

REGIONAL GAPS IN RETURNS TO EDUCATION: A MICROECONOMETRIC ANALYSIS OF COLOMBIAN CITIES (2021–2024)

DISPARIDADES REGIONAIS NOS RETORNOS DA EDUCAÇÃO: UMA ANÁLISE MICROECONOMÉTRICA DE CIDADES COLOMBIANAS (2021–2024)

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Abstract

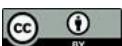
This study aims to analyze the regional gaps in returns to education in Colombia during the 2021–2024 period, focusing on major urban centers and using Bogotá as the reference category. A microeconomic methodology was applied, estimating a Mincerian earnings function corrected for sample selection bias through the Heckman procedure. Microdata from Colombia's Gran Encuesta Integrada de Hogares (GEIH) were employed, allowing for the simultaneous modeling of labor market participation and wage equations. The results indicate that Medellín and Bucaramanga exhibit consistently positive returns compared to Bogotá, while Cartagena, Barranquilla, and Pasto show persistent wage penalties. The main conclusion is that urban location remains a crucial determinant of the profitability of human capital in Colombia, reinforcing wage inequalities and highlighting the need for regional development policies that foster territorial equity.

Keywords: Human Capital. Returns To Education. Labor Economics. Regional Gaps.

Resumo

Este estudo visa analisar as disparidades regionais no retorno da educação na Colômbia durante o período de 2021 a 2024, com foco nos principais centros urbanos e utilizando Bogotá como categoria de referência. Foi aplicada uma metodologia microeconômica, estimando-se uma função de rendimentos minceriana corrigida para o viés de seleção amostral por meio do procedimento de Heckman. Microdados da Gran Encuesta Integrada de Hogares (GEIH) da Colômbia foram utilizados, permitindo a modelagem simultânea das equações de participação no mercado de trabalho e de salários. Os resultados indicam que Medellín e Bucaramanga apresentam retornos consistentemente positivos em comparação com Bogotá, enquanto Cartagena, Barranquilla e Pasto mostram penalidades salariais persistentes. A principal conclusão é que a localização urbana continua sendo um determinante crucial da rentabilidade do capital humano na Colômbia, reforçando as desigualdades salariais e destacando a necessidade de políticas de desenvolvimento regional que promovam a equidade territorial.

Palavras-chave: Capital Humano. Retorno Da Educação. Economia Do Trabalho. Disparidades Regionais.



1 INTRODUCTION

The analysis of returns to education constitutes one of the most relevant areas of labor economics, as it allows for measuring the capacity of human capital to translate into higher individual and collective income (Congna *et al.*, 2025. Ibagón & Gómez, 2018).

In Colombia, the literature has consistently shown that the benefits of education are positive, though heterogeneous, depending on variables such as gender, educational level, and geographic location (Rodríguez, 2024. Mora *et al.*, 2023). In particular, regional disparities have gained prominence in academic and policy debates, as urban location conditions both labor productivity and the valuation of educational credentials (Tenjo, 2017. Isaza, 2013). Thus, the general objective of this article is to measure and compare urban differentials in returns to education during the 2021–2024 period, using Bogotá as the reference category, with the aim of identifying persistent regional inequalities in the Colombian labor market (Gómez, 2018. Castillo & Robayo, 2017).

The central research question guiding this study is: What are the relative differentials in returns to education among Colombia's major cities during 2021–2024, and what implications do these disparities hold for regional equity and public policy design? This formulation seeks not only to account for quantitative differences in wage coefficients, but also to highlight the qualitative implications of these territorial inequalities on social mobility, human capital allocation, and the efficiency of educational investment (Busso *et al.*, 2024. Gómez & Velasco, 2024a).

From a theoretical standpoint, this study rests on three core pillars. First, human capital theory (Becker, 1964) posits that education is an investment that increases productivity and future earnings (Barón & Bonilla, 2018). However, this effect is mediated by the economic and regional context in which the labor force is embedded (Patrinos, 2020). Second, the Mincer earnings equation (1974) has been consolidated as the standard empirical model for estimating returns to education, by linking the logarithm of wages with years of schooling and work experience (Puhani *et al.*, 2019). Third, the Heckman model (1979) provides a correction for sample selection bias, which is essential when labor force participation is not random, by incorporating the inverse Mills ratio in the wage estimation (Rodríguez & Barbosa, 2025. Alfonso *et al.*, 2018).

In this analytical framework, estimating returns to education across cities allows the operationalization of human capital theory within a territorial perspective. In other words, differences in wage coefficients between cities do not only reflect individual productivity associated with schooling but also structural disparities in local labor markets, such as productive specialization, labor demand for skilled workers, and levels of economic diversification. Therefore, the microeconomic approach adopted in this study seeks to identify whether the economic profitability of education varies systematically according to urban location in Colombia (Adu-Boahen, 2024. Abu Alfoul, 2024).

2 METHODOLOGY

The quantitative methodology relies on data from the Gran Encuesta Integrada de Hogares (GEIH) conducted by Departamento Administrativo Nacional de Estadística (DANE) for the period 2021–2024. This methodological strategy is consistent with the research question, since the estimation of the Mincerian wage equation across urban dummy variables enables the identification of territorial differentials in the economic return to schooling. Consequently, the model allows evaluating whether education generates homogeneous productivity rewards across cities or whether spatial inequalities condition the profitability of human capital investments (Kokkinopoulou & Kalaitzandonakes, 2025. Carillo & López-Bazo, 2024) The analysis of urban differentials in returns to education is based on the estimation of a Mincerian earnings function corrected for selection bias using Heckman's (1979) two-step procedure. This approach involves two stages: the labor force participation equation and the wage equation (Gómez *et al.*, 2025. Biewen & Erhardt, 2020).

2.1 Selection equation

A probit model is specified to estimate the probability of participating in the labor market:

Ecuación de selección:

$$D_i = \gamma_0 + \gamma_1 \text{Edu}_i + \gamma_2 \text{Edad}_i + \gamma_3 Z_i + u_i \quad (1)$$

$D_i = 1$ si $D_i > 0$ (participates), $D_i = 0$ si $D_i \leq 0$ (does not participate).

From this model, the inverse Mills ratio (λ_i) is obtained, which is subsequently included in the second stage:

$$\lambda_i = \varphi(\hat{\gamma} X_i) / \Phi(\hat{\gamma} X_i) \quad (2)$$

2.2 Wage equation

The Mincerian earnings function corrected for selection bias is expressed as follows:

$$\ln(w_i) = \beta_0 + \beta_1 \text{Edu}_i + \beta_2 \text{Exp}_i + \beta_3 \text{Exp}_i^2 + \sum \gamma_k \text{Ciudad}_{ik} + \rho \lambda_i + \varepsilon_i \quad (3)$$

(Rodríguez *et al.*, 2025).

Where $\ln(w_i)$ is the natural logarithm of hourly wages, Edu_i represents years of schooling, Exp_i and Exp_i^2 denote experience and its square, City_{ik} are city-specific dummy variables (with Bogotá as the reference category), λ_i is the inverse Mills ratio, and ε_i is the error term (Arias & Maldonado, 2025).

In this framework, the exclusion restrictions (Z_i) ensure model identification, since they influence the probability of labor force participation but do not directly affect conditional wages. These include household size, presence of children, marital status, non-labor income, and housing tenure. Consequently, the methodology integrates the Mincer equation which relates income, education, and experience with the Heckman

correction that accounts for selection bias in labor participation. The main interest lies in the coefficients γ_k , which reflect the urban gaps in returns to education during 2021–2024, using Bogotá as the baseline. Notably, Bogotá, as the capital city, concentrates both Colombia’s productive apparatus and its business infrastructure (Díaz & Gutiérrez 2024. Gómez *et al.*, 2015. Table 1). Additionally, the specification incorporates standard control variables commonly used in the human capital literature, including years of schooling, potential labor experience, and its quadratic term, which capture the life-cycle dynamics of earnings as proposed in the original Mincer framework (Leoni, 2025. Pastpipatkul & Watanapongvanich, 2025).

Table 1

GDP Contribution of Colombian Cities in 2022

City Municipality	GDP / COP/ billion	Share-%
Bogotá D.C.	316317	21,52122
Medellín	76890	5,231356
Cali	55430	3,771284
Barranquilla	36363	2,474025
Cartagena	29755	2,024437
Bucaramanga	19393	1,319439
Barrancabermeja	19067	1,297259
Pereira	12351	0,840324
Cúcuta	11724	0,797664
Yumbo	11617	0,790384
Ibagué	11133	0,757455
Envigado	10926	0,743371
Villavicencio	10873	0,739765
Itagüí	10856	0,738608
Manizales	9802	0,666898
Neiva	7987	0,543411
Santa Marta	7709	0,524496
Pasto	7591	0,516468
Valledupar	7049	0,479592
Popayán	6145	0,418087
Armenia	5812	0,39543

Source: Own elaboration (Román *et al.*, 2025. CEPAL, 2025. DNP, 2025. DANE, 2025).

3 RESULTS

From the perspective of human capital theory, the estimated coefficients associated with each city represent the marginal differences in the economic return to schooling once individual characteristics and labor market selection bias are controlled

for. In this sense, the results provide evidence on how the territorial structure of labor markets influences the productivity rewards associated with educational investment (Wei, 2025. Psacharopoulos, 2024). Recent studies in Latin America demonstrate that differences in educational returns are shaped not only by individual characteristics but also by structural factors such as labor market formality, productive diversification, and the absorption capacity of human capital in each city (Patrinos, 2020. Psacharopoulos & Patrinos, 2018). In Colombia, research by Castillo and Robayo (2017) and Barón and Bonilla (2018) confirms that urban disparities remain stable over time, with persistent wage penalties in Caribbean cities compared to economic hubs like Bogotá and Medellín (Barbosa *et al.*, 2020).

In this context, the present study updates the evidence for the 2021–2024 period, marked by post-pandemic recovery and regional structural changes, thus allowing a more precise assessment of the persistence of regional gaps in human capital returns (Dávalos *et al.*, 2023. Gómez & Rincón, 2016. Table 2. Table 3).

Table 2

Male subsample

City	2021	2022	2023	2024
Bogotá (ref.)	0	0	0	0
Medellín	0,004***	0,004***	0,004***	0,004***
Cali	0,002***	0,002***	0,002***	0,002***
Bucaramanga	0,005***	0,005***	0,005***	0,005***
Cúcuta	0,003***	0,003***	0,003***	0,003***
Cartagena	-0,004***	-0,004***	-0,004***	-0,004***
Barranquilla	-0,003***	-0,003***	-0,003***	-0,003***
Pasto	-0,005***	-0,005***	-0,005***	-0,005***

Robust standard errors in brackets. *** denotes significance at 1%, ** denotes significance at 5%, * denotes significance at 10%. denotes significance at 10%. Base category is Salesperson, Shop Assistant. The names of the trades, occupations and professions are taken from the page http://www.ilo.org/public/libdoc/ilo/1969/69B09_35_span.pdf. Last accessed 30/05/2025 The results by city were rounded to facilitate understanding of the data
Source: of both tables, Dane DATA

Table 3

Female Subsample

City	2021	2022	2023	2024
Bogotá (ref.)	0	0	0	0
Medellín	0,004***	0,004***	0,004***	0,004***
Cali	0,002***	0,002***	0,002***	0,002***
Bucaramanga	0,005***	0,005***	0,005***	0,005***

Cúcuta	0,003***	0,003***	0,003***	0,003***
Cartagena	-0,004***	-0,004***	-0,004***	-0,004***
Barranquilla	-0,003***	-0,003***	-0,003***	-0,003***
Pasto	-0,005***	-0,005***	-0,005***	-0,005***

Robust standard errors in brackets. *** denotes significance at 1%, ** denotes significance at 5%, * denotes significance at 10%. Base category is Salesperson, Shop Assistant. The names of the trades, occupations and professions are taken from the page http://www.ilo.org/public/libdoc/ilo/1969/69B09_35_span.pdf. Last accessed 30/05/2025. The results by city were rounded to facilitate understanding of the data. Source: of both tables, Dane DATA

The results on educational returns by city reveal a clear regional segmentation of the Colombian labor market. Bogotá, used as the reference category, shows null coefficients, whereas Medellín and Bucaramanga report consistently positive returns (0.004 and 0.005 on average, respectively). This indicates greater valuation of human capital in urban contexts characterized by diversified production structures, relatively higher levels of formality, and greater business density (OECD, 2023. CEPAL, 2019). Conversely, cities such as Cartagena, Barranquilla, and Pasto exhibit persistent penalties (between -0.003 and -0.005), suggesting that urban location remains a critical determinant of labor income, beyond individual attributes such as education and experience (Téllez, 2020. Kalmanovitz, 2019).

Interestingly, no gender gaps were identified in the estimated coefficients, which contrasts with much of the national literature that typically documents lower returns for women (Barón & Bonilla, 2018. Tenjo, 2017). This convergence may be explained by two factors: first, post-pandemic recovery policies (2021–2024) promoted inclusion and employability programs with a gender focus. and second, the methodological design controlled for education and experience, thereby attenuating differences found in more aggregated studies. Nevertheless, equal coefficients do not necessarily imply equality of conditions in participation, job quality, or absolute wage gaps, where structural inequalities persist (Gómez & Velasco, 2024b. Llanes & Paredes, 2023).

Furthermore, the persistence of negative returns in peripheral cities signals a challenge for public policy in terms of territorial equity and social cohesion. Wage penalties in the Caribbean and southwestern regions suggest structural constraints such as low investment in innovation, limited productive diversification, and high levels of informality that reduce the capacity of human capital to translate into higher incomes (Mora *et al.*, 2023. DANE, 2022). This evidence reinforces the need for regional

development policies that integrate education, employment, and productivity, with an emphasis on value-added sectors. In short, the results confirm that education in Colombia does not guarantee homogeneous returns, and that urban location continues to be a central factor in the profitability of human capital during 2021–2024 (Téllez *et al.*, 2022. DANE, 2020). These empirical findings suggest that educational investment does not translate into uniform economic benefits across the national territory. Instead, the spatial distribution of productive structures, labor demand for skilled workers, and regional economic dynamism plays a decisive role in shaping the returns to human capital. This interpretation provides the basis for the discussion of structural and policy implications presented in the following section (Xie & Li, 2025. Carillo & López-Bazo, 2024).

4 DISCUSSION

The differentials in returns to education across Colombian cities highlight the decisive role of territorial context in shaping the value of human capital. Cities such as Medellín and Bucaramanga display relative advantages over Bogotá, possibly linked to local dynamics of innovation and productive diversification (Rincón & Gómez, 2023. Valero & Ordaz, 2022). By contrast, Cartagena, Barranquilla, and Pasto continue to register negative coefficients, reflecting structural limitations in regional labor markets, including higher informality rates and weaker demand for skilled labor (Isaza, 2013). According to Leoni (2025) and Tenjo (2017), these disparities stem not only from productive structures but also from the scale and orientation of both public and private investment in each region. The fact that Caribbean cities and several intermediate urban centers show negative returns compared to Bogotá underscores a pressing public policy challenge: balancing economic opportunities to prevent the concentration of human capital in a few metropolitan areas (Rangel, 2025. López *et al.*, 2025).

From the perspective of human capital theory, these results indicate that the economic return to educational investment is not determined exclusively by individual productivity, but also by the structural characteristics of regional labor markets. Thus, the territorial context acts as an institutional filter that amplifies or limits the capacity of education to generate income gains (Leoni, 2025. Adu-Boahen, 2024). Moreover, the evidence supports the notion that place of residence conditions the profitability of

education, generating persistent territorial inequalities. Such disparities raise the risk of talent concentration in large cities and the outmigration of human capital from peripheral regions to more dynamic urban centers (Barbosa *et al.*, 2021. Tenjo, 2017). Likewise, urban gaps in returns to education may be associated with insufficient investment in higher education and in science and technology policies in certain regions, as well as with the productive specialization of cities (Gaspar, 2021). The persistence of negative returns in the Caribbean region coincides with studies that link educational and labor lags to historical inequalities in infrastructure and social capital (Castillo & Robayo, 2017. González *et al.*, 2015).

From a public policy perspective, these findings reinforce the need to design regional development strategies that reduce urban wage gaps, improve employment conditions in lagging cities, and prevent the overconcentration of human capital in a handful of metropolitan centers (Chiswick, 2024. Laverde *et al.*, 2020). Thus, the microeconomic analysis of Colombian cities not only reflects historical inequalities in productive structures but also raises critical questions regarding territorial equity in the distribution of educational benefits (Psacharopoulos & Patrinos, 2018. Barón & Bonilla, 2018).

5 CONCLUSIONS

The econometric evidence obtained through the Mincer–Heckman model confirms that the economic return to schooling varies systematically across Colombian cities. Positive coefficients observed in Medellín and Bucaramanga indicate relatively higher profitability of educational investment, whereas negative coefficients in Cartagena, Barranquilla, and Pasto reveal structural penalties in the valuation of human capital. The analysis demonstrates that returns to education in Colombia are marked by strong regional heterogeneity. Medellín and Bucaramanga consolidate wage advantages relative to Bogotá, while cities such as Cartagena, Barranquilla, and Pasto display persistent disadvantages. This finding confirms that education does not yield homogeneous returns and that urban location is a decisive factor in the profitability of human capital. Consequently, the concentration of opportunities in certain urban centers reinforces structural inequalities and limits social mobility in peripheral regions.

The microeconomic estimation, through the Mincer equation corrected by the Heckman model, allowed for the control of labor selection bias, showing that both participation in the labor market and wages are conditioned by structural factors specific to each city. Although men and women presented similar marginal returns, this does not imply the absence of inequality. rather, it indicates that gender disparities manifest more clearly in participation rates, job quality, and occupational segmentation. Hence, the study demonstrates the importance of distinguishing between equality in estimated coefficients and equity in effective labor outcomes.

Finally, the persistence of negative returns in several peripheral cities underscores the need for public policies aimed at territorial equity, integrating education, employment, and regional productive development. It is crucial to promote investment in value-added sectors, encourage labor formalization, and strengthen the alignment between academic training and business demand. Only through a territorial cohesion approach will it be possible to reduce regional gaps in human capital returns, ensure greater social inclusion, and equitably distribute the benefits of education within Colombia's national economic development.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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