

How economic agglomeration could impact the economic development at the region level an spatial analysis in Colombia

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Abstract

This paper analyzes the economic agglomeration impact in Colombia's economic development by region, taking GDP per capita as a dependent variable and agglomeration, inequality, crime, illiteracy and qualified employment as explanatory variables. We used data from 24 departments in Colombia between 2001 and 2014, identifying the correlation between all variables and estimating an econometric model through a fixed effects panel method. The literature reviewed in this paper shows theoretical concepts about agglomeration and similar studies made in Colombia and other latitudes, where agglomeration economies have contributed significantly to determine public policies and economic development strategies. In line with this literature, we found a strong relationship between economic agglomeration and GDP per capita in Colombia, identifying at the same time a negative effect by inequality, crime and illiteracy in GDP per capita, contrary to qualified employment which has a positive effect in our dependent variable. These findings corroborate the importance of investing in reducing inequality, crime and illiteracy in Colombia and, in this same way, increasing qualified employment to improve levels of GDP per capita. Conversely, today Colombia is a country which concentrates 50% of its population in just 4 departments and the other 50% occupies the other 28 departments. Factors associated with the geography, topography, low transportation and telecommunication infrastructure, crime, inequality, unemployment and education, could explain these sharp differences in economic development at a regional level.

1. Introduction

The economic development of a region could be determined by variables such as economic agglomeration, employment rates, geographical position, crime, inequality and education. If the government knows how these variables impact the economic development of each region, it may build public policies according to the magnitude of each variable. Based on this, it is possible for public institutions to make better decisions for its regions considering also the context and the particular variables of each region.

Colombia is a country where there is a heavy agglomeration, as just 43% of the national territory concentrates 90% of the population (DANE, 2016), due to the historical Spanish and indigenous ancestries, population distribution has predominated the Andean and Caribbean region. Another reason is Colombia's relief and topography, which have made the development of infrastructure routes more difficult. Therefore several major cities in Colombia grew, in contrast to other Latin-American countries in which the urban agglomeration only occurred just in their capital cities (Murad, 2003). This is why it is interesting to study how economy agglomeration could impact the economic development for each region in Colombia, and in this way, and thus contribute academically with this study that allows us to understand this phenomenon through an economic spatial analysis.

The purpose of this article is to determine how agglomeration in the different regions of Colombia could be a competitive advantage for economic development measured through GDP per capita, by performing a spatial analysis and using socio-economic variables. Therefore, first of all, it is necessary to study the results derived from previous research in different latitudes concerning economic agglomeration, spatial analysis and the tendency for industries to cluster. Secondly, the article will compare the geographic localization for industries to cluster in Colombia considering local dispersion (measured in distance by region) and the possible competitive advantage for economic development by means of a descriptive analysis. Finally, it is going to analyze the correlation between GDP per capita¹ and economic agglomeration in terms of population, labor market, crime, inequality and education.

¹ GDP per Capita is a measurement of the total output of a country that takes the Gross Domestic Product (GDP) and divides it by the number of people in the country. (Investopedia)

As a whole, this study shows how agglomeration results in positive effects for the economic development in Colombian regions as well as employment and education rates, which contribute positively to increase GDP per capita of Colombia; whereas illiteracy, crime and inequality have a harmful impact. This could be a result of fewer opportunities given by higher inequality, which leads to low education and an increase in crime.

The structure of this article is as follows. The next section overviews research on theoretical concepts about agglomeration and similar studies made in Colombia and other latitudes. Section 3 shows the empirical model. The data analysis is made in section 4, and the results are showed in section 5. Finally section 6 concludes.

2. Literature review

Agglomeration economies are those which accrue to all of the firms located in the same area and these can be classified into different types, according to the way these are clustered, such as internal returns to scale where it requires a large quantity of capital and a large labor force to be located at the same place. This is why a high spatial concentration of both investment and people is necessary. Another type is economies of localization which accrue to a group of firms with the same industrial sector located at the same place where they can benefit from close proximity to supply firms and customers firm, the ease of exchange of personnel and consultants, and an increasing in the mutual understanding and familiarity of these firms at different phases within the production process. Finally, economies of urbanization accrue to firms across different sectors in order to provide services for the firms and employees of each sector in response to the large local diverse market; for instance cities where live and work people who require retail, educational, health care and leisure services live and work (McCann, 2001).

Fujita and Thisse (2002) studied the reasons for the existence of a large variety of economic agglomerations, identifying some economic causes that stand behind such a strong geographical concentration of consumption and production, such as industry location, demand geography and trade patterns. According to Marshall (1890), externalities are crucial in the formation of economic agglomerations and clusters; principally mass production, availability of specialized input services, formation of a highly specialized labor force and the production of new ideas, both based on the accumulation of human capital and the existence of modern infrastructure.

Based on this, Fujita and Thisse (2002) explain the structure of competition between geographically separate firms and the provision of local public goods. Furthermore, they explain the structure of metropolitan areas and the clustering of firms selling similar products followed by an analysis about the impact of factor mobility on the location of industry. Afterward, Fujita and Thisse (2002) studied how perfect competition in the land market and monopolistic competition in the product market can be combined with the aim of explaining the emergence of cities in a homogeneous setting and investigating the relationship between agglomeration and growth once agents have forward-looking behavior.

Agglomeration can be defined as a reduction in the spatial concentration of economy activity in particular regions. For instance across the nations of Europe as Gardiner, Martin and Tyler (2010) described how spatial agglomeration increased national growth in Europe, and they analyzed whether the concentration of economic activity and employment in particular regions, may be nationally efficient and actually benefit national growth. In the same way, Stohr (2014) estimated the impact of agglomeration on labor productivity and employment growth and he found that agglomeration economies contributed significantly to regional economic growth in Switzerland from 1860 and 2008. On the other hand, Tripathi (2012) investigated the relevant state and city-specific determinants of urban agglomeration, the spatial interactions between cities and the effect of urban agglomeration on India's urban economic growth, considering that in 1991 there were 23 cities with a population above one million and in 2001 it increased to 35 cities, meaning 38% of the total urban population where six mega cities had over five million inhabitants.

According to Sachs and Warner (1997) the geographical factors could influence the agglomeration and economic development in, for instance, the endowment of natural resources, the proximity to rivers and the access to seaports. Furthermore, the geographical location of a region can stimulate economic development, encouraging or otherwise lagging the commercial activities with other regions. They used a lineal regression between economic growth and natural resource intensity where they found that there was an inverse association between natural resource intensity and growth between 1970 and 1990 using information from 95 countries, accompanied by control variables such as openness policy, investment rates, human capital

accumulation rates, government expenditure ratios, terms of trade volatility, and the efficiency of government institutions.

Wang, et al. (2015), using data from 187 countries from 1960 to 2007. Found strong comovement of economic volatility across countries both geographically and economically, that is to say, a country's economic volatility is positively associated with its geographical neighbors' and trade partners' economic volatility. The main conclusion about their study is that during globalization economic distance matters more than geographical distance between regions. This is way countries located close to each other may not necessarily share similar patterns of economic volatility. In contrast, countries that have a closer trade relationship are more likely to exhibit relative comovement in their economic fluctuation.

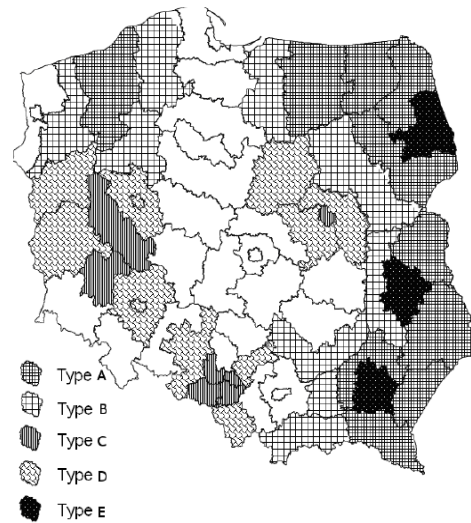
Other authors such as Paul Krugman and Masahisa Fujita have studied how a changing economic environment alters economic geography framed in the distributions of population, demand, endowment, market potential, transport costs and other factors. For instance, in Krugman (1998) is analyzed the centripetal forces (market-size effects by linkages, thick labor markets, pure external economies) and centrifugal forces (immobile factors, land rents, pure external diseconomies such as congestion) and their effects on economic geography, where presumably they are the responsible for economic activity concentration in one location more than in another. Fujita and Krugman (2004) defined the new economic geography as the role of external economies in the industry concentration and international trade, promoted by non-monocentric urban models in which all workers and consumers are free to choose their locations within the city. In consequence, the entire spatial structure of the city is then determined endogenously as an outcome of interactions between firms and households through competitive land and labor markets, including the locations of business centers.

Pietrzak, et al. (2014) defined that through the density labor market by regions, it is possible to calculate the spatial autocorrelation between economic agglomeration and GDP per capita, thus identifying spatial clusters. Moreover, spatial analysis allows to identify types of regions presenting diversified economic development levels and to apply a join-count test to examine spatial dependences among these types. They implemented local indicators for categorical data in the spatial analysis of economic development tests, which examine spatial autocorrelation for

categorical data, for this, they identified classes of regions presenting different economic development levels using taxonomic methods of multivariate data analysis. Then they applied a join-count test to examine spatial dependencies between regions and examined the tendency to form the spatial clusters. Finally, the global test indicates general spatial interactions between regions, while local tests give detailed results separately for each region. The main findings the occurrence of five spatial clusters with three clusters of wealth in Poland (three individual growth centers), where the areas of eastern and north western Poland include clusters of poverty due to are out of range of diffusion influence of bigger agglomerations. The figure 1 summarizes these results, distinguishing five types of regions, where type A has lowest values of economic development, type E has highest values and the white areas display statistical insignificance. As illustrated in Hanink, et al. (2014), China's policy promoted the economic development of coastal areas where access to international markets was easier and where foreign investors have had more experience. The expected outcome of these west-oriented policies was not only to reduce inequality, but also to reduce the pressure of continuing rapid growth along the coast. The spatial method used in this paper includes relatively standard measures used to describe concentration through coefficient of variation (CV) and the index of diversity (ID). The former is calculated as the standard deviation of employment in a sector, if the distribution of each sector's employment were uniformly distributed across the counties of China, then the standard deviation of that distribution would be zero and $CV = 0$. The second index is an approximation of the GINI² coefficient, which is calculated as one-half the sum of the absolute difference in percentages of observed county employment in a sector and the percentage that would occur if employment were uniformly distributed by county; if the minimum value of ID is zero corresponds to a uniform geographical (by county) distribution of actual sectorial employment, while increasing values indicate higher concentration. The figure 2 and 3, show how the accelerated influx of foreign direct investment served, along with the increasing privatization of the coastal province economies, in turn to accelerate agglomeration in those areas as a response to market-based competitive pressures to improve efficiency.

² The GINI Index is a measurement distribution of a country's residents. This number ranges between 0 and 1 and it is based on residents' net income, helps define the gap between the rich and the poor, with 0 representing perfect equality and 1 perfect inequality. (Investopedia)

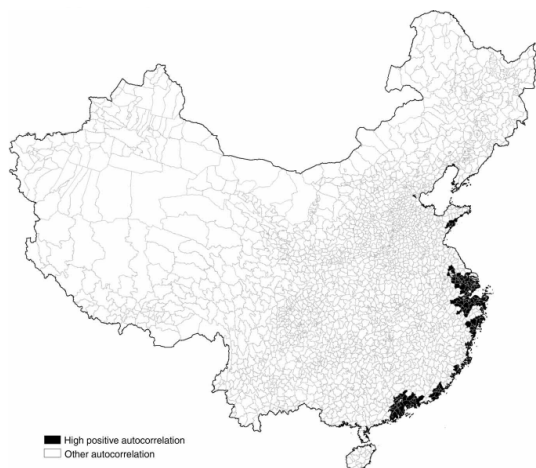
Figure 1. Local join – count test results – five types of regions according to economic development levels and spatial dependences in Poland



Source Pietrzark, et al. (2014)

In line with these studies, Fujita and Hu (2001) found that the agglomeration of Chinese producers across several industries in the coastal region were a market-based response that was unleashed by the government's economic liberalization. It was accelerated by the inflow of foreign direct investment that was guided to the coast by traditional international connections via Hong Kong and Shanghai, and also encouraged in its locational pattern by government policy. They examined trends in regional disparity during the period 1985 – 1994, using GDP and industry output data, according to income distribution and production agglomeration. This period reflects the most intensive effects of globalization and economic liberalization in the Chinese economy, when the income disparity between the coastal area and the interior had been increasing, due to industrial production showed strong agglomeration toward the coastal area, while within coastal provinces there was a trend of convergence. For Fujita and Hu (2001) the main finding of their paper is that driven by geographical advantages, most manufacturing sectors show an increasing trend of agglomeration, even labor-intensive ones.

Figure 2. Spatial clusters of 2000 employment encompassed in levels factor 1 scores in China.



Source: Hanink, et al. (2011).

Figure 3. Factor composition of sectorial employment specialization in China 2000

Factor composition	Sector loading
<i>Common factor 1</i>	
Post and telecommunications	0.845
Catering	0.702
Real estate management	0.613
Consulting	0.663
Technical services	0.615
Financial services	0.875
Insurance services	0.844
Enterprise management	0.784
Teaching	0.631
<i>Common factor 2</i>	
Sewing	0.648
Cultural, educational, and sporting goods	0.627
Plastic products	0.781
Metalwork	0.684
Electrical equipment	0.668
Electronics and telecommunications equipment	0.645

Source: Hanink, et al. (2011).

In 1955 Simon Kuznets introduced the Inverted-U hypothesis, which postulates that “Income inequality tends to increase first and then fall once a certain average income is attained”. This postulation has triggered other investigations in the subject of economic income and inequality such as Castells and Royuela (2014) who studied the effects of agglomeration on economic growth. They analyzed how inequality and agglomeration influence economic growth in function for the country’s level of development and its initial income distribution. They developed an econometric model of growth to analyze the impact of inequality and urbanization using panel data techniques that controls for conditional convergence, levels of human capital and investment. For this study, they used GDP per capita growth as their dependent variable and as the independent variable included GINI coefficient, the rate of urbanization, the initial price of investment, and the initial level of years of schooling for 51 countries with data from 1970 to 2007. The main conclusion in this paper is that high inequality levels limit growth in the long run and urban concentration tends to foster growth. However, increasing agglomeration fosters growth in low-income countries, while increasing urbanization, as opposed to increasing urban concentration, seems beneficial for high-income countries. Indeed, in both high and low income countries the positive effects of increasing agglomeration are felt in low-inequality countries.

Analyzing the case of Colombia, Sanchez and Nuñez (2000) found that the level of municipal income per capita and its growth are responsible for between 35% and 47% of the variance in municipal income per capita, and between 35% and 40% of the variance in municipal income per capita growth. In poor cities, geography is responsible for between 24% and 27% of income per

capital growth variance, while in rich cities geography is less important, accounting only for between 18% and 25% income per capita variance and 16% and 17% of income per capita growth variance. They used income per capita and population density of Colombian by municipalities between 1973 and 1995, including economic activity, social conditions, education, health, infrastructure, crime and geography. Finally, through econometric estimations, Sanchez and Nuñez (2000) constructed a set of geographical variables based on soil, climate and road maps, establishing that geography affects income and its growth via productivity of land, the availability of natural resources such as water and rivers, the presence of tropical diseases, and agglomeration or population density which is also influenced by the availability of infrastructure and access to social services.

Also for the case of Colombia, Royuela and García (2010) investigated not only economic convergence in terms of GDP as a proxy for human well-being, but also social convergence, taking into consideration such aspects as life expectancy, infant mortality, educational enrolment and crime issues for Colombia's regions between 1975 and 2005. For answer the question: "*what is the relationship between convergence and spatial autocorrelation?*" they used econometric techniques to find convergence in living standards: β -convergence, σ -convergence and kernel density. Through this paper, these authors found conflicting results in the economic variables and insignificant long-run beta convergence parameters. However, they found convergence in key social variables but no convergence in real GDP per capita; hence they pose the question for future research: "*What is the relationship in the evolution between social and economic variables at regional level in developing countries?*" Based on this question, in this paper we took social variables such as GINI, crime, illiteracy and qualified employment, and analyzed their effects on this dynamic economy at the regional level, measured through GDP per capita.

Finally, García (2016) analyzed the relationship between wages and agglomeration economies, and the effects on formal and informal productivity using data from Colombia. He found that there are higher agglomeration returns for less educated Colombian workers, contrary to the results from developed countries found in other studies. Therefore, it is interesting to study how agglomeration could impact the economic development of a region, specifically in Colombia, using GDP per capita as dependent variable and qualified employment as explanatory variable,

beside other independent variables such as inequality crime, illiteracy and economic agglomeration.

3. Empirical model

In this section we present a model in which we structure our empirical specification. We estimated a fixed effects panel model to test the impact of agglomeration, education, crime and qualified employment on the gross domestic product (GDP) per capita at the regional level. The basic model for the study can be expressed as follows.

$$\begin{aligned} \text{LogGDP per Capita} = & B_0 + B_1 \log \text{Agglomeration}_{it} + B_2 \text{Inequality}_{it} + B_3 \text{Illiteracy}_{it} + B_4 \log \text{Crime}_{it} \\ & + B_5 \text{Qualified Employment}_{it} \end{aligned} \quad (1)$$

Where the dependent variable is GDP per capita for region i in year t , our measurement of agglomeration takes into account the number of employed people divided by the total size of the department, that is a measure of employment density. For education we took into account two variables. The first one is illiteracy rate measure taking into account only the population older than five years old per every 100 people, and the second is the qualified employment variable that is built after finding out how many employed people have a high school degree or higher per every 100 people. For inequality we used the GINI for each region, and finally for crime we used the homicide rate in each department build with the number of homicides per 100 people.

It is important to mention that initially we thought of using geographical control variables which did not vary over time, but given the model used which is especially used to measure variables that vary from one measurement to the other, they were taken out of consideration.

In terms of impacts of the independent variable we expected that, first the agglomeration variable reflects the number of employed people in every region, according to Fujita and Hu (2001) workers tend to agglomerate in territories as a market – based response to better conditions, thus the coefficient on agglomeration should be positive. Secondly, it can measure the inequality in every region by using the GINI coefficient, this comes in line with the Inverted – U hypothesis postulated by Simon Kuznets (1995), where he estimates that inequality tend to increase at first and the decrease once certain income is attained. Given these characteristics this coefficient

should be negative. The same case comes for Illiteracy and Crime, both variable seek to describe the environment of the region and the opportunities for it's residents. Finally the qualified employment variable, which intent to reflect the number of high quality employees for every region should have a positive effect on the GDP per Capita.

4. Data and Variables

Some of the literature on agglomeration economies uses detailed spatial data of regions over extensive periods of time; this is the case of Wang, et al. (2015), who found data for 187 countries for a period of nearly 50 year. Unfortunately this kind of information is not available for Colombia and other developing countries. Given these limitations, we mainly used information provided by the National Administrative Statistics Department (DANE). This information was in a significant percentage found in the cross-section survey called, the Colombian Great Integrated Household Survey (GIHS), given that this survey gathers information about population's general characteristics, we took detailed information about education, which was measured by illiteracy, number of persons above the age of five who can not read or write, and qualified employment, number of persons who are working and have a high school degree or higher, the crime variable is measure by the number of homicides on a base of 100 people, this information was taken from the violence panel made by the University of Los Andes. As it was said before the agglomeration was constructed using information taken from DANE, this definition of agglomeration comes in line with Krugman and Fujita (1999), in their paper they estate that workers and markets tend to concentrate given different externalities.

We analyzed the period between 2001 and 2014 for 24 departments in Colombia (there wasn't enough information for all 32 departments). There was an important change in methodology made by DANE in 2007, but we consider that change not to have made an impact on the variables we were taking into account. Finally, we have 335 observations with an average of 14 observations per department.

In Table 1, we show some descriptive statistics of these variables. For the GDP per capita we can see that there is a growth in the mean of 36.1%, from 2001 to 2014, the same goes with agglomeration and qualified employment with 28.8% and 36.6%. On the other hand, there is a

diminution for inequality, crime and qualified employment; these are signs of an improvement in the economy of the country.

Table 1. Summary statistics at individual effect

	2001		2007		2014	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
Log GDP per capita*	6,428,926	6,177,431	7,099,549	3,954,601	8,754,736	5,468,698
Log Agglomeration	55.557	88.261	56.975	96.866	71.556	123.28
Inequality	0.522	0.039	0.511	0.032	0.502	0.036
Crime	11.311	5.968	8.773	3.794	6.157	1.908
Illiteracy**	12.845	5.083	11.486	4.905	9.246	3.829
Qualified Employment**	46.741	15.858	58.612	14.116	63.840	10.797

* The data is given in Colombian Pesos
** The data are weighted using person sampling weights from GEIH to be representative

Colombia is a country formed by 32 departments and a capital district, the country has many geographical and cultural singularities, and this is why regions, which are departments with similar characteristics, can divide the country.³

These natural regions can help explain the behavior of some variables that will be shown next. For instance the Andean Region has the largest industrial development due to the presence of the capital, Bogota, and the second largest city by fiscal income, Medellin. This region not only has industrial agglomeration, but also a lot of agricultural development. Meanwhile, the Caribbean region has the advantage of the sea, which makes it easier and necessary for the import and export of merchandise, unfortunately the region hasn't shown big rates of growth and has always been a challenge to the administration. The Orinoquian Region has oli extraction and agriculture: but as it is on the border with Venezuela, it has many challenges in the areas of crime and

³ The natural regions of Colombia are conformed as it is showed next:

Andean Region: Antioquia, Bolivar, Boyacá, Caldas, Cauca, Cundinamarca, Huila, Meta, Norte de Santander, Quindío, Risaralda, Santander and Tolima.

Amazonic Region: Amazonas, Caquetá, Guainía, Guaviare, Putumayo and Vaupés.

Caribbean Region: Atlántico, Bolivar, Cesar, Córdoba, la Guajira, Magdalena and Sucre.

Pacific Region: Cauca, Chocó, Nariño, Valle del Cauca.

Orinoquian Region: Arauca, Casanare, Meta and Vichada.

Insular Region: San Andrés y Providencia.

Figure 4. Political Division of Colombia

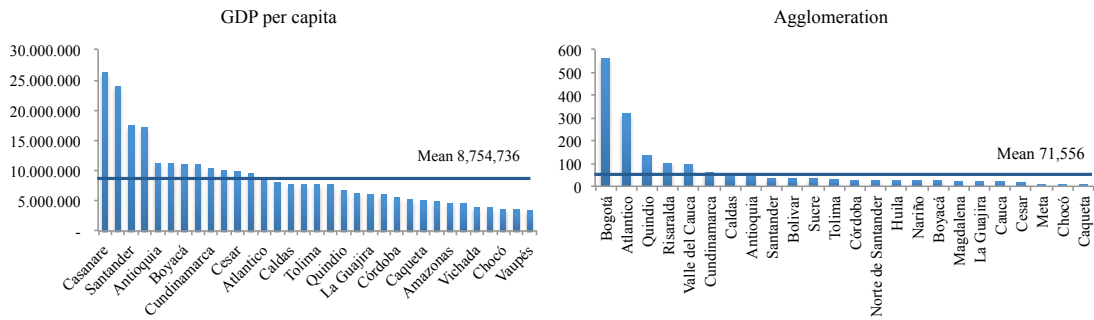


Source: Agustun Codazzi

violence. Finally the Amazonian and Pacific Regions show the smallest industrial development and high levels of inequality and violence.

Figure 5 shows that Casanare and Santander have the biggest GDP per capita, due to the oil extraction in both regions and their low population. Meanwhile the regions with the smallest GDP per capita are Chocó and Vaupes both have experience a lot of challenges in inequality which has lead to big rates of crime, both of them are departments that have suffered a lot of violence and have high rates of unemployment also they show little industrial development which make it difficult to have big income. In general we saw a little equilibrium between the data, which explains the high standard deviation seen in Table 1. For the explanatory variable agglomeration, we found a similar behavior where Bogotá has significantly higher agglomeration than the other regions; this also explains the high standard deviation. The results are logical since Bogotá being the capital of the country has a bigger industrial development, meanwhile the south of the country has experience high rates of violence and little presence from the estate.

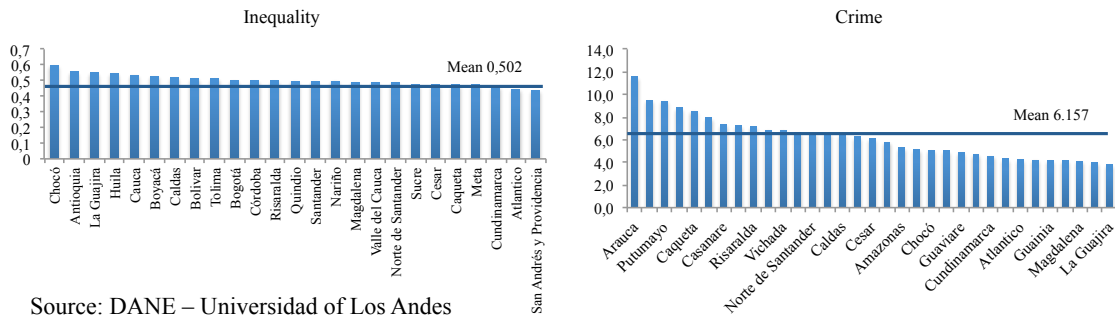
Figure 5. GDP per capita and Agglomeration



Source: DANE

In figure 6 we show the GINI Coefficient used to measure inequality show the most homogenous behavior for the entire country, showing the big challenges the country has in this matter, where the department with biggest inequality is Chocó, and the least is San Andrés and Providencia. These results are coherent with what we saw in GDP per capita where Chocó was also the department with the smallest amount. Meanwhile crime shows higher results in the south of the country, as said before this regions have experience a lot of violence and not enough presence of the state, also its been traditionally where the FARC and ELN have had more power.

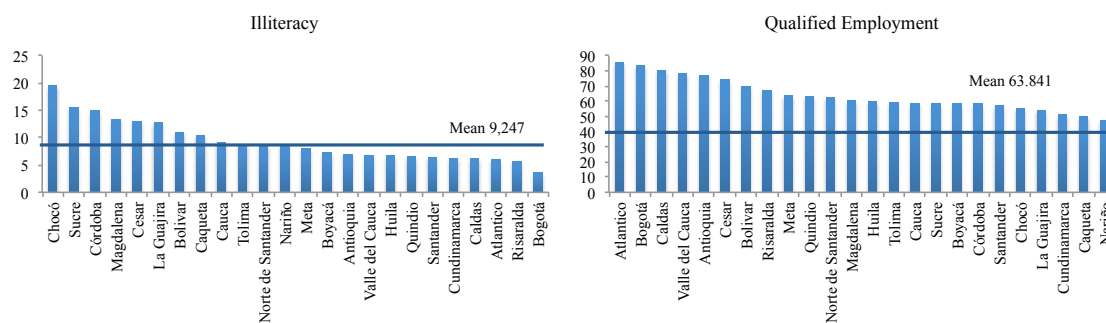
Figure 6. Inequality and Crime



Source: DANE – Universidad of Los Andes

Finally, the results for Illiteracy and Qualified employment are consistent where the regions with higher rates of illiteracy show the smallest rates of qualified employment, and also showing better results in the departments that are a part of the Andean Region.

Figure 7. Illiteracy and Qualified Employment



Source: DANE

The correlation matrix helps us illustrate the results that will be included in this paper, although it is just a first approach about the relationship between the variables. Table 2 shows us the correlations between the variables taken into account. The explanatory variable agglomeration shows a positive and statistical significance correlation with the GDP per capita. Meanwhile, the GDP per capita shows a negative correlation with inequality and illiteracy. These results are consistent with what we expected, given that illiteracy and inequality reduce the GDP per capita, in general the correlation matrix help us understand the relation between all the variables taken into account.

Table 2. Correlation Matrix

	Log GDP per Capita	Log Agglomeration	Inequality	Log Crime	Illiteracy	Qualified employment
Log GDP per capita	1					
Log Agglomeration	0.402***	1				
Inequality	-0.123**	-0.044	1			
Log Crime	-0.069**	-0.235***	-0.054	1		
Illiteracy	-0.614***	-0.578***	0.161**	-0.137**	1	
Qualified Employment	0.424***	0.623***	-0.026	-0.296***	-0.506***	1

* p<0.1 **p<0.05 ***p<0.01

5. Results

In Table 3 we show the results of the econometric model estimated when we included different control variables. It is possible to note that economic agglomeration variable is positive and statistically significant in the five models performed. It implies that Colombian departments with higher number of employees by square kilometer have better levels of GDP per capita. These findings corroborates the forces theory by Krugman and Fujita (2004), where we can see that economic agglomeration activates economic development because there are more demand of trade partners, moderns infrastructure for higher productivity and highly specialized labor force based on the accumulation of human capital.

Moreover, inequality has a negative effect on GDP per capita of 44.4% and it is statistically significant at 90%. It could imply that if inequality increases the GDP per capita decrease because there is a larger part of the population that does not have enough income to consume and stimulate the economy, due to wealth is concentrated in a lesser part of the population.

Likewise, illiteracy tends to decrease GDP per capita in 2% also showing significance. It means that economic development decline if per 100 people increase the number of individuals who cannot read or write, probably because this people will not be able to access a qualified work to increase its incomes. A possible consequence of illiteracy could be the inequality, which has a positive correlation because if there is more inequality, less people could access to education.

Furthermore, crime has a negative effect on GDP per capita affecting it in 33.8% and it is statistically significant at 99%. The possible implication is if there are more homicides per 100 people the region productive capacity is affected, and likewise crime unstimulated investment. By other hand, qualified employment had a direct effect on GDP per capita (12%) and it is statistically significant at 99% in the fifth model. It means that when there are more people with higher education economic development is strengthened because specialized labor force is better paid.

In general, we can see that the agglomeration variable is significant for all the models at 99%. This gives us the tools to state that when the agglomeration is bigger so is the GDP per capita. In the case of model number 3 we note that if agglomeration increases 1% GDP per capita could

grow 36%. For inequality this relation shows a decrease but this variable is not significant in the first and second model. Meanwhile a growth of 1% in crime has a negative effect of 39% in GDP per capita. For model 5 where we included all the independent variables, the results show that an increase of 1% in agglomeration has an effect of 35% in GDP per capita, a growth of 1% in inequality generates a change of -44% in the dependent variable, crime has a negative effect of 33%, a growth in qualified employment generates a change of 0.2% in GDP per capita, and finally illiteracy has a negative effect of 1.2%.

Table 3. Fixed Effect Panel Model
Dependent Variable: Log GDP per Capita

	Only Agglomeration (1)	Agglomeration Inequality (2)	Agglomeration Inequality Crime (3)	Agglomeration Inequality Crime Q Employment (4)	All Variables (5)
Log Agglomeration	0.822*** (0.068)	0.817*** (0.068)	0.360*** (0.068)	0.388*** (0.066)	0.353*** (0.066)
Inequality		-0.273 (0.319)	-0.299 (0.263)	-0.483* (0.259)	-0.444* (0.255)
Log Crime			-0.399*** (0.033)	-0.349*** (0.034)	-0.338*** (0.034)
Qualified Employment				0.003*** (0.001)	0.002** (0.001)
Illiteracy					-0.012*** (0.004)
Observations	335	335	335	335	335
Departments	24	24	24	24	24
R ² Within	0.320	0.321	0.541	0.568	0.584

* p<0.1 **p<0.05 ***p<0.01

6. Conclusions

In this paper we have analyzed how agglomeration could impact the economic development in terms of GDP per capita for each department in Colombia, considering explanatory variables such as inequality, crime, illiteracy and qualified employment.

According to the literature review agglomeration can be defined as economic and employment concentration which has positive effects in urban economic growth, considering explanatory

variables such as distance from the bigger cities, population density, state government, expenditure on transport, size of the state, city population coverage per higher education. On the whole, the studies about agglomeration cited in this paper have as common factor the positive effects of economic and employment concentration, specifically in the regions analyzed, in terms of productivity, GDP per capita and economic growth. However, these studies also agree in that is necessary government take responsibility about public policy for promote and regulate agglomeration in sustainability way, through wealth distribution, environment and demographic control regulation.

The main finding of this paper is the strong relationship between economic agglomeration and GDP per capita by department, indicating that when there is a higher employment concentration in a region, specially qualified employment, increase economic development because there are more demand of trade partners, moderns infrastructure for higher productivity and highly specialized labor force based on the accumulation of human capital. Equally important, we found a negative correlation between GDP per capita and crime, illiteracy and inequality, which are correlated between them. The implication could be that with higher inequality many people cannot access to education, which promotes less opportunities and it encourages crime.

After all, we have found quantitative evidence which allows us to suggest a possible public policy to improve the accessibility of the Colombian rural regions to international markets, however first is necessary to invest in transportation and telecommunication infrastructure which could facilitate economic agglomeration in rural regions connected with urban regions and making exporting from them easier. If agglomeration allows to reduce transactions cost to export and increase the productivity of rural regions, promoting the growth of market economies and accelerating regional economic growth, it could be the focus to take policy decisions, nevertheless these aspects are topics for future research.

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