The "fractal dimension" of the market potential-human capital relation

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abstract

The empirical analysis of the impact of market potential on the spatial distribution of human capital has often taken the approach of using samples of large economic areas (world sample of countries, Europe, single countries). This paper proposes to strengthen the analysis of +the potential "fractal dimension" of the market potential-human capital relation by estimating econometric specifications which relate educational attainment levels to market potential for the 53 Galician counties using yearly data over the period 2005-2012 and census data for 2001 and 2011. We find evidence that market potential exerts a positive impact on the spatial distribution of human capital across the Galician counties, concluding therefore in favour of the fractal dimension. These results could also help to explain the (lack of) convergence in terms of income between the Western and Eastern parts of Galicia.

Keywords: Market potential; Human capital; Galicia

JEL codes: R11; R12

1. Introduction

Human capital is clearly not distributed randomly across space. The urban economics literature explains how human capital differences evolve over cities by focusing on the relationship between economic opportunities at the city level and individuals´location decision. This approach does not incorporate the influence of geography. However, agglomeration economies play a crucial role on the spatial distribution and accumulation of human capital. Geographical Economics Redding and Schott´s (2003) model demonstrate how the benefits of central regions in terms of agglomeration economies (proxy by market potential) translate into higher wages and higher incentives for individuals to invest in human capital. This theoretical prediction was tested at the global, continental and national levels. This paper tries to go one level down testing it at sub-national level with the aim of further corroborate the "fractal dimension" aspect of these predictions, i.e., if the agglomeration economies that shape the human capital endowments across those large economic areas are also present in smaller areas.
Therefore, we focus the analysis on the 53 comarcas[1] in which the the most Northwestern region of Spain, Galicia, is divided. Our results show that market potential exerts a positive impact on the spatial distribution of human capital across the 53 Galician comarcas confirming the "fractal dimension" of Redding and Schott (2003) model´s prediction.

2. A short review of literature

Redding and Schott´s (2003) theoretical prediction has been explored in several papers. The first empirical confirmation is in the empirical section of their paper using a sample of world countries. Later, at continental level, Diebolt and Hippe 2018, Faiña and Lopez-Rodriguez 2006, Lopez-Rodríguez 2007, Lopez-Rodríguez et al. 2007, confirm the market potential-human capital link for the EU regions. At national level several papers are worth mentioning: Karahasan and Bilgel, 2020 (Turkey), Karahasan and López-Bazo 2013 (Spain), Lopez-Rodriguez et al. 2019 (Romania). The common feature in these empirical studies is the use of large economic areas for testing purposes. To our knowledge, there has been no attempt to explore the market potential-human capital link for economic areas smaller than the national level. With this study, using the region of Galicia in Spain as example, we accomplish two goals; expanding the range of empirical contributions by notching down at sub-national level and corroborating the fractal aspect on the impact of agglomeration economies on human capital.

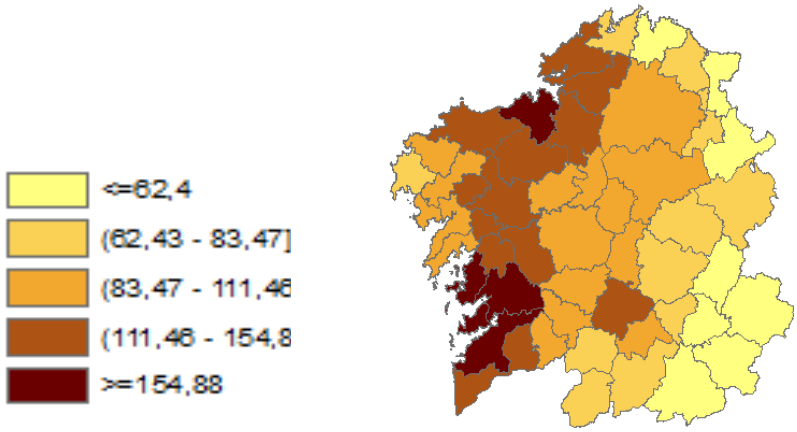
3. Data and Methodology

Galicia, the most Northwestern region of Spain, constitutes a very interesting case study for confirming a "fractal dimension" phenomenon in the market potential-human capital link. From a Geographical Economics point of view, this region shows a remarkable core-periphery structure reflected both in the spatial distribution of market potential across the 53 comarcas in which the region is divided (Map 1), i.e comarcas located in the West have, on average, higher market potential values than those located in the East and in the spatial distribution of per capita GDP levels (Figure 1), i.e. comarcas located in the West are, on average, more developed than those located in the East. These stylized facts, jointly with the need to go one level down in the analysis, make Galicia a suitable candidate for the validation of the theoretical prediction of the Redding and

[1] "Comarca" is the name for territorial units which are one-level above the municipal level. Galicia is divided into 53 comarcas and 313 municipalities. See the list of comarcas in the appendix

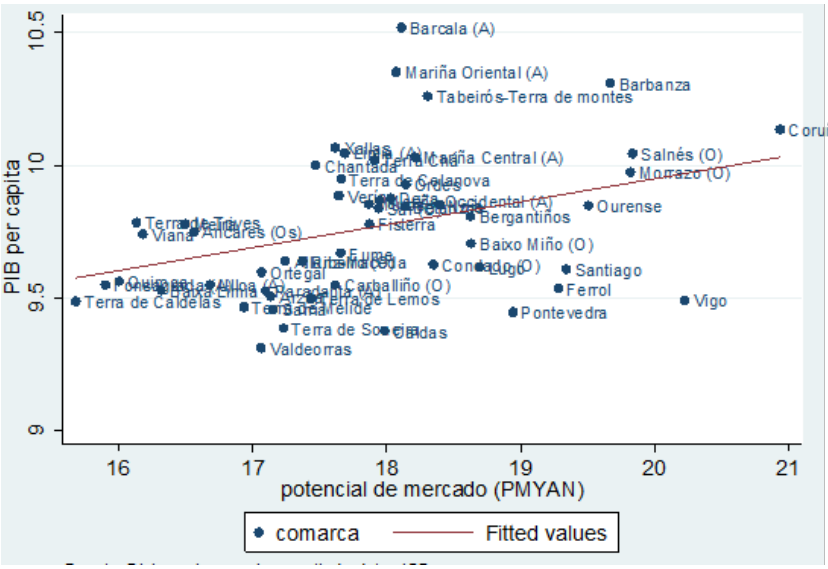
Schott (2003) Geographical Economics Model. These aspects, jointly with the sub-national nature of the region are the ingredients needed for explaining the fractal dimension phenomenon.

Map 1: Market potential across Galician comarcas (Galician average, 2014=100)



Source: Own elaboration based on Galician Institute for Statistics (IGE)

Figure 1: GDP per capita and Market Potential in Galicia



Source: Own elaboration based on Galician Institute of Statistics (IGE)

The following econometric specifications can be used to estimate the impact of market potential on human capital accumulation. Specification (#1) is simply a bivariate regression between human capital and market potential which makes it difficult to distinguish between correlation and causality. Therefore, concerned that the previous estimates might not be robust to the inclusion of other determinants of human capital, we controlled for other important drivers of human capital which are related and influenced by market potential in specification (#2).

$$LnEA(L)_{it} = \alpha_0 + \alpha_1 \ln HMP(K)_{it} + \varepsilon_{it} \qquad [1]$$

$$LnEA(L)_{it} = \alpha_0 + \alpha_1 \ln HMP(K)_{it} + \sum_{l=1}^{L} \gamma_l X_{it,l} + \varepsilon_{it} \qquad [2]$$

Where $EA(L)_{it}$ represents educational attainment levels proxied by: a) the percentage of people with a high school qualification completed according to the census (L=CENSUS; years 2001 and 2011) and b) the percentage of students who are currently attending secondary studies over those in the theoretical age of being enrolled in them (L=SECOND; years 2005-2012). $HMP(K)_{it}$ represents the Harris (1954) market potential computed using the following formula:

$$HMP(K)_{it} = \sum_{j=1}^{n} \frac{M_{jt}}{d_{ij}} = \frac{M_{it}}{d_{ii}} + \sum_{j \neq i}^{n-1} \frac{M_{jt}}{d_{ij}} \qquad [3]$$

Where M represents volume of economic activity; d measures the distance in kilometers or travel times between pairs of regions ($i \neq j$) and the internal distance within each region (i= j). Internal distances (d_{ii}) are approximated by a function that is proportional to the radius of the location. We use $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$ (based on Keeble et al. 1982) and $d_{ii} = 2/3 \cdot r_i = 0.376\sqrt{area_i}$ options (Crozet 2004, Head and Mayer 2000 and Nitsch 2000); n is the number of comarcas in which Galicia is divided (53). K take the values "1" for distances measured in kilometers and $d_{ii} = 2/3 \cdot r_i = 0.376\sqrt{area_i}$, "2" for distances measured in travel times and $d_{ii} = 2/3 \cdot r_i = 0.376\sqrt{area_i}$, "3" for distances measured in kilometers and $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$ and "4" for distances measured in travel times and $d_{ii} = 1/3 \cdot r_i = 0.188\sqrt{area_i}$;. We control for the percentage of manufacturing firms over the population of each comarca devoted to ICT activities (X=PEMTIC) and firms devoted to knowledge-intensive services related to the financial sector (X= EKISFS) with data available for the period 2005-2007 and for the years 2010 and 2012. α_0 is a constant and α_1 and γ_n represent the coefficients associated with the market potential and control variables respectively. Finally, "i" "j" and "t", stand for comarca and period and ε_{it} represents the error term. All data have been taking from the Galician Regional Institute for Statistics (IGE[2]) and the online Michelin Guide[3]. Specifications (#1 and #2) are initially estimated using OLS for the two definitions we use for the dependent variable. Considering that market potential can be simultaneously determined with human capital, to isolate the real effect on human capital accumulation resulting from improving market potential we use an instrumental variables (IV) approach with historical instruments (lag values of HMP). Historical values of market potential have been used in the related literature (see Combes et al. 2010). In this case the reason is that the factors that played a role in the past are uncorrelated to the factors affecting individuals´ current decisions to invest in human capital. The critical parameter in these specifications is α_1 which shows how market potential impacts on human capital accumulation. Considering that regions with high market potential offer higher relative wages for skilled workers, this will give more incentives in these regions to became educated and as a result there will be an increase in the supply of human capital. Therefore, we expect to find a positive and significant estimate for α_1.

[2] IGE: Instituto Galego de Estatística, www.ige.eu

[3] Via michelín, www.viamichelin.es

4. Empirical findings

a) Market potential-human capital relation: a descriptive approach

Table 1 shows EACENSUS data for the Galician comarcas in 2001 and 2011. Map 2 offers a plotting of these data. Comarcas located on the Western part of Galicia enjoy the best eduational attainment levels. Figure 2 links this information with market potentials showing that comarcas with high market potential have high educational attainment levels.

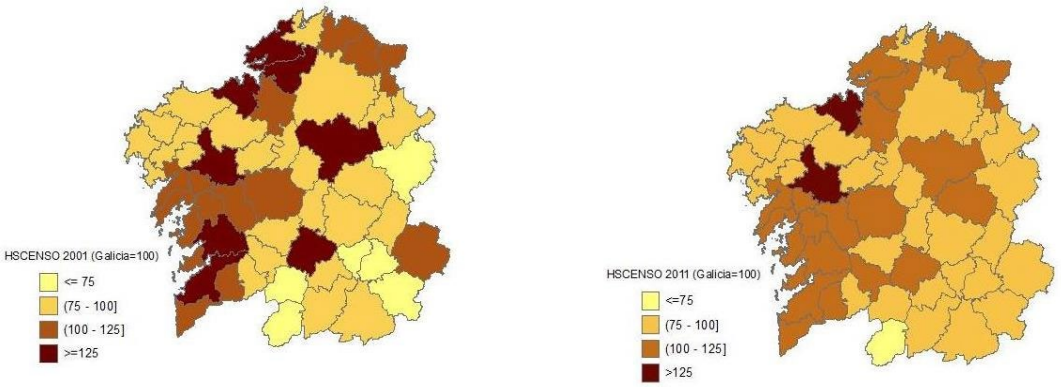
Table 1: EACENSUS

Comarca	**EACENSUS2001**	**EACENSUS2011**	**% Δ 2001-2011**
Allariz-Maceda	38.42	61.73	60.67
Ancares (Os)	32.70	49.95	52.75
Arzúa	37.32	57.2	53.27
Baixa Limia	33.07	46.47	40.52
Baixo Miño (O)	46.69	68.94	47.65
Barbanza	51.64	65.58	26.99
Barcala (A)	43.61	57.46	31.76
Bergantiños	38.95	56.46	44.96
Betanzos	49.99	65.83	31.69
Caldas	46.71	68.39	46.41
Carballiño (O)	42.45	61.23	44.24
Chantada	39.60	60.76	53.43
Condado (O)	46.25	66.13	42.98
Coruña (A)	71.35	78.17	9.56
Deza	48.25	67.11	39.09
Eume	56.89	72.48	27.40
Ferrol	59.82	72.01	20.38
Fisterra	41.74	56.96	36.46
Fonsagrada (A)	35.46	57.06	60.91
Limia (A)	35.06	52.38	49.40
Lugo	61.66	74.29	20.48
Mariña Central (A)	49.56	68.44	38.10
Mariña Occidental (A)	50.69	67.43	33.02
Mariña Oriental (A)	47.26	66.61	40.94
Meira	37.15	57.50	54.78
Morrazo (O)	54.18	69.98	29.16
Muros	42.63	62.14	45.77
Noia	50.38	63.57	26.18
Ordes	44.27	60.15	35.87
Ortegal	41.95	56.47	34.61
Ourense	60.45	73.38	21.39
Paradanta (A)	34.84	55.73	59.96
Pontevedra	61.52	75.85	23.29
Quiroga	36.53	53.43	46.26
Ribeiro (O)	33.98	62.55	84.08
Salnés (O)	54.23	67.79	25.00
Santiago	66.02	79.49	20.40
Sar (O)	50.46	68.11	34.98
Sarria	41.70	63.79	52.97
Tabeirós-Terra de montes	45.69	64.93	42.11
Terra Chá	36.96	58.42	58.06
Terra de Caldelas	29.61	56.37	90.37
Terra de Celanova	27.38	54.96	100.73
Terra de Lemos	43.08	61.49	42.73
Terra de Melide	41.72	53.68	28.67
Terra de Soneira	34.08	49.35	44.81
Terra de Trives	31.35	56.40	79.90
Ulloa (A)	38.82	54.08	39.31
Valdeorras	45.38	60.80	33.98
Verín	34.10	54.26	59.12
Viana	33.31	55.15	65.57
Vigo	62.67	75.74	20.86

Xallas	38.63	52.19	35.10
Average	**44.49**	**62.20**	**43.19**
minimum	**27.38**	**46.47**	**9.56**
maximum	**71.35**	**79.49**	**100.73**
Max/average	**1.6**	**1.27**	**2.33**
Min/average	**0.61**	**0.74**	**0.22**

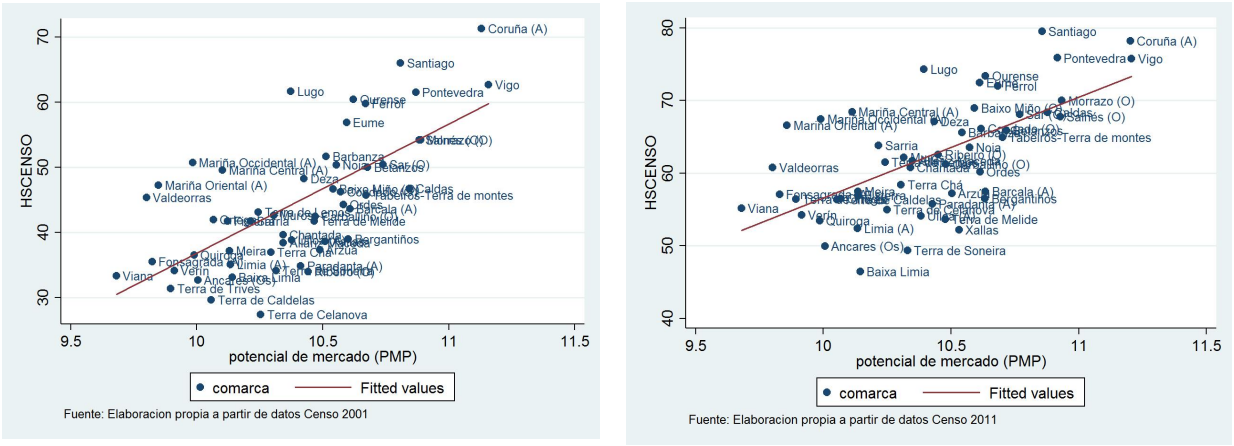
Source: Own elaboration based on Galician population Census.

Map 2: EACENSUS (Galician average = 100, 2001-Left-; 2011-Right-)



Source: Own elaboration based on Galician Institute for Statistics (IGE)

Figure 2: EACENSUS and market potential (2001-left-;2011-right-)



Source: Own elaboration based on Galician Institute for Statistics (IGE)

b) Market potential-human capital relation: Econometric estimates

We estimate specifications (1) and (2) on yearly data for 2005-2012 and on data for the Galician population census of 2001 and 2011.

Table 2 shows the results of regressing EASECOND (Columns 1-4) and EACENSUS (colums 5-6) against different market potential measures (estimation of equation (#1)). The coefficient estimates[4] of the impact of market potential on human capital

[4] The indexes HMP1 compared vis-à-vis with HMP2 (HMP3 vis-à-vis HMP4) differ only in the way distances are measured. We use Kms. in the case of HMP1 and HMP3 and travel times in the cases of HMP2 and HMP4. However, due to the high quality of infrastructures in Galicia, there is a strong

accumulation are positive and statistically significant at the 1% level confirming the theoretical predictions put forward by Redding and Schott (2003). These estimated results confirm that comarcas located in the West of Galicia (core locations) benefit more from agglomeration economies than those located in the East (periphery locations) and therefore are more profitable areas offering higher wages that are beneficial for individuals to increase their human capital levels in these locations. These empirical results are in line with previous empirical estimations (see Diebolt and Hippe 2018, Karahasan and Bilgel, 2020, Karahasan and López-Bazo 2013, Lopez-Rodríguez et al. 2007). These results are a the starting point to corroborate the fractal dimension phenomenon of the market potential-human capital link

Table 2: Market potential and human capital: EASECOND and EACENSUS

Dependent variable	Log EASECOND				Log EACENSUS	
Regressors	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.68	-0.68	-0.36	-0.31	2.25**	2.22**
	(0.71)	(0.68)	(0.53)	(0.52)	(0.26)	(0.25)
HMP1	0.43**				0.21**	
	(0.07)				(0.02)	
HMP2		0.43**				0.21**
		(0.07)				(0.02)
HMP3			0.39**			
			(0.05)			
HMP4				0.39**		
				(0.05)		
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
R2	0.44	0.54	0.45	0.55	0.15	0.15
Prob. (F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00
Number of observations	424	424	424	424	106	106

Note: Robust standard errors for Huber-White heteroskedasticity in parentheses. * and ** mean statistical significance at the levels of 5% and 1%.

Given the greater availability of data when the dependent variable is defined as EASECOND, the next estimations have only been carried out for this case. In these estimates two control variables are included to unravel the effects that market potential has on human capital levels. We have control for the proportion of companies located in the knowledge-intensive services related to the financial sector (EKISFS) as well as for the proportion of manufacturing firms devoted to ICT activities (PEMTIC). These companies are mainly concentrated in the Western areas of Galicia and may be affected by market potential considerations.

The results of the estimation of specification (#2) are shown in Table 3. The estimated market potential coefficients are reduced in relation with the estimates obtained for specification (#1) (elasticity values in the range 0.10-0.14). However, despite this, the coefficients are still positive and statistically significant at the usual significance levels. The signs associated to the control variables are in line with the theoretical expectations and are also statistically significant at the usual significance levels. Columns 5-8

correlation between measuring market potential using travel times or physical distances. This is reflected in coefficient estimates and standard errors of the same size.

present the IV estimates to control for potential endogeneity problems. We have used historical values of market potential as a source of exogenous variation in market potential. The most distant year we can use to build historical values of market potential is 1991. The even columns represent estimates using time dummies to control for the potential effects of the economic cycle and the odd ones without this control. The main results are confirmed. Market potential is again strongly significant and positive confirming the theoretical predictions of Redding and Schott (2003) and corroborating the fractal dimension of the effects of market potential on human capital. The control variables have also the expected signs, they are statistically significant in all regressions.

Table 3: Market potential, human capital and forgotten links (II): Panel estimates with market potential lags (2005-2012*)*

Dependent variable	Log EASECOND							
Regressors	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	2.38**	2.28**	1.08**	1.68**	3.67**	3.62**	3.48**	3.41**
	(0.73)	(0.74)	(0.70)	(0.73)	(0.40)	(0.41)	(0.38)	(0.39)
HMP3	0.10**	0.10**						
	(0.04)	(0.04)						
HMP4			0.14**	0.13**				
			(0.03)	(0.03)				
L14.HMP3					0.07*	0.07**		
					(0.04)	(0.04)		
L14.HMP4							0.09**	0.09**
							(0.04)	(0.04)
PEMTIC	1.29**	0.92**	1.23**	1.28**	1.26**	1.32**	1.24**	1.30**
	(0.34)	(0.33)	(0.34)	(0.34)	(0.34)	(0.35)	(0.34)	(0.34)
EKISFS	0.0004**	0.0004**	0.0002*	0.0002	0.0005**	0.0004**	0.0004**	0.0003**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Estimation	OLS	OLS	OLS	OLS	IV	IV	IV	IV
Time Dummies	No	Yes	No	Yes	No	Yes	No	Yes
R2	0.28	0.29	0.29	0.30	0.26	0.27	0.27	0.28
Adjusted R2	0.27	0.27	0.28	0.28	0.26	0.25	0.26	0.26
Prob. (F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of observations	265	265	265	265	265	265	265	265

Note: Robust standard errors for Huber-White heteroskedasticity in parentheses. * and ** mean statistical significance at the levels of 10% and 5%.

5. Conclussions

This paper contributes to the debate on whether there is a fractal dimension phenomenon on the market potential-human capital link. A further step that was necessary to take in the empirical literature to corroborate this phenomenon was to carry out the analysis for smaller economic areas. Galicia, a region in the Northwest of Spain, with a clear West-East divide or core-periphery structure in terms of economic development offers good features that make it suitable for the analysis. The analysis presented for the 53 comarcas in which Galicia is divided reveals the positive and significant human capital effect resulting from improved market potential. The results are robust for the different estimation approaches reinforcing the “fractal dimension”

nature of the market potential-human capital relation. From a policy perspective, since our analysis shows that agglomeration forces favour a greater concentration of qualified human capital in the Western comarcas, policy interventions are needed to combat against regional gaps in human capital to level out the uneven economic development between Western and Eastern Galicia. Having enough information on regional disaggregated data, for instance municipality data instead of data on comarcas, will give a further push to human capital-market potential studies.

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