

# Declining Wage Inequality in Developing Countries: The Case of Brazil<sup>†</sup>

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*Despite rising inequality in rich countries, many developing economies have experienced a decline in inequality in recent decades. Brazil is a notable example. From 1995 to 2015, its Gini index decreased from 58 to 48 points. An extensive body of research has investigated a diverse set of explanations for this reduction. This article reviews this literature, using Brazil as a privileged case study to understand the broader phenomenon of inequality decline in many parts of the developing world. We present stylized facts about inequality during this period, focusing on the results of decomposition methods. We then examine research that employs quasi-experiments and structural models to assess mechanisms related to labor supply and demand, trade, technological changes, and institutional factors such as the minimum wage and race and gender discrimination. We end by discussing some unanswered questions. (JEL D31, D63, J22, J23, J31, O15)*

## 1. Introduction

While the rise of wage inequality in the United States and other advanced economies since the late 1970s might suggest a global increase in inequality, in many other countries it has fallen in recent decades. For example, the World Bank (2016) calculates inequality trends for 91 countries between 1993 and 2008 and shows that although most industrialized economies experienced an increase in inequality, at least 39 countries saw a decrease in their Gini

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indices during that period, with the average index across the 91 countries dropping from 40.1 to 39.3.

Latin America and sub-Saharan Africa stand out in this regard. In these regions, Brazil emerges as a useful case study because of its geographic and population size, regional heterogeneity, relatively strong data availability for both formal and informal labor markets, and exposure to several economic and policy shocks. For these reasons, Brazil has been a fertile ground for rigorous and comprehensive studies of a wide array of mechanisms that shape the wage distribution in developing economies. Some of these studies would be challenging, if not impossible, to replicate in many countries, highlighting Brazil's significance as a source of relevant and high-quality research on wage inequality. Similar patterns in other Latin American economies indicate that regional factors, alongside country-specific influences, have played a significant role in driving inequality trends (Messina and Silva 2018). By exploring Brazil, we can draw broader implications for addressing inequality challenges worldwide.

Once labeled by the historian Eric Hobsbawm (1995) as “the world contender for the championship of economic inequality” (p. 407), Brazil saw an unambiguous compression in its income distribution in recent decades. Both labor and nonlabor income have contributed equally to the overall downward trend (Rodríguez-Castelán et al. 2016). Figure 1 illustrates the evolution of the Gini index for labor earnings between 1981 and 2019. Until 1994, wage inequality heavily fluctuated around 58 Gini points, which can be attributed to the persistent hyperinflation that occurred before monetary stabilization efforts in 1994. From 1995 to 2015, the Gini index steadily declined from 58 to 48 points. This period was followed by a slight increase in inequality until 2019.<sup>1</sup> Despite the improvement, Brazil remains one of the most unequal countries in the world: while it ranked as the second most unequal in 1989, by 2013 it had only advanced to fifth place (World Bank 2016).

Other studies reveal similar patterns of inequality reduction using Brazilian data from other sources. For example, Engbom et al. (2022) use matched employer–employee administrative data from 1985 to 2018 and survey data from six metropolitan areas covering 2002 to 2015 and draw the same conclusions.

Various factors have been proposed as candidate explanations for the decline in wage inequality in Brazil. On the labor-supply side, Brazil underwent a rapid demographic transition while simultaneously expanding access to education (Maia and Sakamoto 2016; Ferreira, Firpo, and Messina 2022). Additionally, macroeconomic conditions improved substantially, including inflation stabilization, lower unemployment rates, and higher average wages. The minimum wage increased by more than 100 percent in real terms between 1994 and 2013, likely contributing to the narrowing of income disparities. At the same time, labor formalization increased from 38.3 percent in 2002 to approximately half of the working population in 2012 (Firpo and de Pieri 2018). Finally, through trade reforms and a surge in commodity prices, globalization affected skilled and unskilled Brazilian workers in various ways (de La Torre et al. 2015; Messina and Silva 2018). In this review, we examine these possible explanations, focusing on the mid-1990s to the mid-2010s.<sup>2</sup>

<sup>1</sup>These patterns are consistent with alternative measures such as percentile ratios, the Theil index, and the standard deviation of log earnings. See Figures A1 and A2 in Appendix A.

<sup>2</sup>To provide a focused analysis, our review concentrates on this period, excluding classic studies such as Langoni (1973), Lam and Levison (1991), and dos Reis and de Barros (1991). Additionally, we restrict our attention to wage inequality. For an analysis of the overall income distribution, we refer the reader to Barros et al. (2010) and Souza (2018).

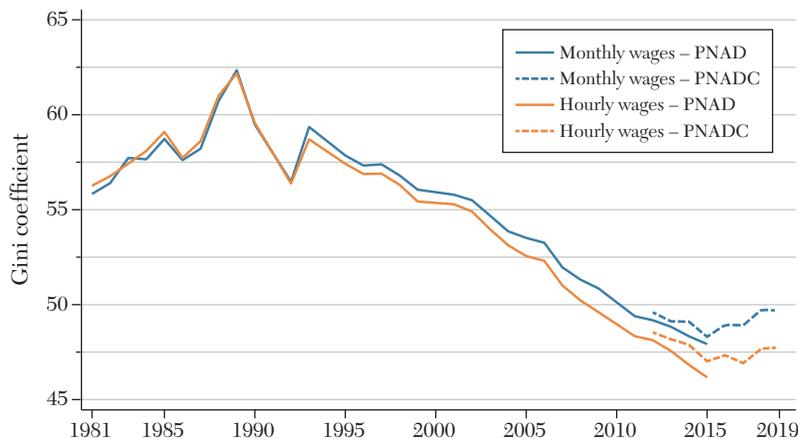


Figure 1. Gini Coefficient in Brazil, 1981–2019

*Notes:* Authors' own calculations based on usual monthly earnings from the workers' main occupation. Data comes from Pesquisa Nacional por Amostra de Domicílios, PNAD Instituto Brasileiro de Geografia e Estatística (2001–2015); Centro de Estudos da Metrópole (1981–1999) and Pesquisa Nacional por Amostra de Domicílios Contínua, PNADC Instituto Brasileiro de Geografia e Estatística (2012–2019). See Section 2.1 for a more detailed discussion on these surveys. For hourly wages, we restrict the sample to individuals working more than 20 hours per week. There is no sample restriction for monthly wages.

We find that the decrease in wage inequality resulted from the interaction of multiple mechanisms and in some cases they have not worked as simple theory would predict. Traditional explanations associated with rising inequality in rich countries, such as globalization and technological change, seem to have played a different role in Brazil. Trade liberalization and the commodity boom helped reduce inequality, but they are far from being the main causes, accounting for only 5 to 10 percent of the reduction. The effects of technological change remain unsettled in the Brazilian context. Aggregated patterns associated with technological change in developed countries—a higher skill premium and more employment polarization—are not clearly present in Brazil, while the few studies with direct evidence from technological updates have conflicting results.

An educational expansion, which some have suggested has been an important driver of lower inequality in Latin America through reducing the skill premium (Barros et al. 2010; Lustig, Lopez-Calva, and Ortiz-Juarez 2013), actually had an ambiguous effect in Brazil because of concomitant changes in workforce composition that increased inequality. The net effect was an increase in the Gini index by approximately 1.3 points. In contrast, a reduction in the experience premium and a decrease in gender and racial conditional gaps accounted for 57 percent and 17 percent of the reduction in the Gini index between 1995 and 2015, respectively, with almost no concomitant compositional effects. Reductions in residual inequality and a compression in firm-specific wage premiums also account for large shares of the decline in inequality.

Nevertheless, a more educated workforce helped reduce inequality indirectly. Research shows that the increase in the minimum wage accounts for almost 50 percent of the reduction

in formal-sector inequality. The educational expansion and the stable and growing economy were instrumental to this result. They helped increase productivity and formality, thus mitigating possible negative impacts of the minimum wage on other labor market outcomes.

But unanswered questions remain. Little is known about the causes of the decline in the experience premium and the compression of firms' payment premiums. Although the rising minimum wage is a leading explanation, limited research has been done on alternative hypotheses. In addition, potential inequality-increasing spillovers of the minimum wage to the informal sector warrant further investigation, given evidence suggesting such effects exist. Similarly, the impact of technological changes on the wage distribution in Brazil and other developing countries remains poorly understood.

This review is structured into two parts. In Section 2, we present key stylized facts concerning the decline in wage inequality. We summarize the results of two approaches. First, we explore how inequality dynamics are related to changes in workforce composition and the wage structure. Our analysis updates the work of Ferreira, Firpo, and Messina (2022), who use recentered influence function (RIF) regressions and Oaxaca–Blinder (OB) decomposition to study variations in the Gini index and other inequality measures (Firpo, Fortin, and Lemieux 2009; Fortin, Lemieux, and Firpo 2011; Firpo, Fortin, and Lemieux 2018). Second, we discuss the findings of Alvarez et al. (2018), who follow the seminal work of Abowd, Kramarz, and Margolis (1999) in decomposing the variance of log wages into worker and firm effects, documenting their evolution over time. Decomposition methods have long been used by labor economists to quantify how different factors contribute to wage differences between groups or changes over time (Oaxaca 1973; Blinder 1973; Fortin, Lemieux, and Firpo 2011). Some economists have proposed extending these methods to investigate changes in inequality over time (e.g., Juhn, Murphy, and Pierce 1993; Card, Heining, and Kline 2013).

Although this first part offers a valuable accounting exercise, it does not reveal the underlying economic mechanisms that caused the observed dynamics of the wage distribution. To do so, the second part delves into studies employing quasi-experiments and structural models to understand the processes driving changes in inequality. We organize our discussion around a few main themes. We begin by discussing studies that model skill premiums based on the relative supply-and-demand framework (Katz and Murphy 1992) in Section 3. These methods help us understand the determinants of schooling and experience premiums—two important components of the decline in inequality. Section 4 investigates whether two factors related to increases in the demand for skilled labor that have been proposed to explain the rise in inequality in developed countries also played a role in Brazil: globalization, in the form of trade liberalization in the 1990s and the commodity boom in the 2000s; and technological changes. Next, we move on to the explanations related to changes in labor supply and institutional factors that are particularly relevant for Brazil and other developing countries. The educational expansion and its ambiguous effect on inequality are discussed in more detail in Section 5. In Section 6 we analyze the role of the large increase in the real minimum wage in the period. The reduction in racial and gender wage gaps is investigated in Section 7. Rather than covering different papers, these sections cover specific topics, and several studies appear in more than one section. In the conclusion, we synthesize the main findings, providing a comprehensive overview of the decline in inequality in Brazil while highlighting some research questions that remain unanswered.

2. Stylized Facts about Inequality Reduction: Results from Decomposition Approaches

This section relies on results from two decomposition approaches to establish some facts about the reduction of inequality in Brazil that guide our discussion throughout this review. The first approach combines RIF regressions and the OB methodology to decompose functionals of the wage distribution into composition and structure effects (Fortin, Lemieux, and Firpo 2011; Firpo, Fortin, and Lemieux 2018). The second decomposes the variance of wages into firm and worker effects (Abowd, Kramarz, and Margolis 1999).

These methods should not be interpreted as uncovering causal mechanisms, but as accounting exercises, as suggested by Bourguignon, Ferreira, and Lustig (2005). They help us to understand what happened to the wage distribution and how different factors explain (in the statistical sense) changes in inequality. However, they do not elicit the economic mechanisms driving these changes or the deep structural parameters behind them.

2.1 Gini Decomposition Using RIF Regressions

We use RIF regressions (Firpo, Fortin, and Lemieux 2009) combined with the OB decomposition (Oaxaca 1973; Blinder 1973) to study changes in the Gini index in Brazil between 1995 and 2019. The OB decomposition was originally designed to estimate wage differences between two groups—such as male and female workers or Black and White workers—and associate them with differences in workforce composition (differences in endowments) and in the wage structure (returns to endowments). This framework can be easily adapted to investigate changes in wages over time by replacing two demographic groups with two time periods. In this case, the log-wage equation for individual  $i$  in period  $t \in \{0, 1\}$  can be written as a linear function of covariates  $\mathbf{X}$ :

$$(1) \quad Y_{i,t} = \beta_{0,t} + \sum_{k=1}^K X_{i,t}^k \beta_{k,t} + v_{i,t}, \quad t = 0, 1.$$

Here,  $X^k$  and  $\beta_{k,t}$  represent the  $k$ th elements of  $\mathbf{X}$  and  $\beta_t$ , respectively, and  $v_{i,t}$  is a mean-0 idiosyncratic independent non-observable component. The traditional OB framework is used to decompose differences in average wages,  $\hat{\Delta}_O^\mu = \bar{Y}_1 - \bar{Y}_0$ :

$$\hat{\Delta}_O^\mu = \underbrace{(\hat{\beta}_{0,1} - \hat{\beta}_{0,0}) + \sum_{k=1}^K \bar{X}_1^k (\hat{\beta}_{k,1} - \hat{\beta}_{k,0})}_{\hat{\Delta}_S^\mu \text{ (Structure)}} + \underbrace{\sum_{k=1}^K (\bar{X}_1^k - \bar{X}_0^k) \hat{\beta}_{k,0}}_{\hat{\Delta}_X^\mu \text{ (Composition)}}$$

An *aggregate decomposition* divides the overall difference in wages,  $\hat{\Delta}_O^\mu$ , into two components. The first component,  $\hat{\Delta}_S^\mu$ , is the structure effect, which arises from differences in the returns to observable characteristics ( $\hat{\beta}_t$ ) and differences in the intercepts between periods. The second component,  $\hat{\Delta}_X^\mu$ , is the composition effect, which arises from differences in workers' characteristics ( $\mathbf{X}$ ) between periods. We can also perform *detailed decompositions*, which account for the contribution of each variable individually. Because of the linearity assumption

in equation (1), the contribution of a variable  $X^k$  to the structure and composition effects is simply given by  $\bar{X}_1^k(\hat{\beta}_{k,1} - \hat{\beta}_{k,0})$  and  $(\bar{X}_1^k - \bar{X}_0^k)\hat{\beta}_{k,0}$ , respectively.<sup>3</sup>

Many alternative methodologies have been proposed to extend the original OB framework beyond its focus on the mean and to allow for the study of changes in inequality between periods.<sup>4</sup> Here, we focus on an application of RIF regressions combined with OB decomposition (Firpo, Fortin, and Lemieux 2009, 2018).

RIF regressions (Firpo, Fortin, and Lemieux 2009) are like standard regressions, but they replace the dependent variable,  $Y$ , with the recentered influence function,  $\text{RIF}(Y; \nu, F_Y)$ , of the distributional statistic  $\nu(F_Y)$ . This distributional statistic can be any functional of a distribution  $F_Y$ , such as the mean, quantiles, variance, or Gini index.

The influence function,  $\text{IF}(y; \nu, F_Y)$ , measures the change in the value of  $\nu(F_Y)$  when an infinitesimally small part of the distribution  $F_Y$  is replaced by a point mass at  $y$  (Van der Vaart 2000, p. 292). It is a widely used concept in robust statistics because, when evaluated at the empirical distribution  $\hat{F}_Y$ , it provides a measure of the influence of the individual observation  $y_i$  on the distributional statistic  $\nu$ .<sup>5</sup> To be concrete, consider the cases of the mean and the variance. For the mean,  $\mu = \int z \cdot dF_Y(z)$ ,  $\text{IF}(y; \mu, F_Y) = y - \mu$ . For the variance,  $\text{var}[Y] = \sigma^2$  and  $\text{IF}(y; \sigma^2, F_Y) = [y - \int z \cdot dF_Y(z)]^2 - \sigma^2 = (y - \mu)^2 - \sigma^2$ .<sup>6</sup>

A property of  $\text{IF}(Y; \nu, F_Y)$  is that its expected value is 0. This can be easily seen in the case of the mean and the variance because  $E[Y] = \mu$  and  $\text{var}[Y] = E[(Y - \mu)^2]$ . The RIF simply adds  $\nu(F_Y)$  back to the IF,  $\text{RIF}(y; \nu, F_Y) = \nu(F_Y) + \text{IF}(y; \nu, F_Y)$ , thus recentering the influence function around  $\nu(F_Y)$ . Therefore, the expected value of  $\text{RIF}(Y; \nu, F_Y)$  is the statistic  $\nu(Y)$ . The sample counterpart of  $\text{RIF}(y; \nu, F_Y)$  is  $\text{RIF}(y_i; \nu, \hat{F}_Y)$ . For the case of the variance,  $\text{RIF}(y_i; \sigma^2, \hat{F}_Y) = (y_i - \bar{y})^2$ , where  $\bar{y}$  is the sample mean. Interestingly, for the mean,  $\text{RIF}(y_i; \mu, \hat{F}_Y) = y_i$ .

The RIF regression estimates the conditional expectation of  $\text{RIF}(Y; \nu, F_Y)$  given  $\mathbf{X}$ . As shown in Firpo, Fortin, and Lemieux (2009), the average derivative of  $E[\text{RIF}(Y; \nu, F_Y) | \mathbf{X}]$  with respect to some covariate  $X_j$ , integrated over the distribution of  $\mathbf{X}$ , corresponds to the partial effect of a small location shift in the distribution of covariate  $X_j$  on  $\nu(F_Y)$ . As this is a general representation, this interpretation holds not only for complex functionals, but also for the mean of  $Y$ . In fact, for the mean,  $\text{RIF}(Y, \mu) = Y$  and the RIF regression is simply the standard regression. Therefore, standard regressions can be seen as establishing the effects of a small location shift in the distribution of covariates  $\mathbf{X}$  on the unconditional mean of  $Y$ . By replacing the dependent variable  $Y$  with  $\text{RIF}(Y; \nu, F_Y)$ , we generalize that and are able to measure the effects of changes in the distribution of  $\mathbf{X}$  on the statistic  $\nu(Y)$ . In the simplest

<sup>3</sup>The OB decomposition can be done in different ways, using different reference groups/periods or counterfactuals. In particular, using the first period as reference, the decomposition terms become  $\bar{X}_0^k(\hat{\beta}_{k,1} - \hat{\beta}_{k,0})$  and  $(\bar{X}_1^k - \bar{X}_0^k)\hat{\beta}_{k,1}$ . There is no correct way of doing so, and the choice depends on the preferred reference period for the counterfactual comparison, with results and interpretation changing slightly because of that. See Fortin, Lemieux, and Firpo (2011) for a detailed discussion.

<sup>4</sup>These include Juhn, Murphy, and Pierce (1993), DiNardo, Fortin, and Lemieux (1996), Machado and Mata (2005), Bourguignon and Ferreira (2005), and Chernozhukov, Fernández-Val, and Melly (2013). See Fortin, Lemieux, and Firpo (2011) for a review of these methods.

<sup>5</sup>The empirical distribution function  $\hat{F}_Y$  puts mass equal to  $1/N$  on each observation  $y_i$ .

<sup>6</sup>The influence function of the Gini index has a more complicated form. It can be found in Firpo, Fortin, and Lemieux (2018), as can the IF for percentiles. A more comprehensive list with the IFs of other functionals often used by economists can be found in Rios-Avila (2020).

case, which can also be interpreted as a linear approximation of the conditional expectation, the regression coefficient of RIF on  $\mathbf{X}$  is  $\gamma_\nu$ :

$$(2) \quad E[\text{RIF}(Y; \nu, F_Y) | \mathbf{X}] = \mathbf{X}'\gamma_\nu.$$

In this case, the parameters in  $\gamma_\nu$  measure the partial effect of small location shifts in the distribution of covariates,  $\mathbf{X}$ , on the statistic  $\nu(Y)$ . Following Firpo, Fortin, and Lemieux (2018), we can estimate the parameters  $\gamma_\nu$  using ordinary least squares (OLS) and then apply the traditional OB decomposition to changes over time of the functional  $\nu(F_Y)$  of the earnings distribution:

$$(3) \quad \hat{\Delta}_O^\nu = \bar{\mathbf{X}}_1'(\hat{\gamma}_{\nu,1} - \hat{\gamma}_{\nu,0}) + (\bar{\mathbf{X}}_1 - \bar{\mathbf{X}}_0)' \hat{\gamma}_{\nu,0} = \hat{\Delta}_S^\nu + \hat{\Delta}_X^\nu.$$

The RIF-regression decomposition has some advantages over the alternatives. Perhaps the most important is that it enables detailed decompositions that are *path independent*, meaning the result does not depend on the order of the steps taken to estimate the contribution of each variable separately. This is a drawback in methodologies such as DiNardo, Fortin, and Lemieux's (1996). However, one limitation of the RIF regression is its reliance on the approximation of the conditional expectation of the  $\text{RIF}(Y; \nu)$  to be linear, which might be mis-specified.<sup>7</sup>

Another important limitation is the invariance of the conditional distribution assumption, which precludes changes in the conditional distribution  $F_{Y|\mathbf{X}}$  in response to changes in the distribution of  $\mathbf{X}$ . This rules out any general equilibrium effects arising from changes in parameters or endowments over time. Therefore, it answers counterfactual *ceteris paribus* questions such as “What would the Gini index in 2015 be if the returns to education were the same as in 2001, with all other factors remaining as they were in 2015?” or “What would the index be if education attainment was the same as in 2001 but returns remained as they were in 2015?” However, it does not provide any causal mechanism explaining why these changes happened and how agents responded to them. Nonetheless, these counterfactual scenarios help us understand what has changed and to what extent these changes account for changes in inequality.

Our application follows closely that of Ferreira, Firpo, and Messina (2022), but we adjust the period covered to 1995 to 2019, rather than 1995 to 2012. We use data from the Brazilian National Household Surveys, Pesquisa Nacional por Amostra de Domicílios, or PNAD (Instituto Brasileiro de Geografia e Estatística 2001–2015; Centro de Estudos da Metr pole 1981–1999), and extend the main analysis to 2019 by including data from the survey's newer, longitudinal version, the Pesquisa Nacional por Amostra de Domic lios Cont nua, or PNADC (Instituto Brasileiro de Geografia e Estatística 2012–2019).<sup>8</sup> Both surveys are representative of the entire Brazilian population and cover not only workers employed in the formal sector but

<sup>7</sup>We direct the reader to Fortin, Lemieux, and Firpo (2011) and Firpo, Fortin, and Lemieux (2018) for a more detailed discussion of this and other methods.

<sup>8</sup>The PNAD is an annual survey conducted from 1976 to 2015. The PNADC is a rotation panel survey, much like the Current Population Survey (CPS), that interviews households for five consecutive quarters, after which they are replaced by a new set of households that represent approximately 20 percent of the sample. Another household survey that could be used for inequality measures is the POF (Pesquisa de Or amentos Familiares), which collects information on household expenditures. However, the POF runs every five years, limiting its utility for decomposition analyses.

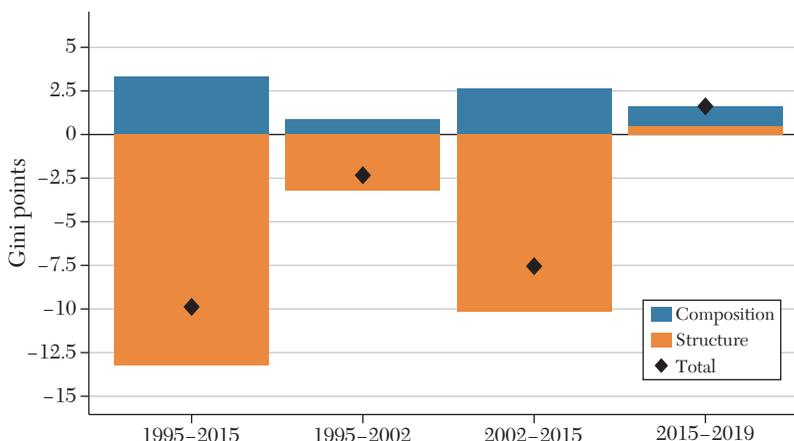


Figure 2. Gini Decomposition

Notes: This figure presents results of the aggregate decomposition across time periods. See equations (2) and (3). The samples for 1995 and 2002 include the next year, while 2015 and 2019 include the previous year. Data come from the PNAD (1995–2015) and PNADC (2018 and 2019). Black diamonds represent total changes in inequality. Results are estimated using the Stata package by Rios-Avila (2020).

self-employed workers and workers in the informal sector, which together represent a sizable share of the workforce in Brazil.<sup>9</sup>

The dependent variable is usual monthly wages, deflated to 2019 prices.<sup>10</sup> Explanatory variables include years of schooling (quartic), potential experience (quartic),<sup>11</sup> dummies for each race–gender combination, dummies indicating the type of labor contract (self-employed, informal, or formal), industry sector (17 categories), and regional variables (rural versus urban, and five region categories). Formal, White, male workers from the urban southeast region in the finance sector are the omitted group.

Figure 2 shows the results of the aggregate decompositions for selected periods. We are especially interested in the decline in inequality between 1995 and 2015, when the Gini index fell by 10 points. This reduction was primarily driven by changes in the wage structure,  $\hat{\Delta}_S^w$  (that is, changes in the coefficients in the RIF regressions). Hypothetically, if only composition effects,  $\hat{\Delta}_X^w$  (that is, only changes in the distribution of covariates  $\mathbf{X}$ ), were considered, inequality would have increased. The most significant reduction occurred between 2002 and 2015, with the Gini index decreasing by 7.5 points. Modifications in the wage structure in this period brought the Gini index down by more than 10 points, while composition effects increased it by 2.5 points. After 2015, the Gini index slightly increased, signaling an end to the period of declining inequality. This increase is mainly attributable to composition effects, with minimal

<sup>9</sup>Up to 2003, the PNAD did not cover the rural regions of northern Brazilian states, but they represent only a small share of the workforce.

<sup>10</sup>We use the Extended National Consumer Price Index (IPCA), provided by Instituto Brasileiro de Geografia e Estatística (2025) from 2002 onward, and the deflator suggested by Corseuil and Foguel (2002, table 2, p. 63) before that year.

<sup>11</sup>Age minus schooling minus six.

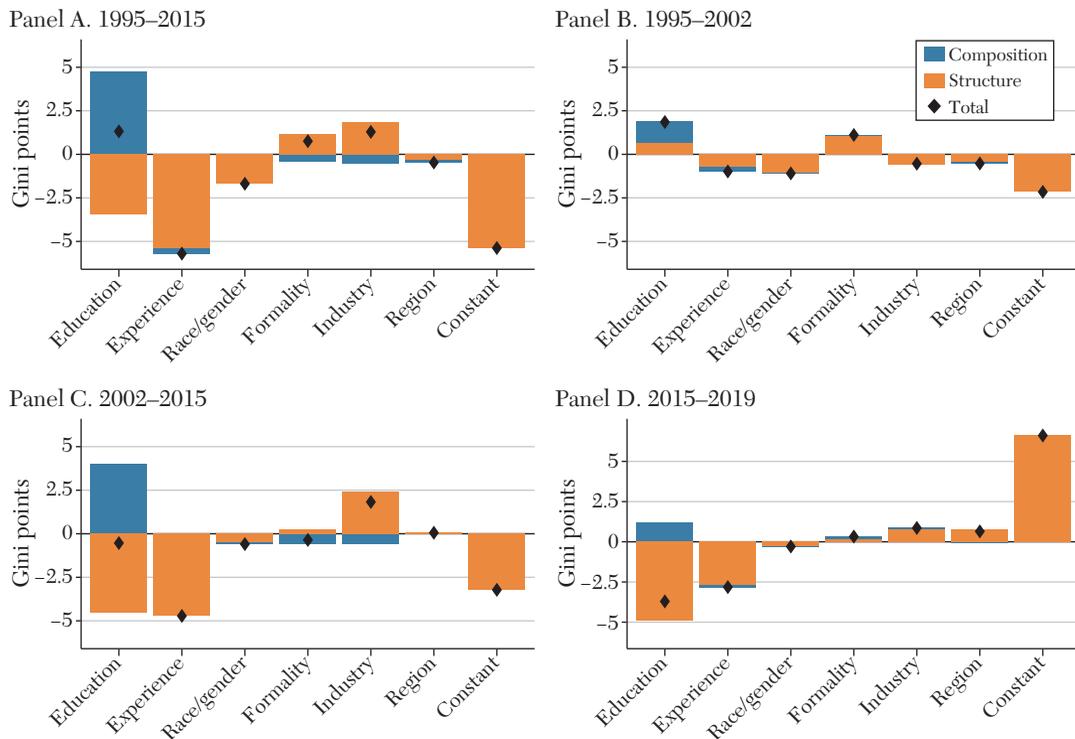


Figure 3. Detailed Decomposition

Notes: This figure presents results of the detailed decomposition across time periods, accounting for the role of each group of variables. See equations (2) and (3). The samples for 1995 and 2002 include the next year, while 2015 and 2019 include the previous year. Data come from the PNAD (1995–2015) and PNADC (2018 and 2019). Black diamonds represent net changes in inequality associated with each factor. Results are estimated using the Stata package by Rios-Avila (2020).

changes observed in the wage structure. These patterns reflect the changes documented in Figure 1.

Ferreira, Firpo, and Messina (2022) reach similar conclusions on the importance of structure effects from 1995 to 2012, also including the decomposition of other inequality measures. Campos-Vázquez et al. (2023) apply a similar methodology to Brazil and other Latin American countries between 2012 and 2019 and find the same patterns of inequality-increasing composition effects and inequality-reducing structure effects.

Figure 3 presents the results of the detailed decomposition, showing the effect of each variable on the Gini coefficient through composition and structure effects as well as their total effects. We consider the same four subperiods as in Figure 2. Starting with the effect of education, we see that between 1995 and 2015, education slightly increased inequality. This was driven primarily by the large composition effect arising from the higher educational attainment of the workforce, which was only partially offset by a structure effect. Reductions

in the education premium were only observed from 2002 to 2015, while between 1995 and 2002 it increased somewhat. As a result, between 1995 and 2002 education was associated with higher inequality through composition and structure effects, while between 2002 and 2015 the net effect was a reduction in inequality, with composition and structure effects moving in opposite directions and the latter being greater. We investigate the drivers of this reduction in the schooling premium in Sections 3, 4, and 5. The increase in inequality through composition effects has been labeled the *paradox of progress* (Bourguignon, Ferreira, and Lustig 2005), which we discuss in more detail in Section 5. The pattern remained the same after 2015, but the structure effect became much larger and accounted for a large reduction in inequality.

Figure 3 shows that potential experience accounts for nearly half of the decline in inequality between 1995 and 2015, corresponding to more than 5 Gini points. This effect is almost solely driven by changes in the experience premium, with almost no composition effects. Ferreira, Firpo, and Messina (2022) reach the same conclusion and point out that this has been a neglected factor in most studies on wage inequality in Latin America. The reduction was particularly salient between 2002 and 2015.

Race and gender are also important factors accounting (in the statistical sense) for the reduction in inequality. Between 1995 and 2015, structure effects arising from these variables correspond to a decrease in the Gini index of 1.7, with almost no change in the composition effect. This implies that while there were no considerable changes in the workforce regarding gender or race, there was a significant decline in what can be termed the discrimination component—that is, race and gender penalties conditional on other observed factors. This reduction was particularly large between 1995 and 2002. We discuss possible drivers of this decline in Section 7. Since 2015, changes in race and gender wage penalties have been minimal.

Between 1995 and 2015, the expansion of the formal sector contributed to the decrease in inequality through composition effects, particularly after 2002. However, the net effect was an increase in inequality, driven by structure effects between 1995 and 2002. We discuss how education and trade liberalization may have affected the size of the formal sector in Sections 5.3 and 4.1. Changes in industry premiums seem to account for an increase in inequality between 1995 and 2015, with these effects appearing mostly after 2002. These results, however, are imprecise and less robust. For instance, Ferreira, Firpo, and Messina (2022) find that these effects are not significant in each period taken separately and that they are only marginally significant across the whole period considered in their study. The same can be said of regional effects, which contributed to a slight reduction in inequality between 1995 and 2015.

A final important factor behind the reduction of inequality is a change in the constant, which captures changes in residual inequality and can be interpreted as a decrease in the return to unobserved skills (Acemoglu 2002; Ferreira, Firpo, and Messina 2022).<sup>12</sup> This accounts for around 5 Gini points between 1995 and 2015, approximately half of the total reduction. We discuss possible explanations for this change throughout this review.

<sup>12</sup>This can be illustrated using the case of the variance and a simple model with two uncorrelated skills. Suppose that log wages are given by  $y_{it} = \alpha_t + \beta_t x_{it} + \gamma_t \varepsilon_{it}$ , where  $x_{it}$  is an observed skill,  $\varepsilon_{it}$  is an unobserved skill, and  $\beta_t$  and  $\gamma_t$  are their respective returns in period  $t$ , while  $\alpha_t$  is a time effect. Assume that  $\varepsilon_{it}$  has a constant variance over time ( $\text{var}[\varepsilon_{it}] = \sigma^2$ ) and its distribution is independent of  $x_{it}$ . Hence,  $\text{var}[y_{it}] = \beta_t^2 \text{var}[x_{it}] + \gamma_t^2 \sigma^2$ , and an RIF regression would estimate the intercept  $\gamma_t^2 \sigma^2$ . The change in variance of  $y_{it}$  between periods 1 and 0 is given by  $\text{var}[y_{i1}] - \text{var}[y_{i0}] = \beta_1^2 \text{var}[x_{i1}] - \beta_0^2 \text{var}[x_{i0}] + (\gamma_1^2 - \gamma_0^2) \sigma^2$ , since  $\sigma^2$  is constant over time. Therefore, changes in the intercept capture changes in the return to unobserved skill  $\varepsilon$ .

In general, this decomposition exercise shows that the decline in the Gini index was mainly associated with a decrease in the return to experience and in residual inequality, followed by a decrease in racial and gender conditional gaps and other less important factors. The educational expansion in the period slightly increased inequality through a significant inequality-increasing composition effect, which was countered by an inequality-diminishing structure effect, especially in the 2000s. Increases in the formality premium also contributed to rising inequality, though a small composition effect in the 2000s helped reduce wage dispersion. Changes in industry premiums also increased inequality, especially after 2002, but these estimates are less precise.

These results are almost identical to those in Ferreira, Firpo, and Messina (2022). Fernández and Messina (2018) conduct analogous decompositions of wage ratios and find similar results for the education and experience premiums. Campos-Vázquez et al. (2023) decompose the change in inequality in Brazil between 2012 and 2019 and reach the same conclusions regarding the composition and structure effects of education.

Comparable results have been found in other countries, especially in Latin America. Lustig, Lopez-Calva, and Ortiz-Juarez (2013) investigate Brazil, Argentina, and Mexico and find that a decline in the skill premium is a key component of inequality reduction in the 2000s. Messina and Silva (2021) document the importance of the education and experience premiums as well as within-skill inequality in driving inequality down in 16 countries in the region. But related patterns are also observed on other continents. For example, the paradox of progress has been documented in other countries by Bourguignon and Ferreira (2005). Gradín et al. (2023) present inequality decompositions for 11 countries in Africa, Asia, and Latin America in the 2000s and 2010s, noting a decrease in inequality in at least one period in all countries except China and Indonesia. In almost every country investigated, changes in the earnings structure were the main driver of changes in inequality. They also report inequality-increasing composition effects of education in Asia and Latin America.

## 2.2 Firm and Worker Effects: The AKM Model in Brazil

Another important strand of research that decomposes changes in inequality is based on the seminal model of Abowd, Kramarz, and Margolis (1999), known as the AKM model. This model posits that wages are determined by workers' skill and a firm-specific premium, recognizing that some firms pay higher wages to equally skilled workers. Changes in inequality (variance of wages) are associated with changes in the variance of firm and worker effects and changes in the sorting between workers and firms. This methodology has been applied to several countries. Here, we focus on the results of Alvarez et al. (2018), who estimate the model using Brazilian data between 1996 and 2012.<sup>13</sup>

Formally, Alvarez et al. (2018) group the data between 1996 and 2012 in four periods of five years each.<sup>14</sup> For each period, the earnings equation is given by

$$(4) \quad \log y_{it} = \alpha_i + \alpha_{j(i,t)} + \Upsilon_t + \varepsilon_{it},$$

<sup>13</sup>Other applications to Brazil include Lopes de Melo (2018), Gerard et al. (2021), Engbom and Moser (2022), and Haanwinckel (2025). Song et al. (2019) apply this methodology to the United States and provide references of applications to other countries.

<sup>14</sup>They also consider two periods between 1988 and 1996 but do not include them in their analysis of changes over time, which is restricted to 1996–2012, when inequality decreased continuously.

where the log earnings of worker  $i$  in period  $t$ ,  $\log y_{it}$ , correspond to a worker fixed effect,  $\alpha_i$ , a firm component,  $\alpha_{J(i,t)}$ , a year effect,  $\Upsilon_t$ , and an error term,  $\varepsilon_{it}$ . Letting  $a_i, a_{J(i,t)}, Y_t$ , and  $e_{it}$  correspond to the estimates of each of these terms, the variance of log earnings within each of the four periods can be decomposed as

$$(5) \quad \text{var}[\log y_{it}] = \text{var}[a_i] + \text{var}[a_{J(i,t)}] + \text{var}[Y_t] + 2 \text{cov}[a_i, a_{J(i,t)}] + 2 \text{cov}[a_i, Y_t] \\ + 2 \text{cov}[a_{J(i,t)}, Y_t] + \text{var}[e_{it}].$$

The first term on the right-hand side is the variance of worker effects, and the second the variance of firms effects. Next are the variance of the year trend and the covariances between the worker and firm effects, as well as the covariances of these effects and the year effects. The last component is the variance of the error term. Following Card, Heining, and Kline (2013), changes in the overall variance of earnings between two periods are decomposed into the sum of changes in each of these factors in equation (5). Alvarez et al. (2018) focus on changes in the variance between the periods 1996–2000 and 2008–2012.

The AKM model requires large matched employer–employee data sets, which in the Brazilian case come from the *Relação Anual de Informações Sociais* (RAIS). One important limitation is that RAIS covers only the formal sector, thus excluding a considerable share of the economy. Although Meghir, Narita, and Robin (2015) and Ulyssea (2020) find overlaps in the productivity and size distributions of informal and formal firms, productivity and size differ on average. Workers in the informal sector also differ from workers in the formal sector. Furthermore, Engbom et al. (2022) show that part of the informality wage penalty in Brazil is due to differences in firm size.

Despite these limitations, the AKM model estimated by Alvarez et al. (2018) provides important insights into trends in Brazilian inequality. First, although worker effects account for more than half of the cross-sectional variance of log wages and firm effects around 20 percent, the decline in inequality between 1996 and 2012 was disproportionately explained by changes in firm effects: They account for 40 percent of the change in inequality, while the variance of worker effects corresponds to 29 percent. The remainder is attributable mainly to reductions in the covariance of worker and firm effects (23 percent) and the variance of the residual (9 percent), both of which are similar in size to their share of the cross-sectional variance. Together, the three terms involving the year effects make a negligible contribution.

Alvarez et al. (2018) also regress the predicted worker and firm effects on, respectively, a vector of worker and firm observables. Their results indicate that reductions in the pass-through of worker and firm characteristics to payment were important factors driving the overall decline in inequality. In other words, changes in the distribution of worker and firm characteristics—education, age, and productivity, for example—do not explain changes in inequality. Rather, a compression in the returns to these characteristics accounts for much of the change. According to their estimates, changes in returns to education and age account for 50 percent of the decrease in the variance of worker effects, or nearly 15 percent of the overall reduction in the variance of wages. Similarly, the large reduction in firm effects does not seem to be linked to changes in the distribution of observable characteristics, such as the value added per worker or the size of the firms, but to the pass-through of these characteristics to firm effects.

The results of the AKM and RIF regression decompositions reinforce each other in two ways. First, both suggest that changes in the wage structure were the main drivers of the reduction in inequality. Second, the compression in firms' wage premium in the AKM model aligns with the result of declining residual inequality from the RIF regression decomposition. To understand this, note that the survey data used in the RIF regression decomposition do not include information on firms. Hence, any changes in the way firms pay equally skilled workers over time will be incorporated as changes in residual inequality—that is, inequality not accounted for by changes in observable variables or their returns. The RIF regression decomposition captures a change in the way firms pay similar workers as a change in the intercept between two periods, which accounts for changes in residual inequality.<sup>15</sup>

There are not many other applications of the AKM model in developing countries. An exception is from Messina and Silva (2021), who decompose the variance of log wages into firm and worker components for Ecuador, Costa Rica, and Brazil. They find that the firm component also played an important role in the first two countries. In Ecuador, the pattern of reduction in inequality was similar to that in Brazil. Costa Rica provides an example in the opposite direction, with an increase in inequality resulting mainly from an increase in the firm component. Cruz and Rau (2022) use the AKM model to study changes in the gender pay gap in Chile between 2005 and 2013. Their results suggest that the equal pay law may have decreased the contribution of firm effects to the gender gap by 6.1 percent.

Taken together, the results of the RIF regression and AKM decompositions indicate that changes in the overall wage structure, which include returns to observed and unobserved skills and firms' pay premiums, account for most of the reduction in inequality in Brazil between 1995 and 2015. In particular, reductions in the return to experience and schooling seem important, although a composition effect emanating from a more educated workforce counteracted the latter. A reduction in wage penalties for female and non-White workers also contributed to decreased inequality. The compression in firm effects and returns to unobserved factors suggests that economy-wide changes in the pass-through from productivity to pay are also responsible for part of the inequality reduction. Other effects played a lesser role. They include composition effects from higher formality that slightly reduced inequality in the 2000s; regional gaps that decreased inequality, especially in the 1990s; and industry and formality premiums, which increased it.

In the next five sections, we follow the supply–demand–institutions framework (Katz and Autor 1999) to evaluate the causal mechanisms behind these patterns. We start by investigating whether supply and demand can account for changes in between-group wage differences and whether globalization and technological advances can help explain these patterns through changes in the demand for skilled labor. We also elaborate on the education expansion in Brazil and how it affected inequality through direct and indirect mechanisms. Last, we investigate how the minimum wage might have shaped the Brazilian wage distribution and what forces could account for the reduction in gender and racial gaps.

<sup>15</sup>See footnote 12. In that simple model, the unobserved skill could be interpreted as a firm pay premium, whose dispersion decreases between two periods.

### 3. *Supply, Demand, and Between-Group Wage Premiums*

Inequality is closely related to wage differences between groups defined by demographic characteristics and skills. If labor markets are roughly competitive, changes in the wage structure are ultimately determined by the relative demand for the labor of each of these groups and by their relative supply. An influential approach to estimating the importance of each of these factors was developed by Katz and Murphy (1992). They used changes in relative wages and supply of several groups of workers in the United States between 1963 and 1987 to estimate how different demand shifts can explain movements in these two variables. Their conclusion, corroborated by others (for example, Bound and Johnson 1992), is that higher demand for skilled workers, not met by an increase in their supply, led to a growth in the skill premium and inequality. Other developed countries displayed similar patterns. This led to investigations of the drivers of these changes in relative demand, focusing mainly on biased technological change and globalization (Katz and Autor 1999).

The framework can be summarized as an aggregate production function that employs  $K$  types of labor input. Katz and Murphy (1992) and most subsequent studies assume constant elasticity of substitution (CES) functions, which yield elasticities of substitution and productivity shifters that affect the relative wage of each group. Applications vary in how they define types of labor input and in the shape of the production function, which can include multilevel nests across labor inputs. Workers are grouped by characteristics such as education, experience, and gender, and the approach uses data on their relative labor supply and wages over several periods. These studies assume the supply of labor is exogenous and inelastic in the short run and that the labor market operates at the competitive-equilibrium demand curve. These are strong assumptions that allow researchers to derive closed-form relative-wage functions for each group of workers. The elasticity of substitution and the relative productivity parameters are estimated based on these wage functions. Predicted changes in the wage premium based only on changes in relative labor supply are then contrasted with observed changes to assess the importance of relative demand trends in explaining the evolution of relative wages.

The main advantage of this method is that it allows one to easily evaluate the determinants of changes in the wage premium across skill groups, something decomposition exercises are unable to do. However, this comes at the cost of restricting differences in wages to these wage premiums, removing any within-group dispersion in wages, which might be an important component of inequality. Despite this limitation, this approach still provides important information to assess the determinants of changes in inequality. This is particularly the case in Brazil, where returns to education and experience played such an important role in the reduction of inequality, especially in the 2000s, as shown in Section 2.

The framework of Katz and Murphy (1992) has been applied to study differences in skill and experience returns in Brazil and other Latin American countries by Manacorda, Sánchez-Páramo, and Schady (2010), Fernández and Messina (2018), and Acosta et al. (2019). Here, we focus on the work of Fernández and Messina (2018), who restrict their analysis to Argentina, Chile, and Brazil. They estimate two elasticities of substitution between educational groups: one between skilled (college) and unskilled (secondary and primary school) workers, and another within the unskilled group, between secondary and primary school graduates. They also estimate elasticities of substitution across four experience groups within each educational group: 0–9, 10–19, 20–29, and 30 or more years of potential experience. They extend the model of Manacorda, Sánchez-Páramo, and Schady (2010) by not assuming

a constant elasticity of substitution between education groups. Moreover, they extend the previous framework by allowing for differential demand trends across experience groups, since the experience premium played such an important role in accounting for changes in inequality. One limitation of their work is that they pooled data from all three countries, so estimates might not provide precise information for each country individually.

Fernández and Messina (2018) estimate the elasticity of substitution between workers with high school and primary school education to be 2.3, but that between college-educated and unskilled workers to be only 1.25. This means skilled labor, especially college-educated workers, is not easily replaced with unskilled labor. For Brazil, the predicted change in the high school premium due to changes in labor supply is  $-68.4$  log points, quite close to the observed reduction of  $-71.9$  log points. The reduction in the college premium predicted by changes in relative supply was  $-67.1$  log points, while the observed decline in Brazil was  $-56.6$  log points. Therefore, changes in relative supply played a more important role in explaining changes in the returns to education in Brazil than did changes in relative demand. Nonetheless, there seems to be room for an increase in the relative demand for skilled workers, as the college premium fell less than predicted by changes in relative supply. We discuss other determinants of the education premium in the next sections.

The results for Argentina and Chile from Fernández and Messina (2018), as well as those from Manacorda, Sánchez-Páramo, and Schady (2010) and Acosta et al. (2019), place more importance on demand shifters rather than changes in supply.<sup>16</sup> Manacorda, Sánchez-Páramo, and Schady (2010) estimate a similar model for the same countries as in Fernández and Messina (2018), plus Mexico and Colombia, covering the 1980s and 1990s. Their results suggest an increase in relative demand that accounts for the growth in the skill premium during the 1990s. Acosta et al. (2019) use data from 16 Latin American countries, including Brazil, between 1991 and 2013 and find a more restricted role for changes in relative labor supply. They highlight that negative demand shifts account for part of the decline in the college premium in the region. Because these studies apply the supply–demand framework to a larger and more diverse set of countries and use a less flexible framework—without experience groups and using elasticities of substitution from the literature—Fernández and Messina (2018) probably provide a better picture of what happened in Brazil in the period.

Some researchers have focused their models exclusively on Brazil but have used different frameworks from that of Katz and Murphy (1992). They include Mak and Siow (2025), Jaime (2021), Haanwinckel and Soares (2021), and Haanwinckel (2025). The first three corroborate the findings of Fernández and Messina (2018) on the importance of supply changes in accounting for changes in the skill premium. Counterfactual exercises from Haanwinckel and Soares (2021) also suggest that changes in workforce composition and productivity account for part of the compression of the firm-size premium, which is associated with firm-specific effects and played an important role in the reduction of inequality (Alvarez et al. 2018).

Different results emerge from Haanwinckel (2025), whose findings suggest a greater role for changes in relative demand in reducing the college and high school premiums, especially

<sup>16</sup>In Fernández and Messina (2018), the observed and predicted high school premiums in Argentina were  $-12.7$  log points and  $-31.9$  log points, respectively. For the college premium, the figures were respectively  $-46.8$  and  $-35.1$  log points. For Chile, they were  $-31.1$  and  $-51.1$  log points for the high school premium and  $-32.8$  and  $-23.1$  for the college premium.

the latter.<sup>17</sup> This finding partially stems from imperfect competition and general equilibrium conditions embedded in Haanwinckel's model. He shows that increases in the supply of skilled workers act through two channels. One is the direct supply channel, which consistently leads to a lower skill premium. The second channel is through reallocation of labor to high-productivity firms, potentially resulting in a higher skill premium where firms have high monopsony power.

While expansions in the supply of college graduates have been shown to increase the skill premium elsewhere (Blundell, Green, and Jin 2022; Carneiro, Liu, and Salvanes 2023), it is unclear whether this finding can be extended to Brazil. First, the mechanism suggested in his model—worker reallocation and firm creation—should also be confirmed in the data. Second, this result could be sensitive to some model specification choices, such as the number of goods, which is important when determining workers' productivity. Finally, his application is restricted to formal workers. A consequence is that the decrease in the skill premium is smaller in his model than documented for the whole economy (for example, Fernández and Messina 2018), which could influence the results.

Although the research reviewed so far has mostly suggested that the expansion in supply appears to be the main determinant of the reduction in the skill premium in Brazil, alternative explanations have been proposed. These include trade liberalization, the commodity boom, technological change, poorer quality of education following its expansion, and the rise in the minimum wage. We evaluate these channels in the following sections.

Fernández and Messina (2018) also investigate how changes in relative supply and demand affect the experience premium. They estimate elasticities of substitution between the experience groups to be greater than the elasticities between the educational groups. Here, we focus on the experience premium of workers with 20–29 years of experience over workers with only 0–9 years. Among unskilled workers (those with up to a high school degree), the estimated elasticity was 3.6, while for skilled workers (college degrees) it was 5.5. Hence, experienced workers are easier to replace among skilled workers than unskilled workers. However, observed changes in the relative supply of experience groups predict only an 11.3 log point reduction in the experience premium for unskilled workers, compared to an observed reduction of 26.6. Meanwhile, for college graduates the observed decline in the experience premium was also 26.6 log points, whereas the predicted drop based only on changes in relative supply is 6.9 log points. These results point to a more prominent role for changes in relative demand in explaining changes in return to experience.

The literature lacks good explanations for the reduction in the experience premium. One possibility is skill obsolescence (Campos-Vazquez, Lopez-Calva, and Lustig 2016), in which skills learned in the past become depreciated because of rapid technological changes. This hypothesis is closely related to the idea of age-biased technological changes (Behaghel and Greenan 2010). However, the evidence for Brazil does not appear to corroborate this hypothesis (Messina and Silva 2018). Another explanation is the minimum wage, which might be an important determinant of experience-premium compression if it is more binding on younger workers than older ones. Engbom et al. (2022) explore patterns of inequality within cohorts as they age, and their descriptive evidence points in this direction. However, there is no formal test of the hypothesis that the minimum wage has affected the experience premium. Another possibility is that the expansion of higher education may have resulted in a delayed

<sup>17</sup>See his discussion on demand shocks in Supplemental Appendix D, particularly Table D7.

labor market entry but caused higher initial wages. At the same time, incentives for retirement may induce experienced workers with high earnings to retire earlier. Developing models capable of testing these possibilities is an important avenue for future research.

#### 4. *Changes in the Demand for Labor: Globalization and Technological Change*

Katz and Murphy (1992) and related studies highlight that increases in relative demand for skilled workers have been an important factor behind the increase in inequality in the United States and other developed countries since the late 1970s. This spurred a literature that aimed to understand the determinants of this trend. Two explanations became prominent. First, globalization has led to outsourcing and increased competition with developing countries, resulting in lower demand for unskilled workers in rich countries. Second, skill- or routine-biased technological change increased the demand for more skilled workers and increased their relative wages (Katz and Autor 1999; Acemoglu 2002; Acemoglu and Autor 2011; Autor and Dorn 2013; Autor and Handel 2013; Goos, Manning, and Salomons 2014).

In this section, we investigate the possible impacts each of these factors may have had on the Brazilian wage distribution in recent decades. We start by discussing the impacts of the trade liberalization episode in Section 4.1 and changes in commodity prices in Section 4.2, focusing on their effect on the skill premium.<sup>18</sup> Section 4.3 discusses research on the impact of technology on the skill premium and wage distribution in Brazil.

##### 4.1 *Trade Liberalization and Its Impact on Inequality*

It is widely agreed among economists that international trade can affect the distribution of earnings within countries by changing the relative prices of goods and factors of production. For instance, the Stolper–Samuelson theorem predicts that increases in the relative price of a good will increase the remuneration of the factor most intensively used in its production. An implication is that trade liberalization will increase the relative price of the relatively more abundant factor of production. By considering two types of labor, skilled and unskilled, this theorem can help us understand how reduced trade barriers affect the skill premium. Because developing countries are relatively more abundant in low-skilled labor, trade liberalization should decrease the skill premium. This is the opposite of the prediction for developed countries, where international trade is associated with a higher skill premium (Katz and Autor 1999; Goos, Manning, and Salomons 2014).

During the late 1980s and early 1990s, many developing countries in Latin America and other regions enacted large tariff reductions. This has provided researchers with fertile ground for investigating the impacts of trade liberalization, including its distributive effects. In general, evidence suggests that the Stolper–Samuelson mechanism has not been quantitatively important to affect inequality in the region, since most Latin American countries have seen the relative wages of skilled workers increase after episodes of trade liberalization (Attanasio, Goldberg, and Pavcnik 2004; Goldberg and Pavcnik 2007; Pavcnik 2017). Moreover, there was scant evidence of between-sector mobility, at least in the short run, an important assumption

<sup>18</sup> Here, we focus on the Brazilian experience. For more comprehensive reviews of this literature, we refer the reader to Goldberg and Pavcnik (2007), Pavcnik (2017), and Dix-Carneiro and Kovak (2025).

in previous general equilibrium models of trade. These findings motivated the development of new models that emphasize other aspects of trade (Dix-Carneiro and Kovak 2025).

Following the overall trend in the region, Brazil experienced a large decrease in protectionism during the late 1980s and early 1990s. Ferreira, Leite, and Wai-Poi (2007) report that the average nominal tariff was reduced to 13.9 percent in 1995 from 43.4 percent in 1987. The effective rates dropped even more, to 20.0 percent from 55.8 percent. Unlike in Latin American countries, early research on trade liberalization using Brazilian data detected a reduction in the skill premium due to this episode (Gonzaga, Menezes Filho, and Terra 2006; Ferreira, Leite, and Wai-Poi 2007). Ferreira, Leite, and Wai-Poi (2007) suggest that a possible explanation for the distinct results is the higher incidence of tariff reductions in more skill-intensive industries in Brazil, while tariff cuts were more prominent in sectors that employed more unskilled labor in other Latin American countries. Therefore, skill-intensive industries were more affected in Brazil, and consequently there was a decrease in the relative wages of skilled workers, reducing inequality. Other Latin American countries experienced the opposite trend.

This early literature focused only on short-term impacts between 1988 and 1995, a period marked by hyperinflation and volatile inequality trends. More recent research expanded the time horizon to a longer period, up to 2010, covering the inequality reduction we are interested in here.

Dix-Carneiro and Kovak (2015) explore how the reduction of Brazilian tariffs affected regional skill premiums using a local labor market methodology and census data from 1980 to 2010.<sup>19</sup> They assume the Brazilian economy is composed of a set of small economies without labor mobility between them. Each region is endowed with skilled and unskilled labor, together with a vector of industry-specific factors, leading to different industry shares between regions. Industries differ by the intensity with which they use skilled and unskilled labor. In their framework, the impact of a uniform tariff reduction on the regional skill premium is mediated by the differential industry composition of each region, weighted by the share of skilled workers employed by each of them. Therefore, the skill premium should fall more in regions more exposed to the tariff decline because their industries employed larger shares of skilled workers.

Their results show that regions faced with more tariff reductions experience larger reductions in the regional skill premium. The effects are significant and similar in magnitude in the 1991–2000 and 1991–2010 periods, meaning that changes in tariffs can have long-lasting effects on skill premiums. Studying the longer period, they estimate that trade liberalization in the late 1980s and early 1990s was responsible for 11 percent to 14 percent of the observed decline in the skill premium. Their main definition of skilled labor divides workers into those who graduated in high school and those who did not. When they instead use a definition based on college completion, the explanatory power is reduced by half.

However, the Stolper–Samuelson theorem is only one mechanism that connects trade and inequality. Among recent alternatives, firm heterogeneity has been suggested as an important channel, as exporting firms are larger and pay higher wages than non-exporting firms. Helpman et al. (2017) look for possible impacts of trade liberalization on interfirm wage differences and

<sup>19</sup>These labor markets are defined based on micro-regions, which are groups of municipalities developed by the Brazilian Bureau of Statistics based on the integration of their local economies.

wage inequality in Brazil between 1986 and 1995.<sup>20</sup> They observe increasing importance in the variance of wages within sectors and occupations in explaining overall wage inequality in the period, in line with findings from Alvarez et al. (2018). Firms select into export or non-export activities based on their productivity and fixed costs of exporting, whereas different screening costs enable firms of the same size to pay different wages.

Based on their model, a reduction in tariffs should result in a higher share of workers in the exporting sector, increasing wage inequality. Focusing only on the formal manufacturing sector, they document that between 1986 and 1995, Brazil experienced a 10 percent increase in the share of workers employed by exporting firms. Their model predicts an increase in the standard deviation of log wages of 2 percent in the period, while the observed increase was 8 percent.

To better assess this result from Helpman et al. (2017), first note that the mechanism being tested is interfirm wage dispersion, not the skill premium, so this result does not necessarily conflict with those of Dix-Carneiro and Kovak (2015) and the prior literature. Second, their period ends in 1995, so it does not cover the unambiguous decline in inequality we are interested in. To our knowledge, no study has tested this mechanism in a longer period.

Perhaps most importantly, including the informal sector might affect the results in Helpman et al. (2017) because of general equilibrium effects, as Dix-Carneiro et al. (2024) suggest. Research shows that regions more exposed to Brazilian trade liberalization experienced a greater long-term reduction in formal employment compared to less exposed regions, with reallocation to informal employment being a significant adjustment margin (Dix-Carneiro and Kovak 2017, 2019; Ponczek and Ulyseia 2022). However, these results are based on difference-in-differences strategies that compare regional outcomes and cannot estimate labor impacts from general equilibrium effects common to all regions. For example, such effects could influence overall unemployment and informality levels through higher productivity, despite benefiting some regions more than others.<sup>21</sup>

Dix-Carneiro et al. (2024) develop a model to capture general equilibrium effects in economies with large informal sectors. In the model, trade openness increases inequality in the formal manufacturing sector, as in Helpman et al. (2017), but when including the informal sector, cross-firm wage inequality decreases. Despite negative local effects increasing relative informality in more exposed regions, Dix-Carneiro et al. (2024) find an overall reduction in informality through general equilibrium effects, reallocating resources to more efficient formal firms and potentially affecting inequality. One limitation of their work is that they do not quantify trade liberalization's effect on inequality or informality for the period.

The results reported here indicate that the trade liberalization episode helped reduce inequality in Brazil during the period, especially through a decrease in the skill premium. This effect, however, was small, accounting for 11 to 14 percent of the observed decrease in the skill premium. Although other mechanisms might have played a role, such as compressing the firm-specific premium and reducing overall informality through resource reallocation across firms, the evidence on these channels is less robust and their magnitudes have not been measured over the long run.

<sup>20</sup>Notice that this period is different from the one investigated by Gonzaga, Menezes Filho, and Terra (2006) and Ferreira, Leite, and Wai-Poi (2007), which starts in 1988. This is relevant because inequality was higher in 1988 than in 1995 but lower in 1986 than in 1995.

<sup>21</sup>For a detailed exposition, see Dix-Carneiro and Kovak (2025).

#### 4.2 *The Commodity Boom*

During the 2000s, Brazil experienced a large improvement in its terms of trade caused by a surge in commodity prices. Other Latin American countries were also affected by this shock, and there is some suggestive evidence that this might help account for the reduction in inequality in the region. For example, Messina and Silva (2021) show that the South American economies, which benefited more from the commodity boom than the countries of Central America and Mexico, were the ones that experienced the greatest reductions in inequality.

This commodity boom was largely driven by China's increasing presence in international trade flows. China's share in the total value of Brazilian exports and imports expanded dramatically between 2000 and 2010, from 2 percent to 14.5 percent and 2.3 percent to 15.1 percent, respectively. The expansion in exports sent to China was mainly driven by agricultural and extractive products, whereas manufactured goods were the primary drivers of increases in imports (Costa, Garred, and Pessoa 2016).

There is evidence of differential impacts of the so-called China shock between regions based on their initial industry composition. Costa, Garred, and Pessoa (2016) explore these regional differences to investigate the impact of the increase in China's import penetration and the increased demand for some Brazilian products. Using data from the Brazilian Census, they show that local labor markets at the eightieth percentile of exposure to increased demand experienced a 0.93 percentage point higher increase in average wages than regions in the twentieth percentile. Similarly, labor markets in the eightieth percentile of exposure to imports from China experienced a 0.82 percentage point drop in average wages of manufacturing workers. Labor markets more exposed to export shocks also increased the share of formal jobs. Finally, Costa, Garred, and Pessoa (2016) also investigate the impact of these shocks on within-region inequality and find that greater import penetration is associated with higher local wage inequality, but they find no effect from export penetration.

If the commodity boom has distinct impacts according to industry composition, we expect that differences in the intensive use of skilled versus unskilled labor across these industries may result in changes in the skill premium and wage inequality. In fact, as documented by Benguria, Saffie, and Urzua (2023), the industries in the commodity sector of the Brazilian economy are more unskilled intensive than in the tradable manufacturing sector, while the non-tradable sector is the most skill intensive.<sup>22</sup> Furthermore, the distribution of the skill intensity of industries in the commodity and tradable sectors is more homogeneous than in the non-tradable sector.

Adão (2016) and Benguria, Saffie, and Urzua (2023) explored this issue empirically. They use differences in industry composition across local labor markets to assess the impact of the commodity boom on the skill premium and wage inequality in Brazil. The first study develops a Roy model, in which heterogeneous workers self-select into commodity and non-commodity sectors based on their productivity in each of them. Higher commodity prices increase the wages of both skilled and unskilled workers, but benefit unskilled workers more because the commodity sector employs them with higher intensity. As a result, workers reallocate across sectors and the regions specializing in producing commodities see a convergence in wages with more industrialized regions. Using data from the Brazilian Census, Adão (2016) estimates

<sup>22</sup>The commodity sector includes agriculture, mining, and fuels. Skilled labor is defined as the college-educated labor force.

that this process accounts for 5 to 10 percent of the reduction in the variance of log wages between 1991 and 2010.<sup>23</sup>

Benguria, Saffie, and Urzua (2023) use matched employer–employee data from the RAIS to investigate the transmission mechanism of commodity booms through labor markets. They consider two channels through which higher commodity prices might affect the economy: a cost channel, resulting from higher labor demand in the commodity sector; and a wealth channel, arising from higher income and increasing demand for products sold in local markets. They show that higher commodity prices are associated with a lower skill premium. The changes in prices observed between 2002 and 2011 were responsible for a 7 log point drop in the skill premium.<sup>24</sup> They also show significant employment reallocation across sectors. Because the tradable sector is more intensive in unskilled labor, it suffers larger employment losses. Furthermore, the wealth effect increases demand locally, so exporters suffer higher employment losses than non-exporters. These mechanisms can have other effects on inequality. First, they compress firm effects because exporting firms are larger and pay a higher premium. Second, these reallocations could lead to changes in industry premiums and composition. However, the authors do not quantify these effects.

Other mechanisms have also been proposed as channels that connect the commodity boom and the reduction in wage inequality, including currency appreciation. As the value of the domestic currency increases, exporting firms suffer losses, which can trigger the mechanism described in the model developed by Helpman, Itskhoki, and Redding (2010). Since exporting firms are larger and pay higher wages, and because interfirm wage dispersion is lower within the non-tradable sector, the reallocation of labor from the exporting to non-tradable sector should result in decreased wage dispersion. Messina and Silva (2018) argue that this is a potential mechanism behind the decrease in wage inequality in Brazil, where two-thirds of the decrease in inequality between workers in the same sector and occupation occurred through a reduction in wage variance between firms. However, there was no rigorous test of these mechanisms.

In general, these results suggest that the boom in commodities contributed to the decrease in the skill premium and inequality, accounting for 5 to 10 percent of the observed decrease. The commodity sector employs mainly low-skilled workers, and the higher demand for commodities boosted their wages. At the same time, a wealth effect helped increase demand locally, which also translated into lower earnings inequality. Other channels, such as currency appreciation, are also possible but have not been properly tested.

### 4.3 *Technological Change*

Technological change that favors high-skilled workers has become the leading explanation of increasing inequality in developed countries (Katz and Autor 1999; Acemoglu 2002; Autor and Handel 2013; Goos, Manning, and Salomons 2014; Acemoglu and Restrepo 2022). However, it remains unclear whether technological change had the same impact on developing

<sup>23</sup>Adão (2016) argues that the regions more affected by the increase in commodity prices had lower average wages. Hence, it is possible that the commodity boom also affected overall inequality through a reduction in the regional premium, but they do not explore this channel.

<sup>24</sup>Fernández and Messina (2018) document a decline in the college premium, relative to secondary and primary schooling, of 56.6 log points between 1995 and 2013 for the entire Brazilian economy.

countries. In fact, their different skill endowments and positions in global value chains have led them to specialize in more routine-intensive jobs (Grossman and Rossi-Hansberg 2008). Evidence suggests that even the same occupations are more routine intensive in developing countries, implying different technologies used in similar jobs (Lewandowski et al. 2022; Caunedo, Keller, and Shin 2023). Using country-specific rather than uniform data on occupational task content yields the result that deroutinization of work is taking place at a faster rate in developed countries (Lewandowski, Park, and Schotte 2023). Hence, it would be no surprise if the impact of technological changes in developing countries were lower than in rich countries or even absent.

Studies on technological change in developed countries have associated it with general economic patterns such as increasing earnings inequality and employment polarization: the growth of jobs at the top and bottom of the earnings distribution and a decline in the share of middle-wage workers (Autor, Katz, and Kearney 2006; Goos, Manning, and Salomons 2014). Some studies have examined these general trends in developing countries as well. The evidence is mixed but does not appear to suggest widespread patterns of polarization in recent decades (Maloney and Molina 2016; Messina and Silva 2021; Das and Hilgenstock 2022; Brambilla et al. 2023; Gradín et al. 2023; Martins-Neto et al. 2024). Regarding Brazil, Maloney and Molina (2016) argue that some trends suggest polarization, while Messina and Silva (2021) and Firpo et al. (2023) find pro-poor growth patterns after analyzing wage changes throughout the wage distribution. Brambilla et al. (2023) study Brazil and five other Latin American countries and find no evidence of polarization, with employment increasing more over time in occupations with higher initial wages. At the same time, as we describe in Section 3, Fernández and Messina (2018) find that the college premium decreased less than predicted by the expansion in the relative supply of college workers. Therefore, despite the lack of clear evidence of polarization, it is possible that skill-biased technological change attenuated the reduction in the education premium caused by the expansion of higher education.

Although the evidence of polarization in Brazil is weak, Firpo et al. (2023) observe a decrease in the intensity of routine tasks resulting from changes in occupational composition. This reduction was greater among workers at the bottom and middle of the wage distribution. Using RIF regression decomposition, they show that changes in routine-task intensity had a small but robust inequality-decreasing composition effect between 2002 and 2012. They also find negative effects due to changes in returns to routine-task intensity, but these effects are sensitive to whether intensity is measured using O\*NET task content or country-specific information; the effect is only statistically significant for the first.<sup>25</sup> Furthermore, Firpo et al. (2023) mention that including routine-task intensity in their analysis leads to a reduction in the importance of changes in education as drivers of the decline in inequality.

Some studies have modeled the Brazilian economy using production technology based on task differentiation. Jaume (2021), for instance, develops a Ricardian economy with a unique good that is produced by the combination of infinitely many occupations that also vary in complexity. In his analysis of changes in occupational composition in Brazil between 1995 and 2014, he observes that it changes much less than the educational composition of the workforce. In his model, an educational expansion without changes in production technology

<sup>25</sup>Note that the Brazilian country-specific routine-task intensity measure does not rely on microdata collected in Brazil but is constructed using predictions based on data from other developing countries.

results in lower occupational attainment for each educational group, meaning that workers perform simpler tasks on average.

The model successfully captures changes in occupational structure, predicting reductions in the mean occupation ranking for each educational group similar to those observed in the data.<sup>26</sup> For workers with at least a college degree, the model predicts a decrease of 0.042 points, on a scale ranging from 0 to 1, while the decline in the data is 0.058 points. The model also predicts changes in the skill premium. For example, the college premium relative to those with high school education decreases by 12.4 percent in the data, and the model predicts a drop of 12.7 percent. Similar predictions are made for other educational groups. These findings can help us understand the inequality-reducing structure effect found by Firpo et al. (2023), as the decline in mean occupation ranking is higher for high- and medium-educated workers than low-educated workers. In addition, they suggest a limited role for technological change in the Brazilian economy, especially in contrast to the large educational expansion during the period.

Haanwinckel (2025) also models the Brazilian economy using a task-based production function and investigates the impacts of changes in education and skill-biased demand shocks. As mentioned, his model suggests an important role for demand shocks in reducing inequality and the skill premium. However, the demand shock includes several components: task productivity, consumer taste, entry costs, and total factor productivity. Therefore, he cautions against interpreting changes in each of these components individually as skill-biased technological changes or shocks from trade openness.<sup>27</sup>

The articles discussed above provide indirect evidence on technological change in Brazil, with few studies directly investigating its impacts. One such study is by Almeida, Corseuil, and Poole (2018), who evaluate the expansion of digital technology in Brazil in the early 2000s through the differential rollout of internet service, varying by municipality, industry composition, and time. This study suggests that firms in municipalities with early internet access and intensive information technology use were incentivized to replace routine and manual jobs with cognitive, nonroutine tasks, potentially increasing inequality.

In contrast, two recent studies caution against viewing technological changes as inevitably linked to labor replacement and inequality, at least in Brazil. De Souza (2022) examines a policy taxing foreign technology leases, using the revenue to subsidize domestic patent development. An increase of 1 percentage point in the share of Brazilian firms issuing patents decreases the skill premium by 0.02 percent while production drops by 0.2 percent. This suggests that while foreign and domestic technologies vary in skill intensity, productivity differences likely outweigh redistribution gains.

Another example is by de Souza and Li (2024), which extends the framework of Acemoglu and Restrepo (2022) to include tools that complement labor instead of replacing it, unlike robots. They examine changes in tariffs on these machines combined with differences in local exposure to labor replacement, using them as instruments in a strategy similar to Acemoglu and Restrepo (2022) and Dix-Carneiro and Kovak (2017, 2019). They find that importing robots in Brazil decreased employment, while importing tools increased it by a similar amount. These effects are focused on low-skilled workers, affecting their wages in similar directions.

<sup>26</sup>Occupations are ranked based on their median wage, so higher-ranked occupations have higher median wages. He uses the ISCO-88 three-digit occupation definition.

<sup>27</sup>See his discussion in Section D.8.2.

They model the Brazilian economy to fit these findings, showing that the price decrease of robots and tools from 1997 to 2014 led to little change in employment but reduced the skill premium by 10 percent.

Finally, technological advances in developed countries might have an indirect effect in poorer countries through global value chains. For instance, evidence suggests that robot adoption in the United States is related to lower employment in Mexico due to reshoring—the return of production previously offshored to Mexico back to the United States (Faber 2020). Similarly, Stemmler (2023) shows that higher exposure to foreign automation in Brazil decreases the employment share in manufacturing and increases the share in mining, but the effects are small. In addition, domestic automation appears to benefit higher-skilled and female workers. However, Stemmler (2023) does not estimate how domestic or foreign automation affect the wage premium or inequality.

In summary, the literature is far from conclusive on the effects of technological change on inequality in Brazil. Although some evidence indicates the presence of skill-biased technological change, its magnitude seems to be small and it is likely canceled out by other demand changes or economic mechanisms triggered by an increase in the relative supply of educated workers. Nonetheless, we caution that there are few studies on this topic, which deserves more attention, both in Brazil and in other developing countries.

### 5. *Changes in the Labor Supply: Education and Inequality in Brazil*

Large expansions in educational systems are known to be important drivers of equality in developed countries (Goldin and Katz 2009). Brazil and other Latin American countries went through great expansions in their educational systems in the late 1990s and 2000s, both in secondary and postsecondary education (Bassi, Busso, and Muñoz 2015; Ferreyra et al. 2017). Some researchers found that these changes helped reduce inequality in the region (Barros et al. 2010; Lustig, Lopez-Calva, and Ortiz-Juarez 2013). However, this conclusion has recently been challenged. As shown in Section 2, the decreases in the education premium accompanied an inequality-increasing composition effect in Brazil, thus reducing and even reversing the gains from the lower premium. Ferreira, Firpo, and Messina (2022), Ariza and Montes-Rojas (2019), Ferreira, Leite, and Litchfield (2007), Fernández and Messina (2018), and Campos-Vázquez et al. (2023) reach similar conclusions.

That expansions in educational attainment lead to an increase in inequality through a composition channel has been labeled the *paradox of progress*, and was first suggested by Bourguignon, Ferreira, and Lustig (2005b). They found this pattern in Argentina, Colombia, Indonesia, Malaysia, and Mexico, but not in Brazil (between 1976 and 1996), China, and Taiwan. More recently, the paradox has been observed in Argentina, Chile, Colombia, and Mexico (Beccaria, Maurizio, and Vázquez 2015; Ariza and Montes-Rojas 2019; Alejo et al. 2024; Campos-Vázquez et al. 2023). With a general equilibrium model of the Brazilian economy, Haanwinckel (2025) finds that the expansion in education increased the variance of log wages, even though the increase in the supply of skilled labor reduced the skill premium. Hence, the paradox does not seem to be only a product of *ceteris paribus* decomposition exercises.

Two sufficient conditions have been suggested for increases in average education to result in higher inequality (Bourguignon, Ferreira, and Lustig 2005; Alejo et al. 2024). The first is that the returns to education are convex. A second reason is that the returns to education are

more heterogeneous among more educated workers. Therefore, as educational attainment increases, workers' wages become more dispersed, resulting in higher inequality.<sup>28</sup>

Because these results contradict some previous research, they deserve some attention. For instance, Barros et al. (2010) used microsimulations to decompose changes in Brazilian inequality arising from education due to quantity (composition) and price (return) effects. They find that both effects contribute to a decline in inequality, although the quantity effect is smaller.<sup>29</sup> They document that the standard deviation of years of schooling reached a peak around 2001 and declined thereafter, which should result in lower inequality.

Replicating the analysis of Barros et al. (2010) using the RIF regression methodology instead of microsimulations, we find that composition effects associated with education continue to increase inequality.<sup>30</sup> Because their methodology is path dependent, the order in which results were estimated could explain the diverging conclusions. Another possibility lies in the way that microsimulations impute residuals from wage regressions. If within-group heterogeneity in returns is an important determinant of the paradox of progress, as suggested by Alejo et al. (2024), then the way the residual imputation is done in Barros et al. (2010) might influence the results. Finally, Ariza and Montes-Rojas (2019) use different methods and confirm that education has inequality-increasing composition effects in Brazil and other Latin American countries, so evidence of the paradox of progress is not exclusive to RIF regression decompositions.

A potential issue is that the composition and structure effects of education might be biased because the returns to education are estimated with OLS instead of more robust methods. This concern is limited for two reasons. First, the magnitude of the bias would need to change over time, as the decomposition compares two periods. But there is no strong reason to believe that this is the case. Second, in a literature review, Deming (2022, p. 77) concludes that "naïve cross-sectional comparisons and studies with strong quasi-experimental research designs yield very similar estimates of the economic return to education." Therefore, the OLS estimates of the return to schooling should be sufficient for these types of decomposition exercises.

Another question is why the paradox of progress has not been documented in richer countries. We believe this question warrants further investigation, but we have a few conjectures. First, returns to education might not have been as convex in developed countries in the past as they are today in developing countries. This might be related to developed countries' historical role as technology leaders. Second, the increasing dispersion of residual inequality in the United States has been linked to composition effects due to higher experience and education (Lemieux 2006), so it is possible that the effect was present but undetected, as many studies focused on trends in inequality adjusted for compositional changes (Katz and Autor 1999). Finally, Bourguignon, Ferreira, and Lustig (2005) note that the paradox of progress assumes constant price effects and therefore does not contradict the hypothesis of a race between technology and education (Tinbergen 1975; Goldin and Katz 2009).

<sup>28</sup>These conditions are not necessary, however. For instance, in the simplest case with two education groups with fixed returns to education that are homogeneous within each group, a marginal increase in the share of highly educated workers will increase the variance of wages as long as the share of highly educated workers is below 1/2. Moreover, the two sufficient conditions are restricted to small location shifts in the distribution of education (Alejo et al. 2024). More generally, as footnote 12 suggests, increases in the variance of education will also increase inequality. In fact, this is the mechanism by which the above case acts, as the variance is determined by the probability of each case in a binary distribution.

<sup>29</sup>Lustig, Lopez-Calva, and Ortiz-Juarez (2013) summarize studies on the paradox of progress for Brazil, Argentina, and Mexico. Conflicting results emerge for Brazil and Argentina, but all results from Mexico indicate that education has an inequality-increasing composition effect.

<sup>30</sup>The results are available in Appendix B, Tables B1 and B2.

### 5.1 *The Degraded Tertiary Hypothesis*

Although there is evidence that the increase in the relative supply of skilled labor was an important determinant of the decline in the skill premium in Latin America, especially in Brazil, other hypotheses also associated with the educational expansion have been suggested. One of them is the *degraded tertiary hypothesis*. According to it, the expansion of higher education was followed by a reduction in the quality of education offered to new cohorts, making them less productive than their previous counterparts (Campos-Vazquez, Lopez-Calva, and Lustig 2016). If this hypothesis is correct, we should expect the skill premium for younger generations to be smaller than for older generations, holding experience constant.

There is mixed evidence for the degraded tertiary hypothesis in Latin America (Messina and Silva 2018). In the best attempt to test this theory in the region, Camacho, Messina, and Uribe (2025) use the Colombian expansion in higher education to assess whether the quality of newly established courses is lower than that of older ones. They find that graduates of new courses perform worse on standardized exams and in the labor market. However, part of the learning disadvantage is due to selection, as graduates from new programs also perform worse on high school exams than graduates from existing programs. The labor market penalty is partially determined by student and program characteristics, including student ability, the high school they attended (network effects), and the duration of their higher education course.

Camacho, Messina, and Uribe (2025) do not investigate whether this penalty can explain the decrease in the college premium in Colombia, and the implications of their results are unclear. On the one hand, there is a labor market penalty for new courses and, therefore, evidence for the degraded tertiary hypothesis. On the other hand, the differences between the value added of new and older courses is small. Hence, if counterfactual wages of individuals attending these new courses when they only completed secondary school are also smaller, we should not expect this to have a significant impact on the college premium.

Jaume (2021) is the best attempt so far to test the degraded tertiary hypothesis using Brazilian data. He investigates whether changes in market conditions or the quantity of human capital drove changes in the wages of workers grouped by their educational attainment. His method follows Bowlus and Robinson (2012) and Heckman, Lochner, and Taber (1998) and consists in estimating changes in the price of human capital using median wages of cohorts for which the quantity of human capital (quality of education) should have remained constant. Once he estimates the change in the price of human capital, the quantity effect is simply the residual difference between observed wage changes and the price effect.

His results suggest that changes in market conditions (supply and demand) account for almost all changes in the wages of workers with less than a high school diploma and workers with a college degree. For workers who completed high school, quantity effects would have driven wages up, were it not for countervailing price effects. He argues that this positive quantity effect is consistent with the improvement in the performance of Brazilian students in the PISA exam for 15-year-olds.

Despite the results from Jaume (2021) not supporting the degraded tertiary hypothesis, more research is needed to confidently quantify the relevance of educational quality in explaining the decline in skill premiums in Brazil. Ideally, researchers would follow Camacho, Messina, and Uribe (2025) and combine existing Brazilian administrative data on high school and college attendance with labor market outcomes to investigate how returns vary by institution, major, and baseline characteristics.

## 5.2 Affirmative Action

In addition to expanding higher education, Brazil has also implemented several types of affirmative actions (AAs) in its public universities. Many studies have shown that these policies have promoted the enrollment of low-socioeconomic status youth in these universities, which are among the most prestigious in Brazil (Francis and Tannuri-Pianto 2012; Estevan, Gall, and Morin 2019b; Vieira and Arends-Kuenning 2019; Mello 2022). If students displaced by AA can afford private outside options that are not available to low-income students, then AA can decrease inequality by increasing the overall supply of college graduates. This seems to be the case, as studies show that displaced students are likely to enroll in other institutions (Francis-Tan and Tannuri-Pianto 2018; Barahona, Dobbin, and Otero 2023).

AA might have other secondary effects. One possible concern is related to behavioral changes that might affect school and effort choices, thus diminishing the possible redistributive effects of such policies. Estevan, Gall, and Morin (2019b) find no significant behavioral responses regarding the performance of targeted students. Mello (2023) finds that AA causes some teenagers to switch from private to public high schools, as enrolling in the latter is necessary to benefit from AA in Brazil. In general, Brazilian public schools are lower quality than private ones. However, transferring students come mostly from low-performing private high schools, so the overall impact on education quality may be limited.

Another concern is the potential efficiency losses due to mismatches, which could adversely affect some targeted students. Barahona, Dobbin, and Otero (2023) investigate this possibility in the Brazilian context. They find that AA increases the quality of the degrees pursued by marginal AA beneficiaries four years later, with benefits larger than the losses experienced by displaced students. This corroborates Estevan, Gall, and Morin (2019a), who show that AA influences targeted applicants' choice of major, directing their applications toward majors with higher admission cutoffs. Once again, this can reduce inequality by placing low-income students in high-return degree programs that would not have been accessible to them in private institutions but are attainable through AA for displaced students.

Barahona, Dobbin, and Otero (2023) also develop a model to understand the overall impact of AA, and not only on the marginal students affected by it. They estimate that targeted students increase their projected lifetime earnings by 1.02 percent relative to a counterfactual without AA, while nontargeted students' losses amount to 1.34 percent. Efficiency is barely affected, with an overall predicted income decrease of less than 0.1 percent. The conclusion is that AA has small redistributive benefits without reducing economic efficiency.

Therefore, although AA appears to reduce inequality, the effect is likely small. However, one caveat is that AA was adopted in Brazil very recently, and it is too soon to observe its impact on the labor market outcomes of affected cohorts. Barahona, Dobbin, and Otero (2023), for instance, use predicted income based on the earnings of previous cohorts rather than actual earnings. A second caveat is that AA applies exclusively to public universities, which account for only a quarter of higher education enrollment in Brazil (Barahona, Dobbin, and Otero 2023). Moreover, most of the expansion of higher education in Brazil in recent decades has been driven by private universities rather than public universities. Finally, we highlight that the effects of AA are likely to be larger in other dimensions of income inequality. In particular, it may have important effects on intergenerational mobility, which is particularly high in Brazil (Britto et al. 2022), and on racial earnings gaps, since most AA measures also target racial minorities (Vieira and Arends-Kuenning 2019). We are unable to find any studies that examine the impacts of AA on these outcomes.

### 5.3 *Education and Formality*

While the expansion of education had ambiguous direct effects on overall inequality—increasing it through composition effects but decreasing it through structure effects—it is possible that indirect effects played a significant role in reducing inequality. One such possibility is education expansion's effect on labor formality. Haanwinckel and Soares (2021) investigate how changes in the economy affect the size of the informal sector in Brazil and the skill, firm-size, and formality premiums. Their model incorporates firm heterogeneity, workers with different skill levels, demand/productivity shocks, and the minimum wage. They show that changes in the skill composition of the labor force were the main drivers reducing informal employment in Brazil between 2003 and 2012. The results of Ferreira, Firpo, and Messina's (2022) RIF regression decompositions show that the higher formality in the Brazilian economy contributed to the reduction of overall inequality in the 2000s.

Changes in the educational composition of the workforce affect not only the school premium but the formality premium. Haanwinckel and Soares (2021) show that in the absence of an increase in the supply of skilled labor, the formal wage premium would have risen rather than declined during the period. Moreover, the combination of changes in productivity and workforce composition has decreased the firm-size wage premium. Without these factors, cross-firm wage dispersion would have increased for both skilled and unskilled workers. Given the correlation between firm size and productivity, this premium mimics firm effects, which have played an important role in reducing inequality in Brazil, as described in Section 2.2. These results highlight the important interplay of economic factors in reducing inequality, showing that no single factor operates in isolation.

## 6. *The Minimum Wage*

The effects of the minimum wage on employment have been a point of relevant empirical investigation at least since Card and Krueger (1994). A less well-known literature attempts to assess the impacts of the minimum wage on the wage distribution (DiNardo, Fortin, and Lemieux 1996; Lee 1999; Autor, Manning, and Smith 2016). In general, evidence from developed countries provides little support for large unemployment effects, but there is some compelling evidence of compression of the wage distribution (Manning 2021; Dube 2019).

Studies in Brazil find neither negative employment responses to the minimum wage nor large displacement to the informal sector (Lemos 2009; Corseuil, Foguel, and Hecksher 2015; Saltiel and Urzúa 2022). Research focusing on earlier periods finds negative effects of the minimum wage on inequality. For the period 1981–1999, Menezes-Filho and Rodrigues (2009) use the semiparametric approach of DiNardo, Fortin, and Lemieux (1996) and find that decreases in the real minimum wage were related to increases in inequality. Covering a period of real increases in the minimum wage between 2001 and 2005, Firpo and Reis (2007) find that they were associated with lower wage inequality. Neumark, Cunningham, and Siga (2006) find that increases in the minimum wage are associated with higher wages at the bottom of the distribution between 1996 and 2001.

Recent studies have made important contributions to the analysis of the effects of the minimum wage on inequality in Brazil. Engbom and Moser (2022) study the effects of the minimum wage on wage inequality in the formal labor market using data from the RAIS between 1996 and 2018. They use differences in the bindingness of the minimum wage based on the Kaitz- $p$

index (the difference between the minimum wage and a given percentile,  $p$ , of the wage distribution) to estimate the reduced-form impacts of the minimum wage at different points in the income distribution relative to the median (Lee 1999; Autor, Manning, and Smith 2016). Using Kaitz-90 as the preferred specification, they detect large compression effects, estimating a reduction of 11.7 log points in the standard deviation of log wages resulting from an increase of 58.6 log points in the minimum wage observed in the period (resulting from an estimated semielasticity of  $-0.20$ ). These compression effects can go as high as the ninetieth percentile of the wage distribution. Finally, they find little evidence of negative employment effects.

Engbom and Moser (2022) develop a model to assess the general equilibrium effects of these minimum wage increases. They estimate that the increase in the minimum wage between 1996 and 2018 was responsible for a reduction of 12 log points in the variance of log wages, or 45 percent of the observed decline in the period. Their model reproduces their reduced-form findings on the effects of the minimum wage across the wage distribution. It performs particularly well in explaining the reduction in the tenth–fiftieth percentile ratio, but explains only a small part of the reduction in the fiftieth–ninetieth ratio. The model produces almost no disemployment effects, as the majority of workers reallocate to more productive firms.

Another feature of the model is that it helps to account for the decrease in the cross-firm premiums and the pass-through from firm productivity to wages. As discussed in Section 2.2, Alvarez et al. (2018) show that both factors are important drivers of inequality reduction in the period. Engbom and Moser (2022) show that changes in firms' wage policies are more important drivers of lower inequality than reallocation of workers across firms. As the minimum wage increases, low-productivity firms raise wages more than high-productivity firms. Hence, the correlation between firm productivity and pay decreases, a fact documented by Alvarez et al. (2018) in the period.

Haanwinckel (2025) also investigates the effects of the minimum wage on wage inequality in Brazil. His model combines supply and demand with imperfect competition, firm heterogeneity, and task-based production functions. The minimum wage affects wages through three channels: the traditional monopsony channel, which increases wages and employment for low-productivity workers; changes in the wage-posting behavior of firms, which affect the within-firm skill premium; and general equilibrium effects that act through the prices of goods and firm creation.

His results suggest a considerable inequality-decreasing effect of the minimum wage in the period. Counterfactual exercises indicate that changing only the minimum wage between 1998 and 2012 would have reduced the variance of log wages by 13 points squared, while the observed reduction was 22 points squared. Furthermore, his model predicts spillovers from the minimum wage to all quantiles of the wage distribution, just as in Engbom and Moser (2022). The minimum wage also reduces firm and worker sorting effects, which reduces inequality as well (Alvarez et al. 2018).

However, Haanwinckel (2025) mentions a few caveats. First, the spillover effects hide heterogeneous causal effects among individual workers. This happens because in his model, very low-productivity workers experience disemployment effects.<sup>31</sup> Hence, part of the spillovers are composition effects.

<sup>31</sup> Disemployment effects for low-skilled workers are also found in the model of Engbom and Moser (2022).

In addition, workers in the middle of the wage distribution experience slight negative wage effects because firms adjust wages when workers switch from low- to high-wage firms.<sup>32</sup>

The analyses in Engbom and Moser (2022) and Haanwinckel (2025) face limitations because they concern only workers in the formal sector. But informality may serve as an important channel for adjusting to minimum wage increases. As mentioned, previous research has found limited impacts on displacement from the formal to the informal sector and no significant disemployment effects as a result of minimum wage increases. However, some recent research challenges this claim. For example, Jales (2018) uses a density discontinuity design to estimate the impact of the minimum wage on the wage distribution and sector allocation in Brazil. He estimates that the informal sector is 39 percent larger than in the absence of the minimum wage, and he attributes this effect to both sectoral displacement and unemployment effects that shrink the formal sector. Similarly, Jales and Yu (2022) estimate that the minimum wage reduces the size of the formal sector by 8 percent. Haanwinckel and Soares (2021) also find that the minimum wage increases in Brazil between 2003 and 2012 would have expanded the informal sector were it not for countervailing forces such as the educational expansion and productivity shocks.

Parente (2024) complements Engbom and Moser (2022) and Haanwinckel (2025). Using data from the PNAD, which include information on the informal sector, Parente presents new facts on the minimum wage and inequality. Similarly to Engbom and Moser (2022) and Haanwinckel (2025), Parente (2024) shows that the minimum wage reduces inequality in the formal sector. However, raising the minimum wage expands the informal sector and increases inequality within it. The net result is higher overall inequality. His empirical strategy relies on comparing the states most and least affected by minimum wage increases, measured using the bindingness of the minimum wage in the formal sector. He also develops an equilibrium model that rationalizes his results.

However, the results of Parente (2024) should be interpreted cautiously. His main finding is based on a comparison between the three most and least exposed states. When these groups are enlarged, the positive impact of the minimum wage on the size of the informal sector and overall inequality becomes smaller and noisier. A similar exercise by Derenoncourt et al. (2021) finds no different effects between the Brazilian states most and least exposed to the minimum wage. Engbom and Moser (2022) also use the approach of Lee (1999) and Autor, Manning, and Smith (2016) using data from the PNAD and the Pesquisa Mensal de Emprego (PME), or Monthly Employment Survey, and find no effect on informality.<sup>33</sup> Engbom et al. (2022) document smaller declines in earnings inequality in the informal sector compared to the formal sector using PME data, but inequality is declining in both sectors.

<sup>32</sup>In his discussion of the results, Haanwinckel (2025) argues that reduced-form estimates might have difficulty in finding disemployment effects and explains why his results differ from Engbom and Moser (2022). One reason is that supply and demand shocks may confound the effects of the minimum wage in a nonlinear way. Another reason is that most reduced-form estimates focus on short-term effects. If markets take time to adjust, disemployment effects might go unnoticed. Neumark, Cunningham, and Siga (2006) also find negative effects on employment in the long run. (See Sorkin (2015) for a discussion of the long- and short-term effects of the minimum wage.) Second, his model is estimated using a local labor market approach, while Engbom and Moser (2022) assume a single large economy. Labor reallocation following minimum wage increases might transfer workers from firms at the bottom to the very top of the firm-effects distribution, which could be precluded in a local labor market approach if these firms are located in distinct labor markets.

<sup>33</sup>The PME is a monthly longitudinal survey that was conducted in six Brazilian metropolitan regions until 2016, when it was replaced by the PNADC.

Importantly, a large mass of informal workers receives the minimum wage, creating what the Brazilian literature has labeled the *lighthouse effect* (see Lemos (2009) and the early literature cited there). This literature suggests that the minimum wage serves as a reference wage and plays a role in coordinating wage policy, even among informal workers. This fact was also pointed out by Lemos (2009) previously and more recently by Derenoncourt et al. (2021), who also document that informal workers who do not receive the minimum wage are all self-employed, domestic, or rural workers. As far as we know, no model including the informal sector has tried to incorporate bunching of informal workers at the minimum wage, which we believe would be an important theoretical and empirical contribution.

Also important is that the possible benefits of the minimum wage are not independent of other factors. Haanwinckel and Soares (2021) show that without increases in productivity and in the share of skilled workers, increases in the minimum wage would have resulted in higher informality. Similarly, Saltiel and Urzúa (2022) show that negative formal employment effects of the minimum wage can be found among Brazilian regions less exposed to the commodity boom. Using data from Brazil and Paraguay, Messina and Silva (2018) find no negative effect of the minimum wage on employment when GDP is growing fast. Haanwinckel (2025) also finds that the minimum wage has interaction effects with changes in demand that attenuate its inequality-diminishing effects.

The bindingness of the minimum wage is another factor that must be taken into account, especially when generalizing the results to other developing countries. Engbom and Moser (2022) show that a less binding minimum wage leads to smaller marginal effects on wage compression. Messina and Silva (2018) document wide variations in the ratio of the minimum wage to the median wage in Latin American countries. In Brazil, this ratio has increased from around 0.4 in 1994 to almost 0.6 in 2014. But in Latin America, it ranged from 0.2 to 0.8 in the same period, resulting in quite different levels of minimum wage bindingness across countries.

## 7. Gender and Racial Wage Gaps

The findings of Ferreira, Firpo, and Messina (2022) and our own results in Section 2.1 show that changes in racial and gender gaps account for an important share of the reduction in wage inequality between 1995 and 2012, especially up to 2003. Because the decomposition exercise includes variables such as education and experience, the structure effect associated with gender and race is likely related to reductions in discrimination or the diminishing importance of unobserved variables that are not equally distributed across these demographic groups. Together, racial and gender gaps correspond to a 1.7-point reduction in the Gini index, out of a nearly 10-point total reduction.

In addition to changes in social norms, market forces can affect wage penalties associated with discrimination. Taste-based discrimination models predict that racial and gender gaps will decrease with increasing competition (Becker 1957). Therefore, trade liberalization may have played a role in reducing wage gaps among minorities. Hirata and Soares (2020) test this hypothesis by examining the evolution of the conditional racial wage gap in Brazil after the trade liberalization in the early 1990s. They find that regions more exposed to foreign competition after trade liberalization experienced larger declines in the Black–White wage gaps between 1991 and 2000. The average reduction in tariffs was associated with an 18 percent decline in the conditional racial wage gap. However, the authors note that this gap fell by only 4 percent in the period, suggesting the presence of countervailing forces.

Similar effects can also affect gender gaps. Dix-Carneiro and Kovak (2025) summarize evidence of this effect in other Latin American countries, but there is no such study using Brazilian data. Given the evidence of gender discrimination in Brazil (Morchio and Moser 2024), it is likely that gender gaps also responded to trade liberalization.

Evidence also suggests that racial and gender gaps are associated with the firm-specific wage premium in Brazil. For instance, Gerard et al. (2021) show that almost 20 percent of the wage gap between White and non-White workers is explained by sorting effects, as non-White workers are less likely to work in firms that pay higher wages. At least one-third of this underrepresentation is due to unexplained preferences for employing White workers in high-paying firms, suggesting discriminatory practices in hiring and retention. Additionally, racial differences in wage-setting policies, which correspond to racial gaps in the firm-specific wage premium, account for 4–5 percent of the total racial wage gap. These effects are greater for highly skilled workers. Morchio and Moser (2024) and Machado, Neri, and Neto (2018) find that firm heterogeneity also plays an important role in explaining gender pay disparities. Morchio and Moser (2024) decompose the overall gender gap into a within- and between-firm pay gap, finding that each component explains half of the difference.

Because the RIF regression decomposition exercise in Section 2 does not include firm effects—hence they are an unobserved variable—we conjecture that the observed decrease in firm heterogeneity during the 1990s and 2000s documented by Alvarez et al. (2018) is related to the reduction in the racial and gender conditional wage gaps. Moreover, none of the studies above estimate changes in conditional gaps over time and how they relate to the firm premium. Furthermore, without causal models, it is not possible to pin down the exact direction of this effect: Did the reduction in firms' heterogeneity lead to a decrease in racial and gender wage gaps, or did a reduction in discrimination partially contribute to the compression of the firm-specific pay premium?

Another important factor that might have contributed to reductions in racial gaps is the large increase in the minimum wage. Derenoncourt and Montialoux (2021) show that the racial wage gap in the United States fell in the late 1960s and early 1970s largely because minimum wage coverage was extended to sectors that employed a large share of Black workers. Derenoncourt et al. (2021) investigate how the minimum wage increases in Brazil have affected racial wage gaps in the 2000s. They show that racial wage differences were eliminated in the parts of the wage distribution in which the minimum wage is binding. There were some spillovers to higher percentiles, but these spillovers became negligible in the high part of the earnings distribution. However, the spillovers do not estimate the effect of the minimum wage on the conditional racial wage gap. To our knowledge, no similar study has been conducted on gender inequality in Brazil.

In summary, few studies document the evolution of racial and gender gaps over time, and even fewer investigate the causes of the reduction of these wage penalties and their impact on overall inequality. The minimum wage, trade liberalization, and compression in firm effects are likely important factors in this process. More research on this topic is necessary, especially linking it to the declining earnings inequality.

## 8. Conclusion

The decline in wage inequality in Brazil and other developing countries between the mid-1990s and the mid-2010s contrasts with rising inequality in developed countries. We

reviewed studies that established the stylized facts of Brazil's reduction in inequality and explored causal mechanisms. The decline from 1995 to 2015 resulted from a combination of factors, many deviating from standard theories. These include a favorable economy, expanded educational attainment, and institutional changes such as minimum wage increases. These factors enabled real wage growth that primarily benefited the bottom of the earnings distribution, thus reducing inequality.

The expansion of education, suggested as the leading cause of the reduction in inequality in the early literature (Barros et al. 2010; Lustig, Lopez-Calva, and Ortiz-Juarez 2013), illustrates the complexities of the inequality reduction in Brazil through its interaction with labor market outcomes and the minimum wage. While a larger supply of educated workers decreased educational returns and lowered inequality, it also raised inequality due to compositional changes—the paradox of progress. Overall, this led to a modest Gini index increase of about 1.3 points from 1995 to 2015.

Nonetheless, indirect effects of education through reduced informality and unemployment were vital for other inequality-reducing policies. Research shows that the minimum wage increase accounts for nearly half the reduction in formal-sector inequality. Studies suggest that without changes in the composition of the workforce, the minimum wage could have led to higher informality and lower inequality reduction. A stable, growing economy, boosted by external factors such as the commodity boom, amplified the minimum wage's impact on inequality and limited its negative labor market consequences. It remains unclear whether the minimum wage's inequality-reducing effects in the formal sector spilled over to the informal sector. This mechanism deserves more attention given the prevalence of informality in Brazil and other developing countries.

Globalization and technological change, identified as factors increasing inequality in richer countries, do not seem as important in Brazil. Trade liberalization and the commodity boom reduced the skill premium and overall inequality by 5–10 percent in the period. Technological changes likely increased demand for skilled labor and limited the decline in the college premium, but their impact on inequality in Brazil remains unclear, as the few studies on this topic reach conflicting results. This warrants future research, as technology's effect on labor markets in developing countries might differ from that in advanced countries.

RIF regression decompositions indicate that declines in the experience premium, racial and gender penalties, and residual inequality account for 57 percent, 17 percent, and 54 percent of the Gini-index decline from 1995 to 2015. Additionally, the compression in the firm-specific wage premium, estimated via the AKM model, explains 40 percent of the drop in formal-sector wage variance from 1996 to 2012. The mechanisms behind these changes are not fully understood. Labor supply changes do not explain the reduction in the experience premium, so shifts in demand or institutions likely occurred. Possible mechanisms include age-biased technological changes, skill obsolescence, changes in labor market selection, and higher minimum wages, though research is limited. The minimum wage is also a primary candidate for the compression in firm-specific wage premiums and the reduced sorting between firms and workers, but other factors, such as monopsony power (Tucker 2017; Card et al. 2018), international trade (Helpman, Itskhoki, and Redding 2010; Messina and Silva 2018), or gender and racial gaps (Gerard et al. 2021; Morchio and Moser 2024), could also play a role. More research is needed on these topics.

APPENDIX A. TRENDS IN WAGE INEQUALITY: ALTERNATIVE MEASURES

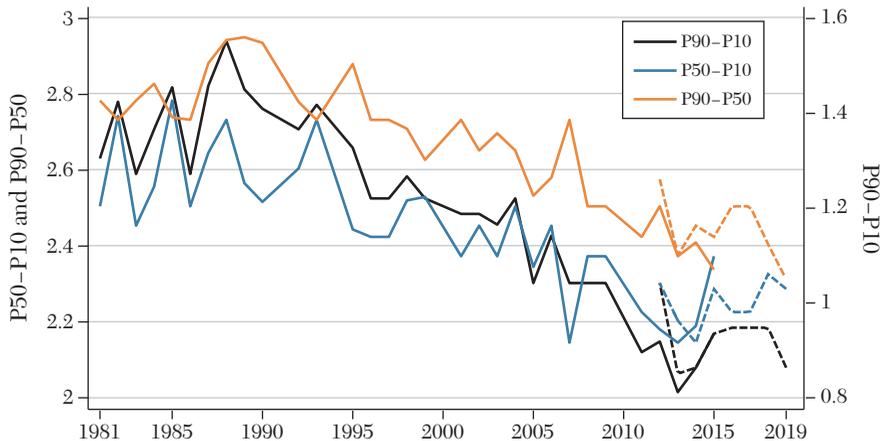


Figure A1. Earnings Inequality in Brazil, Percentile Ratios

Notes: Authors' own calculations based on monthly earnings from the individuals' main occupation. Data comes from the Pesquisa Nacional por Amostra de Domicílios (PNAD, 1981–2015) and the Pesquisa Nacional por Amostra de Domicílios Contínua (PNADC, 2012 and 2019). See Section 3 for a more detailed discussion on these surveys.

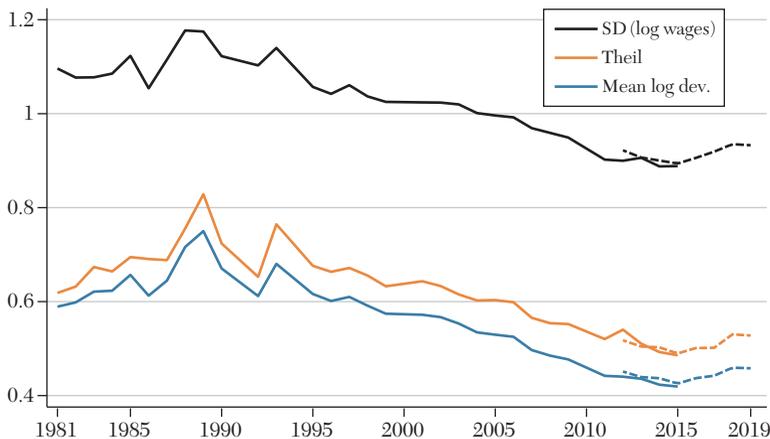


Figure A2. Earnings Inequality in Brazil, Alternative Measures

Notes: Data comes from the Pesquisa Nacional por Amostra de Domicílios (PNAD, 1981–2015) and the Pesquisa Nacional por Amostra de Domicílios Contínua (PNADC, 2012 and 2019). See Section 3 for a more detailed discussion on these surveys.

TABLE B1  
EXPERIENCE AND EDUCATION EFFECTS ON THE GINI INDEX, 2001–2007

	Experience and schooling as quartic polynomials		Experience quadratic schooling linear		Experience quadratic schooling categorical	
	FFM (1)	Barros et al. (2)	FFM (3)	Barros et al. (4)	FFM (5)	Barros et al. (6)
<i>Composition effects</i>						
Experience	-0.181 (0.017)	-0.150 (0.013)	0.310 (0.022)	0.292 (0.020)	0.132 (0.013)	0.164 (0.015)
Education	1.852 (0.090)	0.783 (0.079)	2.104 (0.050)	1.070 (0.035)	0.571 (0.075)	1.555 (0.084)
<i>Structure effects</i>						
Experience	-1.371 (0.705)	-1.357 (0.673)	-1.134 (1.301)	1.056 (1.165)	2.752 (1.225)	1.410 (1.322)
Education	-0.941 (0.478)	0.439 (0.442)	-1.969 (0.403)	-0.482 (0.332)	0.419 (0.401)	-0.855 (0.420)
Observations	286,049	286,049	286,049	286,049	286,049	286,049

*Notes:* This table presents the estimated composition and structure effects of experience and education on the Gini index using RIF regressions. Bootstrap standard errors using 100 repetitions in parentheses. Columns 1, 3, and 5 include all variables listed in Section 3.1 as controls, while columns 2, 4, and 6 use only race, gender, experience, and years of schooling.

## APPENDIX B. REPLICATION OF BARROS ET AL. (2010)

We replicate the methodology of Barros et al. (2010), who find a negative quantity effect of education on inequality, that is, a reduction in inequality driven by a reduction in the variance of years of schooling. Their methodology relies on microsimulations to investigate the role of education and experience in the reduction of inequality between 2001 and 2007. Here, we consider the same time period, but use RIF regressions with different specifications to decompose the change in inequality.

Tables B1 and B2 display the results of RIF-regressions for the Gini index and variance of log wages, respectively. We consider three main specifications: including experience and schooling as quartic polynomials (columns 1 and 2); experience as quadratic polynomial and schooling as linear (columns 3 and 4); and experience as quadratic and schooling as categorical (columns 5 and 6). In addition, odd columns control for all variables described in Section 3.1 and even columns control only for gender and race. In all specifications, an increase in education levels is associated with higher levels of inequality, measured either using the Gini or the variance of log wages.

TABLE B2  
EXPERIENCE AND EDUCATION EFFECTS ON THE VARIANCE OF log WAGES, 2001–2007

	Experience and schooling as quartic polynomials		Experience quadratic schooling linear		Experience quadratic schooling categorical	
	FFM (1)	Barros et al. (2)	FFM (3)	Barros et al. (4)	FFM (5)	Barros et al. (6)
<i>Composition effects</i>						
Experience	−0.010 (0.001)	−0.010 (0.001)	0.013 (0.001)	0.013 (0.001)	0.008 (0.001)	0.008 (0.001)
Education	0.086 (0.003)	0.052 (0.003)	0.087 (0.002)	0.053 (0.001)	0.039 (0.002)	0.072 (0.003)
<i>Structure effects</i>						
Experience	−0.221 (0.025)	−0.228 (0.024)	−0.344 (0.042)	−0.308 (0.039)	−0.218 (0.041)	−0.234 (0.042)
Education	−0.138 (0.020)	−0.113 (0.020)	−0.197 (0.014)	−0.166 (0.011)	−0.088 (0.020)	−0.116 (0.020)
Observations	286,049	286,049	286,049	286,049	286,049	286,049

*Notes:* This table presents the estimated composition and structure effects of experience and education on the variance of log wages using RIF regressions. Bootstrap standard errors using 100 repetitions in parentheses. Columns 1, 3, and 5 follow Ferreira, Firpo, and Messina (2022) and include all variables listed in Section 3.1 as controls, while columns 2, 4, and 6 follows Barros et al. (2010) and use only demographic (race and gender), experience and years of schooling. The way experience and schooling enter the RIF regression is described in the header.

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