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Returns to education in Colombia: Professional differentials

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Abstract

This study aims to estimate the private returns to education in Colombia by profession and gender during the 2021–2024 period, identifying inter-professional differentials and gender-based disparities in human capital valuation. The methodology is based on the Mincer (1974) earnings function, corrected for sample selection bias using Heckman's (1979) two-stage procedure. This includes a probit model for labor force participation and a wage equation incorporating the inverse Mills ratio. Results indicate a stable returns hierarchy: economists and biologists exhibit the highest returns (0.054–0.060), followed by lawyers and engineers/architects (0.044–0.052), while teachers and nurses report the lowest values (0.022–0.033). Women consistently show lower returns than men across all professions, though a slight convergence is observed by 2024. The Colombian labor market remunerates human capital heterogeneously, perpetuating occupational and gender inequities that constrain both efficiency and the social returns of educational investment. Policy interventions are needed to enhance returns in socially strategic professions, reduce gender gaps, and align market incentives with national development goals.

Keywords: Gender gap, Higher education, Human capital, Labor market, Returns to education.

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1. Introduction

The study of returns to education has been the subject of extensive literature dating back to the pioneering works of Schultz [1] and Becker [2] who conceptualized education as an investment that increases individuals' productivity and future earnings. Later, Mincer [3] formulated the semilogarithmic earnings equation, which became the standard tool for estimating the effects of schooling and experience on wages [4].

In the Colombian context, numerous studies have documented positive returns to education, averaging around 10% per year, although with significant heterogeneity across educational levels, regions, genders, and occupations [5, 6]. Disaggregation by profession is particularly relevant, as it allows us to observe the way in which the labor market values the specific skills associated with each field of knowledge [7, 8].

The 2021–2024 period provides a unique scenario: after the crisis triggered by the COVID-19 pandemic, the Colombian labor market faced a recovery process characterized by changes in skill demand, advances in digitalization, and adjustments in strategic sectors [9, 10]. While professions linked to sciences, economics, and technology experienced greater appreciation, others such as teaching and nursing lagged behind despite their social relevance [11, 12]. This article focuses exclusively on that period to identify patterns of professional heterogeneity in the profitability of human capital. How do returns to education vary across university professions in

1.1. Theoretical Framework

The theory of human capital Becker [2] establishes that education generates positive externalities and private benefits in terms of productivity and earnings. Empirically, Mincer [3] earnings function proposes that the logarithm of wages can be modeled as a linear function of years of education and a quadratic relationship with labor market experience. This specification has been widely applied in both developed and developing countries [13, 14].

One of the main methodological challenges in estimating returns is sample selection bias: individuals participating in the labor market are not a random sample of the population, leading to inconsistent estimators. Heckman [15] solved this problem with a two-stage model that incorporates the inverse Mills ratio in the wage equation. This procedure has been validated in subsequent studies and is considered a standard in applied microeconometrics [16, 17].

At the global level, recent reviews confirm average returns between 8% and 10% for each additional year of schooling, although with substantial variations across countries and occupations [18] In Latin America, returns tend to be higher in STEM professions and in economics, while fields such as education or nursing report lower levels [19]. In Colombia, Tenjo [5] and Barón and Cepeda Emiliani [20] highlight the persistence of gender gaps and occupational segmentation, with consistently lower coefficients for women [21, 22].

2. Methodology

The analysis of differentials in returns to education by profession in Colombia was carried out using the Mincer earnings function [3] corrected for sample selection bias following [15]. This strategy allows for the simultaneous modeling of both the decision to participate in the labor market and the wage equation, thus avoiding biases derived from a non-random sample [23, 24].

2.1. Selection Equation (Labor Market Participation)

A probit model was estimated to identify the probability that individual i participates in the labor market:

$D\_i = \gamma 0 + \gamma 1\ Edu\_i + \gamma 2\ Age\_i + \gamma 3\ Z\_i + u\_i$

$D\_i = 1$ if $D\_i > 0$ (individual participates in the labor market), $D\_i = 0$ if $D\_i \leq 0$ (does not participate).

From this estimation, the inverse Mills ratio (λ_i) is obtained:

$\lambda\_i = \varphi\varphi\ (\hat{\gamma} X\_i) / \Phi\ (\hat{\gamma} X\_i)$

2.2. Wage Equation (Corrected Mincer Specification)

The wage equation is specified as follows:

$\ln(win) = \beta 0 + \beta 1\ Edu\_i + \beta 2\ Expire + \beta 3\ Exp\_i^2 + \Sigma\ \delta\_j\ Profession\_ij + \rho\ \lambda\_i + \varepsilon\_i$

Where $\ln(w\_i)$ is the natural logarithm of hourly wages, Edu_i represents years of education, Exp_i and Exp_i^2 capture labor market experience and its square, $Profession\_ij$ are dummy variables capturing each profession (reference: Economics), λ_i is the inverse Mills ratio, and ε_i is the error term [25].

2.3. Model Identification

Exclusion restrictions included in Z_i —such as marital status, household size, and non-labor income—affect labor market participation but not directly wages, ensuring proper identification of the Heckman correction [4]. In summary, the methodological approach makes it possible to estimate the differentials in returns to education by profession, avoiding selection bias and controlling for education, experience, and individual characteristics. Thus, the coefficients obtained for Medicine, Law, Engineering, Accounting, and other fields demonstrate the heterogeneity of professional earnings in Colombia during 2021–2024 [26, 27].

Table 1.
Mincerian coefficients by profession — Men (2021–2024).

Profession	2021	2022	2023	2024
Teachers	0.02900***	0.03000***	0.03200***	0.03300***
Economis	0.05400***	0.05500***	0.05700***	0.05800***
Lawyers	0.04900***	0.05000***	0.05100***	0.05200***
Biologist	0.05600***	0.05700***	0.05900***	0.06000***
Architects / Engineers	0.04400***	0.04500***	0.04600***	0.04700***
Business Administration	0.03700***	0.03800***	0.03900***	0.04000***
Nursing	0.02300***	0.02400***	0.02400***	0.02500***
Public Accounting	0.02600***	0.02700***	0.02700***	0.02800***

Source: of both tables, DANE data.
Robust standard errors in brackets. *** denotes significance at 1%, ** at 5%, * at 10%. Base category: Salesperson, Shop Assistant. The names of trades, occupations, and professions are taken from. Results by city were rounded for ease of interpretation.
Sorce: Rosero and Rodríguez [28]**;** Departamento Administrativo Nacional de Estadística (DANE) [29] **and** International Labour Organization (ILO) [30]

Table 2.
Mincerian coefficients by profession — Women (2021–2024).

Profession	2021	2022	2023	2024
Teachers	0.02700***	0.02800***	0.02900***	0.03000***
Economist	0.04500***	0.04600***	0.04700***	0.04800***
Lawyers	0.03800***	0.03900***	0.04000***	0.04100***
Biologists	0.04800***	0.04900***	0.05000***	0.05100***
Architects / Engineers	0.04200***	0.04300***	0.04400***	0.04500***
Business Administration	0.02900***	0.03000***	0.03100***	0.03200***
Nursing	0.02200***	0.02300***	0.02300***	0.02400***
Public Accounting	0.02600***	0.02600***	0.02700***	0.02700***

Source: DANE data.
Robust standard errors in brackets. *** denotes significance at 1%, ** at 5%, * at 10%.
Base category: Salesperson, Shop Assistant. The names of trades, occupations, and professions are taken from. Results by city were rounded for ease of interpretation.
Source: Rosero and Rodríguez [28]**;** Departamento Administrativo Nacional de Estadística (DANE) [29] **and** International Labour Organization (ILO) [30]

3. Results

The results reveal a clear hierarchy of returns to education in Colombia by profession. Economists, biologists, and engineers/architects are positioned at the upper end of the spectrum (0.050–0.060), while teachers remain at the lower end (0.029–0.033). This is consistent with previous studies indicating that occupations linked to sectors with higher marginal labor productivity generate greater returns [8, 18].

This dispersion reflects not only differences in perceived marginal productivity but also failures in the allocation of human capital, since socially strategic sectors such as education and health do not provide wage incentives proportional to educational effort [31, 32]. Thus, an additional year of education in Biology or Economics can yield a return nearly double that of Teaching, consolidating structural segmentations and conditioning young people's vocational choices, reinforcing inequalities [33, 34].

The gender-based analysis confirms the persistence of gaps: in all professions, women receive lower returns compared to men, even after controlling for observable characteristics [10, 35]. This reflects mechanisms of direct and indirect discrimination, horizontal and vertical occupational segregation, and penalties associated with motherhood. The evidence is consistent with national and international literature indicating that the Colombian labor market does not remunerate female human capital equitably, thereby reducing the private return on women's educational investment and generating social inefficiencies [36, 37].

Comparing these findings with the broader Colombian labor context shows that although unemployment has declined and employment has increased, much of the recovery is concentrated in informal jobs, limiting the materialization of the expected private returns [38]. Data from the Labor Observatory for Education and the GEIH confirm that, although the wage premium for postgraduate studies and the heterogeneity across disciplines are consistent with the results of this paper, informality and the country's low competitiveness (Colombia ranks poorly in international indexes such as IMD) restrict the full valorization of acquired skills. This implies that even as human capital expands, the productive structure does not absorb it efficiently, thereby reducing the social profitability of education [39, 40].

4. Discussion

The persistent hierarchy of returns by profession, the pronounced inter-professional gap between highly profitable disciplines and those with lower coefficients, and the persistence of gender inequalities even after correcting for selection bias are situated within a growing body of studies on Colombia that document heterogeneity in educational returns and structural limitations of the labor market [41, 42]. For instance, evidence from the Central Bank of Colombia shows that heterogeneity in tertiary education returns among low-income youth is wide: for individuals in the 10th percentile, the annualized return can reach up to 12%, while for those in the 90th percentile it is around 3%. This indicates that educational investment is worth much more for the most vulnerable than for those already positioned [40]. This finding

aligns with our observation of pronounced dispersion across professional fields, although our more refined estimation, disaggregated by profession and gender, offers a level of granularity rarely found in aggregated studies [43].

Regarding gender, our finding that women obtain lower β coefficients than men, even under corrected specifications, echoes recent studies on the wage gap and segregation by discipline. Barón and Cepeda Emiliani [20] document that the average gender wage gap among graduates with formal employment is 11%, and that up to 40% of this gap can be explained by differences in field of study rather than by experience, mobility, or promotions. This complements our interpretation that part of the gender gap in returns derives not only from direct wage discrimination but also from a structural division of human capital by field of study [44, 45].

A critical aspect where our findings diverge from traditional literature relates to the rigidity of returns in socially essential professions. Many previous studies rely on aggregated analyses or simple Mincer models; for example, [46] estimates an average return rate for Colombia of 9.1% without professional disaggregation. However, our segmentation reveals that such an average conceals substantial divergences: not all educational backgrounds yield equally, nor do they sustain social mobility in a homogeneous manner. In particular, literature on accounting returns reported relatively low returns compared to other professions [47, 48] a conclusion consistent with our modern estimation for Accounting as one of the professions with the lowest β. This concordance strengthens the validity of our estimates and shows that the persistence of low returns is not a cyclical anomaly but rather a structural phenomenon [49, 50].

Nevertheless, recent literature also highlights nuances worth incorporating. Giraldo [51] documents a significant decline in the gender wage gap between 2019 and 2020, suggesting that external shocks or recent dynamics can temporarily compress labor disparities. Such fluctuations put into tension the idea of rigid norms: labor markets can react, and countercyclical or redistributive policies could have dynamic effects on gender returns in the short term. Another World Bank study underlines that the effects of the pandemic exacerbated preexisting inequalities, which helps contextualize the persistence of gender gaps and the lag of certain professions in our data [37, 52].

From the theoretical standpoint of human capital, the results reinforce the classical model that education and experience explain part of wage variation but also expose that social and private returns diverge in the presence of market imperfections: high informality, gender barriers, occupational segmentation, and institutional rigidity prevent potential marginal productivity from being fully translated into observed remuneration [53, 54]. This gap between potential yield and actual remuneration is fertile ground for policy intervention. Compared to pure human capital models, our findings suggest that certain professions—such as teaching and nursing—are condemned to low private returns under current market rules, contradicting the assumption that markets always remunerate according to expected productivity [55, 56].

Finally, the contrast with competitiveness and productivity rankings suggests that even if Colombia improves its sectoral private returns, the productive environment could remain a bottleneck [57]. In countries with more efficient institutions, competitive infrastructure, and lower informality, human capital returns tend to be better internalized in effective wages [58, 59]. Thus, Colombia's lag in competitiveness limits its ability to convert education into real comparative advantages [60, 61]. In this context, the contribution of our work is to show that expanding education alone is not enough: it is necessary to redesign institutional frameworks, strengthen the formal labor market, and revalorize those critical disciplines that the private market does not adequately reward [50, 62].

5. Conclusions

The first conclusion is that the hierarchy of returns by profession confirms the existence of structural segmentations in the Colombian labor market: while economics and biological sciences generate high marginal profitability, the teaching and nursing sectors exhibit low and persistently lagging returns despite their social value. This pattern indicates that the allocation of human talent is driven more by market incentives than by strategic development needs, reproducing imbalances in educational quality and in the provision of essential services.

The second conclusion is that gender gaps are consistent and resistant even after econometric correction for selection bias. The lower profitability observed for women across all disciplines shows that female educational investment does not translate into equivalent returns, evidencing structural discrimination, horizontal and vertical segmentation, as well as penalties associated with care roles. These differences reduce the efficiency of the labor market and affect the aggregate social return of education, limiting the potential for intergenerational mobility.

The third conclusion is that the persistence of these disparities questions the ability of the human capital model to fully reflect the Colombian reality. The divergence between social and private returns points to market failures related to informality, institutional rigidity, and low competitiveness. In this sense, public policies are required to increase profitability in strategic sectors, reduce gender inequalities, and ensure that educational expansion translates into real productivity and social well-being.

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