The spatial agglomeration of educated people in Colombia

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Abstract

Colombia's education system has been growing in the last decades, and access and coverage has reached higher levels, but this development has been mainly in bigger cities, and has caused an agglomeration of graduates in the tertiary education in these cities and these around them. Education is one of the pillars of development and this process can only be fulfilled with the presence of graduates in tertiary education in all the municipalities. The purpose of this article is to test this hypothesis of agglomeration and intend to see which factors that cause this phenomena, such as life quality, income effects and political security. Empirical evidence are derived from real data obtained by DANE (Departamento Administrativo Nacional de Estadistica) in the Census from 2005 and a variable of violence constructed with IEPRI's (INSTITUTO DE ESTUDIOS POLÍTICOS Y RELACIONES INTERNACIONALES) information of political homicide. In order to stop and reverse this agglomeration, its causes should be understood to make these graduates think differently about where they will work or even live.

keywords: *Education, Education Maps, Spatial Analysis, Moran's Index, Spatial Dependence Models*

1   Introduction

"There are ten policemen for each student and one student for one thousand igno-rants"[1]. After many years, the education system in Colombia has reduced illiteracy rates and increased the access to education. This constitutes a major breakthrough, but despite these great accomplishments and advancements, Colombian cities are developing clusters of educated people that live in them. Tertiary education grad-uates decide to remain in big cities even though the access to education, health and quality of life are improving in small cities. Still they do not want to leave the big cities or return to the city where their family lives for a number of reasons: there may not be enough opportunity to get a well paid job according to their capacities; it does not seems safe enough; or conditions and better opportunities for their childen are perceived to be insufficient. In this way, small cities have less educated people to implement new technologies or projects that could increase a city's opportunity to develop.

In order to compute and observe these clusters data from the 2005 CENSUS done by the DANE[2] will be used. I compute the rate of educated people residing in every municipality that has data available[3] . Furthermore it will show that there is another cluster related to lower rates of graduates in tertiary education.

The factors to be considered are political, social and economic: violence; a lack of public services; poor career opportunities in relation to where graduates decide to live. The relationship between these concepts will be explored and verified in order to see if there is a statistical relationship between them.

The main thesis of this paper follows theoretically an assumption firstly on increasing returns in endogenous economic growth. This can be observed as the agglomeration of skilled people in the main cities (see Easterly, 2001). And sec-ondly, a Harris and Todaro (1970) approach when people tends to migrate based on their income expectations.

This paper is divided into 5 sections besides this one. The second section reviews the literature regarding education and the spatial analysis in Colombia,

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[1]Popular protest song from the 1970's in Colombia. Traslation by the author.

[2]DANE: Departamento Administrativo Nacional de Estadistica. National Administrative Depart-ment of Statistics.

[3] The methods and the data used to calculate this rates are described on the appendix A.

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the third section examine education in the municipalities in Colombia and the 5 classical regions in order to test the agglomeration hypothesis. The forth section analyses the factors related to this agglomeration. The last section concludes the paper.

2   Advances over the last years

Although the literature related to education has been growing during the last 15 years, the analysis has been restricted to case studies, revision of development, and policy recommendations. However in recent years authors have tried to implement new ways to analyze education sector, as will be shown in this section with an overview of recently published documents regarding the education sector in Colombia.

The implementation of spatial analysis has only been applied once for the education sector; Jaime Bonet georeferenced data related to the provision for education in the departments, finding different patterns of agglomeration, and concluded that

> The dotation for education in Colombia is distributed in such way that the departments with a poor provision are surrounded by departments that have the same conditions and the ones with higher levels are surrounded by prosperous also. (Bonet, 2005)[4]

Bonet also highlights the importance of using information by city.

Another article with a very interesting approach and related to the tertiary education done by Mora and Ceballos (2006) found that the the topics taught in technical and technological education are not adequate to fit the needs of the region where they are taught. Consider this one of the main difficulties for some people to remain or go back to their original city. It can be said that this education is not accomplishing its raison d'etre.

Regarding other developments in the education sector it is important to review the works presented by Ramirez and Tellez and Ramirez and Salazar review the history of Colombia's education sector.They provide a good historical account of education in the 20th century underlining the importance of different policies and their effects. It is important to highlight two facts presented by them: first, the

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[4]Traslation made by the author. Page 36.

recent and quick development in the sector after the 1950's at "an unseen velocity" and even after one slow period a subsequent new expansion; and secondly that from the end of the century the sector has been showing other important advances.

The development of the education sector in Colombia can be said to reflect Ramirez and Tellez findings as can be seen by an increase in the access to education highlighted by Iregui, Melo and Ramos(2006). The main problem concerning education in Colombia is more related to efficiency and quality, areas which have not shown constant growth. The same authors have published another article also with an analysis of the efficiency frontier in Colombian schools. Using information from the ICFES which analyses the level of the schools with different factors, they conclude that "private schools are more efficient due to a more favourable environment"[5].

It is also worthwhile to review the results published by the DANE of the 2005 CENSO, which show stable level of literacy in Colombia. It must be said that the percentage of people attending to school has increased greatly and illiteracy rates have lowered over the last 40 years.

3   Education agglomerated in Colombian cities

The rate of educated people in Colombia has increased a lot over the last years. It is easier to access education and special programs have been created to aid students with low or no income to pay for this education, increasing levels of education. Also new universities and technical training centers have been created all over the country, raising the numbers of people educated at tertiary level. But the proportion of graduates from the tertiary level is still low in almost all municipalities.

The rate of graduates in the tertiary education is skewed to the left side as can be seen in the kernel density plot and it must be noted in figure 1 that the larger rates belong to the more populated cities for which the mean rate is 15.7%[6] . But because this kernel is made using the municipalities' rate as the measure unit, this forms the observed skewness or clubs as Quah's convergence.

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[5]Iregui, Melo and Ramos, 2007. Page 21

[6] Calculations made with data from CENSO 2005 and it is important to remark that they are population based and not by municipality.
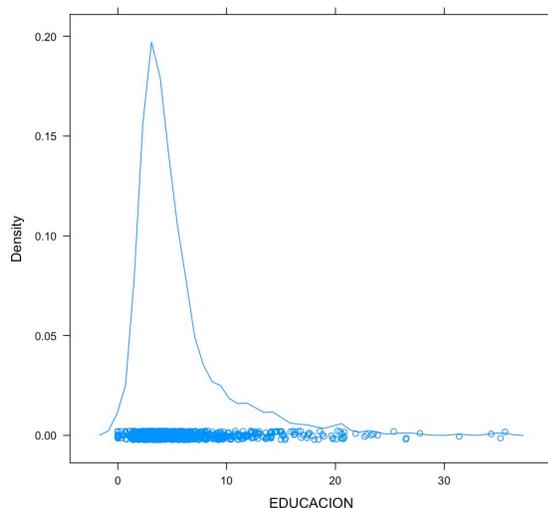
Figure 1: Density kernel of the percentages of tertiary education graduates in Colombia by municipalities. Data: CENSO 2005, DANE.

The existence of spatial relationship between the observations and their neighbours has been widely specified as the first law of geography "Everything is related to Everything else, but near things are more related than distant things" stated by Waldo Tobler in 1970. As Anselin stated standard econometrics analysis can not be used in presence of spatially correlated data.

Spatial localization matters can be seen in figure 2. There appears to be a higher percentage in educated people agglomerated in the municipalities located in the center of the country. Furthermore, these cities are the richest[7] or have the best opportunities in schooling and public services for inhabitants. Different tests to check spatial agglomeration such as Moran's Index, Moran's scatterplot[8], and the Local Indicators for Spatial Association (LISA)[9] will be shown.

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[7]These cities are classified as categories special and 1.

[8]These two are the empirical bayesian Adjustment by population. For more details see Assunção and Reis, 1999.

[9]Anselin, 1995. Also Adjusted to population following the standarization procedure by Assunção and Reis.

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## Percentage of people that attended the tertiary education in Colombia
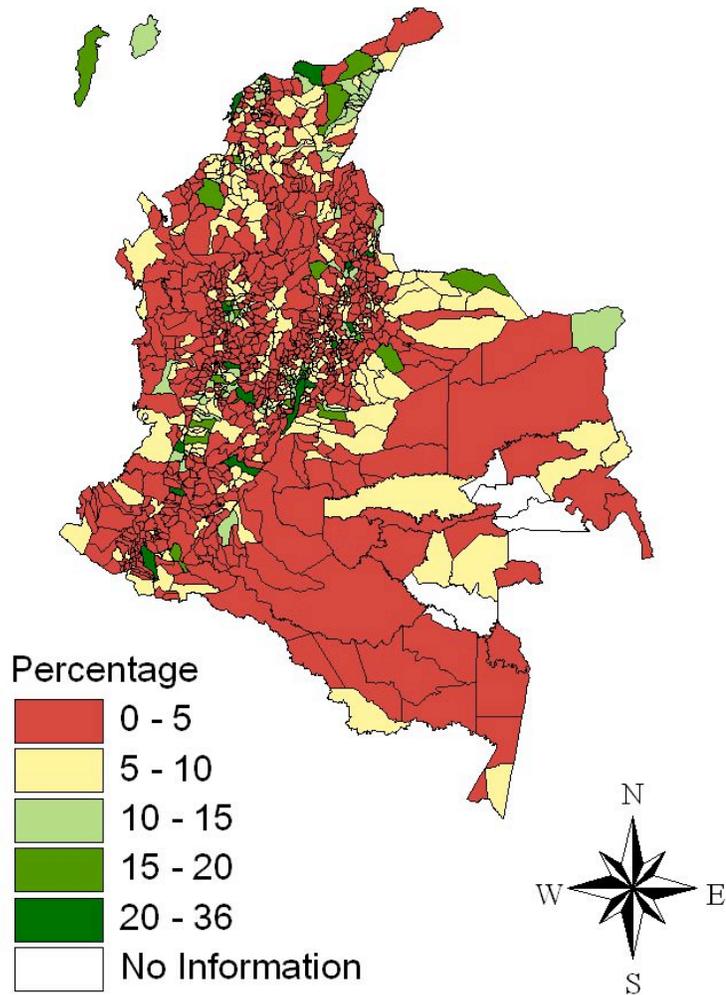
Figure 2: Percentage of tertiary education graduates in Colombia by municipalities. Data: CENSO 2005, DANE.

Categories	Municipalities	Percentage
1	17	1.5%
2	16	1.4%
3	19	1.7%
4	20	1.8%
5	31	2.8%
6	991	88.6%
E(S)	5	0.4%
NC	20	1.8%
TOTAL	1,119	100%

Table 1: Municipal categories. Source: DANE.

The agglomeration of tertiary education graduates in Colombia, as was said before, needs the inclusion of spatial factors. The location of the bigger cities and the surrounding cities seems to have more graduates than other zones in the country. To analyse this aggolmeration it is important to see if there is spatial autocorrelation in the proportion of graduates in the municipalities in Colombia.

The results from the Moran's Index presented in the above table 2 show us that there is strong spatial correlation eventhough when is considered a second level matrix of contiguity which is also shown in the Moran Scatterplot (figure 3). Finally the Local Indicators of Spatial Association (LISA) on figure 4 show the presence of small clusters around the main capitals and specially the ones with categories special and 1, but must be highlighted the presence of low rates clusters in both maps which confirms that the municipalities farther from these capitals are the less attractive for these graduates.

This analysis was also applied to the 5 regions in the country[10] to find smaller cores within them. The results from Moran's Index observed in table 1 and Moran Scatterplots and LISA Maps are in appendix B and they show that not only special, and first categories are important cores, but also that some second and third cathegories become attractors in specific regiones.

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[10]Central, Oriental, Atlantica, Pacific and Amazon and Orinoqua

Region	Type of matrix	Moran I
	Queen1	Queen 2
National	0.1516**	0.0983*
Central	0.0974*	0.0154
Oriental	0.1810**	0.0879
Atlantic	0.2576**	0.0648
Pacific	0.1833**	0.0822
A&O	0.1643**	0.0045
** means significant to 5% and * means nearly significant		

Table 2: Spatial Autocorrelation Analysis. Source: Data used from CENSO 2005-DANE.
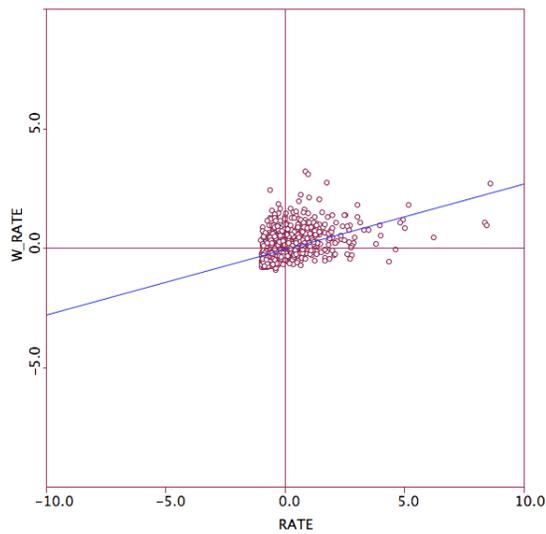
Figure 3: Moran Scatterplot of tertiary education graduates in Colombia. Data: CENSO 2005, DANE.
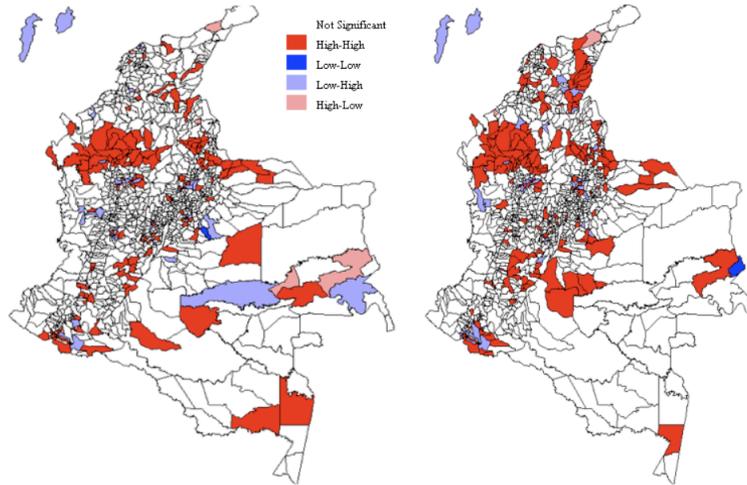
Figure 4: LISA of tertiary education graduates in Colombia by municipalities. On the left the LISA for the Queen matrix level 1 and on the right the level 2. This applies to all the LISA Analysis. Data: CENSO 2005, DANE.

From this analysis a cluster of low education is found in Antioquia, where it border with Choco and Cordoba, and farther away from Medellin. For the Oriental region a high-high cluster can be found near Tunja and Bucaramanga. Instead in the pacific region low-low clusters are found in the Choco and Cauca departments. From the Atlantic region a high-high cluster is observed near the main capitals and a low rates cluster is observed in the south border of Bolivar, Cordoba, Magdalena and Sucre. Finally for the Amazon and Orinoquia region small low rates cluster are observed, and they are also debatable, because of difficulties of transportation between them.

4 Factors explaining the agglomeration of educated people in Colombia

The factors possibly associated in Colombia as mentioned before are social, economic and political. Economic conditions matter to the selection of the place to

live accounting for economic variables, but in addition also social and political factors that affect choices for tertiary graduates. These other factors will condition their decision.

More explicitly one of the factors that affect this choice is that the industrial sector in Colombia is not advanced and the qualifications required are low. On the other hand the preparation of graduates, as stated by Mora and Ceballos, does not focus on the necessary areas. In this way a proxy of the quantity of companies from each sector will be used as an economic measure and then to test if the agglomeration is based mainly on industrial development or other sectors.

Social related factor such as access to public services can be related to economic variables. However this sector in Colombia is not particularly correlated because of the efficiency of public policy and the corruption of goverment employees and politicians who work for other interests. This variable is mostly related to effective social planning in cities. These problems are mainly observed regarding the access to the water supply. This variable will be used to account for social factors.

The political factors must be considered to analyze Colombian development, because the conflict and displacement problem in Colombia in the 1990's and 2000's caused many changes in the structure of the cities. The history and consequences related to the internal conflict can be read in Sanchez, Peñaranda and Hurtado (2007). The proxy used to measure this comes from an estimation of political homicide made by Gutierrez (2006).

The analysis to check the spatial correlation of the data show that it will be necessary to include a spatial term in the related factors and the Equation to be considered originally is the following:

$$PTG_i = \beta_0 + \beta_1 Economic_i + \beta_2 Social_i + \beta_3 Political_i + \epsilon_i \qquad (1)$$

The variables included are:

- PTG_i : The Percentage of University graduates for the city i.

- $Economic_i$: The variable considered for economic purposes is the proportion of economic activity times every thousand persons for the city i and has

been defined as "*Industry*" for the industrial sector, "*Commerce*" for the commercial sector, and *Service* for the service sector.

- $Social_i$:The variable "*Water*" considering the coverage of water supply in the city i.

- $Political_i$: "Violence" is the Variable accounting for the number of political homicide for the years 2000 to 2005 divided by the population in the department and multiplied by 1000[11].

The equations considering spatial data the Spatial Autorregresive (SAR) and Spatial Moving Average (SMA):

$$PTG_i = \rho W_{PTG_i} + \beta_0 + \beta_1 Economic_i + \beta_2 Social_i + \beta_3 Political_i + \epsilon_i \quad (2)$$

$$PTG_i = \beta_0 + \beta_1 Economic_i + \beta_2 Social_i + \beta_3 Political_i + u_i \quad (3)$$

where

$$u_i = \lambda W_{u_i} + \epsilon \quad (4)$$

It can be seen there is important need to include a spatial variable as seen in the Moran Test applied to the residuals in the models done by OLS. The results for the analysis using the spatial Lag of the variable and the error lag are presented in the following tables 3, 4 and 5. Here we see where as can be seen and in the table the Lagrange multiplier test show that the best model is the Maximum Lkelihood Estimation of the Spatial Error Model and also the results seems to support this model. It must be highlighted that all the variables considered seem to be signicant as are the spatial parameters, but this happens in both type of models[12].

It is must be noted that the industrial sector has a lower effect. In the SAR it is not significant and almost in the border for the SMA model. This identifies two possible causes of this problem. Firstly Colombian industries do not require advanced human capital or skilled workers, and secondly, as mentioned by Mora

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[11] I am thankful to Francisco Gutierrez for allowing the use of this information. For more details see the appendix A.

[12] For a complete review on the methods applied see Anselin, 1988 and Arbia 2006

Variable	OLS Model	SAR Model	SMA Model
Constant	0.073	−1.4716**	−0.4532
	(0.3631)	(0.3362)	(0.4332)
Water	8.776**	7.1056**	9.008**
	(0.5112)	(0.5045)	(0.5561)
Violence	−0.9121**	−0.6754**	−0.793**
	(0.226)	(0.2062)	(0.2377)
Industry	0.0136	0.0172	0.0361**
	(0.018)	(0.0164)	(0.0182)
W-PTG		0.4401**	
		(0.0349)	
λ			0.5182**
			(0.0362)
R^2	0.2321		
AIC		5950.45	5914.48
Moran test	0.3067		
Prob	0.00		
LM-Lag	230.963		
Prob	0.00		
Robust LM Lag	0.0056		
Prob	0.93		
LM-Error	286.941		
Prob	0.00		
Robust LM Error	55.984		
Prob	0.00		
LM SARMA	286.947		
Prob	0.00		
** means significant at 5%.			

Table 3: ML Ahalysis for PTG_i in Colombia with the industrial sector. The value on top is the coefficient and the p-value in the parenthesis is the standard error.

Variable	OLS Model	SAR Model	SMA Model
Constant	−0.0406	−1.5988**	−0.5754
	(0.3611)	(0.3332)	(0.43)
Water	8.2104**	6.5**	8.3353**
	(0.5309)	(0.5171)	(0.5665)
Violence	−0.9254**	−0.6886**	−0.8283**
	(0.2245)	(0.2045)	(0.2354)
Commerce	0.03375**	0.0357**	0.0442**
	(0.009)	(0.0082)	(0.008)
W-PTG		0.4437**	
		(0.0344)	
λ			0.5301**
			(0.0357)
R^2	0.2415		
AIC		5932.72	5888.9
Moran test	0.3165		
Prob	0.00		
LM-Lag	235.621		
Prob	0.00		
Robust LM Lag	0.3329		
Prob	0.5639		
LM-Error	305.4774		
Prob	0.00		
Robust LM Error	70.189		
Prob	0.00		
LM SARMA	305.81		
Prob	0.00		
** means significant at 5%.			

Table 4: ML Ahalysis for PTG_i in Colombia with the commercial sector. The value on top is the coefficient and the p-value in the parenthesis is the standard error.

Variable	OLS Model	SAR Model	SMA Model
Constant	−0.1049	−1.654**	−0.648
	(0.355)	(0.327)	(0.425)
Water	7.68**	6.009**	7.8311**
	(0.528)	(0.511)	(0.5608)
Violence	−0.9405**	−0.7031**	−0.869**
	(0.2217)	(0.2016)	(0.2315)
Service	0.108**	0.1078**	0.1272**
	(0.0165)	(0.015)	(0.0149)
W-PTG		0.4438**	
		(0.0338)	
λ			0.5415**
			(0.0352)
R^2	0.2607		
AIC		5901.17	5849.08
Moran test	0.325		
Prob	0.00		
LM-Lag	239.074		
Prob	0.00		
Robust LM Lag	0.739		
Prob	0.389		
LM-Error	323.189		
Prob	0.00		
Robust LM Error	84.854		
Prob	0.00		
LM SARMA	323.92		
Prob	0.00		
** means significant at 5%.			

Table 5: ML Ahalysis for PTG_i in Colombia with the service sector. The value on top is the coefficient and the p-value in the parenthesis is the standard error.

and Ceballos, tertiary education in Colombia does not focused on regions needs.

It is important to observe that the coefficient for the economic variables is significant and the sign shows the expected coefficient of the variable according to what it should be. Economic variables and the variable related to the welfare of the people have positive effects and the variable related to violence has a negative one(table 3, 4 and 5). The previous correlations show us that people tend to go to places where there is less violence and better living conditions and work options. This result is consistant with the matching component of increasing returns to scale as introduced by Easterly (2001) who stated "The economy will exhibit strong concentrations of high skill in a few places surrounded by large swatches of low skill."

5   Conclusions

A review of the data proposed in this article should demonstrate the importance of the agglomeration of educated people as a significant determining factor in the development of Colombian cities and the regions in which they are located. It is important not only to consider the distance between the different municipalities but also the specific location to see the real spatial effect and the real geographic association. The first conclusion to be accounted for confirms findings put forward by Bonet: if you have a prosperous neighbour you will be wealthy or at least more developed, and if you have poor neighbors it is probable that you will be poor, and this will be the same for education.

It is important to consider welfare relationships through the access to public services in order to draw conclusions because these relationships have been vital in creating agglomerations. Furthermore, this access is also agglomerated and therefore access to the water supply as a necessity to live is crucial for this case.

Violence variables must be accounted for as well. Regardless of other factors, an area that is known to have violent reputation strongly discourages people from moving to, or staying in those municipalities. It is important to consider that violent experiences tend to drive people away where that violence occurs. For future studies it could perhaps be signicant to use a proxy that accounted for in greater historical depth violence variables, accounting for people's memory.

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Economic variables are indeed related. However, it can be argued that a two-way and mutually reinforcing relationship exists between educated people and developed or wealthy areas. On the one hand, educated people seek better wages, typically found in wealthy areas, while at the same time educated people stimulate for economic growth and development[13]. This relationship may cast doubts on the results obtained in this paper but should be considered in a comprehensive evaluation of these phenomena. Although as stated by Easterly "The magnitude of the relationship between initial schooling and subsequent growth is more consistent with the story of growth causing schooling rather than schooling causing growth."

Since Spatial factors are considered, this type of analysis gives results that the same information and standard econometrics don't. The spatial association of the data can be seen and as Tobler states it. Regional analysis shows that there are big and small cores to be considered and their presence in the regions is an important factor of socioeconomic relationships.

Furthermore availability of tertiary education in the bigger cities must also be considered as an important factor analyzing this agglomeration and should be clarified that not only are the rates agglomerated but also the population in the cities present agglomeration as was observed by Galvis in "Economic Topography in Colombia".

It is also necessary to identify that this analysis was done using the municipalities as observation units and the result keeps hidden any heterogeneity within the municipality which are also very important in urban areas not visible in this study. Another argument that should be considered is the different definitions of region in the results obtained.

Colombia in no longer the country of one student for one thousand ignorants, at least for the larger cities, however in order to progress this has to happen countrywide.

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[13]This relationship is considered a stylized fact in economic growth.

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A Data description

The data used in for the recent calculations was taken mostly from the CENSO 2005, the information has been publicated during the last year. The information calculated with the data from DANE is the percentage of people which has a degree in the tertiary level of education, the coverage of the water supply in the city and last the economic variables. The construction of the data for use is presented:

- Percentage of Tertiary Graduates (PTG): The percentage of graduates from the tertiary level education in the city is calculated in the following way:

$$PTG = \frac{Pgl_i}{(TotPop_i) - (Peoples15)} * 100$$

  where the data comes from a survey done in the CENSO and Pgl_i is people that graduated at the tertiary level in the city i, $TotPop_i$ is the total population from the survey in the city i, and $Peoples15$ is the population in the survey younger than 15 years old[14]

- The Coverage of the water supply in the city (Servvar): Percentage of people that has access to the service of water[15]. This data is calculated by the CENSO with a survey also.

- The economic variables are calculated using the number of economic units and the specific sector where they belong the Commercial Sector and the Service Sector.

B Education in Colombian cities grouped by regions

The evaluation of the regions seem to be important to observe the presence of attractors in specic regions, as should be considered that Bogota, Medellin and Cali are not the only cores in the country as can be seen mainly in figure 4 from this section, it must be remarked that it is the effect from other capitals and cities near the big capitals which create the cluster of educated people, because they want to avoid the congestions of the bigger cities and search for tranquility with greater contact to nature in their way of living.

Colombia is divided in 5 regions: Central[16], Oriental[17], Pacific[18], Atlantic[19],

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[14]Its used the 15 years old range because the fact that using 20 years would make that some persons considered in the numerator are not considered in the denominator.

[15]Its considered because of the importance and the important necessity of water for a living.

[16]The central region is composed of Antioquia, Caldas, Huila, Quindio, Risaralda and Tolima.

[17]The oriental region is composed by Boyaca, Cundinamarca, Meta, Norte de Santander, Santa Fe de Bogota and Santander.

[18]The pacific region is composed of Cauca, Choco, Nariño and Valle del Cauca

[19]The atlantic region is composed of Atlantico, Bolivar, Cesar, Cordoba, La Guajira, Magdalena and Sucre

and Amazon and Orinoquia[20] [21] this definition of regions is taken like this in order to avoid a further discussion on the different concepts of regions in Colombia.
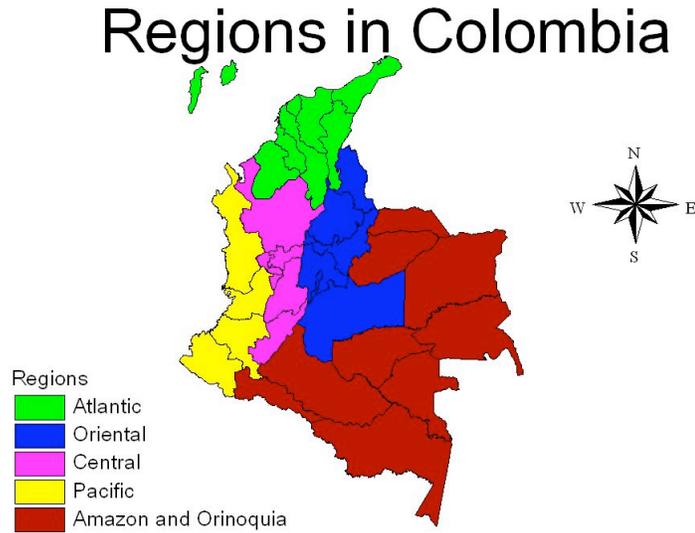
Figure 5: Classification of regions in Colombia. Data: CENSO 2005, DANE.

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[20]The Amazon and Orinoquia (A & O) Region is composed of Amazonas, Arauca, Caqueta, Casanare, Guainia, Guaviare, Putumayo, Vaupes and Vichada.

[21]The regions were formed according to Los Municipios Colombianos hacia los Objetivos de Desarrollo del Milenio. Salud, educación y reducción de la pobreza, 2006 and by discussions with Jorge Aponte.
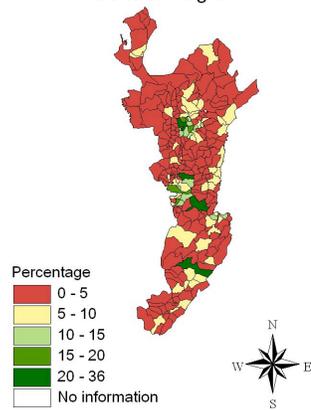
Figure 6: Percentage of tertiary education graduates in the Central Region of Colombia. Data: CENSO 2005, DANE.
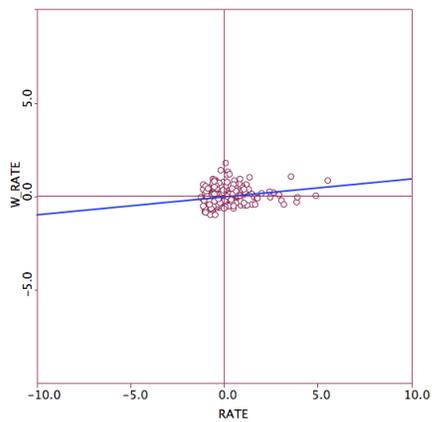

Figure 7: Moran Scatterplot of tertiary education graduates in the Central Region of Colombia. Data: CENSO 2005, DANE.
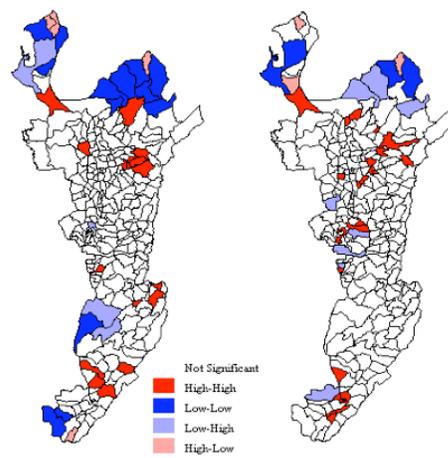
Figure 8: LISA Analysis for the Central region of Colombia. Data: CENSO 2005, DANE.

Percentage of people that attended
the tertiary education in
the Oriental Region
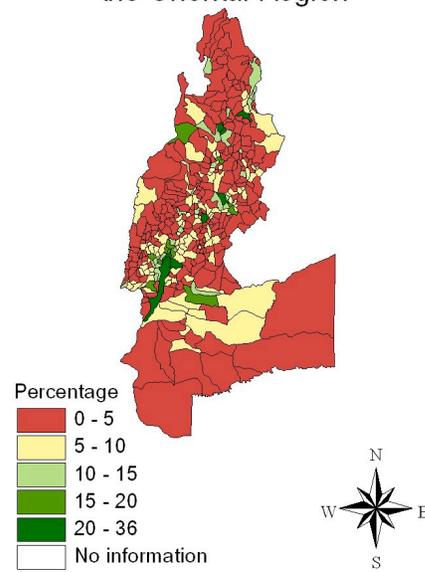
Figure 9: Percentage of tertiary education graduates in the Oriental Region of Colombia by municipalities. Data: CENSO 2005, DANE.
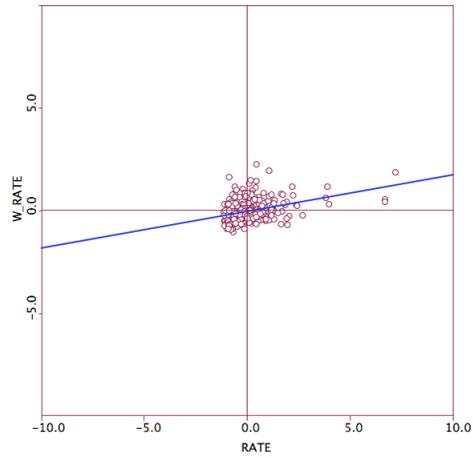
Figure 10: Moran Scatterplot of the tertiary education graduates in the Oriental Region of Colombia. Data: CENSO 2005, DANE.
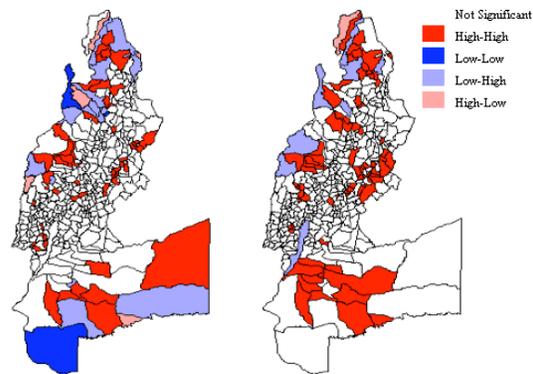
Figure 11: LISA of tertiary education graduates in the Oriental Region of Colombia by municipalities. Data: CENSO 2005, DANE.
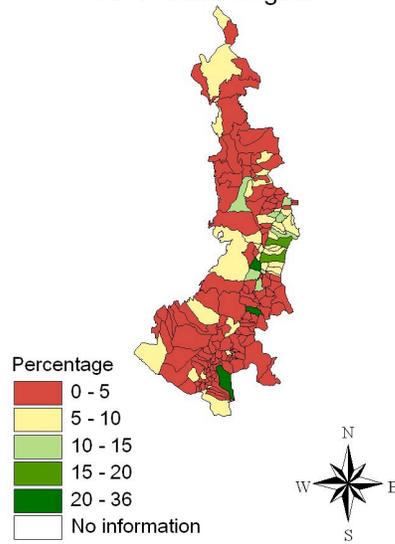
Figure 12: Percentage of tertiary education graduates in the Pacific Region of Colombia by municipalities. Data: CENSO 2005, DANE.
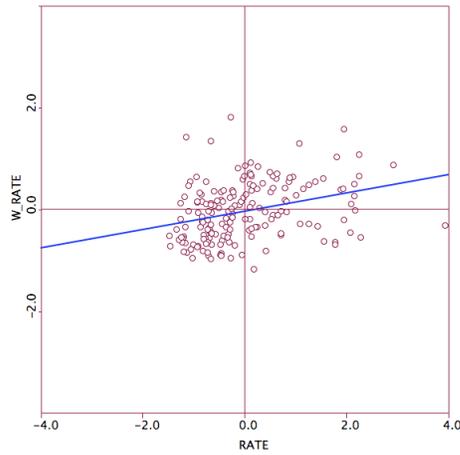
Figure 13: Moran Scatterplot of tertiary education graduates in the Pacific Region of Colombia. Data: CENSO 2005, DANE.
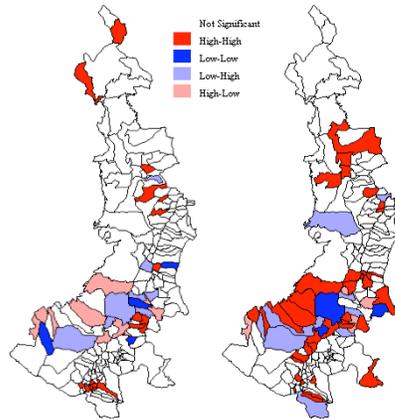

Figure 14: LISA of tertiary education graduates in the Pacific Region of Colombia by municipalities. Data: CENSO 2005, DANE.

Figure 15: Percentage of tertiary education graduates in the Atlantic Region of Colombia by municipalities. Data: CENSO 2005, DANE.
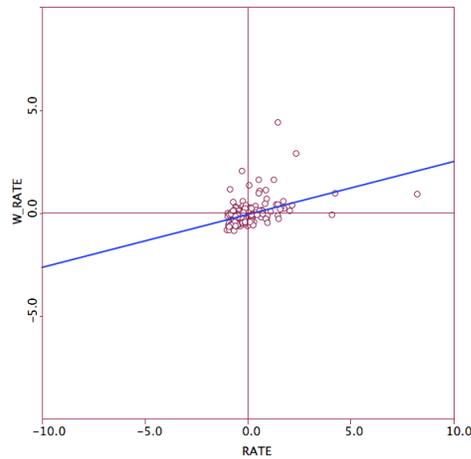
Figure 16: Moran Scatterplot of tertiary education graduates in the Atlantic Region of Colombia. Data: CENSO 2005, DANE.
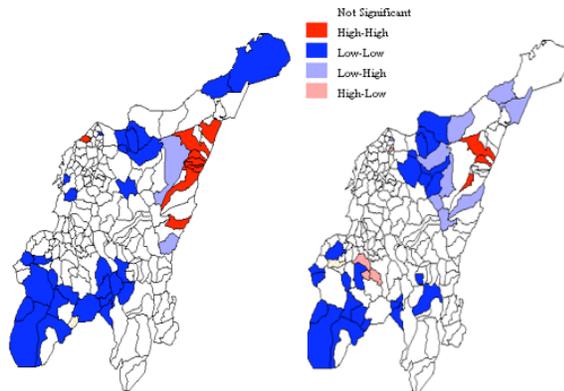
Figure 17: LISA of tertiary education graduates in the Atlantic Region of Colombia by municipalities. Data: CENSO 2005, DANE.

Figure 18: Percentage of tertiary education graduates in the Amazon and Orinoquia Region of Colombia by municipalities. Data: CENSO 2005, DANE.

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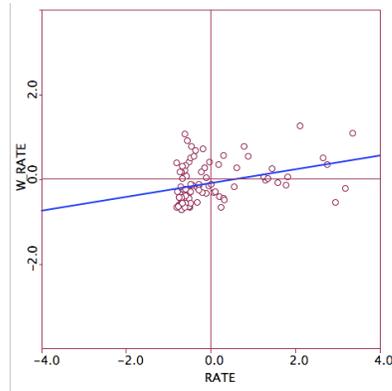
Figure 19: Moran Scatterplot of tertiary education graduates in the Amazon and Orinoquia Colombia. Data: CENSO 2005, DANE.
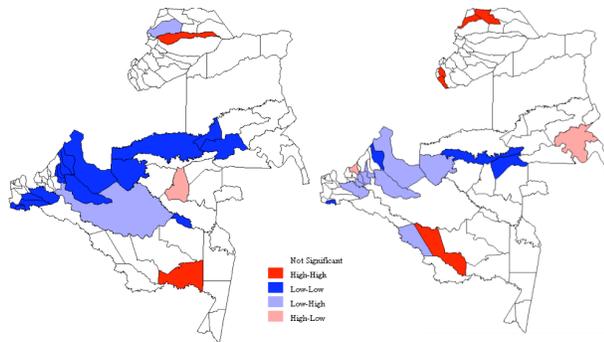

Figure 20: Percentage of tertiary education graduates in Colombia by municipalities. Data: CENSO 2005, DANE.