LUND UNIVERSITY
School of Economics and Management

Master's Programme in Economic Growth, Population, and Development

Education as a Double-Edge Sword: Examining the Dynamics between Education Expansion and Wage Inequality in Colombia

by

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Abstract: This paper provides a comprehensive analysis of the relationship between education and income inequality in Colombia. Using unconditional quantile regressions (UQR) this paper examines the wage returns of different education levels at various points of the wage distribution. Additionally, recentered influence function regressions (RIF) are used to explore the correlation between each education level and two inequality measures. The baseline finding is that, with the exception of higher education, education contributed to the reduction of income inequality. Further examination of three subcategories within the higher education level reveals that technical education produces similar outcomes to basic education, with diminishing returns and an increase in inequality. Moreover, while both undergraduate and postgraduate education result in a wage premium, it is only postgraduate education that is associated with a rise in inequality levels. These patterns are influenced by factors such as educational expansion, institutional reforms, labor market dynamics, and potential misallocation of high-skilled workers. The paper highlights the need for a comprehensive approach to education that addresses quality, accessibility, and alignment with labor market demands to effectively tackle inequality and promote a more equitable society.

Key words: *wage inequality, education expansion, Colombia*

EKHS12
Master's Thesis (15 credits ECTS)
May 2023
Supervisor: Jutta Bolt
Examiner: Viktor Malein
Word Count: 14,080

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1 Introduction

Education is often regarded as an effective tool to tackle inequality and promote a more equitable society. While Latin America remains one of the most unequal regions in the world, it has experienced a notable downward trend in inequality levels in recent decades (Rosa, Flores & Morgan, 2020). Income inequality is influenced by a range of factors, including economic growth, institutional settings, industrialization processes, trade reforms, international market integration, and access to technologies among others (Alvaredo & Gasparini, 2015). Determining the precise contribution of each factor to this development is challenging. However, evidence suggests that education and its expansion in the region have played a substantial role in driving this positive trend (Lustig, Lopez-Calva & Ortiz-Juarez, 2013).

The expansion of the education system in Colombia has had a profound impact on the country's inequality trends, reflecting similar patterns observed globally and regionally (Aristizábal-Ramírez, Canavire-Bacarreza & Jetter, 2015). Although efforts to improve educational coverage at the basic levels began in the 1970s, significant advancements in expanding higher education attainment occurred until the late 1990s and early 2000s (OECD, 2016). The impact of various educational levels and the growing number of workers with diverse educational backgrounds on the labor market is multifaceted. Individuals with different education levels possess distinct skill sets and are equipped to meet varying demands within the labor market. This diversity in educational attainment results in differential contributions and responses to the needs of the labor market (Hanushek et al., 2017)

In this way, to have a comprehensive understanding of how education shapes inequality levels, it’s necessary to make an assessment that recognizes that there are different underlying dynamics between each educational level and income inequality. Therefore, this paper aims to conduct an analysis that acknowledges these differences and provides a detailed assessment of how different education levels affect income inequality in the Colombian context. By examining the recent expansion of educational opportunities across all levels, this paper will provide valuable insights into the evolving dynamics of the labour market and their implications for income distribution in the country.

This analysis uses cross-sectional survey data from the Colombian National Household Survey produced by the National Administrative Department of Statistics, covering the 2009-2010 and the 2018-2019 period for Colombia’s 13 main cities and their metropolitan areas. To address the research question, this paper employs unconditional quantile regressions (UQR) to estimate the wage returns associated with various education levels at different points of the wage distribution. Through this approach, we can examine how education impacts earnings across different income levels. Furthermore, we explore the correlation between each education level

and two inequality measures using a recentered influence function (RIF) regression. A well-suited method that is designed to capture how a marginal change in the prevalence of a covariate impacts some distribution statistic of interest, which is in this case, income inequality measures.

The findings of this paper reveal important insights regarding the relationship between education and inequality levels. The analysis demonstrates that basic education (i.e., primary, secondary, and high school education) exhibits diminishing wage returns and correlates with a reduction in inequality levels. In contrast, higher education is associated with a wage premium and contributes to an increase in inequality levels. Further examination of three subcategories within the higher education level reveals that technical education produces similar outcomes to basic education, with diminishing returns and a concurrent increase in inequality. Moreover, while both undergraduate and postgraduate education result in a wage premium, it is only postgraduate education that is associated with a rise in inequality levels. These findings remain relatively stable across the analyzed time periods, highlighting the consistent relationship between education, wage returns, and inequality levels.

The descriptive analysis presented by this paper doesn't allow to establish causality between the variables analyzed. However, the correlations found and the argued underlying mechanisms are supported by existing theories and previous research. The expansion of education in Colombia has resulted in a change in the labor market's supply of low and high-skilled workers, impacting wage returns and inequality levels. Regarding the three categories of higher education, the quality and legitimacy of technical education have suffered due to limited government monitoring, potentially decreasing its overall quality. Institutional reforms have contributed to more equitable access to undergraduate education, reducing associated inequalities. Finally, the increasing wage premium of postgraduate education may be influenced by the low supply and high demand for skilled workers in the labor market, contributing to growing inequality at the highest educational level attainable in Colombia.

This paper is organized as follows. The second section presents the theory and previous research. The third section provides a description of the data and the inequality measures used. The fourth section is devoted to a detailed explanation of the methodology conducted. The fifth section presents the results obtained for all the education levels and for three subcategories within higher education and a discussion of the results obtained. Finally, the sixth section concludes the paper.

2 Theory and previous research

2.1 Theoretical background

2.1.1 Drivers of inequality

As pointed out before, the primary aim of this paper is to explore the intricate relationship between education and income inequality. However, recognizing the multifaceted nature of inequality and its diverse factors across domains is vital for understanding this relationship. To gain insight into these factors and the underlying mechanisms driving inequality, a theoretical framework serves as an indispensable tool. It provides a lens through which we can analyze and interpret the dynamics within this relationship. Within the extensive body of theoretical literature, various factors that drive inequality have been identified. In this paper, the specific focus will be on the following key factors: (i) economic growth, (ii) demographic trends, (iii) fiscal policies, (iv) labour market policies, (v) trade and commerce, and (vi) human capital.

(i) *Economic growth*. The 'Kuznets curve' is widely recognized as one of the leading theories that seek to explain the determinants of the overall level of income inequality over time. According to the theory developed by Kuznets (1955), income inequality initially rises during the early stages of economic development and subsequently declines as the development process unfolds. This dynamic is attributed to the movement of labour from less developed sectors, such as agriculture, to more advanced sectors that generate higher per capita incomes, such as industry-based and service-based sectors. In the initial phase, individuals who remain in the less developed sectors experience lower incomes, while those who transition to more advanced sectors have higher incomes, leading to increased inequality. Nevertheless, as the economy continues to develop and labor continues to shift away from agriculture, those who remain in the agricultural sector benefit from a reduced labor supply, resulting in higher incomes. Consequently, income inequality gradually decreases during later stages of development.

The hypothesis developed by Kuznets's seminal article made a major contribution to the empirical foundations of inequality and has inspired a bulk of subsequent scholarly articles that attempt to estimate the correlation between economic growth and inequality in various contexts and time periods. While the Kuznets curve provides a valuable framework for analyzing the relationship between economic growth and inequality in countries that have undergone an industrialization process, it overlooks the complex reality of pre-industrial societies, suggesting that income inequality was low and stable during that time (Alfani, 2021). Through an examination of historical evidence, scholars such as Van Zanden (1995), Milanovic, Lindert &

Williamson (2011), and Alfani (2021) have sought to uncover the roots of modern inequality and have found contrasting results that question the notion of pre-industrial societies exhibiting low and stable income inequality.

Van Zanden's (1995) pioneering research explores the roots of modern inequality in earlier historical periods and postulates the existence of a 'super Kuznets curve'. By examining long-term trends and shifts in inequality levels in Western Europe, Van Zanden identifies a phase of increasing inequality levels spanning from the 16th century to the 19th century, followed by a descending phase in the 20th century. Along the same lines, other papers have also found the existence of Kuznets waves in other pre-industrial societies such as the Netherlands (Soltow & Zanden, 1998), Spain (Álvarez-Nogal & De La Escosura, 2013), and Italy (Alfani, 2015).

Although the lack of data has limited the scope of historical research on inequality, this wave of studies examining preindustrial inequality raises questions regarding the underlying factors driving changes in inequality. According to Alfani (2021), this wave of literature and its findings not only fills a gap in existing research but also presents a challenge to the Kuznetsian paradigm that associates economic growth as the primary driver of inequality. The evidence from pre-industrial eras consistently reveals that inequality often intensified during periods characterized by economic stagnation or decline. These finding strongly suggests the need to consider alternative factors to comprehensively understand inequality.

In their research, Milanovic, Lindert & Williamson (2011) explore the dynamics of inequality in European countries from a political and social perspective, shifting the focus away from purely economic aspects. The authors introduce two important concepts: the "Inequality Possibility Frontier (IFP)" and the "Inequality extraction ratio". The IFP represents the maximum achievable level that a society can sustain in the long run. On the other hand, the inequality extraction ratio indicates how much potential inequality was converted into actual inequality, shedding light on the power dynamics, repressive practices, and extractive policies employed by ruling groups and institutions. Their findings indicate that while income inequality in pre-industrial and modern societies does not differ significantly, there are notable differences in the inequality extraction ratio. This not only suggests that countries acquired their 20th century inequalities before the Industrial Revolution, but it also highlights the enduring impact of ruling groups and institutional structures on shaping inequality patterns, both in the past and in contemporary society.

(ii) *Demographic trends*. Demographic forces emerge as a significant factor driving inequality during pre-industrial societies. As a general trend, catastrophic events like plagues, epidemics, conquests, and wars have consistently been associated with decreasing inequality. These events had far-reaching effects on both income and wealth dynamics. On the one hand, population declines resulting from these catastrophic events create a scarcity of labour, leading to increased real wages and a decline in labor income inequality. On the other hand, the destruction of human and physical capital during these catastrophic events disrupts the concentration of wealth and undermines the economic power of individuals or groups. This disruption leads to a more

fragmented and decentralized distribution of wealth, which in turn contributes to a decrease in income inequality (Alfani, 2021; Alfani & Murphy, 2017)

Understanding the factors that influenced inequality levels in preindustrial times may be deemed irrelevant in the context of contemporary inequality dynamics. Nevertheless, examining long-term trends in inequality is crucial as it highlights the oversimplification of attributing inequality solely to one factor. By analyzing the dynamics of inequality over the long term, it's possible to identify that inequality exhibits a cyclical pattern throughout time that can be described as a sequence of Kuznets waves. These waves consist of alternating phases characterized by falling inequality, primarily influenced by factors such as epidemics, conquests, and wars. Conversely, there are phases of rising inequality, driven predominantly by economic forces like technological innovation and structural transformation (Alfani, 2021).

As societies progress, new factors come into play, shaping the dynamic nature of inequality. While the previously discussed factors remain relevant to understanding the inequality dynamics today, it is important to acknowledge that as societies evolve, additional factors become influential in shaping inequality patterns (Piketty, 2014). An illustrative example of a factor that has undergone significant changes from pre-industrial times to the present day, yet remains a significant driver of inequality trends, are institutions. Institutions can shape the distribution of income and wealth in a society through various mechanisms, although this section will focus on two key aspects: taxation and fiscal systems and labour market policy.

(iii) *Fiscal policies*. Taxation and fiscal systems have the capacity to define to a large extent the allocation and distribution of resources within a society (Gerber et al., 2020). The redistributive impact that taxes have depends greatly on the size, progressivity, and design of the fiscal system. Progressive taxation policies, characterized by higher-income earners paying a larger proportion of their income in taxes, broad tax bases, low levels of tax evasion, and well-designed transfer systems, tend to contribute to reducing inequality. In contrast, regressive taxation policies, where lower-income earners bear a higher tax burden relative to their income, narrow tax bases, high levels of evasion, and poorly designed systems, are less effective in addressing inequality (OECD, 2013a). The relationship between fiscal policy and inequality is a subject of complexity and ongoing debate. It is influenced by a range of institutional factors that extend beyond taxation alone and recognizing this complexity is vital when examining the role of fiscal policy as a driver of inequality (International Monetary Fund, 2014).

(iii) *Labour market policies*. Labour market policies play a significant role in shaping inequality. Even though their impact may not be as immediately apparent as that of taxation and fiscal policy, they can have considerable influence on inequality trends. Various regulations and measures, including collective bargaining of wages, unemployment benefits, and employment protection legislation among others, can contribute to addressing or unintentionally exacerbating inequality levels. In this section, we will focus specifically on one key aspect that holds particular relevance for the analysis presented in this paper: the establishment of minimum wages. Minimum wage laws reduce wage dispersion in the labor market by narrowing the wage distribution. However, it is important to note that while this

reduction in wage dispersion may occur, it does not necessarily guarantee a corresponding reduction in overall inequality levels (Dreger, 2016)

Minimum wage laws can contribute to the reduction of wage inequality by setting a floor on wages, lifting the earnings of low-paid workers, and narrowing down the wage gap between low-wage and high-wage workers (Dreger, 2016). Nevertheless, it is important to note that this reduction in wage dispersion is not always associated with a reduction in overall inequality levels. In countries with high informality levels, where a big part of the working population doesn't follow the formal labour laws established by the government, the minimum wage is not binding for all workers and has the potential to rise income inequality (OECD, 2007, 2019a).

When minimum wages are set too high, there can be unintended consequences, particularly for low-skilled individuals at the bottom of the income distribution. If minimum wages exceed the productivity of low-wage workers or the prevailing wages in the labor market, employers may respond by reducing their workforce. This reduction in employment opportunities can disproportionately affect low-income earners and contribute to an increase in inequality levels (Manning, 2021). Therefore, the impact of minimum wage laws on the labor market and inequality levels depends on various factors, including the specific level at which the minimum wage is set, regional economic conditions, and the overall dynamics of the labor market. It is crucial to carefully consider these factors to ensure that minimum wage policies effectively address inequality while minimizing potential adverse effects (Cengiz et al., 2019; Neumark & Wascher, 2006)

(iii) *Trade and commerce.* When countries engage in international trade, it opens up new avenues for commerce and expands market opportunities. This shift from a domestic-focused labor market to a more globalized one means that labor market outcomes are no longer solely determined by domestic factors. Instead, they are influenced by the conditions and dynamics of other countries as well, creating a more interconnected and complex relationship between trade and inequality (Pavcnik, 2017). Taking this into account, we can summarize and understand the relationship between trade and inequality considering two different points of view: one of developed countries and one of developing countries.

On one side, in developed countries trade openness can increase wage inequality between skilled and unskilled workers, as unskilled workers face competition from low-wage workers in developing countries. On the other side, in developing countries wage inequality can increase, as skilled workers benefit from increased demand for their skills while unskilled workers may not (Harrison, McLaren & McMillan, 2010). Nevertheless, it is important to consider that trade can also contribute to decreasing income inequality. In both developed and developing countries, if the conditions allow for it, trade can be considered as a growth-enhancing factor that provides access to new markets, which can lead firms to expand this, at the same time, could create more job opportunities and increase wages for workers in export-oriented industries (UNCTAD, 2019). To summarize, globalization has effects on the distribution of real incomes, however, the way in which these two things are connected is very sensitive to context-specific factors, such as policies and labour market frictions, the degree of

openness of the country, the level of protection that each domestic markets have on different industries.

All of the factors described in this section are complex factors difficult to analyze since their effects on inequality is conditional on a large number of factors. The rise of income inequality that many countries have observed over the past decades has led to an increase in the bulk of literature that identifies the factors that shape the distribution of labour income (Kierzenkowski & Koske, 2013). This sub section aimed at collecting information on the most important factors that drive inequality up and down and tried to explain the way in which each of them affected inequality. The next section will focus on the aspect that is more relevant for this paper: education and how the formation of human capital can contribute to increasing and decreasing income inequality.

2.1.2 Human capital and inequality

We now turn to the theoretical analysis of the relationship between the distribution of education and income inequality. A starting point for this complex relationship is the standard version of the Human Capital Theory proposed by Becker (1964). According to this theory, investments in education and training can enhancing an individual's skills and abilities, thereby increasing their productivity and potential for higher earnings. Within this theoretical framework, individuals are driven to pursue education with the expectation of enhance their competences and value in the labor market in order to have higher wages and greater economic outcomes and monetary rewards in the future. Even though the theory has considerable limitations to capture the nuanced complexities of the real world, this theoretical approach provides valuable insights into the potential impact of education on income inequality. Becker's theory highlights the association between disparities in education and training and the unequal distribution of earnings, shedding light on the significant role education plays in shaping income inequality (Becker, 1964).

Becker's highly influential theoretical concept was further developed by Mincer (1974), who introduced a statistical model that served as empirical evidence supporting Becker's theory by quantifying the returns on investment in education and work experience, both integral components of human capital. This model, along with Becker's contributions, highlights the critical role of education as a key determinant of an individual's productivity and earning potential. It also recognizes the cumulative nature of work experience, where individuals progressively acquire additional skills and knowledge over time, resulting in increased earnings. Regarding inequality, the model suggests that disparities in the distribution of labor income can be partially explained by variations in individuals' investments in human capital. However, the author also recognizes the influence of other factors, such as ability differences, motivation, and changes in the demand for skilled and unskilled labor, in driving these earnings disparities (Mincer, 1975).

The human capital theory conceptualizes the positive association between education and earnings. Nonetheless, it is important to acknowledge that this theory offers a simplified linear pathway that overlooks the intricate dynamics between diverse education backgrounds, work, and earnings (Marginson, 2019). Other theories have sought to provide a more comprehensive understanding of the relationship between education and earnings, including the Signaling Theory proposed by Spence (1973). In this theory, education functions as a signal to employers, indicating the quality and productivity of individuals that may not be easily observable. According to this theory, by obtaining a degree or certification, individuals seek to stand out and demonstrate capabilities to potential employers, which can lead to improved job prospects and higher wages. This signaling model builds upon the concepts of human capital theory and suggests that education serves as a measure of ability, rather than solely increasing productivity (Weiss, 1995).

Even though the signalization model developed by Spence (1973) does not explicitly address how inequality fits into its framework, it sheds light on a mechanism through which education can contribute to the exacerbation of existing inequality levels. When certain groups have better access to the signals valued in the labor market, education, and the signals it conveys can amplify preexisting inequalities. For instance, if employers highly value degrees from prestigious universities, individuals from privileged backgrounds who can afford to attend such institutions may have an advantage over those from less privileged backgrounds who lack similar opportunities. Consequently, this perpetuates a cycle where the already affluent individuals continue to accumulate wealth while the underprivileged face further challenges. In this scenario, the already advantaged individuals possess better means to effectively signal their quality, leading to enhanced employment prospects and higher income levels (Koutmeridis, 2018; Rehme, 2007; Wells, 2006).

When conceptualizing the relationship between education and income inequality, it's also relevant to consider technology as a relevant factor that changes the trends exhibited by income inequality. One theory in particular elucidates another way in which education can affect inequality and this is the so-called skill-biased technological change (SBTC). This concept describes how a technological change can favor skilled labour over unskilled labour by increasing its relative productivity and, consequently, its relative demand (Acemoglu, 2002; Autor, Katz & Krueger, 1998; Berman, Bound & Machin, 1998; David Card, 2001). According to this theory that emphasizes the impact of technological advances on income inequality, technological progress tends to disproportionally favor individuals with higher levels of education and skills, widening the income gap between skilled and unskilled workers, and creating a skill premium for skilled workers (Alvaredo & Gasparini, 2015).

Skill-biased technological change not only plays a significant role in shaping labour market dynamics, but it could also contribute to understanding the role of education on income inequality. The increasing demand for highly skilled workers resulting from this change contributes to widening wage disparities between skilled and unskilled workers, leading to greater inequality (Pi & Zhang, 2018). However, it is important to note that the potential effect that the introduction of new technology can have on inequality also depends to a large extent

on the interaction between the demand for skills in the labour market and the supply of skills provided by the education system. If the increase in the relative demand for skilled workers in the market is counterbalanced by an increase in the supply of skilled labour (i.e., more educated individuals), the influence of technology favoring skilled workers will be less pronounced and the effect of skill improvement will be diminished (Kierzenkowski & Koske, 2013). Additionally, it's important to consider that the type of technology that is being introduced, the institutional environment, and potential changes in the distribution of skills can also determine to a great extent the way in which these technologies affect income inequality and the labour market outcomes (Acemoglu, 2002).

2.2 Previous research

Having previously assesses the theoretical frameworks that link education with wage inequality, we turn to the impacts of education on income inequality. The empirical evidence that has sought to Identify a causal effect of education on inequality has found mixed effects. From a general perspective, Rehme (2007) explores the relationship between education, economic growth, and income inequality through a combination of theoretical discussions and empirical evidence based on data of inequality measures, namely the Gini coefficient, for mainly developed countries that allows to do cross-country and within-country analysis. The finding suggests that education is generally associated with a decrease in inequality, however, the magnitude of the effect depends on the type and quality of education and the domestic labour market conditions.

In a study conducted by Checchi (2001), the relationship between education and income inequality is examined through the construction of a Gini index on educational attainments in different regions of the world. The author uses multivariate regressions and concludes that the average years of education have a significant negative impact on measured income inequality. These findings indicate that the global "education cycle" following World War II had clear consequences in the world's inequality trends. This study highlights that an increase in the average years of education is associated with a decrease in inequality, given two conditions: a low initial level of educational attainment and a rapid increase in average educational attainment.

An analysis by Ferreira & Gignoux (2011) explores the relationship between education and income inequality, specifically focusing on the impact of standardized test scores on inequality measures. The study utilizes data from the Program for International Student Assessment (PISA) and constructs two measures of educational inequality: educational achievement and educational opportunity. The former captures actual educational outcomes, while the latter measures access to education and available resources. The findings indicate that inequality of opportunity contributes to approximately 35% of income inequality, with greater implications in continental Europe and Latin America compared to Asia, Scandinavia, and North America. The paper highlights the lack of consensus on how to measure these concepts (i.e., inequality

in educational outcomes and inequality of opportunity) and emphasizes the importance of accurate measurement in understanding educational inequality.

From a different approach, Abdullah, Doucouliagos & Manning (2015) conduct a meta-regression analysis to examine the impact of education on income inequality in developed and developing countries across Latin America, Asia, and Africa. This study reveals a consistent pattern: education is linked to a decrease in the income share of high-income workers and an increase in the share of low-income workers. By examining different education levels and their impact on income distribution across various wage points and regions, this comprehensive analysis reveals that education has significantly contributed to reducing inequality, particularly in Africa. Notably, secondary education exhibits a stronger effect on income inequality compared to primary education.

A study carried out by Martins & Pereira (2004) examines the relationship between education and wage inequality by estimating the returns to education. Analyzing data from 16 countries and employing quantile regression, the authors find that education plays a larger role in reducing wage inequality among lower-paid workers, but its impact diminishes as one moves towards higher wage levels. This suggests that while education initially helps to decrease wage disparities, the variation in wages within the same educational group tends to increase among higher-paid individuals. The authors propose three possible explanations for this phenomenon: over-education, the interaction between schooling and individual ability, and differences in school quality or fields of study.

First, it is suggested that individuals with higher schooling attainment may choose to take jobs that have low skill requirements and consequently offer lower pay. This would lead to lower earnings for over-educated workers and extends the lower tails of the wage distribution among highly educated individuals, thereby increasing the within-skill dispersion of wages. The second alternative proposes that the most capable are more likely to benefit more from the education level acquired. This results in substantial pay gaps between workers with high and low abilities within higher education levels, further contributing to within-group wage inequality. The third and final explanation centers around differences in school quality or fields of study. In this case, workers at the bottom of the wage distribution may have attended schools with lower quality education or pursued fields of study that are less in demand in the labor market. These disparities in schooling quality and field of study tend to be more prevalent at higher schooling levels, where there is greater variety in educational paths and educational quality.

It is crucial to emphasize that Latin America, including Colombia as the focus of this paper, has a longstanding history of high levels of inequality. The patterns of income distribution and the factors contributing to inequality in this region may significantly differ from those observed in other parts of the world and developed countries (Sánchez-Ancochea, 2021). Therefore, it is important to analyze the role of education in inequality within this specific context. In a comprehensive study examining inequality trends in Latin America, Lustig, Lopez-Calva & Ortiz-Juarez (2012) conducted an in-depth analysis of Argentina, Brazil, and Mexico. The

findings of their research indicate that these countries experienced a notable decline in inequality during the period between 2000 and 2010, driven by two key factors: a decrease in the skill premium and the implementation of progressive government transfers.

The authors highlight that the decline in the skill premium can be attributed to two factors: an increase in the relative supply of skilled labour and a decrease in the relative demand for skilled labour. They argue that the expansion of basic education coverage in the region has led to an increase in skilled labour and a more equitable distribution of human capital, which has contributed to a decrease in the relative supply of unskilled labour. On the other hand, changes in labor demand may have also favored unskilled workers, although the exact mechanism behind this remains unclear. It is suggested that positive terms of trade could have contributed to this development. In Argentina, the decline in the skill premium is primarily driven by a decrease in the relative demand for skilled labor, whereas in Mexico, the change is attributed to an increase in the relative supply of skilled labor. In Brazil, both factors seem to have played a significant role in explaining the decline in the skill premium (Lustig, Lopez-Calva & Ortiz-Juarez, 2012).

Another study conducted by the same authors Lustig, Lopez-Calva & Ortiz-Juarez (2013) delves into the role of education in 16 Latin American countries and its impact on inequality. Through a comprehensive analysis, the study explores how improvements in educational attainment and access have contributed to addressing inequality in the region. The findings indicate that the decline in hourly labor income inequality was driven by changes in the skill premium, specifically the returns to primary, secondary, and higher education. The authors emphasize the influence of a more equitable distribution of human capital on the relative supply and demand of skilled labor. However, they also acknowledge that the decline in inequality varied across countries, and other factors, including economic, social, and political aspects, such as changes in macroeconomic policies, social programs, democratic governance, and labor market policies (i.e., minimum wage policies, collective bargaining agreements), played significant roles in reducing inequality in the region.

Examining the specific case of Colombia, Aristizábal-Ramírez, Canavire-Bacarreza, and Jetter (2015) conducted an empirical study focused on individual-level determinants of wage inequality in Bolivia, Colombia, and Ecuador using annual survey data spanning from 2001 to 2010. By employing wage regressions and adjusted Gini indices, the authors find that Colombia experienced a noteworthy transformation in terms of inequality. From being the most equal country among the three economies in the early 2000s, Colombia transitioned to becoming the most unequal country by 2010. However, when the analysis included educational attainment as a factor influencing inequality, the results were completely reversed, and Colombia emerged as the most equal country in the sample. These findings evidence the differential role of education in shaping income inequality across Colombia, Bolivia, and Ecuador. Notably, education plays a considerably larger role in Colombia's income inequality dynamics compared to the other two countries. The study estimated that approximately 10.8 percent of Colombia's Gini coefficient can be attributed to education, whereas the corresponding figure for Ecuador was 6.2 percent.

These results highlight the significant impact of education on income distribution in Colombia and underscore the value placed on education within the Colombian labor market.

A study conducted by Joumard & Vélez (2013) delves into the role of the labor market in shaping inequality trends in Colombia. The authors emphasize the significance of factors such as high unemployment rates and informal employment in contributing to Colombia's position as one of the most unequal countries in the region. Furthermore, the study highlights the substantial impact of the education premium on the wide wage dispersion observed in the country. While Colombia has made progress in expanding access to education, the authors note persistent disparities in educational quality between private and public institutions, as well as ongoing financial barriers that perpetuate income inequality. Consequently, a significant wage premium is enjoyed by individuals with higher education, but limited access to higher education restricts the supply of highly skilled labor. This scarcity of higher-educated workers contributes to the pronounced wage differentials across various educational levels, further exacerbating inequality levels in the country.

3 Data

3.1 Sample construction and descriptive statistics

This analysis is based on cross-sectional survey data from the Colombian National Household Survey (GEIH, for its acronym in Spanish) which is produced by the National Administrative Department of Statistics (DANE, for its acronym in Spanish). This survey, used as an official source of labour market statistics in Colombia, is collected on a monthly basis and provides information on sociodemographic characteristics of the population, labour market indicators, and employment conditions for urban and rural areas at a national level. This analysis pools the data available for the 2009-2010 and the 2018-2019 period and focuses on Colombia's 13 main cities and their metropolitan areas. In this case, the sample is limited to a subset of the population consisting of salaried workers between the ages of 15 and 60, who reported working a minimum of 16 hours per week. In order to specifically examine wage income inequalities and isolate them from other income sources such as wealth, capital, and physical investments, the sample excludes self-employed workers who typically have diversified income streams.

The number of observations in the dataset was 122,144 for the 2009-10 period and 135,204 for the 2018-19 period. These observations correspond to an expanded database of 7,512,367 and 9,478,487 individuals for the 2009-10 and 2018-19 periods, respectively, resulting in a national-level sample of approximately 16,990,854 individuals. Table 1 presents the descriptive statistics of the variables used in the regression analysis that assesses the influence of education on wage inequality in Colombia. These summary statistics encompass various worker characteristics (i.e., education level, years of education, work experience, gender, and marital status) and work characteristics (i.e., type of contract, firm size, sector, and occupation) that play a significant role in determining individuals' wage returns.

The estimates reported in Table 1 suggest that, in Colombia's 13 largest cities and their metropolitan areas, salaried workers earned an hourly wage of COP $5,231 (1.01 euros) in the 2009-10 period and around COP $5,794 (1.12 euros) in the period 2018-19. The data reveals that the average number of years of education rose from 10.8 in 2009-10 to 11.7 in 2018-19. In terms of educational level, there was a slight increase of approximately 1.9% in the percentage of workers in the sample who completed high school education. However, the most notable change was observed in the percentage of workers with higher education, which rose from 35.1% to 43.8% between 2009-10 and 2018-19 (see Figure 1).

Additionally, the data shows that a significant percentage of the workforce was employed in relatively large firms with permanent or indefinite contracts, a pattern that persisted throughout

both periods. The manufacturing, commerce, and transport sectors employed the largest proportion of workers, with approximately 54% in 2009-10 and around 48% in 2018-19. The most common job roles included assemblers and machine operators, administrative staff, and commerce and sales workers. Overall, the size and sectoral distribution of firms and the occupations of the workers in Colombia's 13 largest cities and their metropolitan areas didn't experience considerable changes between 2009-10 and 2018-19 period.

Table 1. *Descriptive Statistics*

Variables	2009 - 2010		2018 - 2019	
	Mean	S.D	Mean	S.D
Adjusted hourly wages (pesos)	5,231.08	7,025.44	5,794.13	6,564.90
Education				
Primary education	0.13	0.34	0.08	0.27
Secondary education	0.14	0.35	0.09	0.29
High school education	0.37	0.48	0.39	0.49
Higher education	0.35	0.48	0.44	0.50
Worker's characteristics				
Schooling (years)	10.8	3.9	11.7	3.5
Experience (years)	18.0	11.6	18.3	11.8
Female	0.42	0.49	0.44	0.50
Not married	0.48	0.50	0.49	0.50
Work characteristics				
Permanent contract	0.68	0.47	0.68	0.47
Firm size				
Micro	0.34	0.47	0.30	0.46
Small	0.20	0.40	0.19	0.39
Medium	0.06	0.24	0.06	0.23
Large	0.40	0.49	0.45	0.50
Sector				
Manufacturing industries	0.23	0.42	0.18	0.38
Commerce	0.23	0.42	0.22	0.41
Transport and communications	0.09	0.29	0.08	0.27
Construction	0.08	0.26	0.09	0.28
Real estate and business activities	0.08	0.28	0.11	0.31
Hotels and restaurants	0.07	0.26	0.08	0.28
Education	0.05	0.21	0.05	0.21
Financial intermediation	0.03	0.18	0.03	0.18
Occupation				
Assemblers and machine operators	0.32	0.47	0.28	0.45
Administrative staff	0.20	0.40	0.19	0.39
Service workers	0.18	0.38	0.20	0.40
Commerce and sales workers	0.17	0.37	0.15	0.36
Managers and professionals	0.07	0.25	0.10	0.30

Technicians and professionals	0.04	0.20	0.05	0.21
Observations	122,144		135,204	

Note: All figures are in percentages, excepting those indicated in parenthesis. The 'No contract' variable is excluded from the table since accounts for less than 0.003 of the sample in both periods. The firm size is determined by the number of workers: micro (less than 10 employees), small (between 10 and 50), medium (between 50 and 100), and large (more than 100). The sectors: 'Agriculture, livestock farming, forestry and fishing', 'Mining and quarrying', 'Electricity, gas and water supply', 'Other community, social and personal service activities', 'Private households with domestic services', 'Extraterritorial organisations and agencies', and 'Public administration and defence' are excluded from the table since they all together only account for less than 0.08 of the sample in both periods. The occupations: 'Agriculture, forestry, and fishery workers' and 'Senior public administrative staff' are excluded from the table since they all together only account for less than 0.04 of the sample in both periods. Sources: Compiled by author based on GEIH, DANE.

In Colombia, the education system consists of pre-school education, basic education (five years of primary school and four years of secondary school), high school education (two years), and higher education. This final stage of education is commonly referred to as "higher education" and encompasses all formal post-secondary education offered by public and private universities, colleges, technical training institutes, and vocational schools (Ministerio de Educación Nacional, 2022).

The micro-level data provided by the GEIH allows us to disaggregate the higher education level into three subcategories: technical education, undergraduate education, and postgraduate education. Figure 2 illustrates the changes in the number of workers across these three subcategories from 2009 to 2019. Over this period, while the number of workers with undergraduate and postgraduate education exhibited a steady and moderate increase, the number of workers with technical education experienced greater variations and the most significant growth. Particularly noteworthy is the period between 2009 and 2014, during which there was an average increase of 12.5% in the number of workers with technical education.

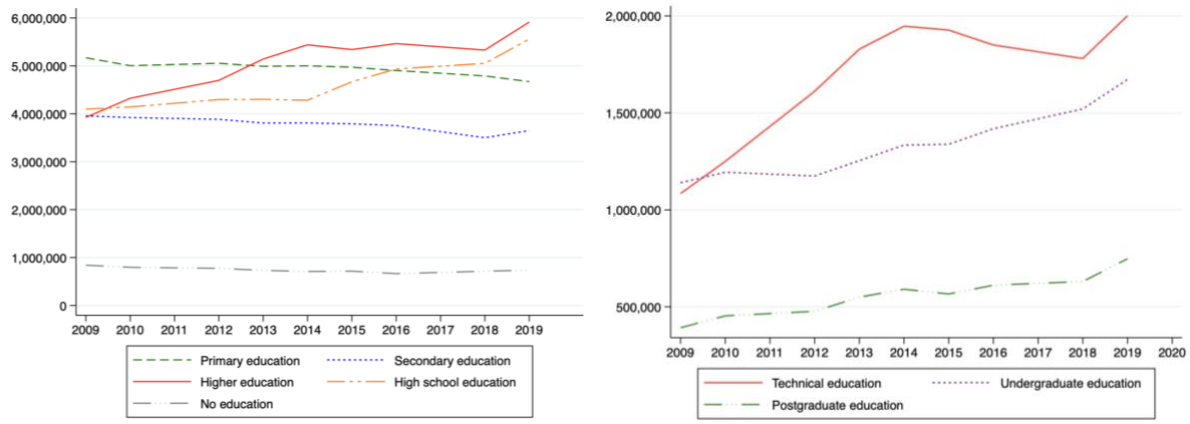

Figure 1. *To the left the number of workers per education level (2009 – 2019). To the right the number of workers with higher education level disaggregated by subcategories (2009 – 2019). Sources: Compiled by author based on GEIH, DANE.*

3.2 Inequality measures: construction and limitations

To measure the effects of education expansion on Colombia's wage inequality, two inequality measures are used: the variance of logarithmic hourly wages and the Gini coefficient. On the one hand, the log hourly wages capture the degree of wage dispersion across the sample. Although this commonly used indicator has some limitations, it provides a comprehensive measurement of wage inequality that is less sensitive to extreme values and outliers in the data and allows to control for basic demographics at the individual level (OECD, 2021). The variance of log hourly wages is a summary measure of inequality that is calculated from adjusted hourly wages. These adjusted wages have been deflated using the Consumer Price Index (CPI), which data series compiled by the Technical and Economic Information Department of the Central Bank of Colombia. In this case, deflating data allows for the comparison of wage levels and trends over time while avoiding the attribution of changes in wages to inflationary effects.

On the other hand, this paper also uses the Gini coefficient, one of the most widely used measures in the empirical literature to measure inequality. This distributional statistic that goes from 0 to 1, where higher values indicate greater inequality, also captures the distribution of wages across a population; however, its use presents some key advantages over the variance of log hourly wages. One of the facts that make the Gini coefficient a more accurate representation of the income distribution is the fact that this variable it's more sensitive to changes around the middle of the distribution and less to the changes at the extreme ends of the wage distribution (Nolan, Richiardi & Valenzuela, 2019).

While both the variance of log hourly wages and the Gini coefficient are useful measures of wage inequality, there are some limitations to their use. The variance of log hourly wages provides a comprehensive overview of the distribution of wages across the entire sample, but it places too much weight on extreme values at the tails of the distribution and can fail to capture relevant components of the wage dispersion (Gottschalk et al., 1994). To address these limitations, the Gini coefficient is used as a complementary measure. This scalar measure estimates the degree of concentration of wages at the top relative to the bottom of the distribution and allows for easy comparisons across different time periods (Bowles & Carlin, 2020). By using the Gini coefficient, we can gain a more nuanced and complete understanding of wage inequality that goes beyond the broad description of the wage distribution provided by the variance of log hourly wages measure alone.

There is no single indicator that can convey a full picture of wage inequality. Even if a more accurate method of measuring wage inequality was available with the current data, certain factors that are significantly relevant to determine wages cannot be captured through household survey-based indicators. Unobserved heterogeneous factors, including ability, quality of education, and motivation, are closely linked to the level of income that an individual can earn, however, this variables are incredibly difficult to quantify with numerical data (Chen, 2008; Mouw & Kalleberg, 2010). Thus, it can be argued that despite the shortcomings and limitations

of the variables employed to estimate wage inequality, they are sufficient in providing an understanding of the interplay between education and wage inequality in Colombia.

4 Methodology

4.1 Ordinary Least Square estimates (OLS) and Unconditional Quantile Regression (UQR)

To assess the impact of education on wage inequality, a Recentered Influence Function (RIF) will be used. The methodology developed by Firpo, Fortin & Lamieux (2009) accurately quantifies the impact of various explanatory variables on distributional statistics of interest. The RIF regression employs Unconditional Quantile Regressions (UQR) to estimate the partial effects of explanatory variables across different quantiles of the unconditional distribution of the dependent variables. In this analysis, the explanatory variable of interest is education, and the dependent variables are the two distributional variables introduced above: the variance of log hourly wages and the Gini coefficient. To gradually delve into the details of this empirical strategy, we will start by considering a simple model in which the wage of an individual *i* is given by the following expression:

$$W_i = \beta X_i + \varepsilon_i \quad (1)$$

Where W_i denotes the logarithmic form of adjusted hourly wages of an individual i, X_i corresponds to a set of covariates that include individual and work characteristics that affect wage income such as education, years of schooling, years of experience, gender, marital status, type of labour contract (i.e., temporary or permanent contract), sector of industry (i.e., mining, electricity, gas and water, construction, sales, hotels, and restaurants, transportation, financial intermediation, and social services among others), and firm size (i.e., micro, small, medium, or large). Finally, ε_i corresponds to the error term which includes unobserved variables or characteristics that could affect the outcome variable and that are not explicitly included in the regression. To enhance the clarity of the relationship under examination, Equation (1) can be re written:

$$W_i = \beta_p primary_i + \beta_s secondary_i + \beta_{hs} highschool_i + \beta_h higher_i + \beta_i X_i + \varepsilon_i \quad (2)$$

In this context, the variables *primary*, *secondary*, *high school*, and *higher* are binary indicators that take the value of 1 if the individual i is a worker who has completed the corresponding level of education, and 0 otherwise. Equation (2) can be estimated using ordinary least squares (OLS) regressions, in which the coefficients β_p, β_s, β_{hs}, and β_h associated with the educational dummies capture the effect of education on log hourly wages. While this model provides a preliminary insight into the correlation between these two variables, it only captures the effect of education on the mean of log hourly wages and fails to consider potential variations across different quantiles of the wage distribution. To overcome this limitation and examine the effect

of education at different points of the wage distribution, it is necessary to estimate a quantile regression model given by:

$$Q_\tau(W_i \,/\, X_i) = \beta_{\tau,i} X_i + \varepsilon_{\tau,i} \quad \text{with } \tau \in (0,1) \tag{3}$$

This model, also known as a conditional quantile regression (CQR), estimates the relationship between the dependent variable of log hourly wages (W_i) and the set of controls previously described (X_i) within a specific quantile of the distribution (τ). Unlike traditional mean regression models such as the OLS, this approach allows for the identification of heterogeneous effects across quantiles, providing a more nuanced understanding of the correlation between variables. The CQR model is robust to response outliers and efficient in estimating parameters when the error term doesn't follow a normal distribution. Furthermore, the CQR model can be estimated even when the dependent variable presents an asymmetrical distribution, as is often the case with wage distributions (Koenker, 2005; Koenker & Bassett, 1978).

All things considered, the CQR model offers a richer characterization of the data and brings several advantages over the traditional OLS model. Nevertheless, it is crucial to acknowledge a key aspect of the model that could potentially impact the analysis conducted in this paper: the dependent variable (W_i) is conditioned to a specific set of covariates (X_i). This implies that the model estimates the relationship between the dependent and explanatory variables at different quantiles but given a set of covariates (Buchinsky, 1998). When applying the CQR model for our analysis, a *conditional* distribution of wages would be generated for each set of covariates (i.e., years of experience). As a consequence, our ability to have a broader understanding of the entire population's wage distribution, regardless of specific covariates, becomes limited (Angrist, 2008).

To understand the restrictions this entails for our analysis, let's assume that primary education has a positive effect on log hourly wages. If we find that this effect, as estimated using CQR, is smaller at the 90th quantile compared to the 10th quantile, it suggests that primary education contributes to the reduction of wage disparities *within* specific groups of workers who share similar characteristics besides the educational level. However, this finding doesn't imply that increasing the rate of primary education enrollment would necessarily reduce overall wage disparities measured by the difference between the 90th and the 10th quantiles of the unconditional wage distribution. To answer this question and comprehensively evaluate the effect of primary education on income inequality across different points of the wage distribution, irrespective of specific covariate values, it is necessary to turn to *unconditional* distribution of wages given by:

$$Q_\tau(W_i) = \beta_{\tau,i} X_i + \varepsilon_{\tau,i} \quad \text{with } \tau \in (0,1) \tag{4}$$

Once again, to highlight the relationship under examination, Equation (4) can be re written:

$$Q_\tau(W_i) = \beta_{\tau,p} primary_i + \beta_{\tau,s} secondary_i + \beta_{\tau,hs} highschool_i + \beta_{\tau,h} higher_i + \beta_{\tau,i} X_i + \varepsilon_{\tau,i} \quad (5)$$
$$\text{with } \tau = 0.1, 0.5, 0.9$$

4.2 Recentered Influence Function (RIF)

Several authors, including Albrecht, Björklund & Vroman (2003), Gosling, Machin & Meghir (2000), Machado & Mata (2005), and Melly (2005), have put forward various methodologies to estimate the unconditional quantile regression of distributional statistics. While these approaches are not conditioned on specific covariate values, they do not generate a marginal effect parameter. Instead, they provide an assessment of the overall effect of changes in the distribution of the explanatory variable on selected quantiles of the unconditional distribution (Firpo, Fortin & Lemieux, 2009). In simpler terms, these approaches examine how variations in a certain factor affect different sections of the overall outcome distribution, but they don't provide a direct measure of the partial effects of that factor.

The limitations of these methodologies in estimating a marginal effect parameter restricts our ability to analyze the isolated impact of education on wage inequality. To address these limitations, this study will employ a Recentered Influence Function (RIF) methodology developed by Firpo, Fortin & Lemieux (2009). This empirical approach allows us to estimate the unconditional quantile regression of distributional statistics and enables the calculation of the partial effect of each explanatory variable. By employing a RIF regression, we can gain a more comprehensive understanding of the specific influence of education on wage inequality across different points of the wage distribution, without being constrained by specific covariate values.

To understand the benefits and advantages of using this methodology it is necessary to grasp the concepts on which the methodology is built: the influence function (IF) and the recentered influence function (RIF). In the first place, the influence function serves as a statistical tool that measures the effect or "influence" of a particular observation on an estimator. By quantifying the sensitivity of estimators to data perturbations, this tool allows to analyze the robustness of distributional statistics to small disturbances in data (Cowell & Flachaire, 2007; Essama-Nssah & Lambert, 2012). The influence function of an unconditional distribution of wages is given by the expression:

$$IF[W_i; q_\tau] = \frac{(\tau - I\{ln(w_i) \leq q_\tau\})}{fw_i(q_\tau)} \quad (6)$$

Equation (7) quantifies how marginal changes in the explanatory variables of the model specified in Equation (1) influence the unconditional distribution of the dependent variable of log hourly wages of an individual i. Here, q_τ refers to the τth unconditional quantile of wages, $fw_i(q_\tau)$ is the probability density function of w_i evaluated at q_τ, and $I\{ln(w_i) \leq q_\tau\}$

corresponds to an indicator variable that denotes whether or not a value of w_i is less than q_τ. Subsequently, the recentered influence function ($RIF[W_i; q_\tau]$) specified in Equation (8) is obtained after recentering the influence function ($IF[W_i; q_\tau]$) at the value of the quantile (τ):

$$RIF[W_i; q_\tau] = q_\tau + IF[W_i; q_\tau] \tag{7}$$

The RIF regression approach outperforms other quantile regression methods in terms of predictive accuracy and goodness-of-fit measures, as highlighted by Firpo, Fortin and Lemieux (2009). It provides a comprehensive assessment of the impact of a specific variable, such as education, on income inequality across various points of the wage distribution. By estimating unconditional quantile regressions, the RIF approach goes beyond estimating wage disparities within specific groups of workers with similar characteristics and enables the analysis of wage disparities across the entire population's wage distribution. Furthermore, this methodology relies on the influence function (IF) and the recentered influence function (RIF). These statistical concepts not only facilitate the analysis of robustness of a distributional statistic to data disturbances but also handles with efficiency variables with considerable heaping or concentration of values, which is often the case of wage distributions (Firpo, Fortin & Lemieux, 2018, 2009; Fortin, Lemieux & Firpo, 2011).

So far, the empirical strategy has been described considering a model that uses the log of hourly wages as the dependent variable (see Equation 1). Although this measure effectively captures wage returns, it falls short in accurately estimate the inequality measures previously introduced. For this reason, it's necessary to replace the log of hourly wages with two variables used to measure wage inequality: variance of log hourly wages and the Gini coefficient. In this way, the regressions that will be estimating the effect of education on wage inequality in Colombia will be given by the following expressions:

$$RIF[var_i; q_\tau] = q_\tau + IF[W_i; q_\tau] \tag{8}$$
$$RIF[gini_i; q_\tau] = q_\tau + IF[W_i; q_\tau] \tag{9}$$

Equation (9) estimates the RIF regression for the variance of log hourly wages and equation (10) estimates the RIF regression of the Gini coefficient. The estimation of this equations involves several steps. First, it's necessary to construct the inequality measures following the methodology described in the data section. Next, specific quantiles of interest such as .10, .50, and .90, are selected, and unconditional quantile regressions are estimated for each of these quantiles. Finally, the RIF regressions are estimated using OLS. The coefficients obtained from the RIF regression provide a comprehensive and robust estimation of the effects of different covariates on income inequality measured by the variance of log hourly wages and the Gini coefficient. By analyzing these effects, it's possible to gain a deeper understanding of how education, and different education levels, influence income inequality at different quantiles of the wage distribution. The results of these estimation are presented in the following section.

5 Empirical Analysis

5.1 Results for all the education levels

5.1.1 OLS and UQR

Table 2 reports the estimates of the effect of different education levels at the mean (OLS) and at the 10^{th}, 50^{th}, and 90^{th} quantiles of the unconditional distribution of hourly wages (UQR) in Colombia's 13 main cities and their metropolitan areas. These estimations, described by equation (5) in the methodology section, are controlled by individual and work characteristics such as education, years of schooling, years of experience, gender, marital status, type of labour contract, sector of industry, and firm size. In this section, a thorough examination is conducted to analyze the specific relationship between each education level and the corresponding income level. Furthermore, we delve into the temporal dynamics of this relationship by comparing the results obtained during the 2009-10 period with those from the 2018-19 period. Although the differences between the results obtained for the two periods of time have not been tested, this descriptive comparison provides valuable insights into the evolution of the results over time.

First, we focus on primary education. The analysis reveals that during the 2009-10 period, individuals with primary education experienced an average reduction of around 18.5% in their hourly wages compared to those with other educational levels. While this negative correlation persists across different segments of the wage distribution, it is possible to identify that the magnitude of the effect becomes significantly greater for individuals at the top of the distribution than for those at the bottom. Specifically, it is estimated that primary education is associated with reductions in hourly wages of 9.5%, 14.5%, and 37.9% at the 10^{th}, 50^{th}, and 90^{th} quantiles of the wage distribution, respectively.

When analyzing the results obtained for the same education level in the 2018-19 period, a similar trend to the findings from the 2009-10 period becomes apparent. According to the OLS estimates, individuals with primary education experienced a reduction of approximately 14,3% in their hourly wage in the 2018-19 period. Furthermore, when examining the correlations at different points of the wage distribution, it becomes evident that the magnitude of the effect also increased for individuals positioned at higher levels of the wage distribution. However, it's worth noting that the magnitude of the negative correlation decreased to 6.7% and to 11.3% at the 10^{th} and 50^{th} quantiles but increased to 47.8% at the 90^{th} quantile in the 2018-19 period.

Next, we delve into the results obtained for secondary and high school education. In this case, the results exhibit remarkably similar trends to those obtained at the primary education level,

indicating a negative correlation between the level of education and log hourly wages at the mean (OLS) as well as at the 10th, 50th, and 90th quantiles that becomes much larger for individuals at the top of the distribution. During the 2009-10 period, secondary and high school education are associated with a reduction of approximately 13.8% and 16.6% in the hourly wages, respectively. The results obtained across different segments of the wage distribution indicate that secondary education was linked to a reduction of wages of 5.4%, 12%, and 33.3% at the 10th, 50th, and 90th, respectively. Similarly, higher education is associated with wage reductions of 0%, 10.6%, and 54.1% at the 10th, 50th, and 90th, respectively.

When comparing the results between the 2009-10 and the 2018-19 periods, notable changes become evident. The OLS estimates for the latter period indicate a reduction in the impact of education on hourly wages for both secondary and high school education, with reductions of 10.6% and 14.2% respectively. Examining the results across different points of the wage distribution reveals further distinctions between the two education levels. On the one hand, secondary education shows an increase in the magnitude of the negative effect at the 10th quantile, a decrease at the 50th quantile, and no changes at the 90th quantile. On the other hand, high school education exhibited an opposite trend with a decrease in the magnitude of the negative effect at the 10th and at the 50th quantile and an increase at the 90th quantile.

Lastly, we examine the results of higher education. This particular education level stands out as the only one analyzed that exhibits a positive correlation with hourly wages. In the 2009-10 period, based on the OLS estimates, individuals with higher education experienced an average increase of around 18.5% in their hourly wages. Considering the effects across different points of the wage distribution, we find that the magnitude of this effect is significantly larger for individuals positioned at the upper end of the distribution compared to those at the lower end. Particularly, it is estimated that having higher education is linked to reductions in hourly wages of 7%, 27.2%, and 106.6% in the 10th, 50th, and 90th quantiles of the wage distribution, respectively. In comparison, the results of the 2018-19 period exhibit that the returns of higher education reduced at the mean to 26.4% and at the 10th, 50th, and 90th quantiles to 6.8%, 18%, and 100%, respectively.

Table 2. *Ordinary Least Square estimates (OLS) and Unconditional Quantile Regression (UQR) Coefficients on Log Wages for all the education levels*

Log hourly wages	2009 - 2010				2018 - 2019			
	OLS	UQR			OLS	UQR		
		10th	50th	90th		10th	50th	90th
Primary education	-0.185***	-0.095***	-0.149***	-0.379***	-0.143***	-0.067***	-0.113***	-0.478***
	(0.00519)	(0.008)	(0.006)	(0.029)	(0.00466)	(0.007)	(0.005)	(0.036)
Secondary education	-0.138***	-0.054***	-0.120***	-0.333***	-0.106***	-0.068***	-0.090***	-0.333***
	(0.00458)	(0.007)	(0.005)	(0.025)	(0.00406)	(0.006)	(0.004)	(0.032)
High school	-0.166***	0.000	-0.106***	-0.541***	-0.142***	-0.015***	-0.083***	-0.550***
	(0.00332)	(0.004)	(0.003)	(0.016)	(0.00257)	(0.003)	(0.002)	(0.017)
Higher education	0.373***	0.070***	0.272***	1.066***	0.264***	0.068***	0.180***	1.002***
	(0.00420)	(0.005)	(0.004)	(0.018)	(0.00317)	(0.004)	(0.002)	(0.020)

Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	80,754	83,904	83,904	83,904	96,779	102,215	102,215	102,215
R-squared	0.368	0.028	0.189	0.257	0.365	0.024	0.181	0.250

*Note: For all estimations, the dependent variable is the logarithmically adjusted hourly wages. This table was constructed considering the basic expansion factor. The controls included in the regression are years of schooling, years of experience, gender, marital status, type of labour contract, firm size, 16 sector industry dummies, and 8 occupation dummies. OLS refers to the ordinary least square estimates of the wage equation with robust standard errors in parentheses and UQR refers to the results of the unconditional quantile regressions. Statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1. Sources: Compiled by author based on GEIH, DANE.*

5.1.2 RIF regression

The results presented in the preceding subsection sheds light on the wage returns of workers with different education levels. Even though it is important to interpret these findings with caution, they can be considered as an initial step towards understanding the complex dynamics that exists between education and hourly wages in the Colombian labour market. To further explore this link, it's necessary to refer to the RIF regression results reported in Table 3. The estimations presented in this table, described by equations (8) and (9), assess the effects of the different education levels on income inequality measured by the variance of log hourly wages and the Gini coefficient in the periods 2009-10 and 2018-19. In this case, all the coefficients are statistically significant at 1% of confidence and are controlled by individual and work characteristics already described.

To start the analysis, we focus on the results measured by the variable of variance of log hourly wages. In the 2009-10 period, the results reveal interesting findings. It is estimated that completing primary education, secondary education, and high school was associated with decreases of 0.094, 0.078, and 0.160 units, respectively, when other variables were held constant. However, completing higher education showed a contrasting pattern by found to be associated with an increase of 0.3 units in the variance of log hourly wages. This suggests that individuals who attained higher education levels tend to exhibit higher variances in their log hourly wages than those without such education.

When examining the results from the 2018-19 period, we observe some notable changes. In this case, completing primary education was associated with a larger decrease of 0.12 units in the variance of log hourly wages, suggesting a stronger impact of education on income inequality. In contrast, completion of secondary and high school education shows smaller decreases of 0.063 and 0.11 units respectively. Additionally, completing higher education remained associated with higher income inequality; however, the magnitude of the coefficient decreased to 0.209 units for the 2018-19 period.

The results obtained for the effect of educational levels on wage inequality, as measured by the Gini coefficient, confirm the results measured by the variable of variance of log hourly wages. According to the results reported in Table 3, in the period 2009-10, completing primary education, secondary education, and high school were associated with notable decreases of 0.061 units, 0.044 units, and 0.073 units, respectively. In contrast, completing higher education

was linked to an increase of 0.15 units in the Gini coefficient, indicating that individuals with higher education levels experience higher levels of income inequality.

Comparing these findings to the results from the 2018-19 period provides further insights. Completing primary education was associated in this latter period with a more pronounced decrease of 0.08 units in the Gini coefficient. On the other hand, completing secondary and high school education shows smaller decreases of 0.038 units and 0.057 units, respectively. Furthermore, completing higher education continues to be associated with higher income inequality, albeit with a reduced coefficient magnitude of 0.12 units for the 2018-19 period. These findings shed light on the evolving relationship between education and wage inequality, emphasizing the importance of educational attainment in shaping income distribution dynamics.

The results presented in Table 3 highlight two significant findings. Firstly, high school education demonstrates the largest negative effect, implying that it plays a crucial role in mitigating wage disparities across the sample. This observation remains consistent across both measures of income inequality and persists over time. Secondly, higher education stands out as the only level of education that contributes to an increase in wage inequality. The estimates reveal that individuals who have completed higher education tend to experience greater disparities in wages. This finding is confirmed with the observed results for the Gini coefficient, which further confirms that higher education is associated with higher income inequality. Overall, these results highlight the complex dynamics between education and wage inequality. While high school education plays a crucial role in mitigating wage disparities, higher education presents a unique challenge by potentially exacerbating income inequality.

Table 3. *RIF Regression of Inequality Measures for all the education levels*

Inequality Measures	Variance		Gini	
	2009 - 2010	2018 - 2019	2009 - 2010	2018 - 2019
Primary education	-0.094***	-0.120***	-0.061**	-0.080***
	(0.017)	(0.017)	(0.020)	(0.021)
Secondary education	-0.078***	-0.063***	-0.044**	-0.038*
	(0.015)	(0.015)	(0.017)	(0.018)
High school education	-0.160***	-0.110***	-0.073***	-0.057***
	(0.010)	(0.008)	(0.011)	(0.010)
Higher education	0.300***	0.209***	0.150***	0.116***
	(0.011)	(0.009)	(0.013)	(0.011)
Controls	YES	YES	YES	YES
Observations	80,754	96,779	80,754	96,779
R-squared	0.136	0.165	0.045	0.061

Note: In columns 1 and 2, the dependent variable considered is the variance of logarithmically adjusted hourly wages. In columns 3 and 4, the dependent variable changes to the Gini coefficient. This table was constructed considering the basic expansion factor. The controls included in the regression are years of schooling, years of experience, gender, marital status, type of labour contract, firm size, 16 sector industry dummies, and 8 occupation dummies. OLS refers to the ordinary least square estimates of the wage equation with robust standard errors in parentheses and UQR refers to the results of the

*unconditional quantile regressions. Statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1. Sources: Compiled by author based on GEIH, DANE.*

5.2 Results for higher education

5.2.1 OLS and UQR

The findings presented in the preceding section highlight a consistent trend linking education to a reduction in income inequality. Nevertheless, it is important to note that higher education exhibits a distinct effect, contributing to an increase in income inequality. This raises the need for a more detailed examination of higher education's impact on income inequality. In order to do this, we conduct a further exploration of three distinct subcategories of higher education: technical education, undergraduate education, and postgraduate education. By analyzing the OLS estimates and Unconditional Quantile regression (UQR) coefficients for these subcategories during the 2009-10 and 2018-19 periods, we gain a thorough understanding into their respective impacts on wage distribution and their role in shaping Colombia's income inequality trends.

First, we examine the category of technical education. Table 4 presents the OLS estimates, which consistently indicate that individuals with technical education earn lower average wages compared to those with other educational levels during both the 2009-10 and 2018-19 periods. This finding is further supported by the UQR coefficients, which consistently demonstrate negative and statistically significant values across all quantiles. Notably, when comparing these results to those exhibited in the 2018-19 period, we observe a decrease in the magnitude of the coefficients for the OLS estimates and the UQR at the 10th and 50th quantiles, along with an increase for the UQR at the 90^{th} quantile.

For the undergraduate education category, the OLS estimates exhibit a significant positive effect, indicating that individuals with undergraduate education earn higher average wages compared to those without such education. While the OLS results are consistent for both periods, the UQR coefficients reveal an interesting dynamic. In the 2009-10 period, we observe a negative and statistically significant coefficient at the 90^{th} quantile, with a confidence level of 1%. Although this coefficient loses significance in the 2018-19 period, it raises the possibility of a diminishing wage premium associated with undergraduate education for individuals at the highest end of the wage distribution.

Finally, for the postgraduate education category, the OLS estimates also reveal a significant positive effect, suggesting that individuals with postgraduate education earn higher average wages compared to those with other educational levels. Furthermore, the UQR coefficients consistently demonstrate positive and significant effects across all quantiles, indicating the existence of a wage premium associated with postgraduate education. Notably, and how it has

been the case for almost all of the results presented so far, this wage premium becomes much larger for individuals at the top of the distribution.

Table 4. *Ordinary Least Square estimates (OLS) and Unconditional Quantile Regression (UQR) Coefficients on Log Wages for subcategories of higher education*

Log hourly wages	2009 - 2010				2018 - 2019			
	OLS	UQR			OLS	UQR		
		10th	50th	90th		10th	50th	90th
Technical education	-0.535***	-0.142***	-0.772***	-0.923***	-0.501***	-0.043***	-0.718***	-1.070***
	(0.00755)	(0.006)	(0.011)	(0.026)	(0.00551)	(0.003)	(0.008)	(0.023)
Undergraduate education	0.186***	0.097***	0.401***	-0.057*	0.147***	0.028***	0.385***	-0.037
	(0.00789)	(0.005)	(0.01)	(0.024)	(0.00598)	(0.002)	(0.008)	(0.022)
Postgraduate education	0.650***	0.043***	0.482***	1.638***	0.691***	0.016***	0.449***	1.844***
	(0.0123)	(0.007)	(0.015)	(0.033)	(0.00960)	(0.003)	(0.011)	(0.029)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	27,563	29,457	29,457	29,457	41,583	45,179	45,179	45,179
R-squared	0.456	0.09	0.371	0.171	0.465	0.051	0.368	0.184

*Note: For all estimations, the dependent variable is the logarithmically adjusted hourly wages. This table was constructed considering the basic expansion factor. The controls included in the regression are years of schooling, years of experience, gender, marital status, type of labour contract, firm size, 16 sector industry dummies, and 8 occupation dummies. OLS refers to the ordinary least square estimates of the wage equation with robust standard errors in parentheses and UQR refers to the results of the unconditional quantile regressions. Statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1. Sources: Compiled by author based on GEIH, DANE.*

5.2.2 RIF regression

To analyze the link between the subcategories of higher education and income inequality, it's necessary to refer to the RIF regression results presented in Table 5. These findings indicate that technical education is associated with a reduction in the variance of log hourly wages. It is estimated that completing technical education decreased the variance of hourly wages by 0.305 units during the 2009-10 period and by 0.34 units during the 2018-19 period. This suggests that individuals who have attained technical education levels tend to demonstrate lower variability in their hourly wages compared to those with different educational backgrounds.

Similarly, undergraduate education followed a similar pattern, indicating a decrease in the variance of log hourly wages. Although the magnitude of the coefficients was smaller compared to those observed for the technical education level, they remained positive and statistically significant. The results revealed that completing undergraduate education was associated with a decrease of 0.26 units in the variance of log hourly wages during the 2009-10 period and 0.24 units during the 2018-19 period. Therefore, completing undergraduate education was also correlated to lower levels of income inequality during both periods.

When examining the results obtained for the postgraduate education level, we identify a contrasting trend. In this case, completing postgraduate education is estimated to be linked with

an increase of 1.05 units in the variance of log hourly wages during the 2009-10 period and 1.052 units during the 2018-19 period. These findings evidence that postgraduate education is the only sub-category of higher education, that according to the RIF regression estimates, is associated with higher levels of income inequality.

The results obtained from analyzing the effect of different subcategories within the higher education level on wage inequality, as measured by the Gini coefficient, align with previous findings based on the variance of log hourly wages. In this case, completing technical education demonstrates a significant association with a reduction in the Gini coefficient. During the 2009-10 period, completing technical education was linked to a decrease of 0.064 units, and during the 2018-19 period, the reduction amounted to 0.083 units. These findings underscore the positive impact of technical education on reducing income inequality.

Furthermore, the findings reported in Table 4 regarding the Gini coefficient also provide evidence supporting a positive correlation between completing postgraduate education and inequality levels. However, it is worth noting that in this particular case, postgraduate education has a relatively modest positive effect on income inequality compared to the results obtained from analyzing the variance of log hourly wages. According to the estimates, postgraduate education is associated with an increase of 0.35 units in the Gini coefficient during the 2009-10 period and a larger increase of 0.406 units during the 2018-19 period.

In summary, the results presented in Table 5 indicate that technical and undergraduate education exhibit a negative correlation with measures of inequality such as log hourly wages and Gini coefficients. This implies that individuals who have completed one of these educational levels tend to experience lower levels of income inequality to those who have pursued postgraduate education. Consequently, the sub-category of postgraduate education stands out as the sole sub-category analyzed that demonstrates a positive association with the inequality measures. This paper does not delve into the analysis of whether this negative relationship is the underlying factor behind the overall negative effect of higher education on income inequality, as reported in Table 3. However, these results do provide valuable insights that enable us to narrow down the negative correlation to a specific segment within the Colombian education system.

Table 5. *RIF Regression of Inequality Measures for subcategories of higher education*

Inequality Measures	Variance		Gini	
	2009 - 2010	2018 - 2019	2009 - 2010	2018 - 2019
Technical education	-0.305***	-0.340***	-0.064***	-0.083***
	(0.021)	(0.015)	(0.015)	(0.012)
Undergraduate education	-0.260***	-0.239***	-0.120***	-0.134***
	(0.019)	(0.014)	(0.014)	(0.011)
Postgraduate education	1.046***	1.052***	0.350***	0.406***
	(0.027)	(0.019)	(0.020)	(0.016)
Controls	YES	YES	YES	YES
Observations	27,563	41,583	27,563	41,583
R-squared	0.089	0.127	0.025	0.039

*Note: In columns 1 and 2, the dependent variable considered is the variance of logarithmically adjusted hourly wages. In columns 3 and 4, the dependent variable changes to the Gini coefficient. This table was constructed considering the basic expansion factor. The controls included in the regression are years of schooling, years of experience, gender, marital status, type of labour contract, firm size, 16 sector industry dummies, and 8 occupation dummies. OLS refers to the ordinary least square estimates of the wage equation with robust standard errors in parentheses and UQR refers to the results of the unconditional quantile regressions. Statistical significance levels: *** p<0.01, ** p<0.05, * p<0.1. Sources: Compiled by author based on GEIH, DANE.*

5.3 Discussion

This paper presents an in-depth analysis of the association between various levels of education and inequality across different quantiles of the wage distribution. While the descriptive nature of the analysis limits the possibility to establish a causal relationship between education levels and income inequality, it does provide valuable correlations that offer insights into the dynamics at play between education and inequality in Colombia. This section aims to offer explanations for the obtained results by examining them under the light of relevant theories and previous findings considered in preceding sections. The discussion is divided into two parts: the first part elaborates on the results obtained for all education levels and the second part narrows the focus to the three categories within the higher education level.

5.3.1 All levels of education and inequality

First, we turn to the analysis of the results obtained for all the education levels. This part will focus on two main findings: the diminishing returns of primary, secondary, and high school education and the wage premium associated with higher education. To understand the mechanisms that might be driving the contrasting returns of different educational levels and the way in which this relates to inequality let us consider one of the main points exalted by the Human Capital Theory and all its subsequent developments: education enhances individual's skills and abilities and prepares them to be competitive in the labour market. In this way, it's possible to consider that basic education (i.e., primary, secondary, and high school education) prepares low-skilled workers and higher education (i.e., technical, undergraduate, and postgraduate) prepares high-skilled workers (Mondragón-Vélez et al., 2010). In this way, education consolidates as a key determinant of the relative supply of workers in the labour market and changes in the educational systems can influence a country's labour market dynamics (Borjas, 2013)

It is estimated that since the turn of the century, Colombia has experienced an education expansion has consider all the educational levels, however, it has been particularly focused on the basic level, that is primary, secondary, and higher education (Delgado, 2014). This has contributed to the increase in the number of enrolled students at these three levels in public and private institutions across all the regions of the country (Hernández-Leal, Duque-Méndez &

Cechinel, 2021). This educational expansion has led to a relative increase in the supply of low-skilled workers relative to that of high-skilled workers. In this way, all other things equal, the kind of labour that becomes relatively abundant causing a decrease in their returns or wages. (Bonilla-Mejía, Bottan & Ham, 2019). This labour supply shift triggered by the education expansion would be consistent with the diminishing returns estimated for the primary, secondary, and high school education level in Colombia for the two periods analyzed.

Following the same line of though this reasoning could also explain the mechanisms behind the wage premium observed for the workers with higher education. In this case, it could be argued that the relative decrease of the high-skilled labour compared to the relative increased just described for low-skilled labour leads to a relative scarcity of highly skilled workers, leading to increasing wages for workers who completed higher education levels. This would also be illustrated by the results obtained in this paper. It is estimated that the returns to investments in higher education in Colombia are high and growing, however, this development is also linked growing wage-premium that fuels wage inequality (Bonilla-Mejía, Bottan & Ham, 2019).

The results suggest that higher education was associated with increases in the hourly wages both at the mean and at different points of the wage distribution. Additionally, according to the estimations obtained from the RIF regression, which while primary, secondary, and high school education are associated with lower levels of inequality, higher education is associated with higher inequality levels. In this way, higher education is the only educational level associated with an increase in the inequality measures. Finding that is consistent with previous findings in the literature that analyzes education and inequality trends in Latin America and Colombia.

While there have been attempts to promote the entrance of people to the higher education system. According to (Joumard & Vélez, 2013) while Colombia has made progress in expanding access to education, the authors note persistent disparities in educational quality between private and public institutions, as well as ongoing financial barriers that perpetuate income inequality. Consequently, a significant wage premium is enjoyed by individuals with higher education, but limited access to higher education restricts the supply of highly skilled labor. This scarcity of higher-educated workers contributes to the pronounced wage differentials across various educational levels, further exacerbating inequality levels in the country.

When certain groups have better access to the signals valued in the labor market, education, and the signals it conveys can amplify preexisting inequalities. For instance, if employers highly value degrees from prestigious universities, individuals from privileged backgrounds who can afford to attend such institutions may have an advantage over those from less privileged backgrounds who lack similar opportunities. Consequently, this perpetuates a cycle where the already affluent individuals continue to accumulate wealth while the underprivileged face further challenges. In this scenario, the already advantaged individuals possess better means to effectively signal their quality, leading to enhanced employment prospects and higher income levels (Koutmeridis, 2018; Rehme, 2007; Wells, 2006). More on signaling in (Arteaga, 2018)

5.3.2 Technical, undergraduate, and postgraduate education and inequality in Colombia

To comprehensively analyze the intricate relationship between higher education and income inequality, it is crucial to explore the distinct dynamics within three categories of higher education. To provide a clearer understanding of these categories, let's further define the types of education they entail. The first category is technical or vocational education, which refers to short degree programs (2 to 3 years) aimed at studying and training practical skills for specific occupations (i.e., plumbing, carpentry, and electricity among others) at technical or technological institutions (Ministerio de Educación Nacional, 2008). Moving on to the second category, undergraduate education refers to bachelor's degree programs (4 to 5 years) (Ministerio de Educación Nacional, 2022). Finally, postgraduate education refers to specializations (1 to 2 years following a bachelor's degree), master's degree programs (2 years following a bachelor's degree), and doctorate studies (4 to 5 years following a master's degree). All levels of education here are offered by public and private institutions (Ministerio de Educación Nacional, 2022).

(i) *Technical education*. Based on the findings reported in the previous section, it can be argued that there is a negative relationship between technical education and wage returns. To understand the diminishing returns of this educational level, it is essential to examine the specific educational developments that took place in the country during the analyzed period. Over the past two decades, Colombia has experienced a remarkable expansion of technical (Figure 1). It is estimated that the number of students enrolled in technical education programs has multiplied by more than four times since the year 2000 (Pineda & Celis, 2017). This expansion has greatly enhanced the accessibility of technical education, which is widely recognized as a valuable alternative for individuals from different socio-economic backgrounds to acquire high-paying skills (Hoeckel, 2018). By being offered free of charge at public institutions, technical education has become a cost-effective alternative that has consistently been acknowledged as an effective strategy for addressing income inequality (OECD, 2016).

In Colombia, technical education has demonstrated its potential to contribute to subsequent increases in earning, particularly when delivered by well-established training organizations (Puryear, 1979). Nevertheless, it is important to acknowledge that the effectiveness of education in yielding favorable returns can be influenced by the quality of the education received (Rehme, 2007). The lack of adequate government control and regulation has been evident in the rapid expansion of the technical education system in Colombia. This has resulted in a concerning proliferation of institutions that fail to meet quality standards and lack legitimacy. This situation raises valid concerns about the competencies acquired by individuals, ultimately diminishing the potential returns on investment for those pursuing technical education (Pineda & Celis, 2017).

(ii) *Undergraduate education*. Continuing the analysis, we now turn our attention to exploring the factors contributing to the wage premium associated with undergraduate education, as well as their relationship with levels of inequality. The results indicate that both undergraduate and postgraduate education are associated with a wage premium in the labor market. However, it is noteworthy that only postgraduate education shows a correlation with increased inequality levels. To better understand this dynamic and its implications it becomes crucial to consider the fundamental differences between undergraduate and postgraduate education in Colombia, as these distinctions could potentially account for the observed trends.

When discussing higher education in Colombia, it's necessary to mention that the massification of higher education has led to the emergence of various types of institutions with different levels of quality and legitimacy. In the private sector, universities range from bottom-tier institutions with lower quality standards to recognized middle-tier universities that offer good-quality education and are financially accessible to a broader population. At the top end, there are prestigious universities with high-quality undergraduate programs but also higher tuition fees (Uribe, 2015). Similarly, the public sector showcases significant variation. This includes small and medium-sized universities that may have lower quality standards compared to private institutions. However, there are also top-tier public universities known for their high-quality undergraduate programs. These institutions either offer tuition-free education or charge minimal tuition fees, but admission is highly competitive and involves rigorous entrance exams (González-Velosa et al., 2015).

The differences in educational quality and legitimacy previously described lead to a market segmentation that reproduces social inequalities by posing financial barriers for low-income individuals (Lozano, Cruz Pulido & García Rodríguez, 2021). It is argued that the persistent disparities in educational quality between private and public institutions in Colombia have played a significant role in the rise of inequality levels, an argument that can be understood through the lenses of the signalization model. According to this model, individuals who can afford quality education, which serves as a highly valued signal in the labor market, have greater opportunities to improve their employment prospects and attain higher incomes. Consequently, individuals from underprivileged backgrounds face financial constraints that restrict their ability to access the same opportunities, thereby exacerbating existing inequality levels in the country (Joumard & Vélez, 2013).

The preceding argument provides insight into the relationship between undergraduate education and inequality. However, it suggests that this level of education is typically linked to an increase in income inequality, which contradicts the findings of this paper. Based on the estimates conducted in this paper, it is observed that undergraduate education has a wage premium, but it is not positively correlated with inequality levels. Therefore, it can be argued that, during the analyzed period, undergraduate education had opportunity-enhancing effects that contribute to reducing inequality. To understand the factors driving this, it is essential to examine the results considering the Colombian context.

Since the turn of the century, significant progress has been made in enhancing the accessibility of undergraduate education for individuals from diverse backgrounds in Colombia. One standout factor that has significantly contributed to this achievement is a series of institutional reforms undertaken by the government in collaboration with the World Bank between 2002 and 2010. These reforms introduced several measures, including increased public funding for education, which expanded access to higher education and improved the monitoring of academic programs quality (de Ferranti et al., 2002). Furthermore, advancements in education financing options have also played a relevant role in enabling individuals from different backgrounds to pursue higher education, particularly undergraduate degrees (Santamaría, 2004). While there is still progress to be made in achieving equitable access to undergraduate education, the efforts thus far have positioned education as a tool for promoting social inclusion and reducing income inequality in Colombia (OECD, 2012, 2013b).

(iii) *Postgraduate education*. To conclude the analysis, we focus on examining the factors that contribute to the wage premium associated with postgraduate education and its connection to the inequality levels. Since 2010, Colombia has experienced a steady but slow increase in the number of students enrolled in postgraduate programs across the country, however, the proportion of workers that have completed this educational remains low if compared to the other education levels (Markus, 2022). While it can be argued that this scarcity in this high-skilled labour has contributed to the wage premium associated to this educational level, the significant rise over time in the postgraduate wage premium can also be attributed to an increase in the relative demand for workers with postgraduate education (Lindley & Machin, 2016).

On the demand side of the labour market, there has been an increase in the demand of workers with postgraduate degrees. In post-industrial economies, the rise in the availability of information, the availability of digital tools in the workplace, the globalization of the labour market, the rapid technological change are factors that have contributed to the evolution of the labour markets and have made that some skills have begun to be more valuable in the labour market (Tremblay, Lalancette & Roseveare, 2012). The rise of an information society has contributed to a rise in the demand for workers with skillsets that make them complementary to the technologies available (Segovia & Checa, 2021). The increase in non-routine occupations that require a continuous adaptation to new technologies have favored workers with postgraduate education, an educational level that prepares individuals for the market-relevant skills, creating a rising postgraduate wage inequality over time (Lindley & Machin, 2016, 2011).

Furthermore, another contributing factor to the association between postgraduate education and increased inequality levels could be the presence of a skill mismatch in the labor market. This occurs when highly skilled workers with postgraduate degrees accept jobs that have low skill requirements and offer lower wages, leading to sub-optimal job assignments (Maier, n.d.). The misallocation of high-skilled workers into low-skilled jobs, which could be performed by individuals with lower levels of education, results in lower incomes for these highly skilled workers. Consequently, this extends the lower end of the wage distribution among highly educated individuals, thereby increasing the within-skill wage disparity (Martins & Pereira,

2004). Although empirical evidence linking high inequality levels to skill mismatch in the Colombian labor market is currently lacking, there is evidence suggesting that the limited availability of wage employment opportunities for young people can lead to the misallocation of highly skilled workers into low-paid jobs (OECD, 2019b)

6 Conclusions

This paper presents a comprehensive analysis of the relationship between education and inequality in Colombia. Using cross-sectional data from a household survey conducted in 13 main cities and their metropolitan areas during the 2009 – 2010 and 2018 – 2019 periods, the study employs unconditional quantile regressions (UQR) to estimate the wage returns of various education levels at different points of the wage distribution. Furthermore, the correlation between each education level and two inequality measures is explored using a recentered influence function (RIF) regression. While the main focus lies on the second set of estimations, which examine the association with inequality measures, the first set of estimations provides valuable insights into the dynamic interplay between education and earnings, offering a deeper understanding of the underlying mechanisms behind the observed correlations.

The findings of this paper consistently revealed that primary, secondary, and high school education were associated with reduced hourly wages across various quantiles of the wage distribution. Moreover, these educational levels had a negative impact on wage inequality, with high school education playing a significant role in mitigating wage disparities. It is argued that the expansion of education, particularly focused on primary, secondary, and higher education levels in the past two decades, has resulted in an increased supply of low-skilled workers relative to high-skilled workers. This shift has led to a decline in the returns of relatively abundant labor (i.e., basic education) and an increase in the returns of relatively scarce labor (i.e., higher education).

While primary, secondary, and high school education were found to be associated with decreased inequality levels, higher education showed an opposite trend by being associated with increased inequality. Further examination of the subcategories within higher education revealed distinct patterns. First, technical education exhibited diminishing returns and was linked to a decrease in inequality levels, mirroring the trends observed in basic education levels. These findings can be attributed to the rapid expansion of technical education in the country, which suffered from inadequate government control. Consequently, a proliferation of educational institutions lacking quality standards emerged, raising concerns about the competencies acquired by individuals, and could have ultimately diminished the potential returns on investment for those pursuing technical education.

Furthermore, the analysis of subcategories within higher education revealed another significant finding. Undergraduate education was associated with a wage premium and a decrease in inequality. This positive outcome can be attributed to a series of institutional reforms implemented between 2002 and 2010, which played a pivotal role in improving access to undergraduate education. These reforms encompassed measures such as increased public

funding and enhanced monitoring of program quality. Additionally, advancements in education financing options have facilitated individuals from diverse socio-economic backgrounds to pursue undergraduate degrees, contributing to social inclusion and a reduction in income inequality. Although still relatively limited, the availability of undergraduate education has gradually expanded in recent years, yielding positive effects on inequality levels.

Lastly, postgraduate education exhibited a wage premium alongside an increase in inequality. These findings can be attributed to two potential mechanisms. Firstly, the limited accessibility of higher education levels contributes to a scarcity of high-skilled workers, thereby reducing the overall supply of individuals with advanced qualifications and leading to an increase in inequality. Secondly, changes in labor market dynamics and evolving company needs have resulted in a growing demand for high-skilled workers. This increased demand, coupled with the relatively limited supply of individuals with postgraduate qualifications, has contributed to rising wage inequality within this group over time. Another plausible explanation is the potential misallocation of high-skilled workers into low-skilled jobs with lower incomes. A phenomenon that extends the lower end of the wage distribution among highly educated individuals, ultimately exacerbating within-skill wage disparities.

In conclusion, this paper provides valuable insights into the complex relationship between education and income inequality in Colombia. It highlights the expansion of education as a transformative factor capable of reducing wage inequalities and shaping individual's earnings. However, it is necessary to acknowledge that the education affects earnings and inequality levels through a number of ways that cannot be captured by a simplistic one-way connection. Education faces various challenges, including ensuring the quality of education provided, addressing resource constraints to make educational opportunities accessible to all, and navigating the dynamic labor market. Additionally, external factors such as globalization, trade, and technology exert considerable influence on inequality and deserve further investigation.

While this paper does not extensively explore these aspects, it offers an initial exploration into the considerations needed to use education as an effective tool for addressing inequality and fostering equal opportunities in Colombia. By examining the influence of different education levels across various points of the wage distribution, this study reveals the intricate dynamics at play between education, wage returns, and levels of inequality. Unveiling these complexities and acknowledging the challenges associated with these relationships is necessary to adopt a comprehensive approach that addresses not only access to education but also its quality, relevance, and alignment with the evolving needs of the labour market. By doing so, education can truly fulfill its potential as a catalyst for reducing income disparities and fostering a more equitable society.

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