian provinces (Per capita gross domestic product measured in thousands of 2007 constant dollars obtained from the Ecuadorian Central Bank), MP denotes the column vector with the market potential values and ε is supposed to be (so far) a well-behaved error term. β is the parameter that captures the impact of MP on per capita income. Besides the increase in the number of observations using the panel data set allows controlling for unobservable regional effects that could be shaping the spatial distribution of income across the Ecuadorian provinces.

We begin by examining how much of the variation in Ecuadorian provincial per capita income levels can be explained when only including information on market potential. We impose constant coefficients across the time period (2007-2014) to smooth variations introduced by short-run fluctuations in GDP. The results of the ordinary least square (OLS) estimates of the parameters in equation (9) are shown in tables 4 and 5. This provides the basis for our baseline estimation (OLS estimates) where we assume that the error term is uncorrelated with the explanatory variables.

However, the models estimated in Tables 4 and 5 are marked by outlying observations as it can clearly be seen in the pictures in Figure 2. The outlying provinces do not correspond with the spatial structure of per capita income levels determined by most of the observations. Outliers will seriously affect the coefficient estimates, if they are influential leverage points, i.e. outlying observations regarding our market potential measure. In order to identify outliers, we have computed the Cook's distance. Cook's distance measures the aggregate change in the estimated coefficients when each observation is left out of the estimation. Values of Cook's distance that are greater than 4/N may be problematic. Therefore, in our case the observations with Cooks distance greater than 4/182=.02 are problematic. The results of this statistic show that the provinces of Orellana and Sucumbios are behaving as ouliers. In order to control for the effects of the identified outlying observations we have carried out our estimations by dropping out these two provinces from the sample.

Table 4 reports the average coefficient on market potential for this baseline specification estimated by OLS for the sample pooled across the period (2007-2014) and using the six market potential measures defined previously[7] (PMYAR, PMVYAR, PMP, PM3YAR, PM3VYAR, PM3P). Table 4 contains six columns where the first one corresponds to the regression of log of provincial real per capita GDP against PMYAR, the second column corresponds to the regression of log of provincial real per capita GDP against PMVYAR, the third one corresponds to the regression of log of provincial real per capita GDP against PMP and the remaining three columns corresponds to the regression of log of provincial real per capita GDP against the same market potential measures but where the internal distances used for computing the domestic component of market potential followed the expression $\mathrm{d}_{ii} = 2/3\mathrm{r}_\mathrm{i} = 0.376\sqrt{area_i}$ instead of $\mathrm{d}_{ii} = 1/3\mathrm{r}_\mathrm{i} = 0.188\sqrt{area_i}$ (used for the first set of market potential measures).

All the coefficient estimates of market potential are both significant and highly economic significant at the usual standard significant levels and therefore the results are in line with the theoretical predictions of the core-periphery geographical economics model. However, there is a sizeable difference in the values of the coefficient estimates depending on the definition of market potential used in the regression. When market potential is measure using as a proxy for the economic mass of each Ecuadorian province the figures of gross domestic product (GDP) or gross value added (GVA) -estimations of columns 1, 2 ,4 and 5- the elasticity estimates of real per capita income with respect to market potential are in the range of 0.42-0.45 which are 57% larger than the ones obtained with the other alternative definitions of market potential, market potential measured using as a proxy for the economic mass of each Ecuadorian province the figures of populations –columns 3 and 6- where the coefficient estimates are around 0.28-0.29. In the estimations of columns 1, 2, 4 and 5, on average doubling market potential increases real per capita income by around 42%-45%, whereas with the alternative definitions the increase is much more modest, on the range 28%-29%. Moreover, these definitions of market potential definitions are more aligned with the theoretical derivation of market potential in the core-periphery geographical economics model and so this fact also explains that the explanatory power (between 13%-21%) of the regressions in columns 1, 2, 4 and 5 is much higher than in the regressions of columns 3 and 6 where the R2 are between 5%-7%.

We have repeated the estimations of Table 4 (Table 5) using an alternative metric to measure the distance between the Ecuadorian provinces. We compute a somewhat more sophisticated version of the Harris' market potential, using lorry travel times (expressed in minutes of travel) as weights instead of physical

[7] *The difference with respect to the previous measures is that in this case, for the calculation of the numerator of the market potential, GDP and GVA values expressed in constant 2007 dollars have been used instead of current dollars.*

distances (we label the market potential measures by adding the letter "T" at the end of the variable). These travel times between the capitals cities of the provinces have been obtained from Google maps taken the option which reports the fastest route (the ones with the lowest time assigned).

The results of the estimations are pretty much in line with the previous ones for columns 1 to 3, whereas for columns 4 to 6 there is a considerable reduction in the elasticity estimates with also a non-significant effect of market potential on per capita income when market potential is defined from population (column 6).

Table 4. *Results of the Estimation of the Baseline Model (2007-2014) (pooled OLS estimates, distance matrix for market potential computations in kms)*

Dependent variable	Log Yrpc					
	(1)	(2)	(3)	(4)	(5)	(6)
Regresors						
Constant	2.68**	3.10**	5.25**	2.56**	3.03**	5.17**
	(0.24)	(0.5)	(1.29)	(0.75)	(0.76)	(1.46)
Log PMYAR	0.44**					
	(0.03)					
Log PMVYAR		0.42**				
		(0.04)				
Log PMP			0.28**			
			(0.11)			
Log PM3YAR				0.45**		
				(0.06)		
Log PM3VYAR					0.44**	
					(0.06)	
Log PM3P						0.29**
						(0.13)
year dummies	No	No	No	No	No	No
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
R2	0.21	0.19	0.07	0.14	0.13	0.05

F-statistic	140.01** [0.00]	115.46** [0.00]	5.99* [0.01]	60.54** [0.00]	50.19** [0.00]	4.90* [0.05]
Observations	166	166	166	166	166	166

Note: *Table displays coefficients and Huber-White standard errors for OLS. The dependent variable is the log of per capita income (at constant 2007 dolars). lof of MP1 to log of MP6 are the logs of the different definitions of market potential. Standard errors for coefficient estimates are in parenthesis. p-values for the statistics are in brackets. * and ** mean statistical significance at 10% and 5% respectively.*

Table 5. *Results of the Estimation of the Baseline Model (2007-2014) (pooled OLS estimates, distance matrix for market potential computations in minutes of travel times)*

Dependent variable	Log Yrpc					
	(1)	(2)	(3)	(4)	(5)	(6)
Regresors						
Constant	2.66**	3.09**	5.25**	6.33**	6.22**	8.99**
	(0.24)	(0.51)	(1.30)	(0.80)	(0.77)	(0.89)
Log PMYART	0.44**					
	(0.04)					
Log PMVYART		0.43**				
		(0.04)				
Log PMPT			0.28**			
			(0.11)			
Log PM3YART				0.16**		
				(0.06)		
Log PM3VYART					0.18**	
					(0.06)	
Log PM3PT						-0.04
						(0.08)
year dummies	No	No	No	No	No	No
Estimation	OLS	OLS	OLS	OLS	OLS	OLS

R2	0.21	0.19	0.07	0.02	0.02	0.00
F-statistic	139.10** [0.00]	115.31** [0.00]	5.88* [0.01]	7.04** [0.00]	8.53** [0.00]	0.36 [0.54]
Observations	166	166	166	166	166	166

Note: *Table displays coefficients and Huber-White standard errors for OLS. The dependent variable is the log of per capita income (at constant 2007 dolars). lof of MP1 to log of MP6 are the logs of the different definitions of market potential. Standard errors for coefficient estimates are in parenthesis. p-values for the statistics are in brackets * and ** mean statistical significance at 10% and 5% respectively.*

4.2 Robustness checks

The pooled OLS estimates of the specification (9) is subject to several concerns. In order to have a consistent estimator of β_1 (elasticity of per capita income with respect to market potential) we must assume that the many potential unobserved time-constant factors which are difficult to control for in our estimations and which are affecting the level of per capita income across the Ecuadorian provinces are uncorrelated with market potential. However, holding this assumption in the context of the estimation of a relationship between per capita income and market potential is not very reasonable and therefore the pooled OLS method does not solve the omitted variables problem we are mentioning and therefore the estimates are biased and inconsistent. For instance. shocks to $Yrpc_{it}$ as captured by ε_{it} are likely to be correlated across regions which in the end raises the issue that ε_{it} is also correlated with MP_{it}. Variables like institutional quality, climatic and another amenity of region, historical factors, and geographical features related to regions, etc. can be considered as additional determinants of income levels. In the case of Ecuador, it is well know that these factors vary across the different provinces and to a certain extent they are likely to be correlated across space. For these cases in which it is reasonable to assume the existence of unobserved regional heterogeneity in the relationship we want to estimate, having a panel data set is very useful since one of the main reasons of panel data is precisely to allow for the unobserved effects to be correlated with the explanatory variables (in our case with market potential). So, the next step we are going to take in the analysis is to introduce regional (province) fixed effects into our specification (9) and carry out the estimation of equation (9) by fixed effects (FE) and first differences (FD) to obtain the fixed effect and first-differenced estimator of β_1.
The equation to be estimated is the following one:

$$\ln Yrpc_{it} = \beta_0 + \beta_1 \ln MP_{it} + a_i + u_{it} \qquad (10)$$

Where the variable a_i capture all unobserved time-constant factors that are affecting $Yrpc_{it}$.

The first four columns of Table 6 correspond to the estimations based on a fixed effects transformation of equation (10) which leads to the estimator based on the standard least squares (within estimator or also known as fixed effects estimator). In these set of estimations we have also controlled for fixed-year effects. The coefficient on market potential shows up as both statistically and economically very significant (columns 1 to 4) with an estimated value of around 0.5 which means that doubling market potential would on average increase real per capita income by 50%. Since market potential is meant to capture market sizes, there is a well-acknowledged endogeneity issue in the Harris´ market potential. The market potential variable MP_{it} which in the definitions of columns 1 (2) and 3 (4) use as a proxy for the economic activity GDP_{it} (GVA_{it}) which in turn is increasing in per capita income, as captured by $Yrpc_{it}$, the dependent variable. There are several ways of dealing with this issue. First, in columns 5 and 6 we use values of MP_{it} lagged one period on the grounds that the factors that played a role in the past are uncorrelated to the factors affecting current productivity shocks in the different provinces, thus avoiding problems arising from shocks linked to spatially correlated but intertemporally uncorrelated omitted variables (for instance nationwide strikes). The results of the estimations show that the coefficient estimates are positive and highly economically significant. Doubling market potential would lead to an increase in the average per capita income of around 47%-48%.

Taking longer time lags of the market potential variable helps to reduce the problems from shocks that are correlated across time. Following Boulhol and Serres (2009) we lag market potential three times. It can be seen that the estimated parameter for market potential which is reported in columns 7 and 8 is very significant and the magnitude is pretty much the same as with one period lags in the market potential. However, it is important to bear in mind that there are some factors that are persistent over time which are very difficult to eliminate with this approach such as for instance institutional quality, locational factors, etc.

Table 6. *Robustness checks I-distance matrix Kms- (fixed effects and lagged values)*

Dependent variable Log Yrpc	Levels							
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	2.08	2.44	1.91	2.28	2.18	2.64	2.23	2.67
	(2.04)	(1.98)	(2.72)	(2.62)	(2.12)	(1.26)	(2.32)	(2.27)

Log PMYAR	0.49**							
	(0.15)							
Log PMVYAR		0.49**						
		(0.16)						
Log PM3YAR			0.51**					
			(0.21)					
Log PM3VYAR				0.51**				
				(0.21)				
Log PMYAR (t-1)					0.48**			
					(0.16)			
Log PMVYAR (t-1)						0.47**		
						(0.10)		
Log PMYAR (t-3)							0.47**	
							(0.17)	
Log PMVYAR (t-3)								0.46**
								(0.18)
year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
R2	0.31	0.29	0.21	0.20	0.19	0.29	0.27	0.25
Observations	166	166	166	166	147	147	105	105
(regions/year)	(21/8)	(21/8)	(21/8)	(21/8)	(21/7)	(21/7)	(21/5)	(21/5)

Note: *Table displays coefficients and Huber-White standard errors for OLS. Standard errors for coefficient estimates are in parenthesis. p-values for the statistics are in brackets. For data sources see text and appendix A. * and ** mean statistical significance at 10% and 5% respectively.*

Another potential way to control for this endogeneity issue will be presented below with the IV estimations. The panel data set we have built allows us to define a set of instruments for market potential that will be used to obtain an instrumental variable estimator of the impact of economic remoteness on per capita income levels across the Ecuadorian provinces. In the earlier literature on this topic the usual approach was to use the sum of the distances of each region to Luxembourg (Breinlich, 2006) or the sum of the distances to Tokyo, Brussels and New York (Redding and Venables, 2004).

However Breinlich, 2006 mentions that one could have objections to this instrument for market potential on the grounds of the fact that Luxembourg is a centroid of regional income´s distribution within the EU and distance to it could be capturing other determinants of income levels besides market potential. Similarly, when Redding and Venables 2004 choose the sum of distances of each country to the three centers of global economic activity (Tokyo, Brussels and New York) as an instrument one can argue that in thirty years' time these centers no longer will be the main poles of attraction. Therefore the choice of these three locations is in itself endogenous. In our case and following (Head and Mayer, 2006) an appealing instrument is to sum the distances of each Ecuadorian province to all the other provinces. In order to take advantage of the panel dimension of the data, we will allow the effect of this time-invariant instrument to vary through time by interacting the sum of the distances of each Ecuadorian province to all other provinces with time dummies defined for each year included in our period of analysis. The proposed instruments are $Z_{it} = h_t \, {}^{1}\!/_{N} \sum_{j \neq i}^{n} d_{ij}$ where N is the number of Ecuadorian provinces and h_t are the time dummies. We will measure d_{ij} as the sum of the distances from province "i" to all other provinces using two metrics (kilometres and lorry travel times), so we will have at our disposal two sets of instruments for market potential. Using lorry travel times allow us to control for the quality of the infrastructure.

The results obtained when market potential is treated as an endogenous variable and the time-varying instruments based on the average distances for each province are used are shown in Table 7. The estimates in the first two columns consider the definition of market potential (PMYAR) and the two sets of instruments defined (according to the two metrics of distances) and the estimates in the last two columns correspond the definition of market potential (PMVYAR). It can be seen that the elasticity estimates of per capita income with respect to market potential are in both cases in line with the theoretical predictions of the model and highly economic significant. The Sargan´s test indicates that the instruments are exogenous.

Table 7. *GDP per capita and economic geography (IV estimates)*

Dependent variable Regresors	Log Yrpc (1)	Log Yrpc (2)	Log Yrpc (3)	Log Yrpc (4)
Constant	5.24**	5.44**	5.42**	5.58**
	(1.50)	(1.56)	(0.42)	(1.50)
Log PMYAR	0.25**	0.23**		
	(0.11)	(0.11)		
Log PMVYAR			0.25**	0.23*
			(0.11)	(0.12)
Fixed effects Region/year	No/Yes	No/Yes	No/Yes	No/Yes
Estimation	IV	IV	IV	IV
R2 (first stage)	0.38	0.35	0.40	0.37
R2	0.18	0.17	0.17	0.16
[a]Sargan´s test (and p-value)	3.35 [0.85]	3.40[0.84]	3.34[0.85]	3.40[0.84]
Observations (regions/year)	166 (21/8)	166 (21/8)	166 (21/8)	166 (21/8)

Note: *Table displays coefficients and t-statistics for IV estimation. The dependent variable is the log of per capita income. The independent variable is the log of market potential (PMYAR) columns 1 and 2 and log market potential (PMVYAR) columns 3 and 4. Instruments for PMYAR and PMVYAR in columns 1 (2) and 3 (4) are based on the time dummies interaction with average distance to other provinces in kms (lorry travel times).[a] Sargan´s overidentification test of all instruments. * and ** signify statistical significance at the10% and 5% levels.*

5. Missing Links (Disentangling Channels of Influence): Human capital

The core-periphery geographical economics model sketched in section 3 provides a theoretical framework for the empirical evidence reported in this paper which consisted in finding a positive relationship between the level of income across the Ecuadorian provinces and their relative access to markets measured by market potential. Although we have reported some variability in the estimated elasticity of income with respect to market potential across the different empirical estimates we have carried out, the coefficient of market potential retained both economic and statistical significance. Therefore, the results obtained can be considered a confirmation that the relative access of the Ecuadorian provinces to markets play an important role in shaping the income structure in Ecuador. Despite this important role played by market potential regarding the income gradient observed in Ecuador it is important to clarify that the estimated baseline model does not account for other potential important determinants of the levels of income across the Ecuadorian provinces. At this point an important driver of income levels which is related and influenced by market potential is worth mentioning: Human capital stocks.

Regarding human capital on the one hand it is quite clear that locations with a better endowment of human capital (a large share of skilled workers) are locations characterized by higher income levels than locations with lower endowments of human capital. A wide range of empirical studies for developed and developing countries provide evidence that skilled or educated workers receive higher wages (see for instance Psacharopoulos, 1994). On the other hand, and from the perspective of the geographical economics literature (Redding and Schott, 2003) have shown that locations with high market potential also provide more long-run incentives for human capital accumulation by increasing the premium for skilled labour.

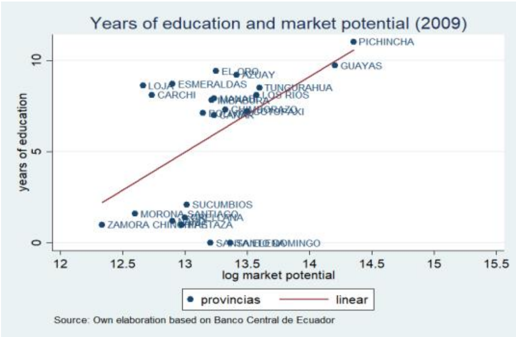
More precisely Redding and Schott, (2003) result emerges from an extension of the standard two-sector (agriculture and manufacturing) economic geography model to allow unskilled individuals to endogenously choose whether to invest in education. They argue that if skill-intensive sectors have higher trade costs, more pervasive input–output linkages or stronger increasing returns to scale, they show theoretically that remoteness depresses the skill premium and therefore incentives for human capital accumulation.

Therefore, this penalty which accrue to remote locations magnifies the effect that economic geography can have on the cross-province differences in income levels observed in Ecuador. Increasing a province relative trade costs not only reduces contemporaneous factor rewards, but also lowers gross domestic product by suppressing human capital accumulation and decreasing the supply of high-income skilled workers.

Figure 3 shows quite clearly that the stocks of human capital are highly correlated with market potential across the Ecuadorian provinces. The graphs show that the endowment of human capital is on average higher in those locations which feature high values of market potential. A remarkable feature we observe in these graphs is the outlying position of the province of Pichincha where the capital Quito is located.

So, assuming that the accumulation of human capital across the Ecuadorian provinces are pretty much influenced by their relative access to markets, a natural way of testing the importance of market potential as a key factor in explaining the spatial distribution of income levels in Ecuador is by incorporating human capital stocks as an additional regressor in the baseline specification estimated earlier.

Figure 3. *Market potential and human capital in the Ecuadorian provinces. Source: Banco Central de Ecuador and authors' own calculations*



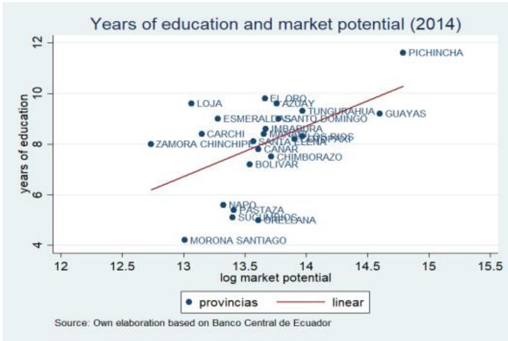


Table 8 reports the results of the extended regression. In columns 1 and 2 (3 and 4) we regress per capita income against log of PMYAR (log of PMVYAR) and log of average years of education. The coefficient estimates for market potential are in all regressions positive and highly statistically significant and remain economically significant. Instrumenting market potential with the interaction of the time dummies with average distance to other provinces in kms reports higher values for the elasticity estimates of income with respect to market potential than when the instruments for market potential are defined as interaction of the time dummies with average distance to other provinces measured in travel times. The values for the elasticity estimates of income regarding PMYAR (PMVYAR) compared vis-a-vis are 0.15 vs 0.13. With respect to the coefficients associated with human capital proxy by the average years of education, the signs are in line with the theoretical expectations.

Table 8. *GDP per capita and economic geography: Disentangling channels of influence (IV estimates)*

Dependent variable	Log Yrpc			
	(1)	(2)	(3)	(4)
Regresors				
Constant	6.33**	6.56**	6.43**	3.13**
	(1.91)	(1.97)	(1.82)	(1.01)
Log PMYAR	0.15**	0.13**		
	(0.03)	(0.03)		
Log PMVYAR			0.15**	0.13**
			(0.04)	(0.04)
Av. years of education	0.02**	0.02**	0.02**	0.02**
	(0.001)	(0.001)	(0.001)	(0.001)
Fixed effects Region/year	No/Yes	No/Yes	No/Yes	No/Yes

Estimation	IV	IV	IV	IV
R2 first stage	0.69	0.67	0.70	0.67
R2	0.13	0.12	0.12	0.12
[a]Sargan´s test	0.87	0.82	0.86	0.89
(and p-value)	[0.93]	[0.93]	[0.93]	[0.92]
Observations	105	105	105	105
(regions/year)	(23/5)	(23/5)	(23/5)	(23/5)

Note: *Table displays coefficients and t-statistics for IV estimation. The dependent variable is the log of per capita income. The independent variable is the log of market potential (PMYAR) columns 1, 2 and log market potential (PMVYAR) columns 3 and 4. Instruments for PMYAR and PMVYAR in columns 1 and 3 (2 and 4) are based on the time dummies interaction with average distance to other provinces in kms (lorry travel times)[a] Sargan´s overidentification test of all instruments. * and ** signify statistical significance at the10% and 5% levels.*

6. Conclusions

In this paper we have analyzed the existence of a spatial structure of provincial per capita income in Ecuador over the period 2007-2014 by testing the so called *nominal wage equation* of the geographical economics models. The nominal wage equation relates income or wages in a location with a weighted sum of the volume of economic activity in the surrounding locations where the weighted scheme is a function of the inverse of the distance measure either in kilometres or travel times between locations. This weighted sum is usually known as market potential or market access.

Therefore our main goal was to test the role of market potential in shaping the spatial income structure observed in Ecuador. To do so, using our panel data set we have estimated a number of different specifications regressing per capita income on market potential. Our first approach to the empirical exercise was to carried out a pooled OLS estimation of the impact of market potential on per capita income over the whole sample period (2007-2014) using 12 different market potential metrics. The results of these baseline estimations of the nominal wage equation were in line with the theoretical predictions of the model, i.e, market potential no matter which definition is used in the regressions exerts a positive and economically significant impact in the expected or average income of the Ecuadorian provinces. The estimated slope parameters vary depending on market potential definition used but they were in the range 0.28-0.44 for distance matrices expressed in Kms. and 0.16-0.44 for distance matrices expressed in lorry travel times. Our next step in the empirical exercise was to carry out some robustness checks in the baseline estimation. Using the panel data character of our data we introduce regional (province) fixed effects in order to control for many potential unobserved time-constant factors and estimated the baseline specification by fixed effects (FE). The results are again in favour of the hypothesis of the nominal wage equation. The estimated coefficients were in the range 0.46-0.51 for the FE estimations and distance matrix expressed in Kms. Our next concern was about the potential endogeneity of market potential. We have approached to this issue by instrumenting market potential a) with two different sets of instruments which consisted of interacting the sum of the distances of each Ecuadorian province to all other provinces with time dummies defined for each year. The results of the IV estimations delivered slope parameter estimates for market potential which were in the range 0.23-0.25 and b) using lagged values for market potential. In this last case the elasticity estimates of per capital income with respect to market potential is around 0.47.

Finally, another important step we took in the estimation of the baseline nominal wage equation was to disentangle the potential effects of human capital since there are reasons both from a theoretical side as well as from an empirical one that the accumulation of human capital across the Ecuadorian provinces is pretty much influenced by their relative access to markets. The results of the extended baseline estimations controlling for human showed that market potential keeps its importance with elasticity estimates in the range 0.13-0.15.

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