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# Analysis of Convergence for the Ecuadorian case at the cantonal level in the period: 2007-2017

## Análisis de convergencia para el caso ecuatoriano a nivel cantonal en el período: 2007-2017

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### Abstract

*The objective of this study is to analyze the existence of convergence and determine its magnitude at the cantonal level for the Ecuadorian economy during the period 2007 to 2017. Following the methodology proposed by Quah, the transition matrix of the Ecuadorian economy at the cantonal level is estimated, following the postulates of Barro and Sala-i-Martin, the sigma convergence process is identified and an econometric model is estimated using OLS and cross-sectional data, to determine the existence and magnitude of the beta convergence. The main findings indicate that Ecuador shows an improvement in the final mobility situation. Furthermore, the absolute convergence rate amounts to 3.62% annual average at the cantonal level, while, by including conditioning factors in relation to physical infrastructure of households, electricity consumption and education, the speed of convergence amounts to 4.67% average annual, which denotes key areas of intervention, among others, in order to shorten territorial gaps in Ecuador.*

### Resumen

El objetivo de este estudio es analizar la existencia de convergencia y determinar su magnitud a nivel cantonal para la economía ecuatoriana durante el período 2007 a 2017. Siguiendo la metodología propuesta por Quah, se estima la matriz de transición de la economía ecuatoriana a nivel cantonal y siguiendo los postulados de Barro y Sala-i-Martin, se identifica el proceso de convergencia sigma y se estima un modelo econométrico utilizando MCO y datos de corte transversal, para determinar la existencia y magnitud de la convergencia beta. Los principales hallazgos indican que Ecuador muestra una mejora en la situación final de movilidad. Además, la tasa de convergencia absoluta asciende al 3.62% promedio anual en el nivel cantonal, mientras que, al incluir factores de condicionamiento en relación con la infraestructura física de los hogares, el consumo de electricidad y la educación, la velocidad de convergencia asciende al 4,67% promedio anual, lo que denota áreas clave de intervención, entre otras, para acortar brechas territoriales en Ecuador.

### Keywords | palabras clave

*Mobility Matrix, Sigma Convergence, Beta Convergence, economic growth, development, cross-sectional data.*
Matriz de movilidad, Convergencia Sigma, Convergencia Beta, crecimiento económico, desarrollo, corte transversal.

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## 1. Introduction

The economic growth is an opportunity for a country to emerge from poverty or improve its current living standards. However, if this growth only concentrates in certain areas that have shown high performance due to their geographic location, concentration of public entities, sea ports and other exogenous advantages, it will cause a problem of polarization of wealth and not a true economic growth and development.

Over the past decade, Ecuador has experienced a period of economic growth and, as a result, the government has taken a number of measures with the aim of closing the gaps between the rich and depressed areas of the country, thus achieving a visible economic integration. However, it is of great interest, both politically and academically, to find evidence as to whether this growth and policies have had the desired effect or, conversely, if the concentration of wealth has maintained in certain regions.

Therefore, this empirical research aims to show the existence and magnitude of convergence at the cantonal level between 2007 and 2017 in Ecuador. For this purpose, three strategies are used, the first is to analyze the mobility of the cantons between different states or strata according to their average annual per capita production for the period 2007 and 2017, through the transition matrix proposed by Quah. Secondly, to identify the existence of convergence and its magnitude over time at the cantonal level, for this reason the postulates of Barro and Sala-i-Martin on sigma convergence are taken into account. The third strategy is to estimate an econometric model using cross-sectional data, following the proposal of Barro and Sala-i-Martin, to demonstrate conditional beta convergence. In this sense, given the economic growth and political stability experienced in Ecuador during the period of analysis, it is possible to hypothesize positive mobility of the cantons, which would show an improvement in the Ecuadorian economy as a whole end of the period analyzed. In addition, due to the size of Ecuador and its level of social development, it is possible to think that the key factors around the levels of savings, technology, capital depreciation and mobility of factors between the cantons within the country may be similar, therefore, it is very likely that the convergence hypothesis will be met.

The importance and originality of this research lies in incorporating different approaches to draw important conclusions from an academic and scientific point of view. In addition, the literary production on this subject carried out in Ecuador is very scarce, limiting the analysis at the provincial level in shorter previous periods, not covering the time section analyzed in this work. As a result, there is an urgent need for a more detailed and comprehensive research analysis that can provide a scientifically rigorous approach for planners and policymakers in the country on the situation of territorial differences and the performance of the economy at the cantonal level.

The main results obtained show that the Ecuadorian cantons analyzed have experienced positive mobility, i.e., at the end of the analysis period, a significant percentage of cantons are in higher relative positions compared to the initial situation. In addition, empirical evidence corroborates the existence of conditional sigma and beta convergence in Ecuador in the period 2007-2017.

## 2. Literature Review

Differences in the growth levels of economies around the world have been explained through various theories over time. Thus, the exchange of ideas in an academic environment has led to two main approaches that explain such differences between countries. First, the neoclassical theory of economic growth formulated by Solow (1956) who mentions that given the existence of a constant, unique and stable state that is accessible regardless the initial conditions, a higher rate of economic growth for poor economies is predicted in contrast to rich economies, and consequently there will eventually be convergence of growth rates and per capita income levels.

On the other hand, endogenous growth theories consider that the rate of economic growth depends basically on three factors: physical capital, human capital, and technical knowledge or progress, which are cumulative and generate externalities. When considering this postulate, the new endogenous growth models replace neoclassical postulates of perfect competition and consistent yields at scale with imperfect competition and increasing yields. As a result, these new theories consider economic growth as an endogenous process of the economic system (Barro & Sala-i-Martin, 1991). In this mainstream, there are several works that analyze this new conception of economic growth, such as Romer (1986), Lucas (1988), Rebelo (1991) and Young (1991), among others.

Based on this latter approach, Barro and Sala-i-Martin (1991) design a proposal to address the issue of convergence, which starts from a neoclassical model and predicts the existence of a negative relationship between initial income and growth rate, under the idea that the difference between economies is due to their initial physical capital stocks. Later, Barro and Sala-i-Martin (1992a) formulate a methodology for the convergence study that consists of estimating a multiple regression model where the rate of GDP growth per capita is a function of the initial GDP per capita and the value in its constant state. However, this methodology has been transformed into a simple linear regression model, where the constant state value of each country's GDP is contained in the term of disturbance. This process implies that all countries approach the same stationary state, which is not correlated with their per capita income level. However, this methodology has been transformed into a simple linear regression model, where the constant state value of each country's GDP is contained in the term of disturbance. This process implies that all countries approach the same stationary state, which is not correlated with their per capita income level.

In addition, Barro and Sala-i-Martin (1992b) also define another type of convergence that relates to the first, which is called sigma. This conception of convergence is closely related to an idea of dispersion of per capita income among groups of countries over time. These two main concepts can be summarized as follows:

Beta Convergence: it establishes the inverse relationship between the growth rate and the initial level of per capita income. This implies faster growth for poor nations.

Sigma convergence: it occurs when the dispersion of per capita income tends to decrease over time, i.e., this indicator expresses a type of inequity in the distribution of income.

In contrast, given the progress made by Barro and Sala-i-Martin in the empirical analysis of inter-country convergence, Quah (1993) argues that there is no need

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to talk about a specific point where economies converge, but these regions form, in the long term, groups of rich and poor nations. Therefore, he proposes a new methodology consisting in the development of a mobility matrix by using per capita income to establish convergence towards two income levels, rather than a single state. This work in the field of long-term dynamics has made an important contribution to understanding the trends followed by a world divided between rich and poor, and today, this approach continues to be used in convergence analysis.

In the global context, the study conducted by Miller and Upadhyay (2002) for a joint sample of developed and developing countries finds statistical evidence, supporting the absolute and conditional β convergence of total factor productivity, but only the conditional convergence of real GDP per worker. In addition, Desli and Gkoulgkoutsika (2019) study the world's highest-income economies by world bank rankings during the period 1980-2016, and conclude that the group of the world's highest-income economies effectively participate in a convergence process underway, although the financial crisis could have disrupted it.

Similarly, Chapsa *et al.* (2015) in their analysis of conditional income β convergence within the EU-15 during the period 1995 to 2013, incorporates two institutional variables, corruption and bureaucracy. The study finds evidence of the negative impact of corruption on growth and the zero effect of bureaucracy on the performance of the EU's wealthiest members. However, the countries analyzed appear to be on the path of convergence once the econometric model is controlled by economic factors such as investment in physical and human capital, inflation, public consumption and openness.

On the other hand, in Latin America, Azzoni (2001) analyses the evolution of regional inequality in Brazil over a period of 57 years through the convergence analysis calculated in two ways, the neoclassical model and the coefficient of variation. The findings indicate the presence of regional income convergence in Brazil, but with significant fluctuations in the evolution of inequality over time. Silva (2010) in the convergence analysis of growth between Colombian states during the period 1975 to 2000, finds statistical evidence supporting the convergence hypothesis, but at low speed, about one percent per year.

Mora (2003) uses the Quah approach to discuss the idea of convergence clubs and argues that, although the discussion on the results of the sigma and beta convergence type, it is reasonable, and the calculation form of M (Stochastic core) is very debatable; therefore, the transition analysis between countries is limited because it is reduced to a one-step Markov chain. In addition, Islam (2003) highlights the benefit of using Quah's approach to analyze convergence in strata, however, the author warns that the analysis should be complemented by other statistical tools to provide a better description of trends in convergence and transition. The use of Markov chains has been extended, and in some cases it has been improved by the use of different variables, Moncada and Hincapie (2013) used Markov chains to build classic and spatial Markov transition probability matrices, concluding that there is convergence in the quality of life as measured by the indicator of the quality of life of the communes and municipalities of Medellin for the period 2004-2011.

In this study, these three approaches are addressed in the following order: Quah's mobility matrix, σ convergence, and then β convergence, to achieve the research objectives.

## 3. Materials and methods

Regarding the data, this empirical work uses Gross Aggregate Value (GVA) data for 220 out of 221 cantons that make up Ecuador, as it is not possible to include Quinsaloma because it was created in 2007 and there is no data for three consecutive periods. The temporary section includes the period 2007 to 2017 due to the availability of data. The information is provided by the official statistics of the Central Bank of Ecuador (ECB), which is in nominal terms, being necessary its transformation to real terms, therefore, using the implicit deflators of the AVA by industry, it was proceeded to calculate the values of the series in thousands of U.S. dollars at 2007 prices. In addition, the estimated annual population which was required to express the variables in per capita terms, was obtained from Ecuador's National Institute of Statistics and Census (INEC).

On the other hand, to make the econometric estimation of the conditional beta convergence model, information on the characteristics of each canton should be collected in order to explain territorial differences. To do this, four variables obtained from the official statistics published by INEC are used in its Population and Housing Census 2010 database, and by the Ecuador Electricity Corporation (CONELEC) for 2012. First, the percentage of homes in acceptable living conditions is defined as the number of houses whose living conditions are considered acceptable from the combination of the predominant materials of the floor, wall and ceiling; and, the status of these materials, expressed as a percentage of the total housing for a canton. Second, the illiteracy rate, defined as the percentage of the population aged 15 or over that cannot read, write or understand a simple and brief text about their daily life, in the survey period. Third, the average schooling of the population aged 24 and over is defined as the average number of years approved in formal education institutions, for people who are 24 years old or older in a specific territory. Finally, the billed Energy of the residences is expressed in gigawatt hours (Gwh) for a specific territory. It should be noted that this last variable is used as a logarithm to facilitate its interpretation.

## 4. Quah mobility matrix

This work follows the same methodology proposed by Quah (1993). In his work, the author transforms the per capita income of the countries analyzed into fractions of the global average per capita income and sets 5 categories that are classified as follows:

- Category ¼: it corresponds to economies whose level of per capita income is lower or equal to the global average.
- Category ½: This category covers those economies that have a higher per capita income than the global average and lower or equal to the global average.
- Category 1: All economies whose per capita income is higher than the global average and lower or equal to the value of the global average.
- Category 2: This category means that the per capita income of the economy is higher than the global average and lower or equal to 2 times the same global average.
- Category ∞: economies whose per capita income level is higher than 2.

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Once the resulting matrix has been formed, values outside the main diagonal show the state change in economies regarding their initial situation.

## 5. Sigma Convergence

According to Barro and Sala-i-Martin (2004), sigma convergence can be expressed as:

$$\sigma^2 = \left(\frac{1}{N}\right)\sum\left[\log(y_{i,t}) - \mu_t\right]^2 \quad (1)$$

Where $y_{i,t}$ denotes the GVA per capita of the economy i in year t and $\mu_t$ is the mean $\log(y_{i,t})$. However, if N is large enough, then the population variance approaches the sample. Since this study considers all cantons in Ecuador, the formula to be used is equation number 1 with variance in population.

## 6. Conditional beta convergence

Sala-i-Martin (1994), proposes the following econometric model to test the convergence hypothesis in per capita terms, at the same rate of income growth and at the same level of capital (stationary state), and if the initial economic differences tend to disappear (known as "absolute β convergence" or unconditional):

$$(1/T)*\log(y_{iT}/y_{i0}) = \alpha - \left[\frac{1 - e^{-bT}}{T}\right]*\log(y_{i0}) + w_{i0,T} \quad (2)$$

However, since in a group of economies i = 1.2 ... N; the rate of per capita income growth between the year t and t-1 can be expressed as $g_{it} = \log(y_{i,t}) - \log(y_{i,t-1})$, and the convergence hypothesis in this approach expresses that the growth rate is a negative function of the income level in the initial period , equation (2) can be restated as:

$$g_{it} = \alpha - \beta\log(y_{i0}) + \mu_{it} \quad (3)$$

Equation (3) is widely used by economic literature in empirical studies (Barro and Sala-i-Martin, 2004). This equation implies that the average growth rate of per capita production of territory i in the period between 0 and T $g_{it}$ has a negative relationship with the level of per capita production in the initial period $y_{i0}$ . where β is a constant, μ is the convergence rate, and μ is the estimation error.

On the other hand, to contrast conditional or relative convergence, a set of variables P $X_{i0}$ can be added to equation (3), which theoretically affect the steady state of each territory, resulting in:

$$g_{it} = \alpha - \beta\log(y_{i0}) + \sum_{p=1}^{P}\varphi_p X_{i0} + \mu_{it} \quad (4)$$

Both equation (3) and equation (4) will be estimated using the ordinary least square method.

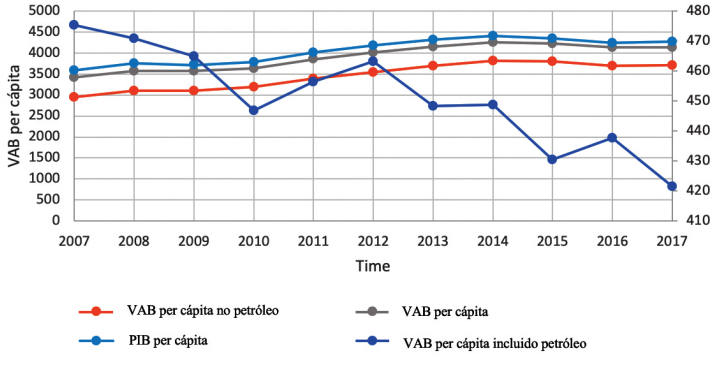
## 7. Results and discussion

This section presents an analytical description of the information to be used, as well as the results obtained from the implementation of the proposed approaches along with an analysis of the implications in terms of economic growth and development.

### *7.1 Data analysis*

Historically, the areas that are most favored with the implementation of public policies have been those where a large part of economic activity is concentrated, either because it is a capital city (as Quito) or because it has seaports through which the goods enter (as in Manta, Guayaquil and Bolívar) or because it is a place of the first colonial settlements (as Cuenca) or because these are places with lots of tourist activity (as Galapagos). This polarization makes these places as a destination for large migration flows or labor force movements, because the dynamic activity generated on these sites is high, requiring a lot of resources. However, despite the measures taken by governments on duty, which aim to reduce the gap between depressed and developed areas (such as the human development bonus and school scholarships), these policies have often undergone continuing variations, making these polarizations even more drastic over time. Therefore, to assess the performance of the economy in terms of convergences, it is important to analyze the trends that Ecuador's main macroeconomic variables have had during the analysis period considered in this study, prices of raw materials exported by Ecuador (such as oil) and the populism of the main authorities.

**Figure 1. Main macroeconomic variables per capita (US dollars 2007)**




Source: BCE, 2019; INEC, 2019.

Figure 1 shows a high fluctuation in gross value added (GVA) due to oil production. Ecuador has characterized as a highly oil-dependent country and after the oil boom after 2007—a period in which the sale price per barrel of oil reached around $121.66 (BCE, 2009, p. 1) the value added of this industry has reduced dramatically. In addition, the total GVA follows a trend very similar to GDP per capita. Therefore, total gross value Added will be used in the empirical study as there is no GDP data at the cantonal level.

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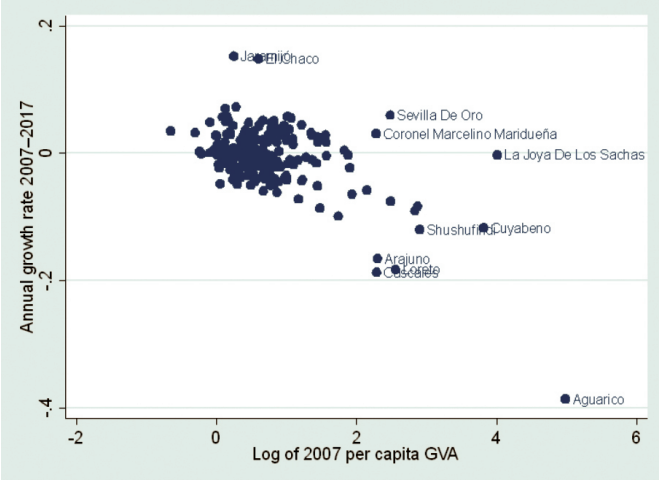
On the other hand, it is also important to analyze the situation of the cantons in terms of GDP and their relationship to the growth experienced during the period analyzed. It should be noted that this work is performed with 220 cantons, as it is not possible to include the canton Quinsaloma in the province of Los Ríos, because it was created in 2007 and there is no data for three consecutive periods.

**Figure 2. Annual growth rate 2007-2017**




Source: BCE, 2019; INEC, 2019.

As shown in Figure 2, there is the presence of certain data that could be considered atypical, therefore, the situation of 6 cantons in particular should be analyzed: Jaramijó, El Chaco, La Joya de los Sachas and Aguarico. Of these, only two belong to the same province, thus a possible geographical influence can be ruled out.

**Figure 3. Trends in the designated cantons (Thousands of US dollars 2007)**


Source: BCE, 2019; INEC, 2019.

The most extreme data, in the negative direction, shown in Figure 2 belong to the Aguarico canton. Figure 3 shows that this canton recorded a high GVA that has decreased significantly over time. However, according to official sources and the local press, this canton has not experienced havoc due to natural phenomena, external shocks, migration or disturbances of any other kind during the period of analysis. It is in the Amazon region of Ecuador, and historically the cities and communities of that region have characterized by being distant and perennially abandoned by central governments, causing a severe limitation for its development; however, this data cannot be classified as atypical, as there is no exogenous factor that may have distorted it.

The data found at the top of Figure 2 corresponds to Jaramijó and El Chaco, which are located in the provinces of Manabí and Napo, respectively. Figure 3 shows that Jaramijó shows a sustained growth pattern that becomes more pronounced since 2014. Although Manabí was hit hard in 2016 by an earthquake, the GVA in this canton does not exhibit a severe recession. On the contrary, El Chaco, belonging to the Amazon region of Ecuador, has benefited from road and highway construction programs, and, according to local press information, due to the initiatives of the current government at that time the tourist activity was also stimulated. However, it cannot be ensured that these initiatives have had an impact that could lead to sustained long-term economic growth, as the change in trend shown in Figure 3 is only evident during the last part of the analysis period. No evidence is found that these two cantons are atypical.

On the other hand, the case of La Joya de los Sachas, a canton of the province of Orellana located in the Amazon, maintained significant growth until 2014, but then it shows a decrease in its pattern. This particular case is an area affected by mining activity in 2018, however, due to the availability of data until 2017, it is not possible to identify the trend of the series after this period. As explained above, this is the case of several other cantons located in the Amazon. However, the data recorded for this canton are high due to the production of cocoa and mango with new agricultural techniques that have allowed these products to be exported (Alvarado, 2015). In addition, during the last century, the missions of Catholic priests contributed to the development of the canton and, thanks to its tourism potential, it is the destination of a large number of retired Americans. Due to this fact, it can be inferred that the situation shown in Figure 3 is close to reality, therefore it does not represent an outlier and it is included in this empirical study.

In summary, the presence of outliers shown in Figure 2 is rejected, with the exception of Quinsaloma, whose observations cannot be included in the analysis, given the limitations detailed above.

## 8. Quah mobility matrix

Based on the process described in the methodological section, the mobility matrix was developed for the 220 cantons analyzed, taking into account the total gross value added at constant prices of 2007. The average value of GVA per capita among the cantons reached in 2007 was US$3621.00, while in 2017 it recorded a value of US$2662.09. This would seem to show a general deterioration in the Ecuadorian eco-

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nomy, however, this behavior is due to the high values recorded by certain cantons in the initial period, for which the standard deviation between the cantons in 2007 is US$ 10941.89, while for 2017 is lower, with a value of US$4106.75. For this reason, the possibility of data inconsistency is rejected.

Each cell in the matrix (i, j) should be interpreted as the probability that an economy in the initial state will transit or move to the final j state. Therefore, the data on the main diagonal of Table 1 show the probability of remaining in the same relative position at the end of the analysis period; the top shows an improvement in the observable situation; below, it is understood that performance has declined over the time horizon. The final column in Table 1 provides information on the total number of cantons located in each category in 2007.

**Table 1. Mobility Matrix of Ecuador, 2007-2017**

| Position in 2007 | Position in 2017 | | | | | Number |
|---|---|---|---|---|---|---|
| | Category 1/4 | Category 1/2 | Category 1 | Category 2 | Category ∞ | |
| **Category 1/4** | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 4 |
| **Category 1/2** | 0.01 | 0.48 | 0.49 | 0.02 | 0.01 | 105 |
| **Category 1** | 0.00 | 0.06 | 0.59 | 0.32 | 0.02 | 81 |
| **Category 2** | 0.00 | 0.00 | 0.18 | 0.41 | 0.41 | 17 |
| **Category ∞** | 0.00 | 0.08 | 0.23 | 0.23 | 0.46 | 13 |
| **Total Observations** | | | | | | 220 |

From the first row in Table 1, the results show a 100% probability of moving to a higher stratum, at a level higher than a quarter of the national average for GVA recorded in 2017 but less than half that value. This result shows that the country's poorest cantons group have improved their situation during the period of analysis. In this category are the cantons 24 de Mayo, Jama (located in Manabí), Huamboya and Taisha (located in Morona Santiago). However, this latter group located in the Amazon region of Ecuador has been controversial in the topics related to the extraction of oil and environmental pollution. As a result, it is not possible to guarantee that the level of economic growth and quality of life of its inhabitants is better today, as the information suggests.

Similarly, the second row in Table 1 shows that only 1% of cantons have deteriorated their situation. However, 49% of all cantons have reached a higher category, and 2% have reached two higher categories, ranking between the national average and twice as high. In addition, this category contains the highest number of observations and the highest positive transition rate recorded throughout the analysis period.

Cantons that recorded below the national average, but higher than half, show the highest probability of remaining in the same state at the general level. However, the percentage of cantons that moved to a higher level is 32%, which is significantly higher than the percentage of reduced mobility.

As a result, cantons whose GVA per capita was higher than the national average at the beginning of the period show a 41% chance of moving to a higher category, which is more than double the national average in the final position. This value matches the probability of remaining in the same state. On the other hand, the probability of moving to a lower category registers a value of 18%. Therefore, the cantons in this category have performed well because they have experienced upward mobility at a level that is twice the national average recorded in that year.

The category that deserves special attention (as well as the poorest economies) is the one that includes the richest cantons. In this case, the results in Table 1 indicate that there has been a significant deterioration of that group, since the probability of heading towards the two recessionary states is 23%, and even more, it is clear that the probability of a three-state reduction is 8%. It is important to note that this category excludes cantons that have concentrated the wealth generated of the country, excepting one (San Cristobal, Galapagos) due to its tourist activities (Vasquez, 2015). As a result, evidence suggests that this set of cantons has impaired their level of economic activity.

The overall results show that Ecuador has experienced a noticeable improvement throughout the analyzed period using Quah's proposed approach. On the other hand, since there is no data available at the cantonal level for previous periods and the existing literature is limited to studies at the provincial level for periods prior to the oil boom experienced in 2007 and the dollarization in 2000, a definitive conclusion cannot be obtained on economic growth and convergence at the regional level in the long term. However, the results of this research are consistent with the findings presented in the study conducted by Chimbo and Ñauta (2012), at the provincial level for the period 2001-2007, in which is argued that Ecuador exhibits positive mobility, marking a continuity in the previously recorded trend.

## 9. Sigma convergence

Following the methodology stated by Barro and Sala-i-Martin, Figure 4 shows the relationship between the deviation of the GVA logarithm per capita recorded at the cantonal level with respect to the period of time analyzed.

The dispersion recorded at the beginning of the analyzed period was 0.3126, reaching a value of 0.2735 at the end of the analyzed period. However, Figure 4 shows that the trajectory of the series has not been sustained, showing the largest increase in 2008 with a value of 0.3262 and subsequently a significant drop. In addition, from 2009 to 2014, the series shows a gradual increase culminating in another significant decrease in 2014 and exhibiting a slight increase over the past three years. Despite the behavior shown, the downward slope of the trend suggests that the dispersion has decreased over time. Therefore, the observed patterns of peaks are strongly offset by falls in the dispersion recorded over time, demonstrating a clear pattern of sigma convergence in Ecuador in the period analyzed.

This result is consistent with the findings presented by Riofrío (2009) at the provincial level for the period 1993-2007, who argues that the dispersion trend at the provincial level has declined at a rate that could be considered sustained in the long term. As a result, in considering these findings, it can be concluded that Ecuador has shown remarkable performance in its attempt to reduce territorial economic differences.

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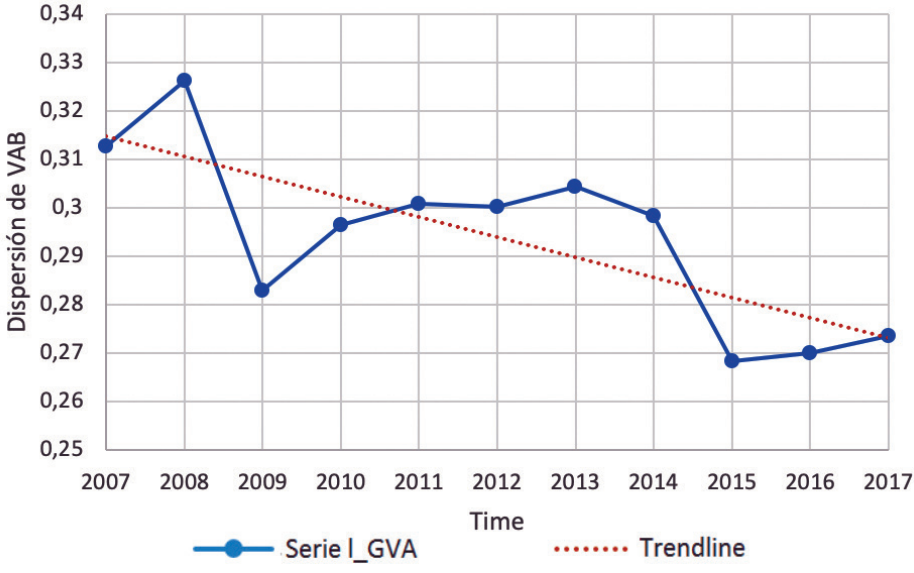
**Figure 4. Dispersion of GVA per capita in Ecuador, 2007-2017**




This finding suggests that efforts by the government on duty to reduce economic gaps between regions could have had the desired impact. However, it is important to note that this period is characterized by political stability in Ecuador, unlike the past decades, where no president was able to complete the term for which he was elected, and even more so to be re-elected in the general elections. This stability plays an important role at the time of the long-term convergence and growth analysis, because regardless of the measures taken, consistency and compliance with a specific project and plan can show positive results without ignoring the articulated efforts of sectional administrations. However, the result obtained cannot be attributed only to this factor (political stability), as there could be other variables and factors present for achieving the results presented.

## 10. Beta Convergence

Table 2 shows the results obtained from equations (3) and (4) using Minimum Ordinary Squares. It should be noted that models 1 and 2 exhibited the presence of heteroscedasticity, therefore estimates are presented using robust standard errors.

**Table 2. Results of the Absolute and Conditional Convergence model**

| Variables | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | Coefficients | Coefficients | Coefficients | Coefficients |
| β | -0.0362*** | -0.0261*** | -0.0460*** | -0.0467*** |
| **Housing** | | | 0.0916*** | 0.0632* |
| **Illiteracy rate** | | | -0.1047 | |
| **lnelec** | | | 0.0064*** | 0.0056** |
| **Average schooling** | | | | 0.0067** |
| α | 0.0220*** | 0.0157*** | -0.0011 | -0.0529*** |
| **Observations** | 220 | 219 | 220 | 220 |
| **F-statistical** | 85.597 | 44.5063 | 10.3982 | 11.0893 |
| **R-square** | 0.2819 | 0.1702 | 0.4601 | 0.4676 |
| **Aic** | -770.618 | -804.963 | -827.3727 | -830.4204 |
| **Bic** | -763.831 | -798.184 | -810.4045 | -813.4523 |
| **legend:** *p<.05; **p<.01; ***p<.001 | | | | |

First, it is important to note that there is evidence of absolute beta convergence at the cantonal level because the coefficient obtained is negative and statistically significant, whose value is around 3.62% annual average. In addition, due to the presence of a value belonging to the Aguarico canton that could be considered an outlier, Model 2 excludes this observation to verify the existence of possible changes in the magnitude of the coefficients. The results are shown in the second column of Table 2. Evidence suggests that the absolute convergence rate decreases to 2.61%, however, the results maintain their validity and statistical significance. As a result, the existence of absolute convergence at the cantonal level in Ecuador is confirmed.

Comparing the results obtained with a previous study carried out for the period 2007 to 2012 by Mendieta (2015), who finds a convergence rate of about 1.37%, it can be seen that the reported value in this work is higher, difference that can be attributed to the time factor. This work considers a longer period of time, and because this type of analysis requires extended time intervals to show statistically stronger results, it is permissible to consider that the convergence rate obtained in this research is closer to reality.

On the other hand, it is necessary to analyze which variables affect this beta convergence process. For this, the conditional beta convergence approach detailed in the methodology section is taken into account and the results are presented in Models 3 and 4 of Table 2. This work uses a set of characteristics related to infrastructure, education and electricity consumption, with the aim of explaining the conditional convergence of each territory. The variables considered for this purpose are: Percentage of homes in conditions of acceptable habitability (housing), illiteracy rate (illiteracy rate), average schooling of the population aging 24 years and older (average schooling), logarithm of billed energy of residences (lnelec), which are obtained

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from the 2010 Census of Population and Housing, except the last one, whose data are recorded by CONELEC for 2012. The difference between the models mentioned above lies in the introduction of the variable that refers to the educational level of the population. In this sense, the introduction in the same model of the variables: average illiteracy rate and schooling would create statistical and theoretical inconsistencies. For this reason, Model 3 takes into account the illiteracy rate, while Model 4 considers the average schooling of the population.

The results shown in Table 2 indicate that the conditional convergence rate is higher for Model 3, compared to the absolute convergence result. The coefficient obtained is negative and statistically significant with an annual average value of 4.60% at a cantonal level. In addition, the conditioning variables bill energy and percentage of households in acceptable living conditions, have positive and statistically significant coefficients, having a logical congruence since a canton that demands a high electricity consumption and has adequate physical infrastructure experiences a higher average growth rate of per capita production. However, although the illiteracy rate is not statistically significant, its appearance seems logical, as a higher illiteracy rate is expected to negatively affect the average growth rate in the analysis period. Finally, an overview of the model allows to show that, according to the value of the F statistic, the variables are statistically significant from a significance level of 1%, in addition, its inclusion improves the R-Squared coefficient, goodness of adjustment.

According to the results of the Model column 4 in Table 2, there is a slight increase in convergence speed that registers a value of 4.67%. The econometric estimation shows a better degree of fit and, as in the case of the previously analyzed model, the statistical significance of the variables is maintained. However, unlike the previous model, all variables introduced in the model prove to be statistically significant at the individual level with a 90% confidence level. A deeper analysis shows that an increase in the percentage of households with adequate habitability is associated with a 0.06 percentage point increase in the average growth rate of per capita production and, in the same way, a 1% increase in the billed amount of electricity produces an estimated average increase of 0.0056% in the average growth rate per capita. This corroborates the hypothesis that, by improving the conditions of domestic infrastructure and increased demand for electricity, it has the effect of reducing territorial economic differences in Ecuador. On the other hand, education is a key factor in the economic growth and development of the territories. These magnitudes are consistent with the higher level of convergence, as the positive impact they produce in the analysis model is positive, denoting their relevance to the convergence process.

A statistical comparative analysis of models makes it possible to establish that the best econometric estimate is presented in Model 4 of Table 2 given the adjustment for the addition of new explanatory variables, according to Akaike (1974) and Schwarz (1978) Bayesian information criteria.

This set of results implies that the government should improve the living conditions of the population in terms of physical infrastructure and access to basic services, as well as the educational level of the population. However, in order to reduce the economic gaps between the different regions of the country, it should be noted that these variables are only a sample of the possible areas of intervention and the

existence of other factors that contribute to the reduction of territorial differences. In this sense, multiple research and empirical evidence point to the importance of education, as well as investment in infrastructure, in a country's economic growth, and even more so in the degree of economic inequality and poverty in a territory. These results are consistent with the findings of Duffy-Deno and Eberts (1991) that show the importance of infrastructure investment and its impact on regional development. Démurger (2001) whose contribution explains the impact that infrastructure development has had on reducing regional differences in China, and Adshead *et al.* (2019), who mentions that long-term infrastructure planning is efficient in meeting the sustainable development goals in Curacao. In addition, the study conducted by Goetz and Hu (1996) highlights the importance of education as a key factor in the formation of human capital and its contribution to the speed of income convergence. Similarly, Kruss *et al.* (2015) and Rivza *et al*. (2015) argue that strengthening the educational process and curricula would lead to an improvement in regional growth trends.

Based on the results, it is possible to analyze two relevant aspects that help explain the degree of territorial convergence and its long-term impact. First, Ecuador currently shows major deficiencies in terms of physical infrastructure among cantons, with the most disadvantaged being those with a large percentage of indigenous, Afro-descendant population and, mainly, the Amazon region. While it is true that during the analyzed period the political stability and investment in social dimensions such as work, health and education has been observed, there are still great differences between the territories that concentrate the wealth of the country because of their historical and geographical characteristics, and those that have no such advantages. This is reflected in the results, specifically in the relatively low value of the convergence rate.

Second, an effective and immediate measure widely suggested in the economic literature consists of an academic stimulus that, as noted above, has great benefits both in the short and long term. However, in Ecuador, access to formal education is strongly conditioned in many cases by the socio-economic level of the household. Although education at the primary and secondary levels is mostly free, its quality is widely questioned. One way or another, there are large differences between schools, the best being generally located in the big cities (which concentrate most of the country's economic activity), in contrast, those schools located in the rural sector lack of many comforts. Rural education is one of the most important factors in the regional development (Biriescu & Babaita, 2014), thus sectional and municipal governments should focus more efforts on strengthening education programs in the rural sector. This reality produces an incentive for internal migration, however, often this decision is conditioned by the economic situation of the household (opportunity cost) and the perception of future benefits in relation to employment. In this scenario, it is very likely to note that when the decision is made to migrate, it is not done with the desire to return to the area of origin since, in many cases, there are no jobs that allow to exploit the acquired knowledge. On the other hand, the decision to remain implies a low level of education in the territory. Both phenomena contribute to depressed areas to continue, while rich areas continue to grow, increasing territorial differences in Ecuador.

On the other hand, a mathematical exercise, based on the informed magnitude of the beta coefficient and the assumption of geometric growth used in the conver-

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gence hypothesis, provides an idea of the degree of convergence in temporal terms. Taking as a reference the rate of absolute convergence reported by Model 1 of Table 2, it is possible to determine that the canton Salitre of the province of Manabí (the poorest) would take approximately 120.86 years to reach the average production per capita of La Joya de los Sachas of the province of Orellana (the richest). This result shows that while there is statistical evidence of absolute convergence, it is not enough to close economic gaps in Ecuador in the short term. Conversely, when considering the conditional convergence coefficient obtained from Model 4 in Table 2, a canton would broadly take approximately 14.5 years on average to reach twice its per capita production recorded in 2017, *ceteris paribus*. These results show more clearly the magnitude of the cantonal convergence process in Ecuador and its temporal implications. As a result, in addition to empirical corroboration of the beta convergence hypothesis at the cantonal level during the period 2007-2017, it has been shown that it can be considered slow when analyzing its temporal dimension.

## 11. Conclusions

The results of this investigation can be grouped into three main findings. First, it is concluded that Ecuador has experienced internal mobility in a positive sense at the cantonal level, i.e. according to Quah's mobility matrix, a significant part of the cantons analyzed shows an improvement in the final situation, ranking in categories higher than initially reported. The implications of this outcome suggest that the policies implemented and the political stability experienced in this period (given the coincidence with the period of government at the time) could have contributed to improving the economic situation of the country and its economic growth. However, more studies are needed to ensure the importance of the political variable.

Second, the evolution in the degree of dispersion in per capita production shows that Ecuador has experienced a systematic reduction in the variability of this indicator over time, which supports the existence of sigma convergence. In this sense, Ecuador's economy, as a whole, shows a continuous improvement during the period of analysis.

Third, empirical evidence corroborates the existence of absolute and conditional beta convergence at the cantonal level for the period 2007-2017. In the first case, the rate of convergence amounts to the average 3.62% per year, while, in the second case, when considering the physical infrastructure of households, their electricity consumption and their educational level, significant results are obtained, reaching 4.67% annual percentage. Therefore, the existence of beta convergence for the Ecuadorian case is concluded.

On the other hand, the combination of the approaches used in this study ensures that, although the main findings are favorable and show good performance of the Ecuadorian economy, they are still not sufficient to effectively close the gaps in the medium term and probably in the long term. Overall, Ecuador has shown a systematic improvement in its economic situation over time, however, it is up to the government in turn to undertake new, more effective initiatives to ensure an effective reduction of economic differences between the territories of the country, since the period analyzed

is characterized by an oil boom; therefore, it would be it is important to verify that the obvious closure of the gaps in this study is not reversed in the coming years.

The main reflections for economic policymakers in Ecuador are the emphasis to be placed on improving the quality of household infrastructure and the educational level of individuals as factors relevant to the development, among other. However, the incidence of other variables that were not included in this study and their relevance in reducing economic differences in a territory is not ruled out. In addition, the empirical evidence provided by this study in Ecuador during the period 2007-2017 is supported by the economic literature and works carried out on this subject.

The main limitations found were in relation to the data availability. At the moment, Ecuador does not maintain a cantonal record for years outside the analysis period considered in this study. Similarly, official statistical sources do not have information at the cantonal level on the relevant factors that the economic literature suggests to include in a conditional convergence analysis.

Finally, future research could include longer periods of time and discuss the possibility of including other conditioning factors that help explain the territorial differences present in Ecuador.

## References

Adshead, D., Thacker, S., Fuldauer, L. I., & Hall, J. W. (2019). Delivering on the Sustainable Development Goals through long-term infrastructure planning. *Global Environmental Change, 59*. https://doi.org/10.1016/j.gloenvcha.2019.101975

Akaike, H. (1974). A New Look at the Statistical Model Identification. I*EEE Transactions on Automatic Control, 19*(6), 716-723. https://doi.org/10.1109/TAC.1974.1100705

Alvarado, R. J. (2015, diciembre). *Potencial de las empresas petroleras para el desarrollo local amazónico: análisis a partir de su incidencia en el sector agropecuario del cantón la Joya de los Sachas*. (Tesis de maestría). Quito: Repositorio Digital FLACSO Ecuador. Recuperado de: https://bit.ly/2HgXyRM

Azzoni, C. (2001). Economic growth and regional income inequality in Brazil. *The Annals of Regional Science, 35*, 133-152. https://doi.org/10.1007/s001680000038

Barro, R., & Sala-i-Martin, X. (1991). Convergence Across States and Regions. *Brookings Papers on Economic Activity, 22*(1), 107-182.

Barro, R., & Sala-i-Martin, X. (1992a). Convergence. *Journal of Political Economy, 100*(2), 223-251. https://doi.org/10.1086/261816

Barro, R., & Sala-I-Martin, X. (1992b). Public Finance in Models of Economic Growth. *The Review of Economic Studies, 59*(4), 645-661. https://doi.org/10.3386/w3362

Barro, R., & Sala-i-Martin, X. (2004). *Economic Growth* (2nd ed.). Cambridge: Massachusetts Institute of Technology.

BCE (diciembre de 2009). Banco Central del Ecuador. Recuperado de: https://bit.ly/38o4QyZ

BCE (mayo de 2019). Banco Central del Ecuador. Recuperado de: https://bit.ly/39sh7T6

Biriescu, S., & Babaita, C. (2014). Rural Education, an Important Factor of Regional Development in the Context of Local Government Strategies. *Procedia-Social and Behavioral Sciences, 124*, 77-86. https://doi.org/10.1016/j.sbspro.2014.02.462

Chapsa, X., Tsanana, E., & Katrakilidis, C. (2015). Growth and Convergence in the EU-15: More Evidence from the Cohesion Countries. *Procedia Economics and Finance, 33,* 55-63. https://doi.org/10.1016/S2212-5671(15)01693-7

Retos, 10(19), 2020


Chimbo, J., & Ñauta, F. (2012). *Movilidad de las provincias del Ecuador desde el punto de vista del VAB, 2001-2007. Matriz de Quah*. Cuenca: Degree Work, Universidad de Cuenca. Recuperado de: https://bit.ly/2SnA7fQ

Démurger, S. (2001). Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China? *Journal of Comparative Economics, 29*(1), 95-117. https://doi.org/10.1006/jcec.2000.1693

Desli, E., & Gkoulgkoutsika, A. (2019). Economic convergence among the world's top-income economies. *The Quarterly Review of Economics and Finance*. https://doi.org/10.1016/j.qref.2019.03.001

Duffy-Deno, K. T., & Eberts, R. W. (1991). Public infrastructure and regional economic development: A simultaneous equations approach. *Journal of Urban Economics, 30*(3), 329-343. https://doi.org/10.1016/0094-1190(91)90053-A

Goetz, S. J., & Hu, D. (1996). Economic growth and human capital accumulation: Simultaneity and expanded convergence tests. *Economics Letters, 51*(3), 355-362. https://doi.org/10.1016/0165-1765(96)00827-0

INEC (2019, mayo). Instituto Nacional de Estadísticas y Censos. Recuperado de: https://bit.ly/39CDeGR

Islam, N. (2003). What have We Learnt from the Convergence Debate? *Journal of Economic Surveys, 17*(3), 309-362. https://doi.org/10.1111/1467-6419.00197

Kruss, G., McGrath, S., Petersen, I.-h., & Gastrow, M. (2015). Higher education and economic development: The importance of building technological capabilities. *International Journal of Educational Development, 43*, 22-31. https://doi.org/10.1016/j.ijedudev.2015.04.011

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*(1), 3-42.

Mendieta, R. (2015). La hipótesis de la convergencia condicional en Ecuador: un análisis a nivel cantonal. *Retos. Revista de Ciencias de la Administración y Economía, 5,* 13-26. https://doi.org/10.17163/ret.n9.2015.01

Miller, S. M., & Upadhyay, M. P. (2002). Total factor productivity and the convergence hypothesis. *Journal of Macroeconomics, 24*(2), 267-286. https://doi.org/10.1016/S0164-0704(02)00022-8

Moncada, J., & Hincapié, D. (2013). Convergence of the Quality of Life in Medellin 2004–2011. A Spatial Nonparametric Analysis. *Ensayos sobre Política Económica, 30*(70), 267-314. doi:https://doi.org/10.1016/S0120-4483(13)70034-4

Mora, J. J. (2003). Crecimiento y convergencia: A propósito de Quah. *Estudios Gerenciales, 89,* 57-72. Recuperado de: https://bit.ly/2SoMmZW

Quah, D. (1993). Empirical cross-section dynamics in economic growth. *European Economic Review, 37*(2-3), 426-434. https://doi.org/10.1016/0014-2921(93)90031-5

Rebelo, S. (1991). Long Run Policy Analysis and Long Run Growth. *Journal of Political Economy, 99*(3), 500-521.

Riofrío, L. (2009). *Capital humano y procesos de convergencia en el Ecuador.* Degree Work. Loja: Universidad Técnica Particular de Loja. Recuperado de https://bit.ly/39x6zlK

Rivza, B., Bikse, V., & Brence, I. (2015). Evaluation of Higher Education Study Programmes and their Development Trends as Drivers of Regional Growth. *Procedia Economics and Finance, 26*, 643-650. https://doi.org/10.1016/S2212-5671(15)00804-7

Romer, P. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy, 94*(5), 1002-1037.

Sala-i-Martin, X. (1994). Cross-sectional regressions and the empirics of economic growth. *European Economic Review, 38*(3-4), 739-747.

Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics, 6*(2), 461-464. https://doi.org/10.1214/aos/1176344136

Silva, A. (2010). *Economic Growth and Poverty Reduction in Colombia*. Frankfurt Am Main: Peter Lang AG. https://doi.org/10.3726/978-3-653-00274-4

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics, 70*(1), 65-94.

Vásquez, M. E. (2015). Propuesta para implementar un ecoturismo rural en la isla San Cristóbal. (Tesis de Pregrado). Guayaquil, Ecuador. Recuperado de: https://bit.ly/31QaN5r

Young, A. (1991). Learning by Doing and the Dynamic Effects of International Trade. *The Quarterly Journal of Economics, 106*(2), 369-405.