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Higher Education and Economic Growth in Planning Zone 3

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ABSTRACT

Education enables individuals to improve their socioeconomic status by providing access to better employment opportunities and higher incomes. This research aims to determine the impact of higher education on economic growth in the provinces of Ecuador's Planning Zone 3. To achieve this, a fixed-effects panel data model was employed using annual data from 2015 to 2022. The main findings suggest that as expenditure on education, enrollment, and coverage in higher education increase, the economic growth of the provinces in Planning Zone 3 also improves. This underscores the significance of higher education for regional economic development.

Keywords: Higher education, economic growth, panel data.

INTRODUCTION

Education enables individuals to improve their socioeconomic status by providing access to better employment opportunities and higher incomes, which allow them to meet their basic needs such as health, housing, and clothing. Traditional authors like Barro and Lee (1994) explain that one of the most critical sources of economic growth in countries is the initial level of human capital in the form of educational and health achievements. Lucas (1988) highlights that human capital—understood as knowledge and experience—is a crucial factor for economic growth, as this theory considers that increased human capital enhances labor productivity, thereby boosting production. Similarly, Romer (1991) posits that economic growth relies on human labor and technological knowledge, implying that economies with greater human capital stocks experience faster growth.

Recent research emphasizes the importance of education and increased human capital as vital sources of economic growth. Authors like Palacios (2009), Valdez Ibarra (2015), Alvarado et al. (2019), Valdés et al. (2018), and Miró (2019) argue that education is fundamental for increasing production levels in countries, improving incomes, and thereby enhancing individual and collective well-being. Education equips individuals with knowledge that elevates productivity and promotes higher economic growth.

Higher education, which completes the academic training of individuals, endows them with specific skills, abilities, and knowledge that increase their productivity. For years, there has been considerable debate about the importance of university education. It is believed that additional years of education result in greater knowledge and that an increased number of graduates will support faster production growth. However, authors like Hanushek (2016) argue that empirical analysis does not support this general proposition, as the measurement of knowledge capital reveals no direct relationship between years of schooling and economic growth.

In Ecuador's Planning Zone 3, economic growth levels remain modest. By December 2024, the region's GDP contribution to the national total was only 5.9%, potentially influenced by variables such as the quality and quantity of graduates from higher education institutions and the state's investment in tertiary education. This research seeks to explore the influence of higher education variables on production growth in the provinces of Zone 3.

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LITERATURE REVIEW

Numerous authors have studied the impact of higher education on economic growth. These studies have been carried out using various tools and methodologies.

One of the most important authors studying economic growth is Barro (2013), who concludes that growth is positively related to the initial level of average years of schooling for adult men at the secondary and higher education levels. This is because individuals who achieve a higher level of education complement new technologies, and he suggests an important role for the diffusion of technology in the growth and development process. In parallel, Barro estimates that growth is not significantly related to the years of schooling for women at the secondary and higher education levels, implying that highly educated women are underutilized in the labor markets of many countries.

Other research highlights the importance of higher education as a crucial tool that supports economic growth. In a study conducted across 50 countries, Chentukov, Omelchenko, Zakharova, and Nikolenko (2021) find that nations with highly competitive higher education systems tend to have higher levels of socioeconomic development, international competitiveness, and innovation, as well as sufficient knowledge-intensive GDP, which confirms the dependency of high-tech production and exports on the quality of the higher education system. In Mexico, Gabriela Sánchez Trujillo, Basurto Hernández, and Galván Vargas (2020), using a panel data model, find that when the proportion of workers with lower levels of education decreases, capital accumulation increases, and the exchange of goods and services with foreign markets intensifies, the production level rises.

Studies conducted in Colombia by Baron Ortegon (2019), using a VEC model, find an equilibrium relationship in the long term between the growth rate of higher education enrollment from 1971-2016 and per capita economic growth, confirming a bi-directional Granger causality between the two variables, which helps explain the dynamics of Colombia's per capita economic growth. In a study for the European Union (EU) countries, Volchik, Oganesyan, and Olejarz (2018), using the Mincer equation, demonstrate that higher education has a significantly positive economic impact on local citizens, EU citizens, and nationals from third countries. They also suggest that the current higher education system requires deeper institutional reforms to reflect the EU's openness to immigrants from non-EU countries, with implications for its labor market and recent trends in higher education.

Shabbir and Hina (2018) explain that in public universities in Punjab (Pakistan), most students consider that higher education strongly affects employment and is a predictor of it. Moreover, both variables show a significantly positive relationship, and it is concluded that the labor market requires more efficient and highly skilled individuals. Mungaray, Pimienta, and Ocegueda (no date) demonstrate that in Mexico, during the 2004-2015 period, the impact of average schooling on both GDP and per capita income was sufficiently high and significant, but statistical evidence suggests that public investment in higher education did not have a statistically significant effect on either GDP or its growth rate. This implies that the investment was not effective in fostering the productivity of the population and, therefore, did not contribute to Mexico’s economic growth with social well-being.

Ocegueda, Pimienta, and Mungaray (2022) analyze the impact of STEM (Science, Technology, Engineering, and Mathematics) careers on productivity, industrial activity, and economic growth in Mexico. The results suggest that the higher education policy implemented between 2010 and 2015 has not been effective in generating better economic conditions. This is explained by a low graduation rate in STEM fields and the presence of a weak industrial sector, which has not been able to translate the effects of higher education into higher growth rates. Maneejuk and Yamaka (2021) found for the ASEAN-5 countries during the 2000-2018 period that there are non-linear effects of government spending per tertiary student on economic growth in the ASEAN-5 region, as an increase in unemployment among workers with higher education positively impacts economic growth. Additionally, regional analysis shows that the impacts of higher education are amplified when enrollment rates exceed a certain level. In other words, secondary education enrollment rates positively affect economic growth.

In Latin American countries, Moreno-Brid and Ruiz-Nápoles (2010) found that public universities ensure research and the teaching of scientific disciplines fundamental for long-term development and growth. However, these disciplines are the most costly and seem to have less demand today, which could lead to seeking private funding, as economic development requires specific numbers of technicians, professionals, and scientists in different areas of the economy and society to achieve balanced development.

Using data from universities in 78 countries, Valero and Van Reenen (2019), through subnational fixed-effects models between 1950 and 2010, found that increases in the number of universities are positively associated with future per capita GDP growth, maintaining a robust relationship between both variables. Additionally, part of the effect of universities on growth is mediated by a higher supply of human capital and greater innovation.

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Maneejuk and Yamaka (2021) also found non-linear effects of government spending per tertiary student on economic growth in the ASEAN-5 countries during the 2000-2018 period, and that secondary education enrollment rates positively affect economic growth. However, higher education is key to future growth and sustainability.

Overall, these studies affirm that higher education significantly impacts economic growth, primarily by enhancing workforce productivity and thereby boosting global production.

HIGHER EDUCATION AND HUMAN CAPITAL

All studies on the importance of education are fundamentally rooted in human capital theory—a major contribution of the Neoclassical School to labor market analysis. This theory, developed by Gary Becker (1964), posits that individuals' rational decisions to invest time and resources in education and training improve their skills and knowledge, enhancing productivity and contributing to economic growth at the national level (De la Rica & Iza, 1999). Villalobos Monroy and Pedroza Flores (2009) expand on this premise, asserting that education is an investment yielding future utility and that human resource development is a pillar for knowledge generation, ultimately fostering economic growth.

In the context of higher education, Garrido Trejo (2007) links human capital schooling, occupational roles, and productivity growth to strengthening the relationship between universities and the productive sector. This underscores the role of higher education institutions as essential instruments for human resource development, supporting national growth.

Knowledge management emerges as a strategic approach for leveraging organizational knowledge in processes that drive institutional objectives. For universities, this entails balancing quality teaching and research with efficient administration in a competitive environment (Cranfield & Taylor, 2008). While maintaining academic values is paramount, higher education institutions face external pressures to adapt and enhance productivity and competitiveness (Farfán & Garzón, 2006; Topete et al., 2012).

Silva Payró et al. (2020) question the actual contribution of educational institutions to economic growth, noting that in many countries, overproduction of human capital leads to underemployment in low-paying jobs. Similarly, Riquelme Silva et al. (2020) highlight the declining efficiency of public spending on higher education in Chile, where such investments have failed to yield economic returns. Fleisher et al. (2007) found that human capital positively affects worker productivity and growth, with skilled labor contributing more significantly to production outputs.

METHODOLOGY

This research employs a panel data model to analyze the relationship between education and economic growth in Planning Zone 3 of Ecuador. Panel data models compile values of one or more variables for multiple sample units or entities at the same points in time. This means that in panel data, the same cross-sectional unit is observed over time, allowing for the analysis of both spatial and temporal dimensions (Gujarati, D. & Porter, D., 2012). These models aim to capture unobservable heterogeneity, whether among economic agents or over time, which cannot be detected with time series or cross-sectional studies. This methodology enables the examination of unobservable heterogeneity: specific individual effects and temporal effects (Mayorga, M. & Muñoz, M., 2000).

Panel data consist of observations for the same $\boldsymbol{n}$ individual entities over two or more time periods $\boldsymbol{T}$. If the dataset includes observations of variables $\boldsymbol{X}$ and $\boldsymbol{Y}$, the data are expressed as (Stock, J. H. & Watson, M. W., 2012):

$$(X_{it}, Y_{it}) \; i=1, \ldots, n; \; t=1, \ldots, T \qquad (1)$$

The subscript i refers to the individual entity being observed, and t refers to the time period of observation.

The regression model follows this general form (Greene, 2018):

$$y_{it} = x'_{it}\beta + z_i'\alpha + \varepsilon_{it} \qquad (2)$$

Here, xit includes K regressors excluding a constant term, while the heterogeneity or individual effect is represented by ziα, where zi contains a constant term and a set of individual-specific or group-specific variables. These variables, whether observed or unobserved, are assumed constant over time t.

Unobservable heterogeneity can remain constant over time for each individual or be uniform across individuals at a given time, or a combination of both. This heterogeneity is often captured in the constant term of a regression model as an average that explicitly accounts for differences among individuals and/or over time. Based on how unobservable heterogeneity is incorporated, panel data models can be specified as fixed effects or random effects models (Mayorga, M. & Muñoz, M., 2000).

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Fixed Effects Regression

This regression accounts for omitted variables in panel data when the omitted variables differ across entities but remain constant over time. Fixed effects regression includes nnn different intercepts, one for each individual entity, represented using a set of binary variables (indicators) that absorb the influences of all omitted variables differing across entities but constant over time (Stock, J. H. & Watson, M. W., 2012).

In a general panel data model, if zi is unobservable but correlated with xit, the least squares estimator of β is biased and inconsistent due to omitted variable bias:

$$y_{it} = x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (3)$$

where $\boldsymbol{\alpha_i = z_i'\alpha}$ includes all observable effects and specifies an estimable conditional mean. Here, the term "fixed" refers to its constancy over time rather than its stochastic properties.

This study applies a fixed effects panel data model to assess the relationship between education and economic growth in Planning Zone 3. Balanced cross-sectional data spanning from 2015 to 2022 were used. The dependent variable, economic growth, is represented by the natural logarithm of per capita GDP (at 2018 prices), as this measure reflects the increase in income per capita. For the independent variable, education, the following metrics were considered:

1. **Higher Education Coverage (COESU)**: Reflects access to higher education and is associated with human capital dynamics. A positive relationship with per capita provincial income levels is expected (Lemus-Vergara, A.; Casas-Herrera, J., & Gil-León, J., 2015).

2. **Public Expenditure on Higher Education (GPEDS)**: Represents annual government spending on tertiary education. Data are logarithmically transformed.

3. **Tertiary Enrollment Rate (TMES)**: Indicates the total number of individuals enrolled in higher education as a percentage of the total population of official tertiary education age.

Based on these theoretical elements, the proposed model to explore the relationship between education and economic growth in Zone 3 is as follows:

$$PIBpc_{it} = \beta_0 + \beta_1 COESU_{it} + \beta_2 GPEDS_{it} + \beta_3 TMES_{it} + \mu_{it} \quad (4)$$

Where:

$PIBpc_{it}$: Per capita GDP, log-transformed to address heteroscedasticity issues.

$COESU_{it}$: Higher education coverage, calculated as the ratio of enrolled individuals to the provincial population.

$GPEDS_{it}$: Public expenditure on higher education, log-transformed.

$TMES_{it}$: Tertiary enrollment rate, as a percentage of the total population of oficial higher education age.

μ_{it}: Disturbance term for province iii and period ttt.

RESULTS

Higher Education in Planning Zone 3

In Ecuador, aiming to achieve state decentralization under the coordination of the National Secretariat for Planning and Development (SENPLADES), administrative planning levels were implemented: zones, districts, and circuits nationwide. This initiative resulted in the establishment of 10 planning zones across the country. One of these, Zone 3, is located in central Ecuador and comprises four provinces: Chimborazo, Cotopaxi, Pastaza, and Tungurahua (SENPLADES, 2012).

As of 2022, Zone 3 had 14 universities and 29 technological higher education institutes, with Chimborazo and Tungurahua hosting the largest number of higher education institutions (HEIs), accounting for 34.9% of the total in both provinces combined.

During the study period, the total number of students in Zone 3 increased by 40.4%, from 61,196 in 2015 to 85,912 in 2022. The province with the highest growth in student enrollment was Cotopaxi, with a 60.3% increase, followed by Pastaza (57.1%), Tungurahua (40.2%), and Chimborazo, which had the lowest growth rate (29.0%). From 2015 to 2022, there was an average annual growth rate of 3.1%, though a declining trend was observed. Annual growth rates were 7.3% in 2019, 6.6% in 2020, dropping to 0.3% in 2021, and ending with -2.0% in 2022.

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Table 1 *Enrollment in Universities in Planning Zone 3 Period: 2015-2022*

Año	Chimborazo	Cotopaxi	Pastaza	Tungurahua
2015	23.961	11.864	2.397	22.974
2016	23.945	14.196	3.709	21.646
2017	27.633	16.000	5.076	23.763
2018	27.491	16.058	5.680	27.122
2019	28.890	18.422	5.048	29.584
2020	31.224	20.026	5.017	31.167
2021	31.474	20.127	3.512	32.274
2022	30.914	19.019	3.765	32.214

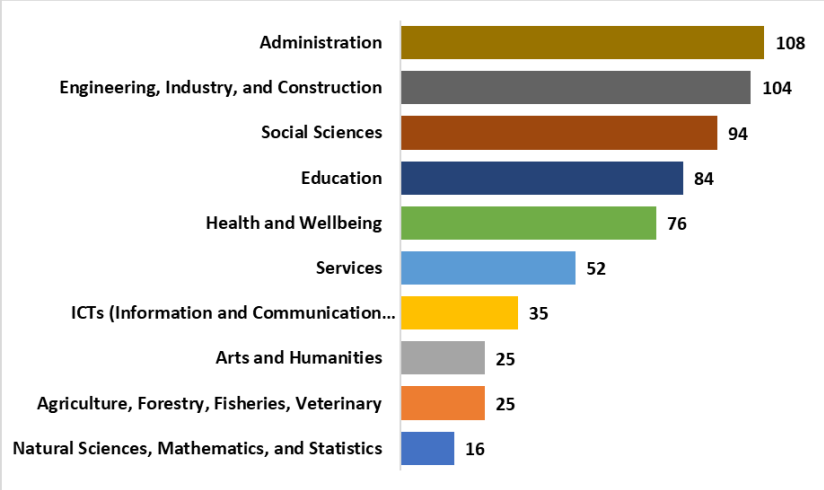
Note: Information obtained from SENESCYT (2024).

The universities in this zone offered 619 academic programs, with institutions in Tungurahua providing the most options (56.9% of the total). This was followed by Chimborazo (24.9%), Cotopaxi (13.2%), and Pastaza (5%). Most of the programs offered were in Administration (17.4%), Engineering, Industry, and Construction (16.8%), Social Sciences (15.2%), and Education (13.6%).

Regarding funding, 68.8% of the universities in Zone 3 were publicly financed, while the remaining 31.2% were privately funded.

In 2022, Tungurahua hosted the majority of programs (56.9%), followed by Chimborazo (24.9%), Cotopaxi (13.2%), and Pastaza (5%). In terms of financial structure, 11 universities were publicly funded, while 5 were privately funded.

Figure 1 *Academic Programs Offered by Universities in Planning Zone 3 Year: 2022*



Note: Information obtained from SENESCYT (2024).

SCIENTIFIC RESEARCH OUTPUT

In 2020, the latest year for which data was available (SENESCYT, 2020), HEIs in Zone 3 published a total of 2,220 indexed articles, representing 21.7% of the national total. Tungurahua and Chimborazo contributed the most, accounting for 49.9% and 41.8%, respectively. The remaining contributions came from Pastaza (4.5%) and Cotopaxi (3.8%). Research output experienced notable growth over the five years studied, increasing by 268.2%. This growth was driven by regulatory requirements and objectives set by oversight bodies. HEIs in Tungurahua had the highest increase (470.6%), followed by Chimborazo (309.3%) and Cotopaxi (21.4%), while Pastaza's Amazonian State University experienced an 11.6% decline in output.

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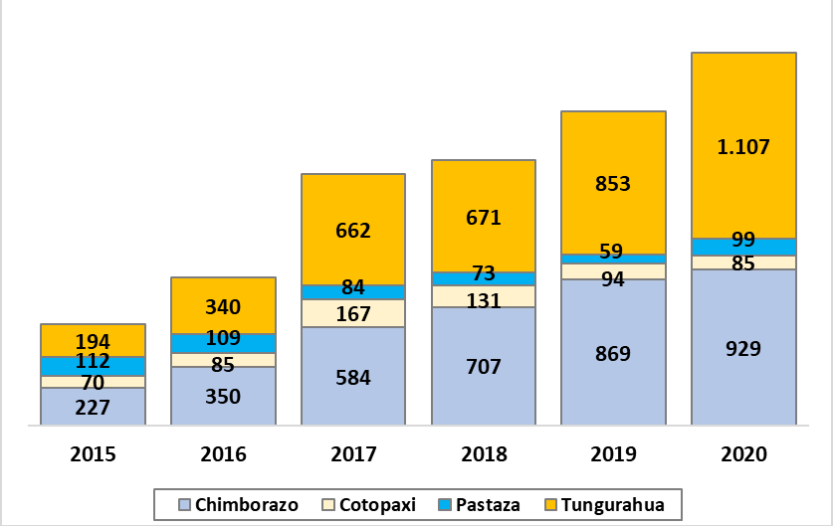
Figure 2 *Research in Higher Education in Planning Zone 3 Period: 2015-2020*



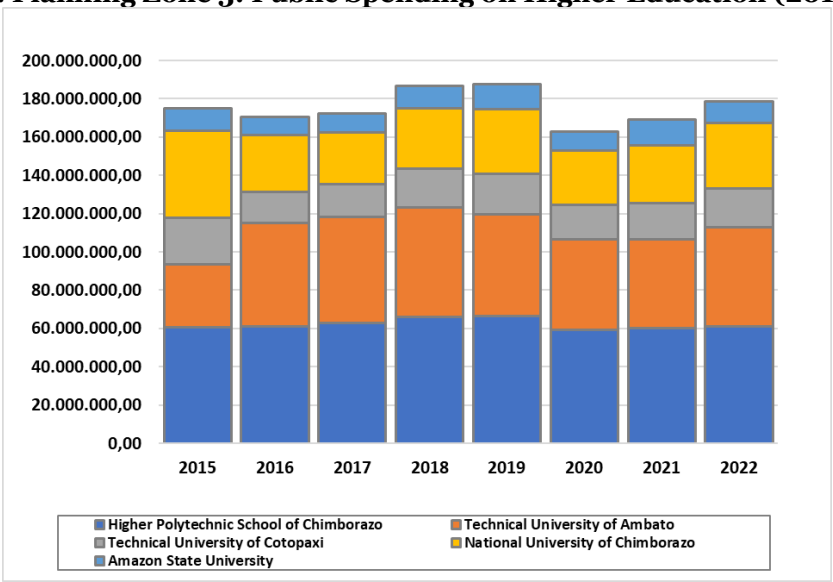
Note: Information obtained from SENESCYT (2024).

PUBLIC SPENDING ON HIGHER EDUCATION

In the central region, the state invested an average of 0.62% of the General State Budget in higher education during the period 2015–2022, reaching a value of $178.4 million in 2022. The universities receiving the highest share of the budget were the Escuela Superior Politécnica de Chimborazo (ESPOCH), accounting for 34.7% of the total, the Universidad Técnica de Ambato (UTA) with 29.2%, and the Universidad Nacional de Chimborazo with 18.7% of the resources allocated to the region.

Regarding the evolution of public funding for higher education institutions (HEIs) in Zone 3, the total resources increased by only 1.9% over the eight years of this study. The Universidad Técnica de Ambato exhibited the highest growth in its funding, with a 56.9% increase over the analyzed period. Meanwhile, the Escuela Superior Politécnica de Chimborazo experienced a modest growth of 0.8%. Conversely, the Universidad Nacional de Chimborazo, Universidad Técnica de Cotopaxi, and Universidad Estatal Amazónica saw decreases in funding of -14.1%, -16.5%, and -7.8%, respectively, between 2015 and 2022.

Figure 3. Planning Zone 3: Public Spending on Higher Education (2015–2022)



Source: Ministry of Finance of Ecuador, 2024.

ECONOMIC GROWTH IN ZONE 3

For Planning Zone 3, projections for 2022 estimated total production at $6,705.55 million, contributing 5.9% to the country's total production. Over the 2015–2022 period, the region averaged a 6.5% share of national

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production. The provinces with the highest contributions were Tungurahua (2.51% of national GDP), followed by Cotopaxi (1.72%), Chimborazo (1.66%), and Pastaza (0.58%).

Regarding growth, Zone 3 experienced a 12.7% increase in total production over the analyzed period. Cotopaxi achieved the highest growth (17.2%), followed by Pastaza (5.8%). In contrast, production in Chimborazo and Tungurahua decreased by -11.6% and -3.8%, respectively.

Table 2. Gross Domestic Product by Province in Planning Zone 3 (2015–2022) *In millions of dollars (Base year: 2018)*

Año	Cotopaxi	Chimborazo	Pastaza	Tungurahua
2015	1.665,20	1.788,14	589,59	2.651,68
2016	1.653,84	1.921,39	531,96	2.610,02
2017	1.804,95	1.866,06	623,27	2.806,42
2018	1.952,86	1.854,46	713,84	2.866,04
2019	1.818,68	1.768,19	730,53	2.797,82
2020	1.760,15	1.533,49	463,55	2.291,85
2021	1.887,11	1.607,81	612,29	2.545,00
2022	1.951,59	1.580,46	623,67	2.549,84

Source: Central Bank of Ecuador (2024).

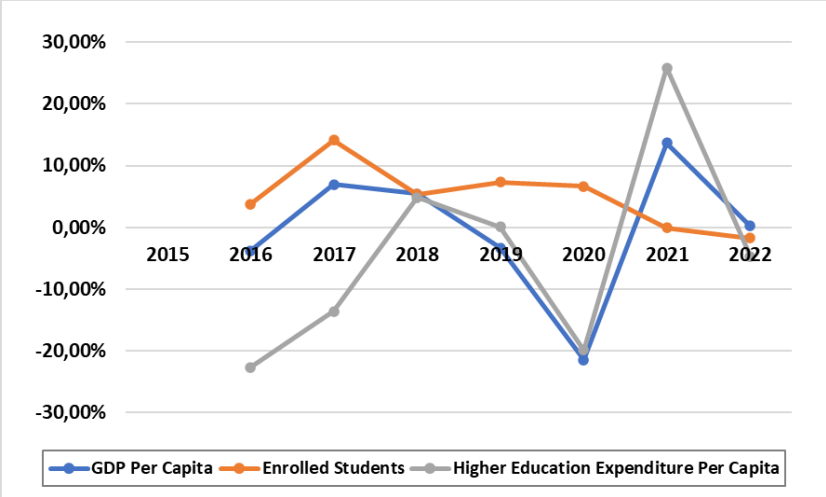
In this region, the primary sectors of production include construction (12.9%), wholesale and retail trade (10.6%), transportation and storage (8.8%), education (7.8%), social and health services (5.7%), and public administration, defense, and compulsory social security (5.3%).

EDUCATION AND ECONOMIC GROWTH

Considering the evolution of education and economic growth variables, the rates of per capita GDP, university enrollment, and per capita education spending were analyzed.

The trends of per capita GDP and public spending on education initially diverged but aligned from 2018 onward, which is expected given that public spending depends on GDP. However, when these two variables are related to the higher education enrollment rate, distinct trends emerge from 2018 onward, suggesting that higher education enrollment may not significantly influence economic growth.

Figure 4. Evolution of Education and Economic Growth Variables (2015–2020) *Percentages*



Source: Central Bank of Ecuador, 2024.

The quantitative relationship between higher education and economic growth in Planning Zone 3 was tested using a fixed-effects panel data model to determine the correlation between individual effects and explanatory variables. Wooldridge and Wald tests identified autocorrelation and heteroscedasticity issues, which were corrected using the Prais-Winsten method. The final fixed-effects model results are presented below:

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Variable	Coefficient	Significance	Standard Error
GPDES	0.285875	**	0.1205453
COESU	15.96309	***	5.031.2380
TMES	-2.043734	***	1.6145735
_cons	1.430774		0.9153970

*Significance levels: *** = 1%; ** = 5%; * = 10%*

Model Summary:

- R-squared: 82.53%
- Wald chi2 (3): 34.69 (p-value < 0.0000)
- rho: 0.67722

The model explains 82.53% of the variability in the dependent variable (per capita GDP) based on the independent variables, with a rho value of 0.67722 indicating that 67.62% of error variance is due to specific unit differences (unobserved effects). The Wald chi2 statistic confirms the statistical significance of the selected explanatory variables—per capita spending on higher education, higher education coverage, and enrollment rates—in explaining economic growth variability.

The coefficients reveal that a 1% increase in education spending results in a 0.2858% rise in per capita GDP over time and across provinces. Similarly, a 1% increase in higher education coverage leads to a 15% production growth in Zone 3, while a 1% change in enrollment rates raises per capita GDP by 2.04373%.

These findings demonstrate the significant role of higher education in enhancing the economic growth of the provinces in Planning Zone 3, underscoring the importance of investments in education for regional economic development.

CONCLUSION

Ecuador is characterized by a centralization of production in the larger provinces, Pichincha and Guayas, which also results in a concentration of population in these provinces, and, of course, of universities and university students. This is reflected in the indicators found in this research for the provinces of Planning Zone 3, which can be considered small. In these provinces, production is still incipient and is mainly based on products from the construction, wholesale and retail trade, transportation, and storage sectors. The GDP of this zone represents only 5.9% of the country's total production, with a growth of 12.7% over the entire period.

Regarding education indicators, during the study period, there was an increase in the total number of students by 40.4%, with 619 programs offered by the universities in this zone. The majority of this offer is in the fields of Administration, Engineering, Industry and Construction, Social Sciences, and Education, with the funding predominantly public, at 68.8%.

As for the relationship between GDP per capita and education variables, it can be determined that public spending on education shows distinct trends in the first two years when considering public spending on higher education. However, starting in 2018, they show the same trend. When the growth rate of enrollment in higher education is included, starting in 2018, they maintain distinct trends, which may indicate that there is no strong influence of higher education enrollment rates on economic growth.

Finally, the results from the econometric modeling conclude that the variables of public spending on higher education per capita, enrollment rate, and coverage of higher education are statistically significant in explaining the evolution of GDP per capita. The values found for the coefficients explain that as public spending on education, enrollment, and coverage of higher education increase, the economic growth of the provinces in Planning Zone 3 of Ecuador increases

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