THREE ESSAYS ON BRAZIL LABOR MARKET

AN ABSTRACT

SUBMITTED ON THE FIFTH DAY OF APRIL, 2016

TO THE DEPARTMENT OF ECONOMICS

OF THE SCHOOL OF LIBERAL ARTS OF

TULANE UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

BY

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Abstract

This dissertation is a collection of three empirical essays related to the decline of wage inequality in Brazil between 1995 and 2013. The first essay tries to quantify how much of the decline in wage inequality was due to changes in the composition of workers' characteristics in the labor force and how much was due to movements in returns to workers' characteristics in the labor market, with a particular interest on the impact of education expansion on wage inequality. The results show the changes in wage structure were the main force in converging wage distribution, while the shifts in the composition of workers' characteristics had a mild un-equalizing impact and the education expansion, mainly through the decline in education premium, also contributed to the decline of wage inequality.

The second essay analyzes how the expansion of tertiary education impacted the tertiary premium. The tertiary premium declined between 2004 and 2013. The education expansion shifted the relative supply of tertiary-educated workers and also implies a possible decline in the average quality of those workers of the more recent cohorts. This essay examines whether there was in fact any significant decline in the average quality of the tertiary-educated workers of the recent cohorts and how the changes in cohort quality impacted the relative wage of the tertiary group. The results demonstrate that although the growth in the relative supply had a significant negative

impact, the decline in average quality of the tertiary-educated workers of the more recent cohorts accounted for the majority of the decline in tertiary premium.

The third essay analyzes the impact of the minimum wage in shifting the lower tail of employees' wage distribution. During the entire 1995-2013 period, the monthly minimum wage increased significantly and was always binding at the lower tail, and the lower tail inequality of employees' wage distribution experienced a dramatic decline. The results demonstrate the effectiveness of minimum wage in decreasing lower tail dispersion. The minimum wage was also effective in lowering the wage differential between gender, education, and experience groups, but its impact on inequality within these groups was negligible.

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A DISSERATION

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Chapter 1

General Introduction

Brazil has had a long history of high income inequality. Brazil ranked as the second most unequal country in the world in 1989, when its Gini coefficient of household per capita income equaled 0.63. Starting in 1990, however, household income inequality declined continuously and significantly in Brazil, especially once its hyperinflation ended and the country regained its economic stability around 1995. In 2013, the Gini coefficient of household per capita income was 0.52 (SEDLAC).

There are two fundamental instruments working simultaneously in decreasing the income inequality in Brazil: one is the high taxation and large-scale social spending (Higgins & Pereira, 2013); the other is the convergence of wage income distribution since 1990. Brazil launched the Bolsa Familia, a conditional cash transfer program, in 2003. Combined with the Beneficio de Prestacao Continuada, the non-contributory rural pension, and other social spending programs, non-wage income changed the household income distribution significantly. According to the existing estimates, the non-wage income accounted 35%-50% (Azevedo et al., 2013; Barros et al., 2010) of the decline in household income inequality. Meanwhile, the convergence in the wage income distribution accounted for the other 40-55% (Barros et al., 2010) of the decline in overall income inequality. Calculated from the Brazil National Household Survey, the Gini coefficient of the hourly wage of full-time workers aged 16-65 was 0.53 in 1995 and continuously declined to 0.45 in 2013. This dissertation focuses on analyzing the change in wage income distribution, but the importance of taxes, social spending and other non-wage income resources is not discussed. The analysis focuses on the period between 1995 and 2013, which is the period after Brazil's hyperinflation, in order to avoid the noise in the household survey data caused by several currency changes.

The overarching purpose of this dissertation is explaining the decline in wage inequality in Brazil. It tries to identify the key reasons driving the decline in wage inequality in Brazil between 1995 and 2013. Earning inequality is affected by the distribution of skills, both observed and unobserved, and the prices of those skills in the labor market (Katz & Autor, 1999). Prices are influenced by both market and institutional forces. Market forces determine skill prices through the interaction of the demand and supply for skills. In the first essay, I try to quantify how much of the decline in wage inequality between 1995 and 2013 was due to changes in the distribution of skills in the labor force and how much was due to movements in prices of skills in the labor market, with a particular interest in the impact of education expansion on wage income distribution. In the second essay, I focus on the tertiary-educated workers and investigate the reasons behind the decline of the tertiary premium. In the third essay, I analyze the effectiveness of the minimum wage in shifting the lower tail of the employees' wage distribution.

The first essay tries to understand the key forces behind the change in male wage distribution. According to the Brazil National Household Survey data, wage distribution of full time male workers ages 16 to 65 shifted to the right and became less dispersed between 1995 and 2013. The Oaxaca-Blinder (OB) and Re-Centered Influence Function (RIF) decomposition methods are employed to decompose the increase in average wage and increase at the 10th, 50th and 90th quantiles, as well as the decrease of wage inequality. The results show that the movements in wage structure were the main force in converging the wage distribution, the changes in the composition of workers' characteristics had a small unequalizing impact, and the education expansion, mainly through the decline in education premium, contributed to the decline of wage inequality. This essay contributes to the literature by examining the wage distribution change in the most recent period using the decomposition methods. While Ferreira et al. (2015) emphasize other aspects of wage structure changes that have affected the wage distribution, this essay emphasizes the impact of education expansion on wage inequality, which provides an empirical examination of the existence of the "paradox of progress" in the Brazilian context.

Coinciding with the decline in wage income inequality, tertiary education has expanded quickly in Brazil since 1990, with the number of private for-profit universities increasing significantly. The relative return to tertiary education declined between 2004 and 2013. The education expansion definitely increased the relative supply of tertiary-educated workers, which would have interacted with the change in relative demand and moved the relative return. Moreover, the average quality of the tertiary-educated workers of the more recent cohorts might also have declined as a result of the education expansion, which would also account for the decline of the tertiary premium. The second essay examines whether there was any significant decline in the average quality of the tertiary-educated workers of the recent cohorts and how the changes in cohort quality impacted the relative wage of the tertiary group. This essay contributes to the literature as the first piece of research exploring the reasons behind the recent decline in the tertiary premium in Brazil as well as the first piece of research trying to identify possible deterioration of the average quality of the tertiary-educated group, which provides important policy perspectives for education reform in Brazil.

In addition to market forces, institutional factors are also determinants of prices of skills. Between 1995 and 2013, Brazil's minimum wage increased by 150%, from 86 reals to 215 reals (1995 prices) per month. Plotting the kernel density estimation of the log monthly wage of full-time employees shows that the minimum wage was always binding at the lower tail of the wage distribution, which suggests the potential effectiveness of the minimum wage in converging the lower tail of the wage distribution. In addition, when looking at the lower tail and upper tail of the wage distribution separately, the lower tail inequality declined more significantly over the 1995-2013 period compared to the change of the upper tail, which suggests the importance of the minimum wage. The third essay analyzes the impact of the minimum wage on employees' wage distribution and simulates the counterfactual wage distribution in the absence of the increase in minimum wage between 1995 and 2013. The results demonstrate that the continuous increase in the minimum wage had a significant impact in converging the lower tail of employees' wage distribution, thus contributing to the decline of overall wage inequality. The minimum wage also contributed to lowering the wage differential between gender, education, and experience groups, but its impact on inequality within these groups was negligible. This essay contributes to the literature by exploring the impact of minimum wage on wage distribution in Brazil using a household survey with comprehensive coverage of the country and a new method developed by Lee (1999) and Autor et al. (2015).

The rest of the dissertation is organized as follows. Chapters 2, 3, and 4 are the three independent essays briefly introduced in the preceding paragraphs. Following the three essays, Chapter 5 discusses the general conclusions of this dissertation.

Chapter 2

Decomposing Changes in Male Wage Distribution in Brazil

2.1 Introduction

Brazil has been a country of high income inequality. It was the 2nd most unequal country in the world in 1989 when its Gini coefficient of household per capita income equaled 0.63. Starting from 1990, especially after the end of the country's hyperinflation and the retrieve of its economic stability at around 1995, income inequality declined continuously and significantly in Brazil. Its Gini coefficient of household per capita income was 0.52 in 2012. There are two fundamental instruments of the significant decline of income inequality in Brazil: one is the high taxation and large scale of social spending (Higgins and Pereira, 2013); the other is the convergence in earnings income inequality which happened in the country since 1990. According to the existing research, the non-wage income had contributed to 35%-50% of the decline of household income inequality, and the movement in the wage income distribution accounts for the other 40-55% of the change of overall income inequality (Ferreira et al., 2015).

During the period of 1995-2012, according to the Brazil National Household Survey data, the wage distribution of full-time male workers aged between 16 and 65 shifted to the right and became less dispersed. There was a decrease in the average hourly wage of male workers between 1995 and 2004, followed by an increase after 2004, which finally resulted in a 17.7% increase from 4.01 R$[1] in 1995 to 4.72 R$ in 2012. However, this increase did not evenly benefit the entire wage distribution. The 10th percentile of hourly wages increased by 102.3%, the 50th percentile increased by 41.3%, and there was only a 6.9% increase at the 90th percentile. Barros et al. (2010) find that the changes in wage income distribution accounted for 31-46% of the decline of income inequality between 2001 and 2007. This convergence in male wage distribution indicates a decline in male wage inequality: the Gini coefficient of 16-65-year-old male full-time workers' hourly wages decreased from 0.56 in 1995 to 0.47 in 2012.

There are two factors working simultaneously in changing a country's wage distribution. One is the changes in the distribution of workers' characteristics in the labor force, which is named the "composition effect"; the other is changes in returns on workers' various characteristics in the labor market, which is called the "wage structure effect". The Brazil National Household Survey data show shifts in the returns to workers' different characteristics and some significant changes in the composition of male workers' characteristics. This essay attempts to identify the relative importance of the wage structure effect and the composition effect in shifting

[1] All wage measures in this essay are in 1995 prices.

the male wage distribution in Brazil between 1995 and 2012 using the Oaxaca-Blinder (Oaxaca, 1973, Blinder, 1973) and the Recentered Influence Function (Firpo et al., 2007, 2009) decomposition methods.

Among all factors, how the education upgrades and changes in the return to education contributed to the movements of wage distribution is of primary interest. The period of declining wage inequality coincides with education expansion, which significantly changed the composition of the labor force. The average number of years of education of male full-time workers was 5.5 in 1995, increasing to 8.3 in 2012. The proportion of workers with incomplete middle school (0-7 years) declined from 68% in 1995 to 37% in 2012 as more workers completed middle school or a higher educational level (8+ years). At the same time, not only had the relative education premium of each education group but also the absolute wages of better-educated groups (8-10, 11-14 and 15+ years of education) declined. Because of the education expansion, education inequality decreased--the Gini coefficient of the years of education declined from 0.42 in 1995 to 0.28 in 2012. Thus, it is also of interest to check the existence of the "paradox of progress" (Bourguignon, Ferreira and Lustig, 2005) in Brazil, which refers to the notion that a more equal distribution of education increases wage income inequality because of the convexity of the return to education.

How educational advancement impacted wage distribution is an important research question. Menezes-Filho, Fernandes and Picchetti (2006) study the impact of education expansion on male wage distribution between 1977 and 1997. Their results show that the upgrade in the education composition of the labor force increased inequality. Andreas Blom and Verner (2001) study the period between 1982 and 1998 and conclude that the mild decrease in wage inequality was primarily caused by a decline in the return to education. Ferreira et al. (2007) find that education expansion in the context of a highly convex return was an important reason for the increase in inequality during the 1980s and that the decline in inequality between 1993 and 2004 was accounted for by declines in returns to education. Barros et al. (2010) find that the accelerated education expansion in Brazil during the period 2001-2007 accounted for half of the decline in wage income inequality and that the recent decline in wage income inequality was caused not only by a decline in the return differentials across education levels but also by a more equal distribution of education. Moreover, the change in the wage differential is more important than education expansion in explaining the decline.

Our decomposition analysis shows that both changes in returns on workers' various characteristics and upgrades in the composition of work characteristics contribute to increases in both the average wage and wages at the 10th and 50th percentiles. The shifts in returns on skills have a decreasing impact on wages at the 90th percentile but are dominated by the positive composition impact; thus, wages at the 90th percentile also increased from 1995 to 2012. The changes in the wage structure are also identified as the primary force reducing wage inequality. Regarding the contribution of education expansion, the decline in relative returns on different levels of education has an equalizing impact on the wage distribution and a mild decreasing effect on the wage level of male workers. The improvement in educational attainment had a small increasing impact on wage distribution thus demonstrating the existence of the "paradox of progress", and significantly increased the wage level of male workers.

This essay makes the following contributions. First, the decomposition analysis quantifies both the extent to which the change in male wage distribution is driven by changes in the composition of workers' characteristics and the extent to which it is caused by movements in the wage structure. Second, identification of the impact of education expansion on wage distribution in Brazil provides important policy perspectives on education reform. Third, this research provides an empirical examination of the existence of the "paradox of progress" in the Brazilian context.

The policy implications of this essay are the following: first, policies aiming at supporting the labor force's educational advancement would be beneficial in terms of both reducing wage inequality and promoting economic growth; second, the convergence of the educational premium might discourage people from gaining more education; thus, education subsidies or conditional cash transfers from the government would help; third, the increased relative return to the group with lower education may cause some unemployment among these low-skilled workers; thus, the government should also pay attention and provide the appropriate support; moreover, because of the very significant decline in both overall and wage-income inequality observed since the 1990s, an investigation of the fundamental forces of the change in inequality in Brazil would provide useful policy perspectives to other countries.

This chapter is organized as follows. Section 2 reviews the decomposition methods. Section 3 describes the data and male samples under analysis. Section 4 presents the decomposition results, and section 5 concludes.

2.2 Review of Decomposition Methods

Decomposition analysis is generally a partial equilibrium approach and does not attempt to understand the structural relationship between factors. The key to decomposition analysis is to create a counterfactual, which is a simulated wage distribution in which workers with a particular distribution of characteristics are paid according to a different wage structure. For example, in this analysis, the counterfactual wage distribution can be constructed either by assuming that workers in 2012 are paid according to the wage structure of 1995 or by assuming that workers in 1995 are paid according to the wage structure of 2012.

Aggregate decomposition aims to quantify two main effects that work simultaneously in changing the wage distribution: one is the “wage structure effect,” which refers to the effect of changes in returns on the labor force’s various characteristics in moving the wage distribution, in which workers are assumed to be the same group of people; the other is the “composition effect,” which refers to the effect of changes in the distributions of workers’ characteristics, where returns to different characteristics are assumed to be stable. Based on the counterfactual, the contributions of different covariates to the two separate effects can be further quantified, a phenomenon that is known as “detailed decomposition.”

The most widely employed decomposition approach is the Oaxaca-Blinder decomposition (Oaxaca, 1973, Blinder, 1973), which can decompose the difference in the mean values of any two groups, e.g., time 0 and time 1, female and male, immigrants and natives. The key limitation of this method is that it cannot extend beyond the mean to analyze more complex changes. One may be interested in comparing measures other than the mean value, given that examining changes at different points in a distribution could enable a better understanding of the change in inequality. This interest has led to other approaches that can decompose distributional statistics other than the mean value that help to view the entire distribution and identify the reasons of changes. The existing distributional approaches include the Residual Imputation Procedure (Juhn, Murphy and Pierce, 1991, 1993), Inverse Propensity Reweighting (DiNardo, Fortin and Lemieux, 1996), the Quantile Regressions Method (Machado and Mata, 2005), the Recentered Influence Function Regression (Firpo, Fortin and Lemieux, 2007, 2009) and the Estimation of Conditional Distribution (Chernozhukov, Fernandez-Val and Melly, 2009). The main difference among these approaches is the methods of generating the counterfactual distribution; all of these approaches have advantages and disadvantages. One outstanding approach proposed by Firpo, Fortin and Lemieux (2007, 2009) is the Recentered Influence Function (RIF) regression method, which replaces the independent variable Y of a regression with a recentered influence function of the distributional statistics. The recentered influence function of the mean value is itself; thus, the RIF decomposition result of the mean value will be the same as that in the Oaxaca-Blinder decomposition.

In this analysis, based on the Mincer wage equation, the Oaxaca-Blinder decomposition is employed to decompose the increase in the average wage between 1995 and 2012; then, the RIF decomposition is employed to decompose the changes in distributional statistics, including 10th, 50th and 90th quantiles, 90-10, 50-10 and 90-50 differentials, variance and Gini coefficient.

2.2.1 Oaxaca-Blinder Decomposition

The first step of the Oaxaca-Blinder decomposition is to create a counterfactual distribution. Assume wage Y_i is a function of worker's observable characteristics X_i and unobservable characteristics ε_i and that the wage structure is $\omega(\cdot)$. Then, the wages of workers in 2012 and 1995 can be represented as $Y_{2012i} = \omega_{2012}(X_{2012i}, \varepsilon_{2012i})$ and $Y_{1995i} = \omega_{1995}(X_{1995i}, \varepsilon_{1995i})$, respectively. There are three sources of difference between the wage distributions in 2012 and 1995: the difference between the wage structures $\omega(\cdot)$, the difference between the observable characteristics X and unobservable characteristics ε. The counterfactual can be either $Y_{ci} = \omega_{1995}(X_{2012i}, \varepsilon_{2012i})$ or $Y_{ci} = \omega_{2012}(X_{1995i}, \varepsilon_{1995i})$.Being widely employed in decomposition literature, the wage structure $\omega(\cdot)$ is always assumed to take a linear form; thus, the wage equations for 1995 and 2012 should be estimated separately to obtain $\hat{Y}_{1995} = \hat{\beta}_{1995} \cdot X_{1995}$ and $\hat{Y}_{2012} = \hat{\beta}_{2012} \cdot X_{2012}$, respectively. Then, the counterfactual can be either $\hat{Y}_C = \hat{\beta}_{1995} \cdot X_{2012}$ or $\hat{Y}_C = \hat{\beta}_{2012} \cdot X_{1995}$.

The second step is to decompose the change between two years, which can be expressed by the following equation:

$$\widehat{Y}_{2012}-\widehat{Y}_{1995}=(\widehat{Y}_{2012}-\widehat{Y}_{C})+(\widehat{Y}_{C}-\widehat{Y}_{1995})$$

$$=\left[(\widehat{\alpha}_{2012}-\widehat{\alpha}_{1995})+\sum_{i=1}^{K}\overline{X}_{2012k}\left(\widehat{\beta}_{2012k}-\widehat{\beta}_{1995k}\right)\right]+[\sum_{i=1}^{K}(\overline{X}_{2012k}-\overline{X}_{1995k})\widehat{\beta}_{1995k}]$$

$$=\left[(\widehat{\alpha}_{2012}-\widehat{\alpha}_{1995})+\sum_{i=1}^{K}\overline{X}_{1995k}\left(\widehat{\beta}_{2012k}-\widehat{\beta}_{1995k}\right)\right]+[\sum_{i=1}^{K}(\overline{X}_{2012k}-\overline{X}_{1995k})\widehat{\beta}_{2012k}]$$

where the first term is the wage structure effect, which measures the effect of the differences in the wage structure between 1995 and 2012 in changing the mean value, where workers are assumed to be the same group of people, and the second term is the composition effect, which measures the effect of changes in the observed characteristics of workers, where returns on different characteristics are assumed to be at either the 1995 level or the 2012 level. Because of the constant term, the wage structure effect considers the returns on both the observable characteristics and the unobservable characteristics. The contributions of each covariate to the wage structure and composition effect can also be quantified. Separating the wage structure effect and the composition effect is the main goal of “aggregate decomposition,” and the quantification of the contributions from each covariate is

2.2.2 Recentered Influence Function (RIF) Decomposition

The Recentered Influence Function (RIF) decomposition also involves two steps. The first step is to aggregately decompose the change in the distributional statistics of wage distributions into the wage structure effect and the composition effect, which can be achieved by a reweighting technique. Specifically, suppose that the distributional statistics in 1995 and 2012 are represented by $f(Y_{1995})$ and $f(Y_{2012})$ and that the corresponding statistics of the counterfactual distribution are represented by $f(Y_C)$; the change in the wage distribution can be decomposed according to the following equation:

$$f(Y_{2012}) - f(Y_{1995}) = [f(Y_{2012}) - f(Y_C)] + [f(Y_C) - f(Y_{1995})]$$

The counterfactual Y_C is generated by reweighting the wage distribution in 1995 by a reweighting factor. The first term in the equation is the composition effect and the second term is the wage structure effect. The reweighting factor is defined (Firpo et al., 2007) as $\varphi_i = \frac{1-P(X_i)}{P(Xi)} \cdot \frac{p}{1-p}$, where $P(X_i)$ is the probability of a worker being at time 1995 given characteristics X_i in the joint sample of 1995 and 2012; thus, $P(X_i)$ can be estimated by a discrete choice model and p denotes the sample share of 1995 in the joint sample. Here, the counterfactual wage distribution is $Y_c = \varphi_i \cdot Y_{1995}$, and the counterfactual can also be generated by reweighting the 2012 sample in a similar manner.

The second step of RIF decomposition is to measure each covariate's contributions to the wage structure effect and the composition effect by running RIF regressions on the distributional statistics of the two original wage distributions and the counterfactual distribution. The RIF regression is a regular regression in which the dependent variable Y is replaced by its recentered influence function. According to Firpo et al. (2007, 2009), it can obtain the average effects of independent variables on a distributional statistic. The recentered influence function of quantile q_τ is defined by the following equation:

$$RIF(Y; q_\tau) = q_\tau + \frac{\tau - I(Y \le q_\tau)}{f_Y(q_\tau)},$$

where $f_Y(\cdot)$ is the probability density function of Y and I(·) is an indicator function. Next, the RIF quantile regression can be specified as $E[RIF(Y; q_\tau)|X] = X\beta_\tau$, where β_τ is the marginal effect of the covariates on the wage quantile q_τ.

After estimating the RIF regressions for the wage distributions of 1995, 2012 and the counterfactual, the difference in the τth quantile of the 2012 and 1995 wage distributions can be decomposed by resembling the Oaxaca-Blinder decomposition procedure, which can be represented by the following equation:

$$\hat{q}_\tau(Y_{2012}) - \hat{q}_\tau(Y_{1995}) = \bar{X}_{1995}\left(\hat{\beta}_C^\tau - \hat{\beta}_{1995}^\tau\right) + \left(\bar{X}_{2012} \cdot \hat{\beta}_{2012}^\tau - \bar{X}_{1995} \cdot \hat{\beta}_C^\tau\right)$$

$$= \sum_{i=1}^{K} \bar{X}_{1995k}\left(\hat{\beta}_{Ck}^\tau - \hat{\beta}_{1995k}^\tau\right) + \sum_{i=1}^{K}\left(\bar{X}_{2012k} \cdot \hat{\beta}_{2012k}^\tau - \bar{X}_{1995k} \cdot \hat{\beta}_{Ck}^\tau\right),$$

where the first term is the sum of the wage structure effects of each covariate and the second term is the sum of the composition effects.

2.3 Data and Descriptive Analysis

The data employed in this analysis are from the 1995-2012 Brazil National Household Survey (PNAD) by the Brazilian Institute of Geography and Statistics (IBGE). The PNAD survey covers the general characteristics of the population, including health, education, job characteristics, household income and housing conditions. The sample analyzed in this research is restricted to full-time male workers between 16 and 65 years of age with positive working experience, working at least 140 hours per month, not currently a student, and not working without pay or as a domestic worker. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. For the purpose of comparison across years, the monetary incomes of each year are deflated to real values in 1995 prices using the CPI conversion factors from the Brazilian Institute of Geography and Statistics. Data from each survey cohort between 1995 and 2012 are used to describe the evolution of male wage inequality and the characteristics of male workers; then, the decomposition analysis compares only 1995 and 2012. Moreover, 5 education groups are defined: workers who are illiterate or who have an incomplete primary education (0-3 years); workers with 4-7 years of education, which can be viewed as the complete primary and incomplete middle school level; workers with 8-10 years of education, which includes complete middle school and incomplete high school; workers with 11-14 years of education, which is equivalent to complete high school and incomplete college; and workers with 15 or more years of education, which includes complete college and graduate study.

2.3.1 Male Wage Distribution between 1995 and 2012

According to the PNAD data, the average hourly wage of male full-time workers decreased between 1995 and 2004 and then increased after 2004, resulting in a 17.7%

increase over the entire period. The increase in wage income did not evenly benefit all workers across the entire distribution: comparing 2012 with 1995, the overall increase in hourly wages at the 10th percentile was 102.3%, and the 50th percentile increased by 41.3%. However, there was only a 6.9% increase at the 90th percentile, comparing 2012 with 1995. Figure 1 depicts the evolution of hourly wages at the 10th, 50th and 90th percentiles over the entire period. Wage income has been indexed with respect to the average of 1995 and 1997 for all three series. As depicted in the figure, the 10^{th} percentile wage series increased over the period and the median series exhibits a similar changing pattern but increases at a lower speed. Wages at the 90th percentile decreased between 1995 and 2005 and then increased afterwards.

Indeed, comparing 1995 and 2012, the speed of the increase in real wages monotonically decreases as we move to the right of the wage distribution. Figure 2 shows the changes in the hourly wage between 1995 and 2012 at each 10th percentile, showing an essentially linear pattern with a negative slope. This pattern demonstrates a convergence across the entire wage distribution and is consistent with the observed decrease in wage inequality. The Gini coefficient of hourly wages was 0.56 in 1995 and 0.47 in 2012, which is a 16.2% decrease. The 90-10 log hourly wage differential decreased from 2.4 in 1995 to 1.8 in 2011, the 50-10 log hourly wage differential decreased 34.4%, and the 90-50 log hourly wage differential decreased 20%, indicating that convergence at the lower tail is more significant than it is at the upper tail.

Changes in the wage distribution exhibit different patterns within each education group. Figure 3 depicts the evolution of hourly wages at each 10th quantile within each education category between 1995 and 2012. As shown, workers with 0-3 years of education experienced the largest relative increase in hourly wages; the wages of workers with 4-7 years of education also increased across the entire wage distribution of this educational group. However, the wages of workers with 8-10 and 11-14 years of education increased at the lower tail but declined at the upper tail of the distribution. The wages of workers with 8-10 years of education increased by 7.5%-40.4% at different quantiles up to the 30th quantile, and workers with 11-14 years of education experienced an increase in wages by 18% only up to the 20th quantile. Most of the group with 11-14 years of education and all of the workers with a complete tertiary education experienced a decline in wages between 1995 and 2012 ranging between 6% and 32%. The 20th percentile of the tertiary group experienced a 32% decline; the decline at the 90th percentile was only 23%. Generally, the increases/decreases at the lower percentiles are always higher than the increases/decreases at the higher percentiles, thus indicating a decrease in each education group's wage inequality. Table 1 shows that other than workers with 15 or more years of education, whose Gini coefficient increased from 0.42 to 0.45, the Gini coefficient and Theil index of all other educational groups declined throughout the entire period. In each year, the better-educated group always exhibited higher wage

2.3.2 Changes in Workers' Characteristics between 1995 and 2012

Table 2 summarizes the samples under analysis between 1995 and 2012. As the numbers show, many characteristics of full-time male workers did not change much during the period: the average age of the male samples was always approximately 36-38; the proportion of white workers changed from 56.3% in 1995 to 46.6% in 2012; the average years of experience in the current job and the average years of overall working experience[2] were always approximately 8 and 23, respectively, during the period; and there were fewer workers with union status in 2012, although that change is small. Given the relatively stable composition of male workers' characteristics, the effects of these characteristics on changing the wage distribution would be small in terms of the composition effect and would mainly work through the wage structure effect.

The most significant changes in the composition of male workers' characteristics over the period under analysis are the improvement of educational attainment. For full-time male workers, the average years of education increased from 5.52 to 8.25, and the Gini coefficient of the years of education decreased from 0.42 to 0.28, indicating educational expansion and a less-dispersed distribution of education within the male workforce. The proportions of workers with 0-3 years and 4-7 years of education decreased from 33% to 14% and from 35% to 24%, respectively. Simultaneously, workers with 8-10 years of education increased from 13% in 1995 to 18% in 2012, workers with complete high school and incomplete college increased from 13% to

[2] Here, experience is defined as physical age minus 7 minus number of years of education.

35%, and 10% of workers had completed a college education in 2012 compared to 5% in 1995. Moreover, the allocation of workers between employers and employees and between formal workers and informal workers also changed. Fifty-five percent of workers were formal employees in 2012 compared to 44% in 1995, and informal employees, employers and self-employed workers all showed proportional decreases. These changes in the composition of workers' characteristics could affect the wage distribution through both the wage structure effect and the composition effect.

2.4 Decomposition Results

The kernel density estimation of log hourly wages of 1995 and 2012 are depicted in Figure 4. The 2012 wage distribution became less dispersed and moved to the right compared to the 1995 wage distribution, indicating growth in average wages and a decline in inequality. Moreover, the long right tail in both years indicates the existence of very high-wage earners; the right tail also extended further in 2012.

2.4.1 Change in Wage Structure

Table 3, which reports the ordinary least squares (OLS) estimates of the Mincer wage equations for 1995, 2012 and the pooled samples, documents the wage structure change among Brazilian male workers. For the Mincer regressions, the log hourly wage is the dependent variable, and the omitted education category is workers with 0-3 years of education. The results show that male wages experienced a significant increase, given that the estimated coefficient of the year 1995 dummy in the pooled regression is both negative and significant. The estimated coefficients of the education dummies are all positive and significant, which indicates that workers with better education normally earn more than workers who are illiterate or who have an incomplete primary education. Moreover, a comparison of the estimates associated with the education dummies in the 1995 results with those in the 2012 results shows a decline in relative returns at all education levels in 2012; the better-educated group experienced a greater decline, which is also depicted in Figure 5. Figure 6 shows the evolution of the relative returns for each education group, generated based on the Mincer regression results for each year between 1995 and 2012.

As shown in Tables 2 and 3, both the composition of male workers' characteristics and the wage structure experienced significant changes between 1995 and 2012, which supports the application of the decomposition approaches. The decomposition results of the changes in average value, the values at the 10^{th}, 50^{th} and 90^{th} quantiles and the inequality measures are reported below.

2.4.2 Decomposition of Increase in Average Wage

The Oaxaca-Blinder decomposition results of the increase in average wages between 1995 and 2012 are reported in Table 3 for the counterfactuals generated using the OLS estimates for the 1995, 2012 and pooled samples. When using the OLS estimates of the pooled regression as the reference, an underlying assumption is that the wage structure change can be completely captured by the year-fixed effect. There was an approximately 0.35 log unit increase in the average hourly wage between 1995 and 2012. The estimated wage structure effect is positive, which means that changes in the returns on workers' different characteristics had an increasing impact on average wages, assuming the composition of workers' characteristics is fixed. The changes in the composition of workers' characteristics also had an increasing impact on average wages, which means that the average wage would increase because of changes in the composition of the male labor force, assuming no change in the wage structure. Moreover, the wage structure effects always account for a larger proportion of the increase than the composition effects, regardless of how the counterfactual is generated.

The contribution of educational expansion to the increase in average wages is also reported in Table 4. For the 4-7 years of education group, the wage structure effect and the composition effect are both negative, which means both that the decline in the relative return to those with 4-7 years of education, as reported in Table 3, had a decreasing effect on average wages and that the decrease in the proportion of workers in this education group, as reported in Table 2, also decreased average wages. Similarly, the composition effects of the 8-10, 11-14 and 15+ education groups are all positive and based on Table 3, we know that the proportions of workers in these three groups increased, which means that the educational improvement of the male labor force had an increasing effect on average wages. The negative wage structure effects of these 3 education groups show that decreased relative returns on education had a decreasing effect on average wages. The negative wage structure effects are dominated by the positive composition effect; thus, the overall impact of educational improvement on average wages is positive.

In brief, both the changes in the composition of male workers' characteristics and the changes in the wage structure between 1995 and 2012 in Brazil contributed to the increase in average wages. For each education group, the decline in relative returns had a negative impact on average wages that was dominated by the positive impact of the educational improvement of male workers. These findings are robust for different counterfactuals.

2.4.3 Decomposition of Changes across the Wage Distribution

The RIF method is employed to decompose the changes at the 10th, 50th and 90th quantiles and the changes in the inequality measures, including the 90-10, 50-10 and 90-50 differentials, variances and Gini coefficients. The counterfactual is generated by reweighting the wage distribution of 1995, which means that the difference between the actual 2012 distribution and the counterfactual distribution represents the "composition effect" and the difference between the actual 1995 distribution and the counterfactual is the "wage structure effect."

The unconditional quantile regression results for the 10^{th}, 50^{th} and 90^{th} quantiles in both years are reported in Table 5, which shows the wage structure at different income levels in both years. The results show that the relative return at each education level becomes higher as it moves to a higher quantile in both years. The reason for this result is the positive relationship between education and unobservable skill, according to Arias et al. (2011), in which more skilled workers, who are more likely to be at the top of the wage distribution, would benefit more from educational investment. Additionally, each estimate associated with education in the

1995 results is higher than the corresponding estimate in the 2012 results, which demonstrates the decline in relative returns to each education group. Returns on experience and tenure also exhibit declining patterns similar to the returns on education. Workers who are white and have a union affiliation are always paid better at each quantile. Wage differences between employers versus employees and the self-employed increase when moving to higher quantiles.

The quantile decomposition results of changes at the 10th, 50th and 90th quantiles are documented in Table 6. The log hourly wage increased at all three quantiles in 2012: the 10th quantile increased the most, and the 90th quantile increased the least, as shown in panel A of Table 6. Panel B reports decomposition results based on the RIF regressions. The changes in the wage structure had an increasing effect on the 10th and 50th quantiles but a decreasing effect on the 90th quantile. The composition effects are positive for all three quantiles. At the 50th and 90th quantiles, the composition effects account for most of the change, and the wage structure effects are much smaller.

Moreover, the contributions of each education group to the wage structure effects at the 50^{th} and 90^{th} quantiles are all negative, which means that the decline in the relative returns on education had decreasing effects on wages at the 50^{th} and 90^{th} quantiles. Additionally, the impacts are larger at the 90^{th} quantile. However, the wage structure effects of each education group at the 10^{th} quantile are positive. The composition effects of each education group are similar to the mean decomposition results shown in Table 4: the decrease in the proportion of workers with 4-7 years of education decreased wages at each quantile and the expansion of better-educated groups increased wages throughout the distribution.

In brief, the quantile decomposition results show that changes in workers' characteristics increased wage income at the 10th, 50th and 90th quantiles. The changes in returns to different characteristics had an increasing impact on the 10th and 50th quantiles, but the wage structure effect decreased wages at the 90th quantile. The expansion of better education groups had an increasing impact at each quantile. The decrease in the relative returns of each education group had an increasing impact on the 10th quantile and a declining impact on the 50th and 90th quantiles.

The RIF decomposition is also applied to decompose the decrease on inequality between 1995 and 2012. The results, reported in Table 7, show that movements in the wage structure during this period had an equalizing impact on the wage distribution and that changes in workers' characteristics had an unequalizing impact on the wage distribution. Moreover, the unequalizing composition effects are always offset by the equalizing wage structure effect; thus, the degree of inequality decreased. In terms of education, a positive composition effect of education expansion demonstrates the existence of the "paradox of progress" (Bourguignon, Ferreira and Lustig, 2005), which means that a more equal distribution of education increases wage income inequality because of the convexity of returns to education. However, the negative wage structure effect dominates the positive composition effect, which means that the overall impact of education was equalizing. The results are also depicted in Figures 7 and 8. [3]

2.5 Conclusions

This essay investigates the changes in the male wage distribution of Brazil from 1995 to 2012 using PNAD data. The Oaxaca-Blinder decomposition is used to decompose the change in average wages between 1995 and 2012. The RIF decomposition is applied to decompose changes in other distributional statistics. The shift in the wage distribution coincides with education expansion; thus, the contribution of education is particularly interesting.

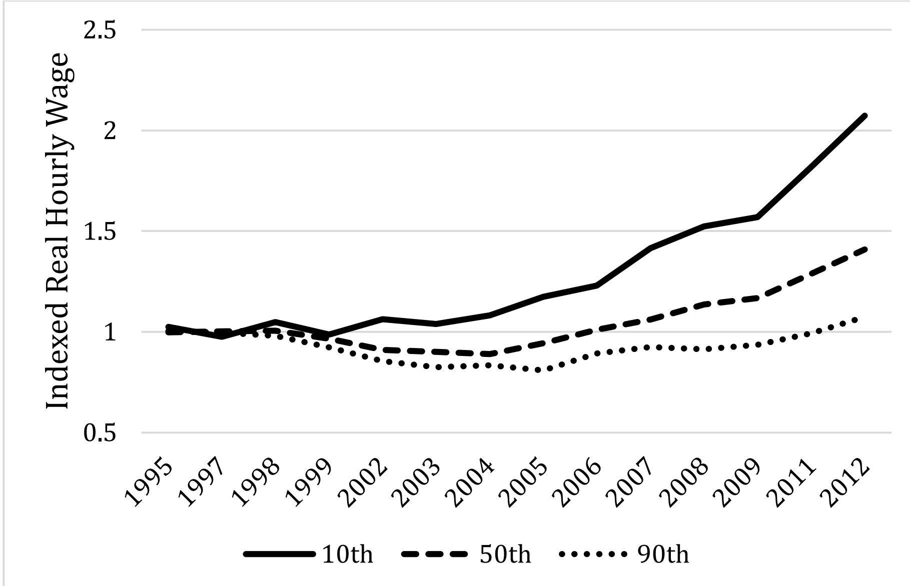
The wage structure in Brazil changed during the period under analysis; however, the composition of male workers' characteristics also changed. The results show that although both changes in the wage structure and changes in the composition of workers' characteristics increased both average wages and the wages at the 10th and 50th quantiles, the wage structure effect decreased wages at the 90th quantile. Regarding the decline in wage inequality, the wage structure effect was the main force in decreasing male wage inequality, and the composition effect was actually working in the opposite direction but was much smaller compared to the wage structure effect. The detailed decomposition results show that the decline in relative returns on different education groups had a decreasing effect on average wages and wages at

[3] All results reported in this section are robust when alternative decomposition methods are applied, which include the Residual Imputation Procedure (Juhn, Murphy and Pierce, 1991, 1993), Inverse Propensity Reweighting (DiNardo, Fortin and Lemieux, 1996), the Quantile Regressions Method (Machado and Mata, 2005) and the Estimation of Conditional Distribution (Chernozhukov, Fernandez-Val and Melly, 2009).

different quantiles, in addition to decreased inequality. The improvement in the education composition of the male labor force had an increasing impact on wage income and wage inequality, which demonstrates the existence of the "paradox of progress."

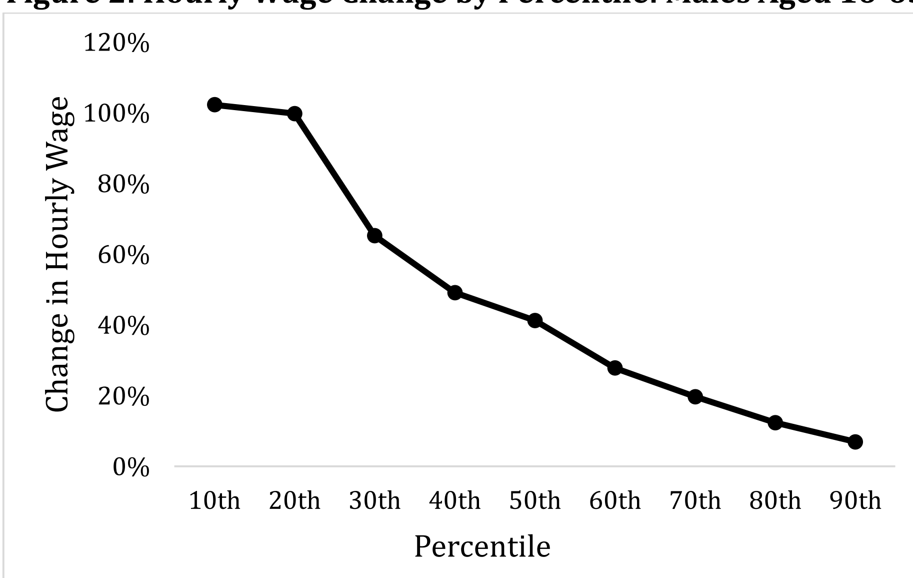
The coincidence of education expansion and the decline in the educational premium warrants further exploration given its contribution to the evolution of the entire wage distribution. The identification of the causes of the decline in the educational premium would also provide useful policy perspectives for education reform. Moreover, as noted in the previous section, the lower tail inequality declined more significantly than the upper tail inequality over the entire period under analysis; it would also be interesting to observe how institutions have different impacts on the lower and upper tails of the wage distribution.

Figure 1: Indexed Hourly Wage by Percentile: Males Aged 16-65



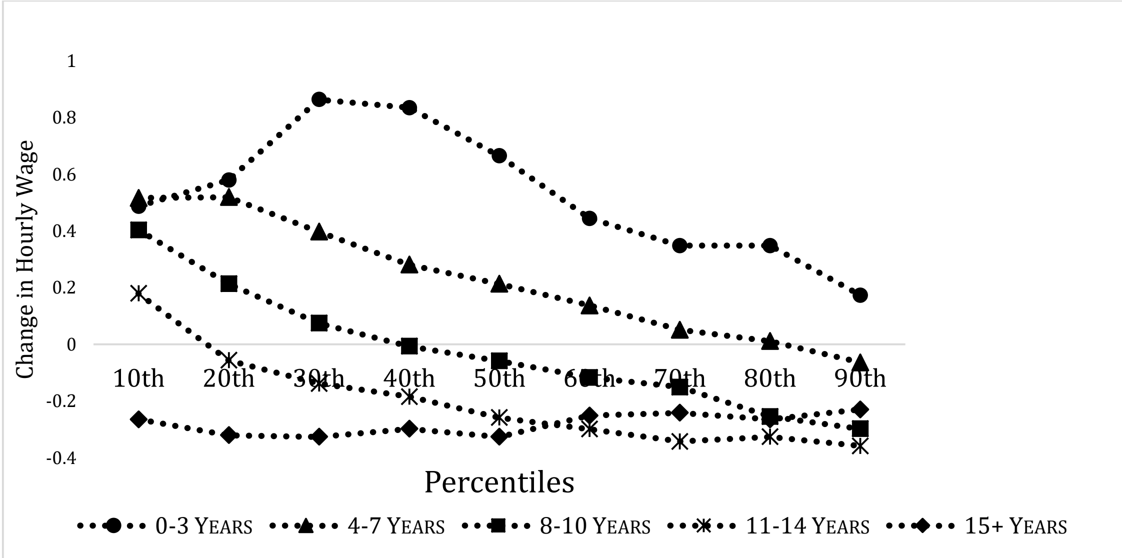
Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, and between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. The wage measure is in constant 1995 prices.

Figure 2: Hourly Wage Change by Percentile: Males Aged 16-65



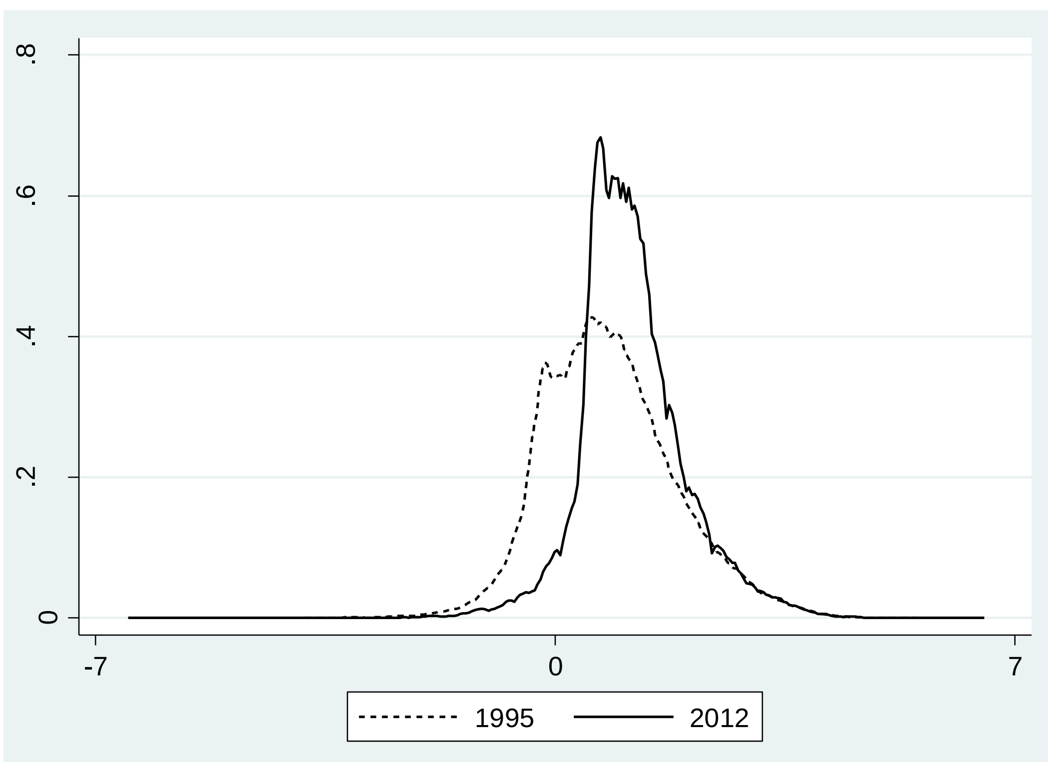
Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, and between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. The wage measure is in constant 1995 prices.

Figure 3: Hourly Wage Change at Different Education Levels: Males Aged 16-65



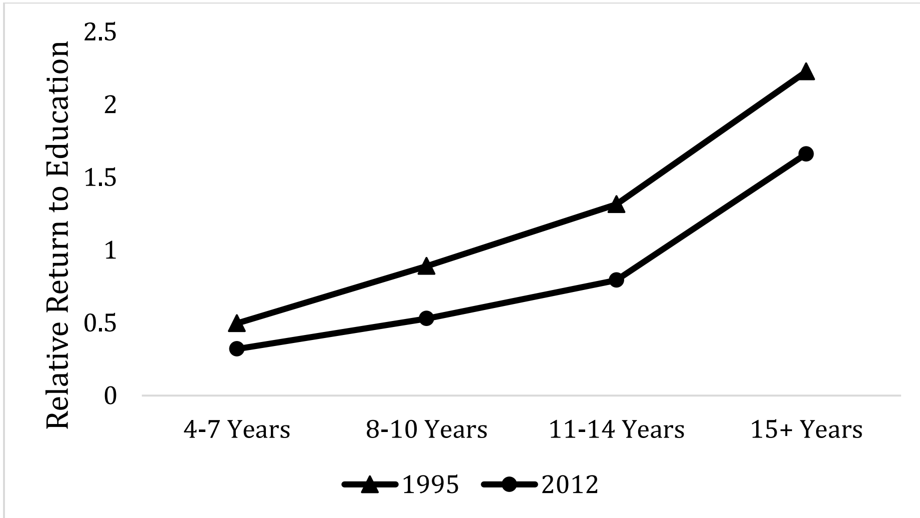
Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. The wage measure is in constant 1995 prices.

Figure 4: Kernel Density Estimation of Log Hourly Wage: Males Aged 16-65



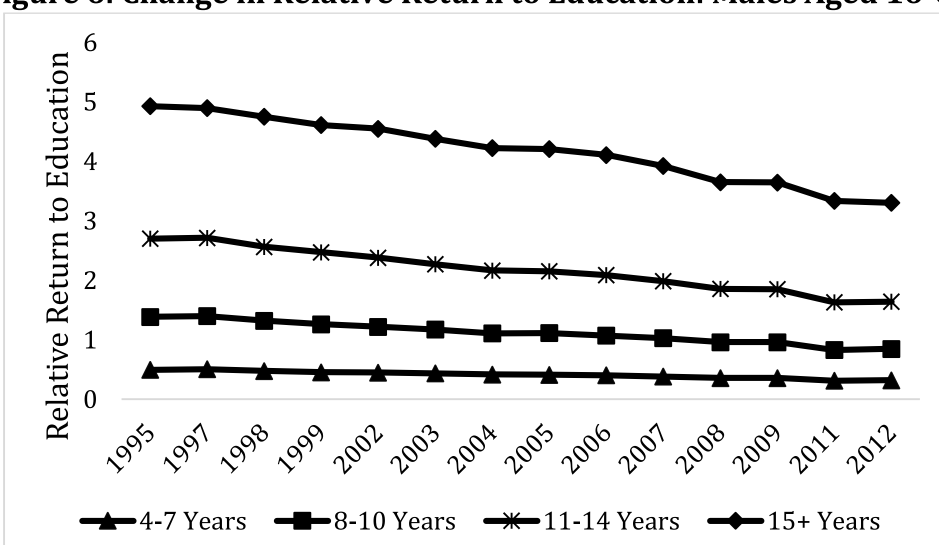
Note: Calculated based on full-time male workers between 16 and 65 years of age based on PNAD's 1995-2012 data.

Figure 5: Relative Return to Education: Males Aged 16-65



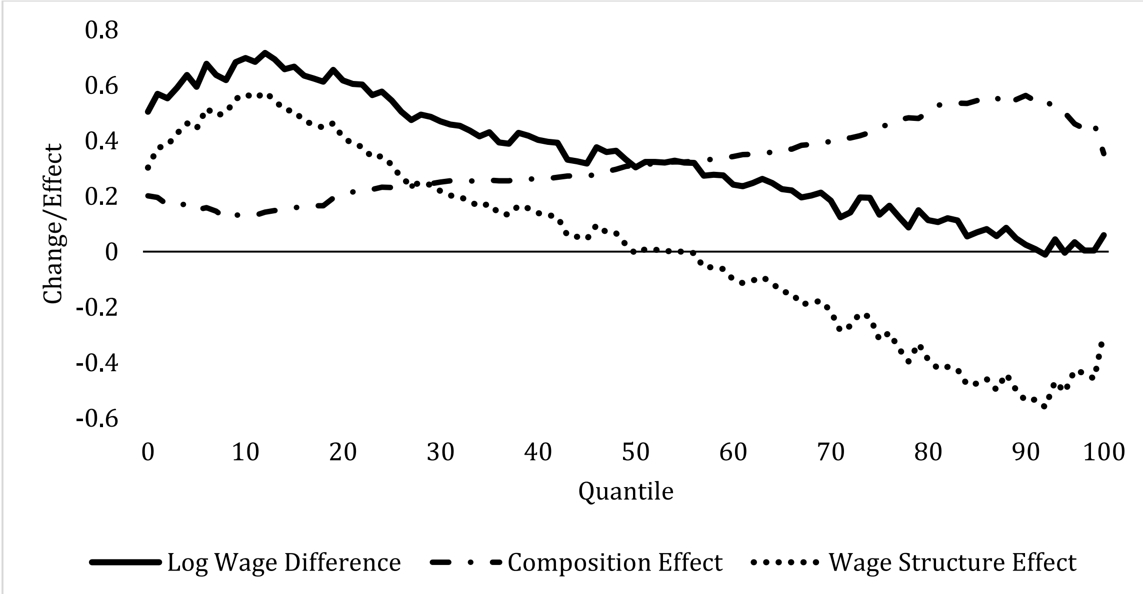
Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. The wage measure is in constant 1995 prices.

Figure 6: Change in Relative Return to Education: Males Aged 16-65



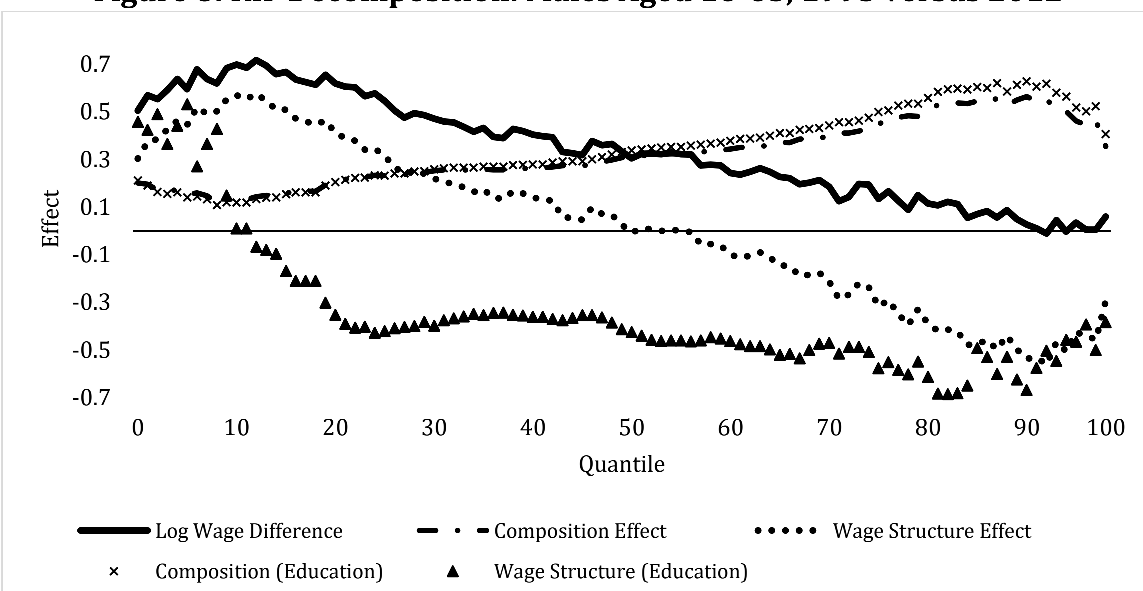
Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. Wage income in the analysis includes both cash income and the values of the goods and products paid from the primary job. The wage measure is in constant 1995 prices.

Fig 7: RIF Decomposition: Males Aged 16-65, 1995 versus 2012



Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles.

Figure 8: RIF Decomposition: Males Aged 16-65, 1995 versus 2012



Note: Calculated based on full-time male workers with positive working experience, working at least 140 hours per month, not currently a student, not working without pay or as domestic workers, between 16 and 65 years of age, based on PNAD's 1995-2012 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles.

Table 1: Inequality Measures of Hourly Wage Within Education Groups: Male Aged 16-65

		1995	1997	1998	1999	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012
0-3 Years	Gini	0.44	0.45	0.43	0.42	0.40	0.40	0.38	0.38	0.37	0.38	0.37	0.37	0.37	0.37
	Theil	0.37	0.41	0.38	0.34	0.33	0.34	0.28	0.28	0.28	0.28	0.28	0.26	0.28	0.28
	Obs	20298	19352	17344	17377	17099	15949	16459	15983	14930	14114	13202	12845	11567	9965
4-7 Years	Gini	0.44	0.43	0.42	0.41	0.41	0.40	0.40	0.39	0.39	0.39	0.37	0.36	0.35	0.35
	Theil	0.37	0.36	0.34	0.32	0.34	0.31	0.31	0.31	0.34	0.32	0.28	0.27	0.25	0.27
	Obs	22269	21953	20908	21208	21764	21126	21619	21946	21477	20138	19228	19429	15260	16291
7-10 Years	Gini	0.44	0.44	0.42	0.42	0.41	0.41	0.41	0.40	0.39	0.38	0.38	0.37	0.35	0.34
	Theil	0.36	0.40	0.34	0.35	0.34	0.33	0.37	0.33	0.31	0.30	0.33	0.30	0.27	0.23
	Obs	8321	9025	9048	9189	10554	10784	11580	11946	12439	12928	13093	12730	12359	12642
11-14 Years	Gini	0.46	0.47	0.45	0.46	0.46	0.45	0.45	0.44	0.44	0.42	0.42	0.41	0.39	0.40
	Theil	0.39	0.44	0.38	0.40	0.40	0.39	0.38	0.38	0.38	0.34	0.37	0.33	0.30	0.35
	Obs	8848	10058	10451	11041	15073	16052	17847	19756	20846	21066	22498	23901	22637	23870
15+ Years	Gini	0.42	0.42	0.43	0.41	0.43	0.43	0.43	0.45	0.44	0.45	0.45	0.47	0.46	0.45
	Theil	0.30	0.30	0.33	0.28	0.32	0.32	0.32	0.37	0.35	0.37	0.37	0.45	0.38	0.36
	Obs	3302	3570	3659	3732	4164	4214	4468	4748	5137	5443	5846	6454	6047	6561

Note: Author's calculation based on PNAD 1995 to 2012 data, wage is adjusted to 1995 price using CPI conversion factors. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently in school, not working without pay or domestic workers.

Table 2: Characterisitcs of Labor Market: Male Aged 16-65

Variable	1995	1997	1998	1999	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Years of Education	5.52	5.79	6.02	6.07	6.56	6.78	6.89	7.07	7.29	7.44	7.65	7.82	7.98	8.25
0-3 Years Education	33.00%	31.00%	29.13%	28.57%	24.88%	23.18%	22.65%	21.40%	19.80%	18.90%	17.81%	17.00%	16.62%	14.08%
4-7 Years Education	35.34%	34.34%	33.83%	33.90%	31.86%	30.99%	30.11%	29.43%	28.73%	27.26%	25.97%	25.65%	22.43%	23.53%
8-10 Years Education	13.13%	13.88%	14.58%	14.55%	15.20%	15.85%	15.97%	15.96%	16.39%	17.46%	17.55%	16.78%	18.25%	17.99%
11-14 Years Education	13.36%	15.23%	16.56%	17.15%	21.92%	23.52%	24.84%	26.69%	28.02%	28.83%	30.63%	31.82%	33.56%	34.78%
>=15 Years Education	5.18%	5.55%	5.89%	5.83%	6.15%	6.46%	6.43%	6.53%	7.05%	7.55%	8.05%	8.76%	9.15%	9.61%
White	56.26%	55.74%	56.16%	56.08%	54.43%	53.68%	52.75%	50.99%	50.78%	49.91%	49.16%	48.75%	48.23%	46.60%
Non-white	43.74%	44.26%	43.84%	43.92%	45.57%	46.32%	47.25%	49.01%	49.22%	50.09%	50.84%	51.25%	51.77%	53.40%
Tenure	7.64	7.85	7.79	7.90	7.80	7.96	7.92	7.89	7.91	8.07	7.89	8.07	8.05	7.99
Experience	23.82	23.89	23.86	23.99	23.65	23.50	23.49	23.19	23.17	23.21	23.10	23.19	23.26	23.14
Union	20.72%	19.65%	19.02%	19.11%	19.49%	19.93%	20.38%	20.54%	20.95%	19.62%	20.09%	19.75%	18.36%	17.54%
Formal Employee	44.34%	43.22%	43.26%	42.38%	43.77%	44.67%	45.69%	46.22%	47.46%	49.70%	51.75%	51.99%	54.21%	54.70%
Informal Employee	20.99%	21.33%	21.50%	21.57%	22.16%	21.32%	21.51%	21.16%	20.63%	19.50%	18.73%	18.25%	16.37%	16.09%
Self-Employed	28.56%	29.23%	29.19%	29.81%	27.85%	27.73%	26.83%	26.40%	25.47%	25.31%	23.23%	23.41%	24.84%	24.18%
Employer	6.11%	6.21%	6.06%	6.24%	6.21%	6.28%	5.97%	6.22%	6.45%	5.49%	6.30%	6.35%	4.58%	5.03%
Age	36.34	36.68	36.88	37.07	37.21	37.28	37.38	37.26	37.46	37.66	37.75	38.01	38.25	38.39
Monthly Wage	817.36	814.72	817.68	754.15	730.20	691.53	681.79	700.78	746.88	778.75	795.64	824.19	873.24	921.61
Monthly Hours	209.94	211.13	212.32	210.20	210.25	209.38	207.79	206.55	205.56	204.70	202.90	202.00	199.92	198.74
Hourly Wage	4.01	3.97	3.97	3.70	3.58	3.40	3.37	3.49	3.73	3.90	4.02	4.18	4.46	4.72
Log Hourly Wage	0.82	0.81	0.83	0.78	0.75	0.72	0.73	0.77	0.84	0.91	0.96	1.00	1.10	1.17
HH PC Inc	392.35	395.35	402.86	378.67	389.46	374.90	375.90	396.57	432.16	450.83	467.96	489.63	523.21	564.26
Obs	63038	63958	61410	62547	68654	68125	71973	74379	74829	73689	73867	75359	67870	69329

Note: PNAD 1995-2012 Survey data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers.

Table 3: OLS Regression Results: Male Aged 16-65

Dependent Variable: Log Hourly Wages

	Year 2012 Coef.	Year 1995 Coef.	Pooled Coef.
Time=1995			-0.09***
			(0.005)
4-7 Years Education	0.306***	0.469***	0.425***
	(0.01)	(0.008)	(0.006)
8-10 Years Education	0.501***	0.835***	0.698***
	(0.01)	(0.011)	(0.007)
11-14 Years Education	0.748***	1.232***	0.966***
	(0.01)	(0.012)	(0.008)
>=15 Years Education	1.590***	2.096***	1.824***
	(0.015)	(0.018)	(0.011)
Experience	0.032***	0.05***	0.039***
	(0.0008)	(0.001)	(0.0006)
Experience^2	-0.0004***	-0.0007***	-0.0005***
	(0.00001)	(0.00002)	(0.00001)
Tenure	0.005***	0.002***	0.004***
	(0.0004)	(0.0005)	(0.0003)
White	0.179***	0.256***	0.216***
	(0.005)	(0.007)	(0.004)
Self-Employed	-0.631***	-0.698***	-0.678***
	(0.017)	(0.018)	(0.012)
Formal Employee	-0.433***	-0.492***	-0.480***
	(0.016)	(0.017)	(0.012)
Informal Employee	-0.710***	-0.878***	-0.814***
	(0.018)	(0.018)	(0.013)
Union	0.03***	0.081***	0.065***
	(0.007)	(0.009)	(0.006)
Constant	0.540***	0.041*	0.333***
	(0.021)	(0.022)	(0.016)
Observations	69329	63,038	132,367
R-squared	0.397	0.48	0.449

Note: PNAD 1995-2012 Survey data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Oaxaca-Blinder Decomposition Results: Male Aged 16-65

Reference Group:	*Using 1995 Coef.*		*Using 2012 Coeff.*		*Using Pooled Coef.*	
Decomposition Method: Oaxaca-Blinder	*Overall Change=0.346*		*Overall Change=0.346*		*Overall Change=0.346*	
	*Composition Effect=0.321****	*Wage Structure Effect=0.0244****	*Composition Effect=0.208****	*Wage Structure Effect=0.137****	*Composition Effect=0.256****	*Wage Structure Effect=0.0896****
4-7 Years Education	-0.055***	-0.038***	-0.036***	-0.058***	-0.05***	-0.04***
8-10 Years Education	0.041***	-0.06***	0.024***	-0.044***	0.034***	-0.05***
11-14 Years Education	0.264***	-0.168***	0.160***	-0.065***	0.207***	-0.111***
>=15 Years Education	0.093***	-0.049***	0.071***	-0.026***	0.081***	-0.037***
Exp	-0.034***	-0.417***	-0.022***	-0.430***	-0.027***	-0.425***
Exp^2	0.017***	0.204***	0.011***	0.211***	0.013***	0.209***
Tenure	0.0007***	0.022***	0.002***	0.022***	0.001***	0.022***
White	-0.025***	-0.036***	-0.017***	-0.043***	-0.021***	-0.04***
Self-Employed	0.031***	0.016***	0.028***	0.019***	0.03***	0.017***
Formal Employee	-0.051***	0.032**	-0.045***	0.026**	-0.05***	0.031***
Informal Employee	0.043***	0.027***	0.035***	0.035***	0.04***	0.03***
Union	-0.003***	-0.009***	-0.001***	-0.01***	-0.002***	-0.009***
Constant		0.500***		0.5***		0.500***

Note: PNAD 1995-2012 Survey data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers.

Table 5: Quantile Regression Results: Male Aged 16-65

Year:		**1995**			**2012**	
Quantile:	**10th**	**50th**	**90th**	**10th**	**50th**	**90th**
4-7 Years Education	0.351***	0.428***	0.427***	0.311***	0.233***	0.254***
	(0.011)	(0.008)	(0.013)	(0.01)	(0.007)	(0.014)
8-10 Years Education	0.637***	0.784***	0.845***	0.440***	0.391***	0.440***
	(0.016)	(0.011)	(0.018)	(0.011)	(0.008)	(0.016)
11-14 Years Education	0.930***	1.223***	1.339***	0.547***	0.596***	0.815***
	(0.016)	(0.012)	(0.018)	(0.011)	(0.008)	(0.015)
>=15 Years Education	1.825***	2.151***	2.212***	1.132***	1.541***	1.943***
	(0.023)	(0.016)	(0.026)	(0.014)	(0.01)	(0.019)
Experience	0.040***	0.05***	0.055***	0.019***	0.028***	0.04***
	(0.001)	(0.001)	(0.002)	(0.0009)	(0.0006)	(0.001)
Experience^2	-0.0006***	-0.0007***	-0.0008***	-0.0003***	-0.0004***	(0.0006)***
	(0.00002)	(0.00002)	(0.00003)	(0.00002)	(0.00001)	(0.00002)
Tenure	-0.0006	0.005***	0.011***	0.00006	0.008***	0.013***
	(0.0006)	(0.0004)	(0.0006)	(0.0004)	(0.0003)	(0.0005)
White	0.194***	0.232***	0.249***	0.128***	0.164***	0.161***
	(0.009)	(0.007)	(0.01)	(0.006)	(0.004)	(0.008)
Self-Employed	-0.742***	-0.683***	-0.701***	-0.681***	-0.638***	-0.684***
	(0.02)	(0.015)	(0.023)	(0.015)	(0.011)	(0.021)
Formal Employee	-0.271***	-0.548***	-0.825***	-0.161***	-0.498***	-0.780***
	(0.02)	(0.014)	(0.022)	(0.015)	(0.01)	(0.02)
Informal Employee	-0.637***	-0.901***	-1.094***	-0.602***	-0.717***	-0.906***
	(0.021)	(0.015)	(0.025)	(0.016)	(0.011)	(0.022)
Union	0.09***	0.127***	0.135***	0.006	0.061***	0.099***
	(0.012)	(0.008)	(0.013)	(0.008)	(0.006)	(0.011)
Constant	-0.642***	0.0691***	0.956***	0.042**	0.697***	1.305***
	(0.028)	(0.021)	(0.033)	(0.021)	(0.014)	(0.029)
Observations	63038	63,038	63,038	69,329	69,329	69,329
R-squared	0.198	0.288	0.360	0.194	0.220	0.334

Note: PNAD 1995-2012 Survey data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Quantile Decomposition Results: Male Aged 16-65

Reference Group: 1995 Coef.	**10th percentile**		**50th percentile**		**90th percentile**	
A. Raw log hourly wage gap:	0.704		0.345		0.067	
B. Decomposition Method: RIF						
Mean RIF Gap	0.683		0.333		0.049	
	Composition Effect=0.124	Wage Structure Effect=0.559	Composition Effect=0.293	Wage Structure Effect=0.0397	Composition Effect=0.506	Wage Structure Effect=-0.457
4-7 Years Education	-0.045	0.019	-0.061	-0.062	-0.026	-0.019
8-10 Years Education	0.025	0.027	0.048	-0.0928	0.032	-0.058
11-14 Years Education	0.108	0.074	0.266	-0.207	0.349	-0.340
>=15 Years Education	0.0220	0.0291	0.0629	-0.0328	0.2110	-0.1550
Exp	-0.010	-0.058	-0.023	-0.4690	-0.030	-0.571
Exp^2	0.0028	0.0552	0.0070	0.228	0.0094	0.3010
Tenure	-0.0030	-0.0077	0.0017	0.016	0.0082	0.0249
White	-0.012	0.004	-0.027	-0.037	-0.023	-0.021
Self-Employed	0.010	-0.040	0.017	0.022	0.051	0.039
Formal Employee	0.003	0.046	-0.036	0.036	-0.145	0.098
Informal Employee	0.022	-0.013	0.042	0.040	0.074	0.028
Union	0.002	-0.011	-0.004	-0.012	-0.006	-0.004
Constant		0.434		0.611		0.219

Note: PNAD 1995-2012 Survey data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers.

Table 7: RIF Decomposition of Changes in Wage Inequality: 1995-2012, 16-65 years old male sample

	90-10		90-50		50-10		Variance	
Overall Changes:	-0.635		-0.285		-0.35		-0.323	
	Composition Effect=0.382	Wage Structure Effect=-1.016	Composition Effect=0.213	Wage Structure Effect=-0.497	Composition Effect=0.169	Wage Structure Effect=-0.519	Composition Effect=0.184	Wage Structure Effect=-0.506
4-7 Years Education	0.019	-0.038	0.035	0.043	-0.016	-0.081	0.028	-0.017
8-10 Years Education	0.007	-0.084	-0.016	0.035	0.023	-0.120	-0.006	-0.038
11-14 Years Education	0.241	-0.414	0.083	-0.133	0.158	-0.281	0.084	-0.213
>=15 Years Education	0.189	-0.184	0.148	-0.122	0.041	-0.062	0.118	-0.150
Exp	-0.020	-0.513	-0.007	-0.102	-0.013	-0.411	-0.007	-0.227
Exp^2	0.007	0.246	0.002	0.073	0.004	0.173	0.003	0.118
Tenure	0.011	0.033	0.006	0.009	0.005	0.023	0.009	-0.016
White	-0.011	-0.024	0.004	0.016	-0.014	-0.041	0.002	0.016
Self-Employed	0.041	0.079	0.034	0.018	0.007	0.061	0.023	0.027
Formal Employee	-0.148	0.052	-0.109	0.062	-0.039	-0.010	-0.094	0.036
Informal Employee	0.052	0.041	0.032	-0.013	0.020	0.053	0.029	-0.001
Union	-0.008	0.007	-0.002	0.008	-0.006	-0.001	-0.005	0.007
Constant		-0.215		-0.392		0.177		-0.048

Note: Author's calculation based on PNAD 1995 and 2012 data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers aged between 16 and 65 with positive working experience, worked at least 140 hours per month, not currently schooling, not working without pay or domestic workers.

Chapter 3

Education Expansion and Decline in Tertiary Premium in Brazil: 1995-2013

3.1 Introduction

Wage inequality declined substantially in Brazil between 1995 and 2013. According to the Brazil National Household Survey[1] data, the Gini coefficient of hourly wages of all full-time workers continuously declined from 0.53 in 1995 to 0.45 in 2013. Wage inequality is determined by distribution of skills in the labor force and the prices of the skills in the labor market (Katz & Autor, 1999). Decomposition analysis concludes that the changes in prices of workers' different skills were the main force in changing the wage distribution in Brazil during this period (Ferreira et al., 2015). Among all the movements in skill prices, the change in educational premium is the most conspicuous: the relative average return of each education group with respect to the incomplete primary education group (0-3 years) declined throughout 1995 to 2013, with the most significant decline occurring among the tertiary group (12+ years). In

[1] In Portuguese, the survey is called "Pesquisa Nacional por Amostra de Domicílios."

absolute terms, the average hourly wage of workers with college educations and above decreased from 7.9 reals in 1995 to 6.3 reals[2] in 2013. The average hourly wage of workers with complete secondary educations also declined, from 3.1 reals in 1995 to 2.5 reals in 2013. For workers with other lower education levels, the average hourly wage increased between 1995 and 2013, with the extent of the increase in negative correlation to the education level.

The wage convergence among education groups coincides with a large expansion of higher education, which has been one of the most significant changes in the labor markets of Brazil and other Latin American countries since the 1980s. In 1995, among all economically active people aged 16-65, 9.5% had tertiary education; this ratio increased to 18.9% in 2013. On the other hand, 47.1% of this population had a primary education or less (0-3 years) in 1995, declining to 19.9% in 2013. Given the coincidence of the decline in education premium and the education expansion, an immediate question is to what extent the change in education premium in Brazil is accounted for by the shifts in relative supply of more-skilled workers and how that change is related to the decline in wage inequality.

In addition to the impact of relative supply, the change in relative demand would also affect relative skill premium. According to the Heckscher-Ohlin model, globalization would increase the skill premium in countries which possess more skilled labor and decrease the skill premium in countries with more abundant less-skilled labor, which is the case of Brazil (Goldberg & Pavcnik, 2007; Harrison & Hanson, 1999). According

[2] All wage measures mentioned in this essay are in 1995 prices.

to Autor, Katz, and Kearney (2008), the evolution of the college to high school premium in the US includes a decline during the 1970s, a significant increase during the 1980s, and then a mild increase since the 1990s. In contrast, both Brazil and Mexico (Campos-Vazquez et al., 2014) have observed declines in the relative return to tertiary education in the past two decades. Thus, it is also of interest to know whether the decline in education premium in Brazil was caused by a decrease in relative demand for more-skilled workers, or by the increase in supply dominating the change in relative demand.

Other than the shifts in relative supply and relative demand for more-skilled workers, the decline in relative return to tertiary education could also be caused by a decline in the average quality of the tertiary-educated workers of the more recent cohorts in the process of education expansion, which is called the "Degraded Tertiary Effect" (Lustig, Lopez-Calva, & Ortiz-Juarez, 2013). The education expansion started in Brazil after the World War II and has accelerated since 1990. The government had mainly focused on the growth of tertiary education but didn't put enough effort to develop the basic-level education. In 1996, the government started to allow private for-profit universities to offer degrees (In Brazil, public universities offer education with the best quality and the degrees offer by them are the most well-recognized). As a result, the number of private for-profit universities grown very fast: there was 1004 private for-profit universities in 2000 and increased to 2069 in 2009, which takes around 80% of the higher education institutions in Brazil. As results of the neglect, now the basic education is not functioning satisfactorily in preparing students to meet the expectations of the public universities.

The change in the average quality of the tertiary group is an important indicator of the efficiency of the education expansion. Taubman and Wales (1972) find that the average quality of the tertiary group increased in the US during the 1990s based on a series of test score statistics. Juhn, Kim, and Vella (2005) find a small decline in the average quality of the more educated cohort during the 1940-1990 period in the US, which only accounted for a small fraction of the change in the college wage premium. Canerio and Lee (2011) demonstrate a decline in the average quality of tertiary workers during 1960-2000 in the US. However, little research has been conducted in the context of less developed countries, even though this question is particularly important for countries with scarcer resources.

This essay decomposes the change in the tertiary premium in Brazil during the 1995-2013 period into both the "price effect," which refers to the change in the educational premium due to the impact of shifts in relative supply and relative demand, and the "composition effect," which identifies whether there was any significant change in cohort quality and how the changes in cohort quality impacted the relative wage of the tertiary group. This research explores the following two questions. First, the changes in the relative return to the tertiary group in Brazil between 1995 and 2013 are examined to see how much of the change is accounted for by the shifts in the relative supply and relative demand of workers with tertiary educations, following the supply-demand approach of Autor, Katz, and Kearney (2008). Second, the "degraded tertiary effect" is examined following Juhn, Kim, and Vella (2005). The specific hypothesis is whether the tertiary premium paid to workers from a more educated cohort decreased, controlling for everything else that also affected the tertiary premium. The educational level of each cohort is controlled by the variation in the relative size of tertiary-educated workers of each birth-year cohort. The decrease in the average quality is inferred from the decrease in the relative wage. This essay contributes to the literature as the first research exploring the reasons behind the decline in the tertiary premium in Brazil in the most recent period. Additionally, the identification of the impact of relative demand on skill premiums contributes to an empirical testing of the Heckscher-Ohlin model in the context of Brazil. Moreover, identifying whether there is any deterioration of the tertiary education provides important policy perspectives for efficient education reform.

When analyzing changes in the relative wage and the relative supply of the tertiary group, the reference group is comprised of those with an incomplete secondary education. The results demonstrate that the growth in the relative demand was the main cause for the mild increase in the relative return to the tertiary group during the 1995-2004 period. The decline in the tertiary premium during the 2004-2013 period was due to the increase in the relative supply, exceeding the increase in the relative demand. Thus, it is proved that there was no decrease in relative demand for skilled workers in Brazil in the past two decades. Subsequently, the change in the average quality of the tertiary group is further tested; while controlling for the impact of expanded supply, which is measured by the proportion of workers with tertiary education in each birth-year cohort, we find that the tertiary premium of the most recent cohorts decreased, from which we make the inference that the average quality of the tertiary group declined during this period.

The chapter is structured as follows. Section 2 summarizes the relevant literature. Section 3 introduces the data and samples for analysis as well as the evolution of wage inequality, wage structure and education distribution in Brazil between 1995 and 2013. Section 4 describes the supply-demand framework employed for analysis and presents estimates of the role of supply and demand in the changing wage differential of the tertiary group. Section 5 analyzes the degraded tertiary hypothesis, and section 6 concludes the essay.

3.2 Relevant Literature

This section summarizes two themes in the literature: variation in tertiary premium and how educational composition and educational premium are correlated with wage inequality. Little research has been performed on identifying the causes behind variation in educational premium in the context of Brazil, however.

On the subject of the change in tertiary premium in Brazil, Green et al. (2001) studied the skill premium in Brazil between 1981 and 1999. They found an increase in return to tertiary education after 1990, which was mainly attributed to an increase in relative demand. The impact of this increase in tertiary premium on wage inequality is negligible due to the small size of the tertiary group. Blom et al. (2001) studied a similar period, 1982 to 1998, and found the return to tertiary education increased sharply while the return to primary and secondary education declined. The change in return to education is the main reason for the mild decline in wage inequality. Both Green et al. (2001) and Blom et al. (2001)'s findings suggest increasing access to higher education would be beneficial in terms of reducing wage inequality. Barros et al. (2010) found that wage differentials of different education levels started to decline in 1995 and that the reduction was more obvious after 2002, especially for secondary and tertiary education. This reduction is one of the most important factors contributing to the recent decline in wage income inequality.

On the relation between education expansion and wage inequality, Green et al. (2001) found that the Gini coefficient of wage income increased from 0.55 in 1981 to 0.61 in 1989, then declined after 1990 when the trade reform took place in Brazil. Ferreira and Barros (1999) found that wage inequality was basically unchanged in a comparison of 1976 to 1996 because the impact of the decline in return to higher education counterweighted the impact of education expansion of the labor force. Ferreira et al. (2007) found that education expansion in the context of highly convex return was an important reason for the increase in inequality during 1980s and that the decline in inequality between 1993 and 2004 was accounted for by declines in returns to education, convergence between rural and urban, effective transfer programs, and a decline in inequality among races. Barros et al. (2010) found that the accelerated education expansion in Brazil during 2001 to 2007 accounted for half of the decline in wage income inequality and that the recent decline in wage income inequality was caused by a convergence in return differentials across education groups as well as a more equal distribution of education. Additionally, the change in educational premium is more important than education expansion in explaining the decline.

3.3 Data and Statistical Analysis

The data employed in this analysis come from a series of the annual Brazil National Household Survey (PNAD), covering the period between 1995 and 2013. The PNAD survey is collected by the Brazilian Institute of Geography and Statistics (IBGE), which covers the general characteristics of the population, including health, education, job characteristics, household income and housing conditions. The wage income in the analysis includes both cash income and the value of goods and products paid by one's primary job. For the purpose of comparison across years, the nominal wages of each year are deflated to real values in 1995 prices utilizing CPI conversion factors from IBGE. The education groups defined in this research are the following (Blom, Holm-Nielsen, & Verner, 2001; Ferreira & Barros, 1999; Ferreira, Firpo, & Messina, 2014): primary incomplete (0-3 years of education), primary complete (4 years of education), secondary incomplete (5-10 years of education), secondary complete (11 years of education), and tertiary incomplete and complete (12+ years).

Two sets of samples are defined for answering the research questions: the wage samples and the supply samples. For both sets of samples, the 1st and 99th percentiles are trimmed for each gender-education-year group. First, the wage samples include all *full-time* workers aged 16-65 who reported working at least 140 hours per month, are not currently students, and are not working without pay or as domestic workers; employers, employees and the self-employed are all included. The wage measure employed in this analysis is the hourly wage generated by dividing the reported monthly wage by 4.33 times the reported hours worked per week (Campos-Vazquez et al., 2014). Second, the supply samples include all individuals aged between 16 and 65 who reported working *at least 1 hour* during the survey month; students and those working without pay are excluded from the supply; all employers, employees, self-employed and domestic workers are included.

Based on this survey data and sample selection criteria, the following several paragraphs describe the evolution of wage inequality, changes in wage structure and increase in education attainment of the labor force.

3.3.1 Changes in Wage Inequality and Wage Structure

Brazil is a country of great diversity and high income inequality. The evolution of income inequality in Brazil has been well documented. It rose between 1960 and 1976, then declined between 1977 and 1981. According to Ferreira, Leite, and Litchfield (2008), income inequality increased between 1981 and 1989, rising to a peak period during 1989 to1993, then inequality declined between 1993 and 2004, which changed Brazil from the second most unequal country in the world in 1989 to the tenth in 2004. A more recent study by Barros et al. (2010) found that the Gini coefficient declined from 0.593 in 2001 to 0.552 in 2007 and that the changes in wage income distribution accounted for 31% to 46% of the decline.

According to our data, the wage inequality declined continually and substantially from 1995 to 2013. Figure 1 presents the evolution of hourly wage inequality across those years for all full-time workers, in which the Gini coefficient and 90-10 log differential significantly declined. The data exhibits a similar pattern of change when females and males are analyzed separately. The decline in wage inequality is also observed in every education group except the tertiary group. As shown in Figure 2, the wage inequality of the tertiary group was stable and always the highest among all educational groups during the 1995-2013 period, in contrast to all other education groups.

The main cause of the decline in wage inequality was the significant change in the wage structure between 1995 and 2013. In a comparison of 2013 and 1995, the real average hourly wage of all full-time workers increased 26%, which includes a decline during 1995-2004 and an increase during 2004-2013, as shown in Figure 3. Figure 4 shows the evolution of the average hourly wage of each education group; as the figure shows, the tertiary group experienced the most significant decline. Comparing 2013 with 1995, the average absolute wage of the incomplete primary group increased 52%, the complete primary group increased 13%, the incomplete secondary group increased 5%, and both the complete secondary and tertiary group declined about 20%.

While analyzing the change in the tertiary premium, the relative return and relative supply of the tertiary group is measured with respect to the incomplete secondary group—those with 5-10 years of education. Figure 5 presents the relative return to tertiary education compared to incomplete secondary education across years. Figure 5 is generated based on the wage samples, and the relative premium is composition-adjusted.[3] The composition-adjusted tertiary premium represents the premium for a fixed composition of workers—the average composition over the 1995-2013 period according to Autor, Katz, and Kearney (2008); thus, the changes in relative wage reflect only the change in wage structure but not changes in the composition of workers' characteristics. Correspondingly, the relative supply measure is in efficiency units. These are conventions for analyzing the impact of supply and demand on relative wages (Acemoglu & Autor, 2011; Autor, 2014; Autor, Katz, & Kearney, 2008; DeLong, Goldin, & Katz, 2003; Goldin & Katz, 2007; Katz & Murphy, 1992), which allows us to filter out the possible impact of the deterioration in workers' average quality while analyzing the impact of supply and demand. As the graph demonstrates, the tertiary premium increased slightly between 1995 and 2004 and then declined between 2004 and 2013. Correspondingly, Figure 6 presents the log of the relative supply of the tertiary group with respect to the incomplete secondary group. Figure 6 is generated based on the supply samples, and supply is measured in efficiency units, which are comparable to the composition-adjusted wage measure. As we see, the relative supply was stable between 1995 and 2004 and then increased sharply after 2004, reflecting the fast expansion of tertiary education. Comparing Figure 5 with Figure 6, the increase in the tertiary premium between 1995 and 2004 might reflect the increase in the relative demand for the tertiary workers given the stable relative supply. Given the sharp increase in the relative supply of the tertiary-educated workers, the decline in the tertiary premium between 2004 and 2013 could be due to

[3] See the data appendix for information about how the composition-adjusted wage measure and supply measure in efficiency units are constructed.

a change in the relative demand that was not fast enough to digest the growth in the relative supply.

3.3.2 Changes in Educational Attainment

The average years of education for male workers aged 16-65 increased from 5.53 in 1995 to 8.34 in 2013. Among all economically active male workers aged 16-65 (in the supply samples, employers, employees, self-employed and domestic workers are included), 52% had primary or less education in 1995, and 12% had attended college in 1995. In 2013, the proportion with primary or less education had declined to 24%, and the proportion who had attended college had increased to 30%. The evolution of the education distributions of economically active females exhibited a similar pattern during the period under analysis. In addition, throughout the entire period, economically active females were always more likely to have attended college compared to economically active males in Brazil.

Additionally, there was an acceleration in education attainment among the younger cohorts. Figure 7 presents the average years of education of each birth year cohort at age 30 separately for economically active males and females aged 16-65. To generate this graph, all economically active males and females aged 16 to 65, which covers those born between 1932 and 1994, were pooled together, and then the male and female samples were grouped into cells defined by birth year and age. The log of the average years of education in each cell is regressed on a set of birth year dummies and a quartic in age (R-squared for both male and female regressions is above 0.9), and then the estimated coefficients associated with age variables are employed to create the age-adjusted schooling measures evaluated at age 30.[4] As we see, there was an acceleration in the increase in average years of education of cohorts born after 1975.

The change in the composition of workers' education levels across the wage distribution implies the possible decline in the average quality of the tertiary group. Figure 8 compares the composition of workers with different education levels at each fifth percentile of the wage distribution in 1995 with those in 2013. As we see, there were few tertiary-educated workers receiving a wage lower than the median wage in 1995; however, 14.3% of the tertiary-educated workers received a wage lower than or equal to the median wage in 2013. This is consistent with the degraded tertiary hypothesis in that those new entrants with tertiary education but lower quality are paid less (in accordance with their actual quality level), thus dragging down the average wage of the tertiary group. The average wage of the tertiary group would be higher than what we observed from the data without those people.

3.4 The Impact of Supply and Demand

3.4.1 The Supply-demand Framework

Following Autor, Katz, and Kearney (2008), assume that the CES production function takes the following form:

[4] The processing of data follows DeLong, Goldin, and Katz (2003).

$$Q_t = A_t(N_{Ut}^{\rho} + \alpha_t N_{St}^{\rho})^{1/\rho}$$

in which Q_t is total output at time t, and N_{Ut} and N_{St} are the quantities of employment of unskilled and skilled labor at time t. A_t is the skill-neutral technology change at time t, and the skill-biased technology change would increase α_t, which is a measure of relative productivity of skilled workers over unskilled workers. The elasticity of substitution between skilled and unskilled labor equals $1/(1-\rho) = \sigma$.

By calculating the marginal product of skilled and unskilled labor, the relationship between relative wage and relative supply can be expressed by the following equation:

$$\ln(w_{St}/w_{Ut}) = ln\alpha_t - (1/\sigma)\ln(N_{St}/N_{Ut}) = (1/\sigma)[lnD_t - \ln(N_{St}/N_{Ut})]$$

in which $lnD_t = \ln({\alpha_t}^{\sigma})$ represents the relative demand shifts due to skill-biased technology changes. As the elasticity of substitution σ increases, the impact of the relative supply on the relative wage decreases, and the change in the relative wage that should be accounted for by the demand change becomes greater.

While empirically implementing this framework, a time trend and the log of the unemployment rate of male workers are used as measures of the change in demand. The model specification is the following:

$$\ln(w_{St}/w_{Ut}) = \beta_0 + \beta_1 t + \beta_2 ln(N_{St}/N_{Ut}) + \beta_3 \ln(Unemp_t) + \varepsilon_t \quad (1)$$

in which $1/\beta_2$ is the estimate of elasticity of substitution σ.

In this analysis, the skilled group is workers with tertiary education (12+ years) and the unskilled group refers to those with incomplete secondary education (5-10 years). Most of the following results are robust if utilizing the complete secondary group (11 years) as the reference group. In the case of less developed countries compared to the US, it is of interest to extend the two factor CES production function to include three factors. In Brazil, workers with primary or less education should still comprise a substantial proportion of the economically active people and there are significant variations in productivity among workers with primary, secondary and tertiary levels of education.

Considering that workers with the same education level but different experience levels are imperfect substitutes, it is expected that the relative supply of a specific age group would have a varying degree of impact on the tertiary premium of all age groups. Autor, Katz, and Kearney (2008) also extend the previous equation (1) to account for changes in the relative supply of different groups with varying experience levels.

The extended model is the following:

$$\ln\left(w_{Sjt}/w_{Ujt}\right) = \beta_0 + \beta_1 t + \beta_2 ln(N_{St}/N_{Ut}) + \beta_3\left[ln\left(N_{Sjt}/N_{Ujt}\right) - ln(N_{St}/N_{Ut})\right] + \beta_4 \ln(Unemp_t) + E_j + \varepsilon_t \quad (2)$$

in which j represents experience group j and E_j is a set of dummies indicating the experience groups under analysis.

3.4.2 The Role of Supply and Demand

Following the approach presented in section 4.1, several regressions are run to see how shifts in supply and demand affected the log educational differentials between 1995 and 2013. Between 1995 and 2004, we observed an increase in the tertiary premium and stable relative supply. The decline in the educational premium of the tertiary group between 2004 and 2013 coincided with a rise in the relative supply. Given these changes in price and supply, the market-clearing condition requires an increase in demand for tertiary-educated workers during 1995-2004 and a slower growth in relative demand compared to supply during 2004-2013.

Figure 9 depicts the detrended log relative supply and detrended log relative wage of workers with tertiary education with respect to those with incomplete secondary education. As we can see from the graph, the deviations in relative supply from a linear trend are negatively correlated with the changes in the detrended relative wage.

The results are shown in Table 1 for overall samples as well as male and female subsamples. The log tertiary premium is regressed on the log relative supply, controlling the demand shifts. In column 2, the time trend and male unemployment rate are used as controls for the demand shift. The estimate associated with the log relative supply is -0.33; thus, the estimated elasticity of substitution equals 3. The estimate of the time trend is positive and significant, which indicates an increase in the relative demand. As we noted in the previous statistical analysis, the relative supply during 1995-2004 did not change much, and the growth in the premium should be primarily accounted for by the shift in demand. This is proved by column 1, which documents the estimates of the 1995-2004 period and exhibits an insignificant impact of the relative supply and a significant and positive time trend. In columns 3 and 4, we test whether there is an extraordinary pattern associated with the demand shift. First, we allow a break in 2004, and the results in column 3 demonstrate there was no significant decline in demand after 2004. Then, we add a quadratic term of the time trend; the results imply a slight slowdown of demand growth during the period. The same set of analyses is run for male and female subsamples, and the results are documented in columns 5-8 and columns 9-12, respectively. The results are all comparable with the results based on the total samples.

It is of interest to test whether the change in the tertiary premium varies across age groups. The regression results of equation 2 are documented in Table 2. Columns 1 and 2 show the results when 4 experience groups (1-10 years, 11-20 years, 21-30 years and 31+ years) are pooled, controlling for group dummies. The results show the significant impact of both aggregate supply and group-specific supply changes. Columns 3-6 are the regression results of each experience group, which demonstrate the significant impact of the shift in the aggregate demand and the aggregate supply on the relative return. These findings based on the aggregate samples are also true for the male and female subsamples.

Based on the regression results, we can conclude that the increase in demand for workers with tertiary education is the main cause for the mild increase in the tertiary premium during 1995-2004. The decline in the tertiary premium during 2004-2013 is mainly due to the rapid increase in the relative supply. Although the relative demand was still increasing during this period, the increase was not fast enough to digest all of the increase in the relative supply; thus, the premium declined.

3.5 The Degraded Tertiary Hypothesis

As stated previously, the period of wage structure change coincides with education expansion in Brazil. As a result, the quality composition of the tertiary-educated workers might also have deteriorated, which is called the "degraded tertiary hypothesis" according to Lustig, Lopez-Calva, and Ortiz-Juarez (2013). The change in the average quality of the tertiary group could also be a reason for the decline in the tertiary premium. Thus, a research question to be further explored is whether the expansion of tertiary education leads to a decline in the average quality of the recent cohorts of the tertiary group and to what extent the decline in the tertiary premium is accounted for by the change in the average quality.

Assume that there is a threshold of individuals' ability, where individuals above this threshold could benefit from education and individuals with ability below it cannot effectively learn the knowledge. If the education expansion goes beyond this threshold, resources are wasted. Preventing education expansion from going beyond the threshold is beneficial to society from a welfare perspective because people with capability still receive opportunities to develop themselves. Even if the expansion is completely beneficial, the average quality of the tertiary group might still be degraded. First, if most of the individuals admitted into college due to the expansion possess ability levels lower than the average level of the previously admitted group, and assuming one's quality growth due to college education is an increasing function of one's ability level, the average quality of the tertiary group might decrease; the possibility of decline in average quality is also positively related with the scope of the expansion. Second, when there are more students sharing the same amount of educational resources, the quality growth of those previously admitted might be disturbed due to the dilution of resources. Thus, the decline in average quality of the tertiary group is also related to how the education expansion is implemented and whether there is sufficient and qualified support of resources.

3.5.1 Datt-Ravallion Decomposition

There is some consistent evidence of the "degraded tertiary hypothesis" shown in the previous paragraphs; one more piece of supporting evidence could be generated by the Datt-Ravallion decomposition (Datt & Ravallion, 1992), which decomposes the change in the proportion of individuals below a given threshold in two time periods —the "headcount ratio"—into a parallel shift of the distribution (the "growth effect") and a change in the shape of the distribution (the "redistribution effect"). The following formula calculates the Shapley value of Datt-Ravallion decomposition as proposed by Shorrocks (2013) in which C_G^S denotes the growth effect and C_R^S denotes the redistribution effect, and H refers to the headcount ratio which can be expressed as a function of average income μ and the Lorenz curve L. The Shapley Value approach of the D-R decomposition avoids the issues that the D-R is not an additive decomposition and that it is path dependent.

$$
\begin{cases}
\Delta H = H(\mu_1, L_1) - H(\mu_0, L_0) = C_G^S + C_R^S \\
C_G^S = \frac{1}{2}[H(\mu_1, L_0) - H(\mu_0, L_0) + H(\mu_1, L_1) - H(\mu_0, L_1)] \\
C_R^S = \frac{1}{2}[H(\mu_0, L_1) - H(\mu_0, L_0) + H(\mu_1, L_1) - H(\mu_1, L_0)]
\end{cases}
$$

Table 5 presents the results of decomposing wage distributions of full-time male workers aged 25-65 with tertiary education (12+ years). In supporting the "degraded tertiary hypothesis," the D-R decomposition shows that there were more tertiary workers in 2013 earning a lower wage, which was caused by not only a left shift of the wage distribution but also by an enlarged lower tail. As shown in Table 5, when utilizing the average 1995 wage of the male tertiary group as the threshold, the "headcount ratio" increased 12.39% between 1995 and 2013, which could be decomposed into a 8.48% growth effect and a 3.92% re-distribution effect; employing the average 2013 wage of this group as the threshold, the "headcount ratio" would have increased 15.34% between 1995 and 2013, which could be decomposed into a 9.49% growth effect and a 5.85% re-distribution effect.

3.5.2 Identifying the Change in Average Ability

Juhn, Kim, and Vella (2005) make an inference about the change in the average quality of the recent cohorts of the tertiary group in the US from the change in the tertiary premium, controlling for other relevant variables. The approach employed here follows the idea of Juhn et al. (2005). The wage and supply samples analyzed in this section are males aged 25-65 with tertiary education, considering that those aged 16-24 might not have finished their study yet. Table 6 presents the average hourly wage by birth cohort in each survey year of the samples under analysis. The variation along each column for different birth year cohorts in each specific year reflects both the return to experience and the change in the average quality, and it is always monotonically increasing. The variation along each row reflects both the return to experience and the impact of aggregate economic conditions for the same birth cohort. More importantly, along each diagonal line, the variation of the same age group that comprises different birth cohorts in different years reflects both the change in the return to different cohorts and aggregate economic shocks. In addition, the difference across diagonal lines reflects the change in the return to different age groups. As we see, essentially for every age group, the variation during the period is the same as the general trend, which declined during 1995-2004 and increased during 2004-2013.

The variation along and across diagonal lines shown above is employed for identifying the change in the average quality. Therefore, the dependent variable is the change in the relative return to tertiary workers of a specific age group between any two years, that is, $\Delta\log(\frac{w_{aTt}}{w_{at}})$, in which T indicates the tertiary group, a denotes the age group, and t denotes year t. The regressor of primary interest is the change in the relative supply of tertiary workers within each age group, that is, $\Delta\log(\frac{N_{aTt}}{N_{at}})$. Because the variation along each diagonal line also reflects the aggregate economic shocks of each year, a set of year dummies should be controlled for. In addition, the variation among different diagonal lines reflects changes in the supply of tertiary workers across age groups, so it also controls for the size of each age group within the tertiary group, that is, $\Delta\log\left(\frac{N_{aTt}}{N_{Tt}}\right)$, as well as for dummies for age groups (25-35 and 36-50 years old). The specification is the following:

$$\Delta\log(W_{aTt}/W_{at}) = \beta_1\Delta\log(N_{aTt}/N_{at}) + \beta_2\Delta\log(N_{aTt}/N_{Tt}) + D_t + D_a + \varepsilon_{at}$$

in which D_t and D_a are year dummies and age group dummies, respectively.

Figure 10 depicts the changes between 1995 and 2004 as well as between 2004 and 2013 in the log relative wage and the log share of male workers with tertiary education at different ages. Both graphs exhibit a negative correlation between changes in the relative wage and changes in the relative supply, and the negative correlation between 1995 and 2004 appears more obvious. For the following regressions, the changes in the log relative return $\Delta\log(W_{aTt}/W_{at})$, log relative supply $\Delta\log(N_{aTt}/N_{at})$ and log relative size of each age group within the tertiary group $\Delta\log(N_{aTt}/N_{Tt})$ are differences taken between 1995 and 1997, 1997 and 1999, 1999 and 2001, 2001 and 2003, 2003 and 2005, 2005 and 2007, 2007 and 2009, 2009 and 2011, and between 2011 and 2013.

3.5.3 Estimation Results

The regression results reported in Table 7 demonstrate that after controlling for the increase in the relative supply, the tertiary premium of male workers of the recent cohorts is lower than that of the previous cohorts, which can be seen as evidence of the decline in cohort quality.

As we see from Table 7, the coefficient of the tertiary share variable is negative and statistically significant. The results demonstrate that a 10% increase in the ratio of male workers with tertiary education would lower the tertiary premium by 3.1%, cateris paribus. The regressions are also run separately for younger workers (25-35 years old) and older workers (36-65 years old) to see whether the cohort quality effect also varies with age. Column 2 of Table 7 demonstrates that the impact of the cohort quality on the tertiary premium is no longer significant when analyzing younger samples (25-35 years old, male), but the estimated impact is robust for the older samples (36-65 years old), as shown in column 3. This might be because the implicit assumption of this regression that workers with different ages are perfect substitutes for each other is more valid for older workers, which allows for separating the quality and quantity effects (Juhn et al., 2005).

3.5.4 The Contribution of the Price Effect and Composition Effect on Change in Tertiary Premium

Based on the cohort regression results in this section, the overall change in the tertiary premium during 1995-2013 could be decomposed into the change in the cohort quality and the price effect, which is an aggregation of the supply and demand shifts and macro-economic shocks. According to the data, the relative wage of male workers aged 25-65 with tertiary education declined by 36% between 1995 and 2013, 24% of which was due to the increase in the share of the tertiary group. The other 12% of the decline resulted from changes in supply and demand as well as from aggregate time effects.

3.6 Conclusions

Using PNAD 1995-2013 data, this essay presents the decline in wage inequality and changes in the wage structure in Brazil. One notable change in the wage structure was the convergence in the educational differential in which the average wages of the tertiary group and the complete secondary group declined and the average wages of other education categories increased. The decline in the education premium also coincided with education expansion. When analyzing changes in the relative wage and relative supply of the tertiary group with respect to those with incomplete secondary education, we find that the growth in the relative demand was the main cause for the minor increase in the relative tertiary premium during the 1995-2004 period. The decline in the relative return to tertiary-educated workers during the 2004-2013 period was due to the relative supply increasing more sharply and faster than the relative demand. Then, the change in the average quality of the tertiary group as a possible consequence of the education expansion is further tested, and while controlling for the impact of supply, we find that the tertiary premium decreased, from which we make the inference that the average ability of the tertiary group declined.

When analyzing the impact of shifts in demand and supply on skill price, a two factor CES production model was adopted following Autor, Katz, and Kearney (2008). However, this only allows us to compare workers with two education/skill levels, which fails to capture the entire variation across all education groups. A possible solution might be aggregating the unskilled groups by assuming a certain elasticity of substitution among them to capture all education/skill groups in one picture.

In addition, the analysis of the tertiary group and the change in the tertiary premium do not fully answer why there was a constant decline in wage inequality in Brazil between 1995 and 2013, although the stability of inequality within the tertiary group and the decline in inequality between the tertiary group and others account for it. Looking at the upper tail and lower tail of the wage distribution separately, we notice that between 1995 and 2013, the upper tail inequality measured by the 90-50 log differential of the hourly wage is rather stable, but the lower tail inequality measured by the 10-50 log differential declined continually, which means that to better understand the change in wage inequality in Brazil, it is also important to examine the changes at the lower tail, where the minimum wage might have played a role.

Data Appendix

While analyzing the impact of shifts in supply and demand, the relative return is composition-adjusted, which is for a fixed composition of workers—the average composition over the 1995-2013 period; thus, the changes in premium only reflect the change in wage structure but not changes in the composition of workers' characteristics. In correspondence, the relative supply measure is in efficiency units. This is a convention for analyzing the impact of supply and demand on relative wages; see Katz and Murphy (1992), DeLong, Goldin, and Katz (2003), Acemoglu and Autor (2010), Autor (2014), Goldin and Katz (2007), and Autor, Katz, and Kearney (2008). The data are processed following the procedures described below (Autor, Katz, & Kearney, 2008) to obtain the composition-adjusted relative wage measure and relative supply measure in efficiency units.

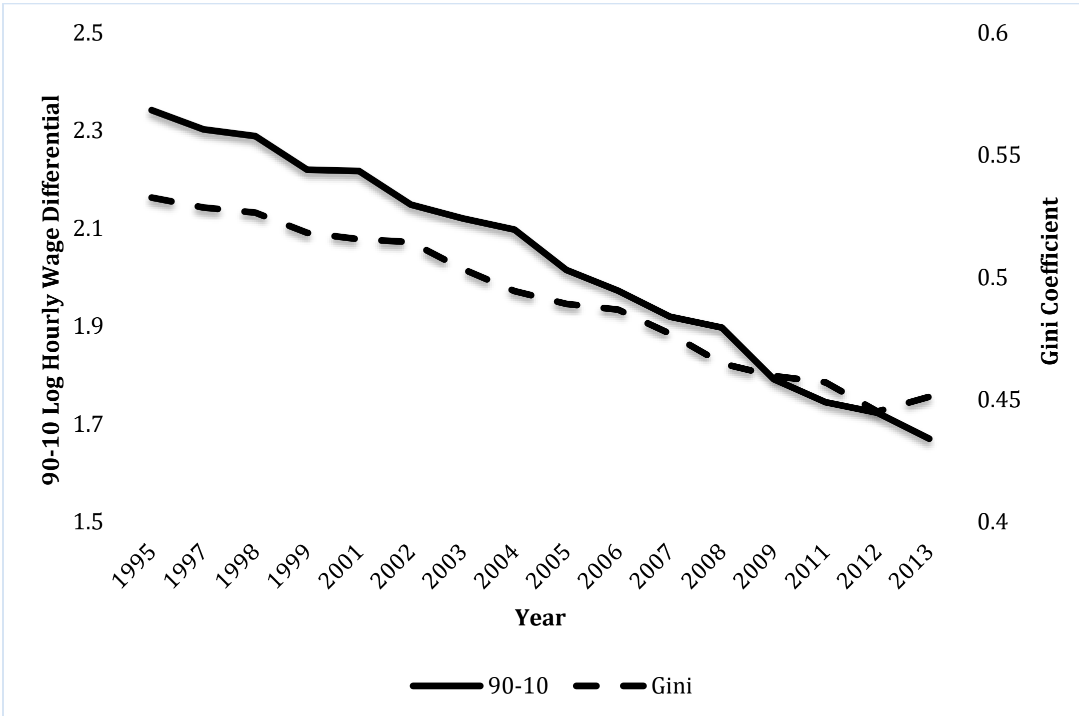
To calculate composition-adjusted wage measures:

1) Samples of each year are sorted into 40 groups defined by gender (male and female), education (incomplete primary, complete primary, incomplete secondary, complete secondary, tertiary) and experience levels (1-10, 11-20, 21-30 and 31+ years);
2) Separately by gender and for each year, the log hourly wage is regressed on 4 education dummies, a quartic of experience and a white dummy;
3) The average log hourly wage of each of the 40 groups in a given year is the predicted wage evaluated for whites, at the relevant experience levels (5, 15, 25, 35 for each corresponding experience group);
4) The average log hourly wage for any broader group in each year represents weighted averages of the relevant groups utilizing a fixed set of weights that are equal to the mean share of total hours worked by each group during the 1995 to 2013 period from the "supply samples."

To calculate supply measure in efficiency units:

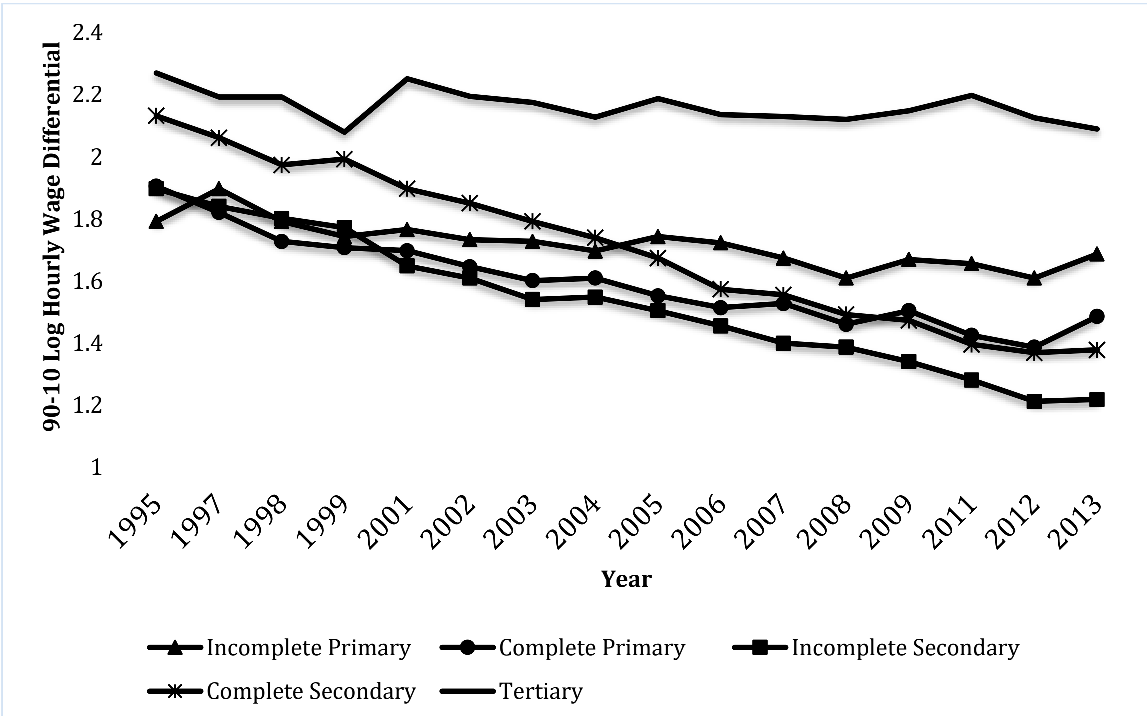
1) Based on the "Supply Samples," total hours worked per month of the 40 groups defined by gender, education and experience levels are calculated;
2) Employing the "Wage Samples," the average hourly wage of each of the 40 cells in each year is generated, which is then normalized to be in relative terms by dividing each measure by the average wage of a reference group, say male workers with incomplete secondary education and 11-20 years of experience in each corresponding year (the choice of the base group is harmless);
3) Compute the "efficiency unit" measure for each cell as the arithmetic mean of the normalized wage measures of that cell during 1995-2013;
4) The efficiency unit of labor supply of each cell in year t equals the "efficiency unit" wage measure of the cell times the quantity of labor supply of that cell in year t;
5) Calculate the aggregate supplies of the tertiary and incomplete secondary groups in each year; then, the log relative supply in each year can be generated.

Figure 1: Wage Inequality: Total Samples, 1995-2013



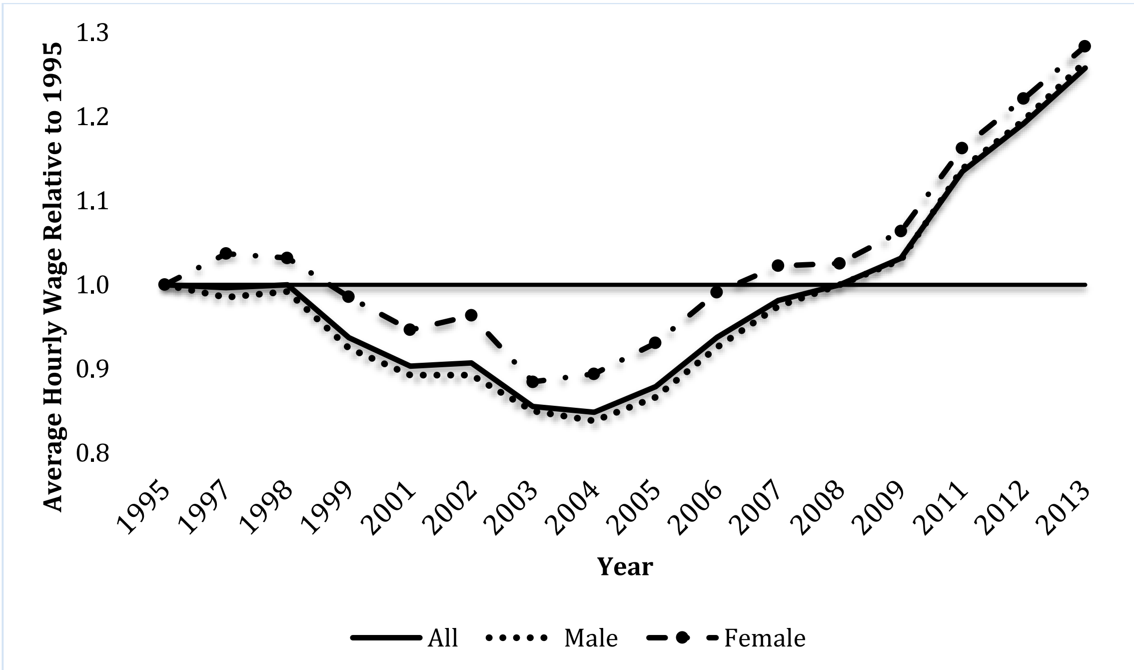
Note: Wage inequality is measured by the 90-10 log differential and Gini coefficient of hourly wage, which are calculated based on full-time workers aged 16 to 65 from the PNAD 1995-2013 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles.

Figure 2: 90-10 Log Hourly Wage Differential:
Total Samples, by Education Level, 1995-2013



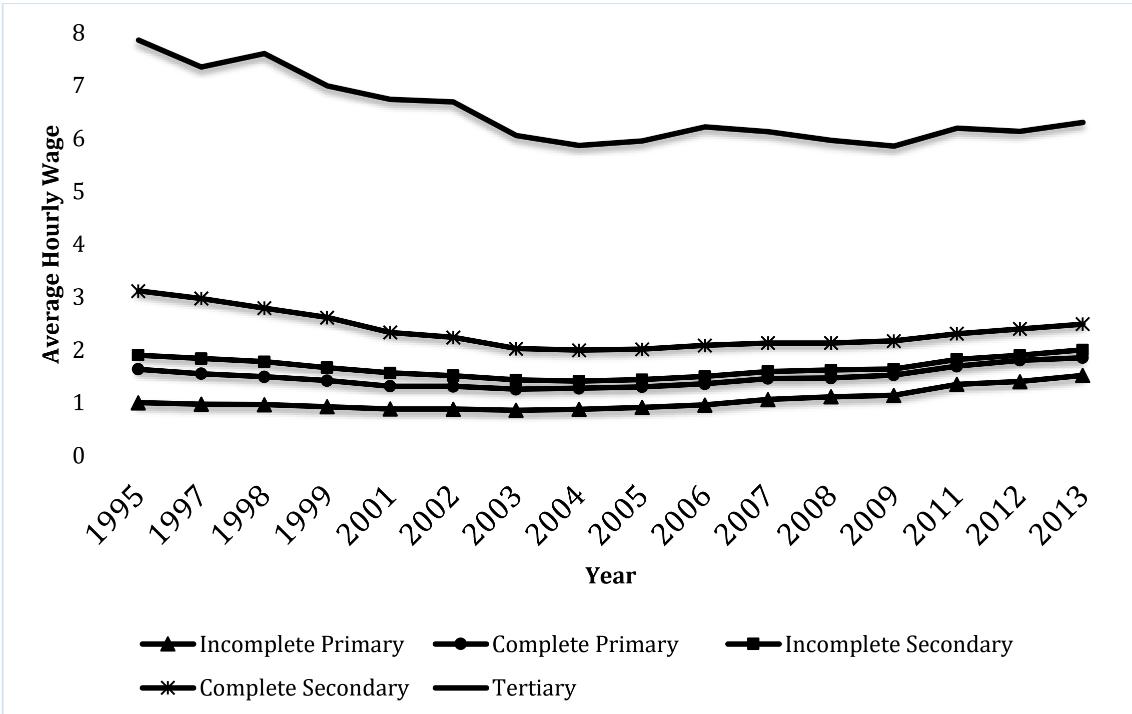
Note: Wage inequality is measured by the 90-10 log differential of hourly wage, which is calculated based on full-time workers aged 16 to 65 from the PNAD 1995-2013 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. The incomplete primary education group includes all of those with 0-3 years of education, the complete primary education group includes all of those with 4 years education, the incomplete secondary education group includes all those with 5-10 years of education, the complete secondary education group includes all of those with 11 years of education, and the tertiary education group includes all of those with 12+ years of education.

Figure 3: Average Hourly Wage
Full-Time Workers Aged 16-65, 1995-2013



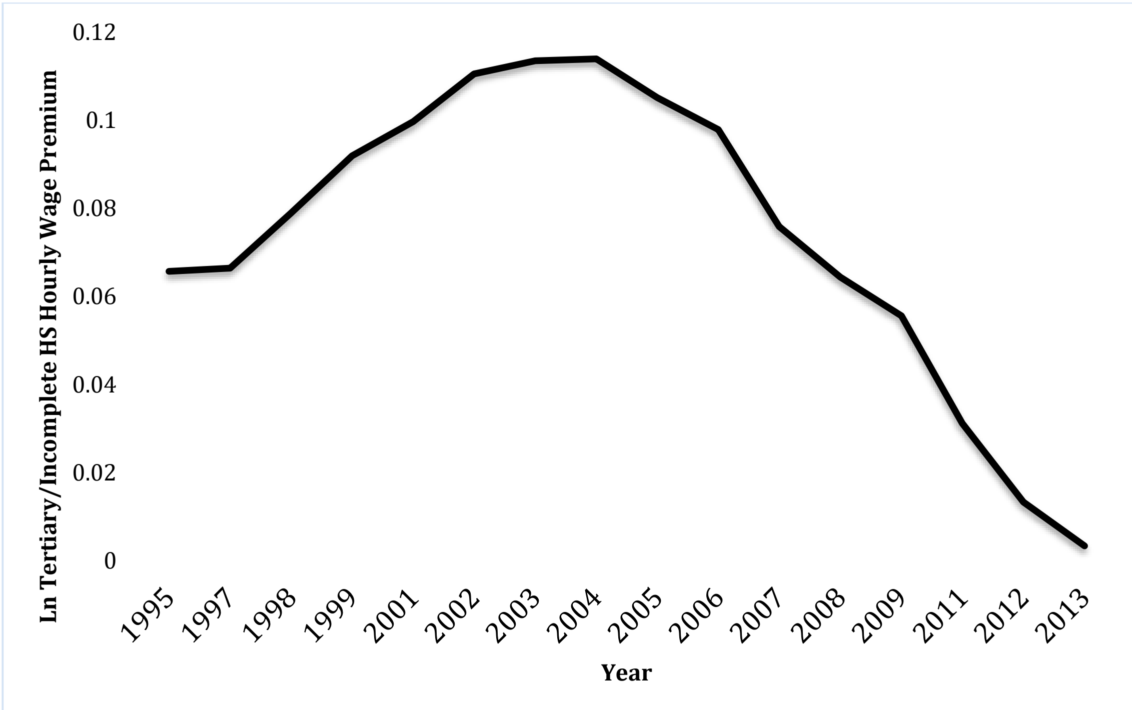
Note: Calculated based on full-time workers aged 16 to 65 from the PNAD 1995-2013 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. The wage measure is in constant 1995 prices.

Figure 4: Average Hourly Wage by Education Group:
All Full-Time Workers Aged 16-65, 1995-2013



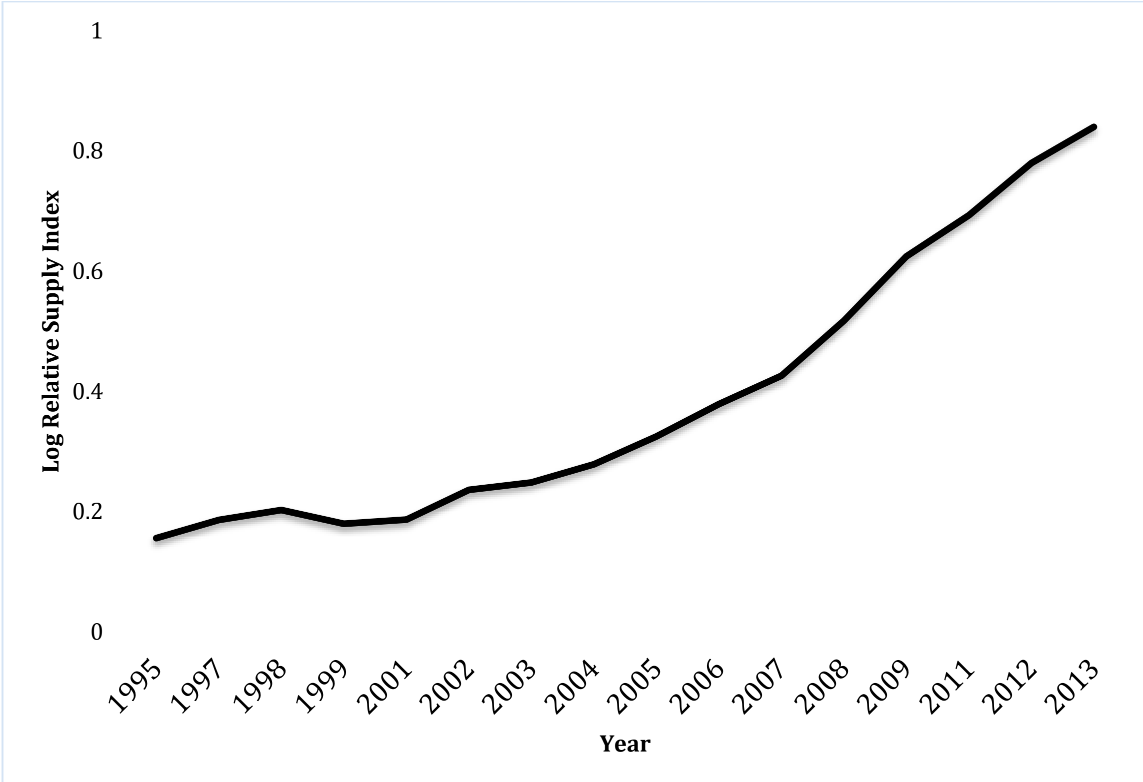
Note: Calculated based on full-time workers aged 16 to 65 from the PNAD 1995-2013 data. The sample of each group defined by gender, education level and year is trimmed at the 1st and 99th percentiles. The incomplete primary education group includes all of those with 0-3 years of education, the complete primary education group includes all of those with 4 years education, the incomplete secondary education group includes all of those with 5-10 years of education, the complete secondary education group includes all of those with 11 years of education, and the tertiary education group includes all of those with 12+ years of education. Wage measure is in constant 1995 prices.

Figure 5: Tertiary/Incomplete Secondary Hourly Wage Premium (Composition Adjusted)
All Workers Aged 16-65, 1995-2013



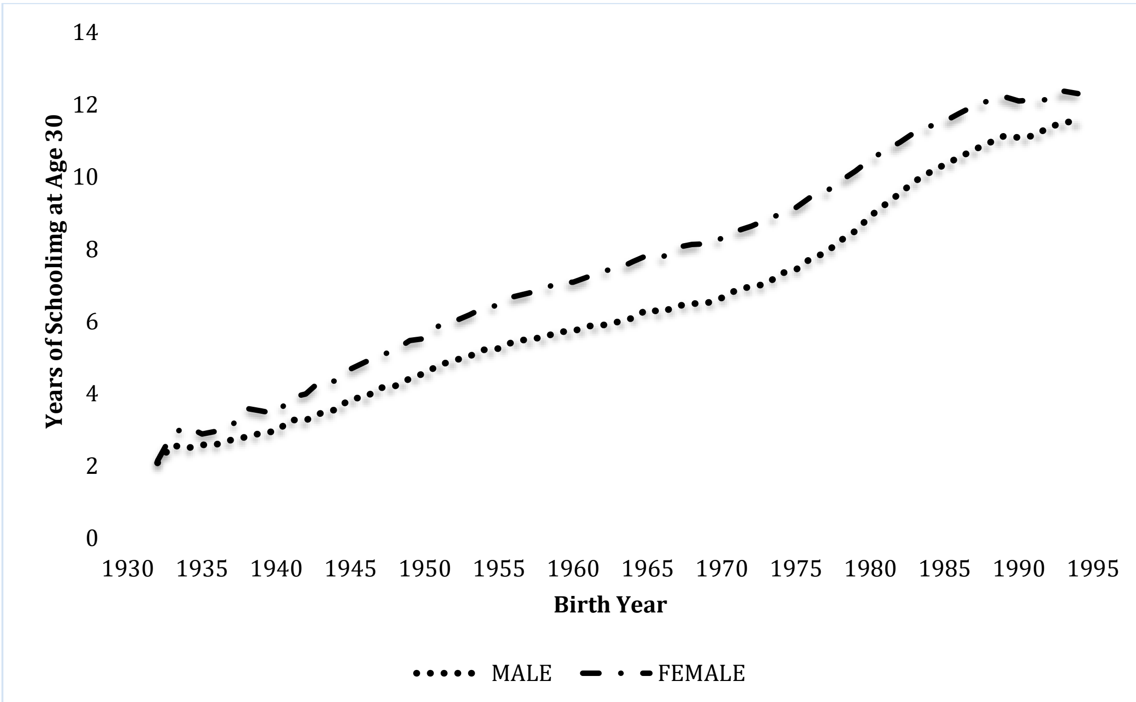
Note: Generated based on all full-time (worked at least 140 hours in the survey month) workers (employers, employees and the self-employed) aged 16 to 65 from the 1995-2013 PNAD surveys. The tertiary group includes those with 12+ years of education (incomplete and complete college as well as those with graduate study), and the incomplete secondary group are those with 5-10 years of education. The wage premium is composition-adjusted, which means that the tertiary premium is for a fixed composition of workers—the average composition over the 1995-2013 period; thus, the changes in wage reflect only the change in wage structure but not changes in the composition of workers' characteristics.

Figure 6: Log Relative Supply: Tertiary/Incomplete Secondary All Workers Aged 16-65, 1995-2013



Note: All workers (supply samples include employers, employees, self-employed and domestic workers who worked at least 1 hour in the survey month) aged 16 to 65 in the 1995-2013 PNAD surveys. The tertiary group includes those with 12+ years of education (incomplete and complete college as well as those with graduate study) and the incomplete secondary group are those with 5-10 years of education.

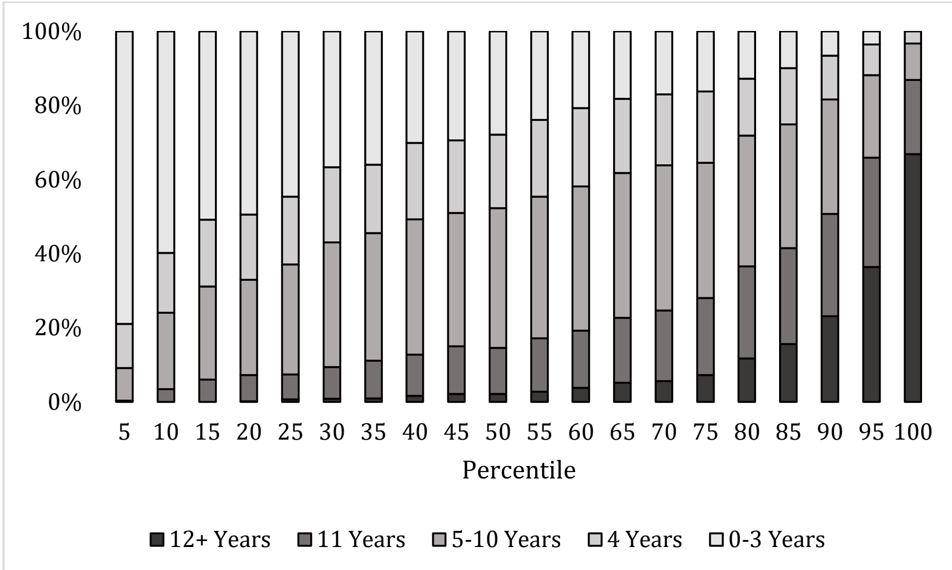
Figure 7: By Birth Cohort: Average Years of Schooling at Age 30, Workers Aged 16-65, Cohorts 1932-1994



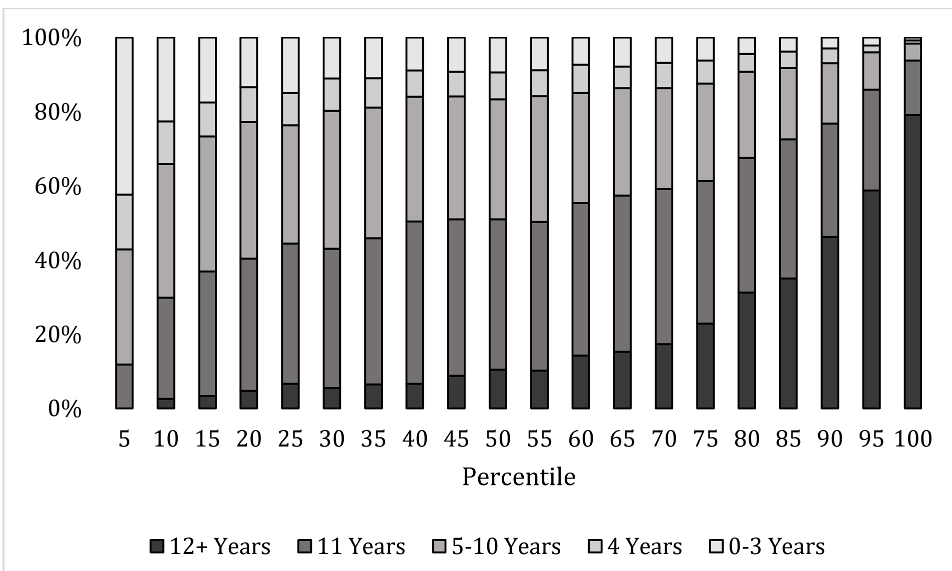
Note: All male/female workers (supply samples include employers, employees, the self-employed and domestic workers who worked at least 1 hour in the survey month) aged 16 to 65 in the 1995-2013 PNAD surveys (which covers those born between 1932 and 1994) are polled together; then, the male/female samples are grouped into birth year-age cells. The log of average years of education in each cell is regressed on a set of birth year dummies and a quartic in age (R-squared for both male and female regressions are above 0.9), and then, the estimated coefficients associated with the age variables are employed to create the age-adjusted schooling measures evaluated at age 30.

Figure 8: Education Composition at Each 5th Percentile of Wage Distribution

a. Year 1995

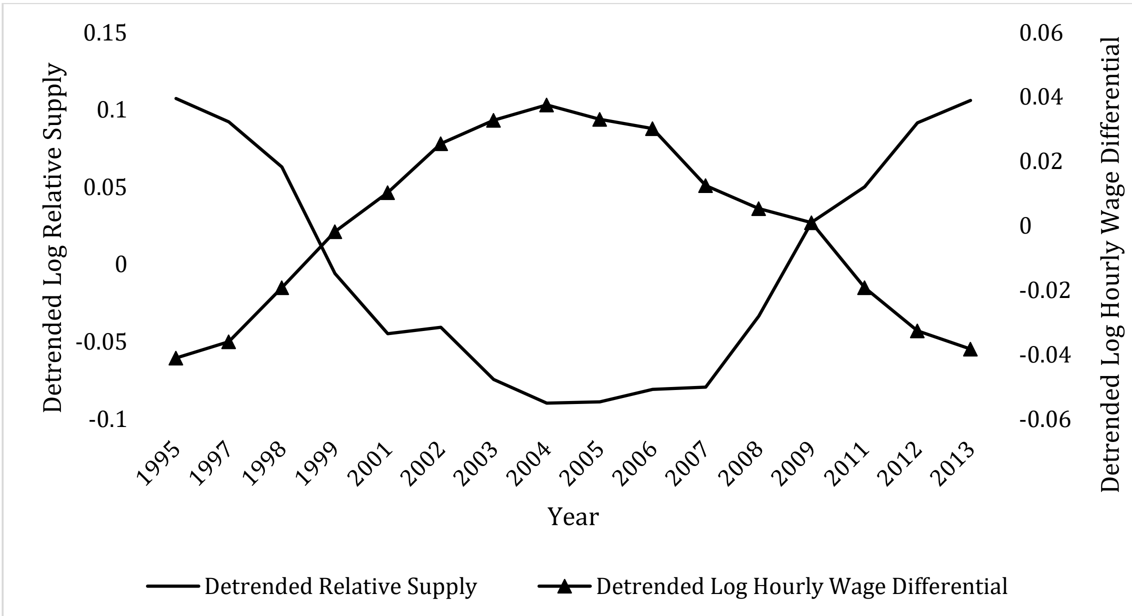


b. Year 2013



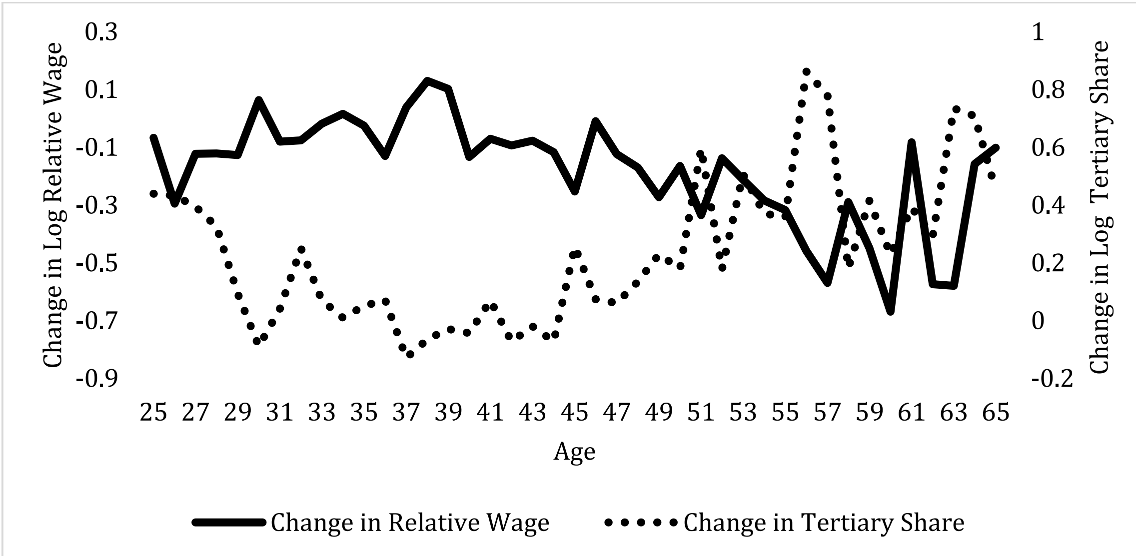
Note: Generated based on male full-time (worked at least 140 hours in the survey month) workers (employers, employees and the self-employed) aged 16 to 65 from the 1995-2013 PNAD surveys.

Figure 9: Detrended Relative Wage Differential and Relative Supply: All Samples Aged 16-65



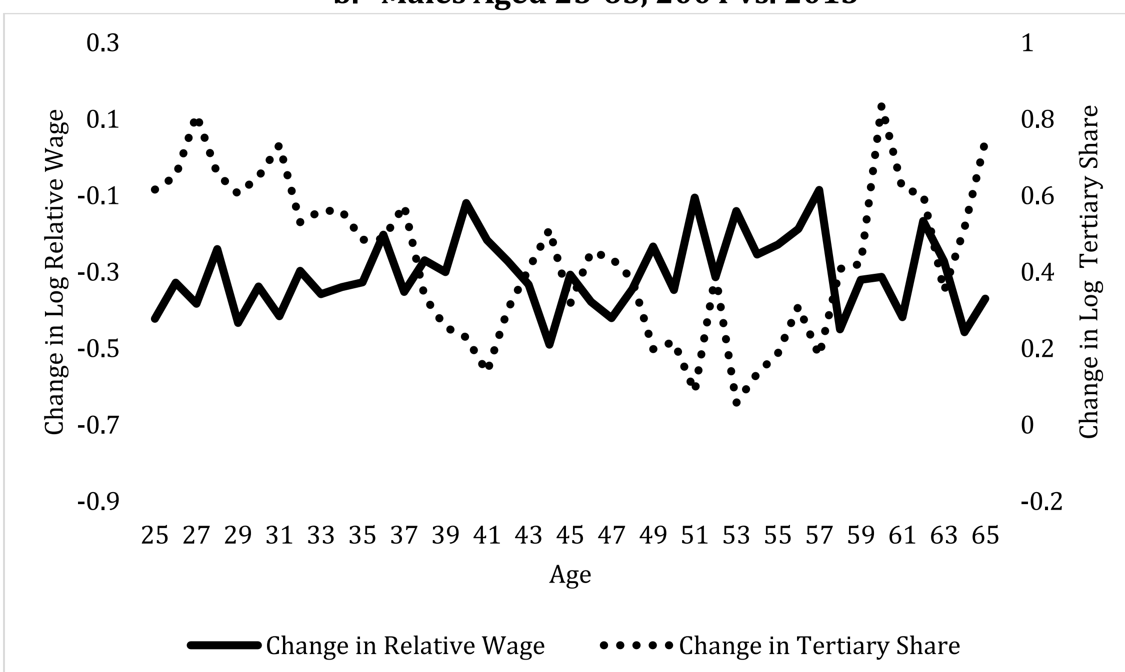
Note: The relative wage measure is the composition-adjusted log hourly wage of the tertiary group with respect to incomplete secondary workers. The log relative supply is log monthly hours worked in efficiency units of the tertiary group with respect to the incomplete secondary group.

Figure 10: Change in Log Relative Wage and Log Tertiary Share:
a. Males Aged 25-65, 1995 vs. 2004



Note: The change in log relative wage is generated based on the wage samples from the PNAD 1995 and 2004 data, and the change in log tertiary share is generated based on the supply samples from the PNAD 1995 and 2004 data.

b. Males Aged 25-65, 2004 vs. 2013



Note: The change in log relative wage is generated based on the wage samples from the PNAD 2004 and 2013 data, and the change in log tertiary share is generated based on the supply samples from the PNAD 2004 and 2013 data.

Table 1

Determinants of Tertiary Wage Premium: Workers Aged 16-65

	Pooled Samples				Male Samples				Female Samples			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	1995-2004	1995-2013			1995-2004	1995-2013			1995-2004	1995-2013		
Tertiary/Incomplete	-0.144	-0.333***	-0.339***	-0.160	-0.156	-0.362***	-0.365***	-0.162*	-0.1	-0.232***	-0.236***	-0.095
Secondary Supply	(-0.104)	(0.031)	(0.035)	(0.09)	(0.11)	(0.039)	(0.044)	(0.083)	(0.078)	(0.028)	(0.031)	(0.059)
Time Trend	0.01**	0.011***	0.012***	0.015***	0.011***	0.009***	0.01**	0.017***	0.006	0.008***	0.009**	0.01***
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Time^2				-0.001*				-0.001**				-0.0006**
				(0.0003)				(0.0003)				(0.0002)
Time*After 2004			-0.0006				-0.0003				-0.0004	
			(0.001)				(0.002)				(0.001)	
Male Unemployment	-0.115	-0.282	-0.179	-0.210	-0.071	-0.282	-0.223	-0.178	-0.256	-0.441**	-0.362	-0.258
Rate	(0.218)	(0.225)	(0.352)	(0.204)	(0.254)	(0.298)	(0.466)	(0.248)	(0.222)	(0.186)	(0.296)	(0.172)
Constant	0.058	0.062	0.078	0.038	-0.015	-0.038	-0.029	-0.042	0.178**	0.208***	0.221***	0.170***
	(0.044)	(0.04)	(0.059)	(0.038)	(0.043)	(0.051)	(0.074)	(0.042)	(0.055)	(0.039)	(0.056)	(0.036)
Obs.	8	16	16	16	8	16	16	16	8	16	16	16
R-squared	0.974	0.967	0.967	0.976	0.975	0.952	0.952	0.97	0.904	0.965	0.965	0.978

Note: Regression based on samples generated from PNAD 1995-2013 data. Log relative supply is the log of ratio of total hours workers by workers in the corresponding education group. Tertiary includes all with 12+ years of education, Inomplete secondary includes all with 5-10 years of education. Wage measures are composition adjusted, supply measures are in efficiency unit. See appendix for how the data is processed. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 2: Regression Results for Tertiary/Incomplete Secondary Log Wage Differential by Experience Groups, 1995-2013, All Full Time Workers Aged 16-65

	Potential Experience Groups					
	All Experience Groups	All Experience Groups	1-10 Years	11-20 Years	21-30 Years	31+ Years
Aggregate Supply	-0.083***	-0.041***	-0.074***	-0.084***	-0.085***	-0.062***
	(0.004)	(0.012)	(0.011)	(0.018)	(0.008)	(0.008)
Group Supply-Aggregate Supply	-0.005**	-0.005***	0.009	-0.023	-0.03	0.025
	(0.002)	(0.002)	(0.018)	(0.021)	(0.026)	(0.016)
Unemployment Rate	-0.07**	-0.052*	-0.074	-0.07	-0.051	-0.051
	(0.03)	(0.027)	(0.056)	(0.066)	(0.061)	(0.047)
Time	0.003***	0.004***	0.002	0.003***	0.002***	0.002***
	(0.0002)	(0.0004)	(0.001)	(0.001)	(0.0005)	(0.0004)
Time^2		-0.0002***				
		(0.00005)				
Constant	0.017***	0.011**	0.024	0.019	0.023	0.00597
	(0.005)	(0.005)	(0.014)	(0.012)	-0.0137	-0.0084
Observations	64	64	16	16	16	16
R-squared	0.967	0.974	0.969	0.97	0.969	0.972

Note: Regression based on samples generated from PNAD 1995-2013 data. Log relative supply is the log of ratio of total hours workers by workers in the corresponding education group. Tertiary includes all with 12+ years of education, Inomplete secondary includes all with 5-10 years of education. Wage measures are composition adjusted, supply measures are in efficiency unit. See appendix for data processing. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Regression Results for Tertiary/Incomplete Secondary Log Wage Differential by Experience Groups, 1995-2013, Male Full Time Workers Aged 16-65

	Potential Experience Groups					
	All Experience Groups	All Experience Groups	1-10 Years	11-20 Years	21-30 Years	31+ Years
Aggregate Supply	-0.091***	-0.041***	-0.084***	-0.084***	-0.091***	-0.062***
	(0.005)	(0.011)	(0.012)	(0.016)	(0.01)	(0.008)
Group Supply-Aggregate Supply	-0.007***	-0.007***	-0.001	-0.043**	-0.04	0.041**
	(0.002)	(0.002)	(0.017)	(0.018)	(0.04)	(0.016)
Unemployment Rate	-0.068*	-0.042	-0.075	-0.053	-0.044	-0.04
	(0.039)	(0.033)	(0.081)	(0.078)	(0.081)	(0.052)
Time	0.002***	0.004***	0.002*	0.003***	0.002**	0.002***
	(0.0002)	(0.0004)	(0.001)	(0.0005)	(0.001)	(0.0003)
Time^2		-0.0002***				
		(0.00005)				
Constant	-0.006	-0.007	-0.004	-0.016	-0.003	-0.017*
	(0.007)	(0.006)	(0.016)	(0.014)	(0.018)	(0.009)
Observations	64	64	16	16	16	16
R-squared	0.949	0.964	0.952	0.967	0.954	0.972

Note: Regression based on samples generated from PNAD 1995-2013 data. Log relative supply is the log of ratio of total hours workers by workers in the corresponding education group. Tertiary includes all with 12+ years of education, Inomplete secondary includes all with 5-10 years of education. Wage measures are composition adjusted, supply measures are in efficiency unit. See appendix for data processing. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Regression Results for Tertiary/Incomplete Secondary Log Wage Differential by Experience Groups, 1995-2013, Female Full Time Workers Aged 16-65

			Potential Experience Groups			
	All Experience Groups	All Experience Groups	1-10 Years	11-20 Years	21-30 Years	31+ Years
Aggregate Supply	-0.058***	-0.024***	-0.052***	-0.061***	-0.061***	-0.048***
	(0.004)	(0.008)	(0.008)	(0.013)	(0.008)	(0.008)
Group Supply-Aggregate Supply	-0.0002	-0.0002	0.012	-0.002	-0.008	0.009
	(0.002)	(0.002)	(0.011)	(0.014)	(0.016)	(0.016)
Unemployment Rate	-0.11***	-0.065***	-0.093*	-0.122*	-0.111*	-0.084
	(0.025)	(0.024)	(0.043)	(0.056)	(0.054)	(0.052)
Time	0.002***	0.003***	0.001	0.002**	0.002***	0.002***
	(0.0002)	(0.0002)	(0.001)	(0.001)	(0.001)	(0.0004)
Time^2		-0.0001***				
		(0.00003)				
Constant	0.049***	0.04***	0.057***	0.068***	0.06***	0.036***
	(0.005)	(0.005)	(0.011)	(0.011)	(0.013)	(0.011)
Observations	64	64	16	16	16	16
R-squared	0.988	0.991	0.972	0.965	0.964	0.958

Note: Regression based on samples generated from PNAD 1995-2013 data. Log relative supply is the log of ratio of total hours workers by workers in the corresponding education group. Tertiary includes all with 12+ years of education, Inomplete secondary includes all with 5-10 years of education. Wage measures are composition adjusted, supply measures are in efficiency unit. See appendix for data processing. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Datt-Ravallion Decomposition (Shapley Value) : Full Time Male Workers Aged 25-65 with Tertiary Education (12+ Years), 1995 VS 2013

Case 1 :Average wage of male tertiary group in 1995 as the threshold u0=1, u1=average in 1995/average in 2013=1.228		
Growth Effect=	.5*[H(u1,L1)-H(u0,L1)+H(u1,L0)-H(u0,L0)]	**0.0848**
Redistribution Effect=	.5*[H(u0,L1)-H(u0,L0)+H(u1,L1)-H(u1,L0)]	**0.0392**
Case 2 :Average wage of male tertiary group in 2013 as the threshold u0=average in 2013/average in 1995=.815, u1=1		
Growth Effect=	.5*[H(u1,L1)-H(u0,L1)+H(u1,L0)-H(u0,L0)]	**0.0949**
Redistribution Effect=	.5*[H(u0,L1)-H(u0,L0)+H(u1,L1)-H(u1,L0)]	**0.0585**

Note: The above is calculated based on PNAD 1995 and 2013 data, samples are full time (worked at least 140 hours in the survey month) male workers (employer, employee and self-employed are all included) with 12+ years of education, aged between 25 and 65, wage measure is in 1995 price.

Table 6:

Average Hourly Wage by Birth Cohort in Each Survey Year: Male with Tertiary Education (12+ Years) Aged 25-65						Number of Observations in Each Birth Cohort-Survey Year Cell:					
	Survey Year						Survey Year				
Cohort Group	1995	1999	2003	2007	2011	Cohort Group	1995	1999	2003	2007	2011
1985-1988					4.38	1985-1988					467
1981-1984				4.37	5.64	1981-1984				482	1256
1977-1980			4.24	5.47	6.62	1977-1980			311	1090	1300
1973-1976		5.28	5.13	6.54	7.83	1973-1976		237	727	977	1050
1969-1972	5.73	6.09	6.82	7.22	9.02	1969-1972	200	579	727	923	923
1965-1968	7.44	7.57	7.29	8.16	7.18	1965-1968	595	743	801	924	1191
1961-1964	8.51	8.68	8.69	9.10	9.31	1961-1964	766	833	863	933	874
1957-1960	9.41	8.75	8.76	9.38	10.76	1957-1960	825	817	838	843	650
1953-1956	10.96	10.03	9.18	10.33	11.53	1953-1956	787	777	724	730	522
1949-1952	11.72	10.08	10.13	10.71	12.26	1949-1952	665	596	586	517	379
1945-1948	12.47	10.74	9.88	11.03	11.83	1945-1948	500	452	352	332	180
1941-1944	12.24	10.89	10.71	10.34		1941-1944	312	225	204	127	
1937-1940	14.97	10.97	11.03			1937-1940	192	145	111		

Note: Generated based on PNAD 1995-2013 data, full time (worked at least 140 hours in the survey month) male workers (employer, employee and self-employed are included) aged 25-65 with tertiary education (12+ years). Hourly wage measure of each year is in 1995 price. The 1st and 99th percentiles of each year's wage distribution are trimmed.

Table 7: Effects of Cohort-Specific Tertiary Share on Relative Wage of Tertiary Group: Male Aged 25-65

	All Samples	Younger: 25-35	Older: 36-65
	(1)	(2)	(3)
Cohort Tertiary Share	**-0.310*****	**0.049**	**-0.381*****
	(0.101)	**-0.173**	**(0.122)**
Cohort Size	0.102	-0.165	0.168
	(0.096)	(0.152)	(0.116)
Young Age Dummy	0.025		
	(0.016)		
Middle Age Dummy	0.017		
	(0.014)		
Year Dummy	Included	Included	Included
Constant	-0.062***	-0.068**	-0.059**
	(0.02)	(0.026)	(0.025)
Observations	369	99	270
R-squared	0.196	0.335	0.196

Note: Based on PNAD 1995-2013 data, wage is adjusted to 1995 price using CPI conversion factor. Samples include full time male workers with tertiary education (12+ years) aged between 25 and 65 with positive working experience, worked at least 140 hours per month, not working without pay or domestic workers. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Chapter 4

The Impact of Minimum Wage on Wage Distribution in Brazil: 1995-2013

4.1 Introduction

The wage income inequality in Brazil has experienced a continuous and dramatic decline since the 1990s. The Gini coefficient, calculated utilizing the 16- to 65-year-old full-time workers sample of the Brazil National Household Survey (PNAD), declined from 0.63 in 1995 to 0.45 in 2013. Decomposition analyses (Barros et al., 2010) demonstrate that the movement in returns to workers' different characteristics was the main cause for the decline in wage dispersion in Brazil between 1995 and 2013. The PNAD data show the changes in wage structure involved a reduction in the gender gap and a convergence in the wage differential across education groups as well as a decline in returns to experience over the entire period (1995-2013). The literature has tried to explain the wage structure changes from the perspectives of supply and demand, international trade, and technology changes. One neglected possible cause of the change in wage distribution, however, is the minimum wage. After the hyperinflation period, between 1995 and 2013, Brazil's minimum wage continuously increased by 150%, from 86 reals to 215 reals (1995 prices) per month. By plotting the kernel density estimation of the log monthly wage of full-time employee (both formal and informal) samples from the PNAD data, we noted the minimum wage was always binding at the lower tail of the wage distribution during 1995-2013, which suggests the potential effectiveness of the minimum wage.

In addition, when looking at the lower tail and upper tail separately, the lower tail inequality declined significantly over the 1995-2013 period, and the upper tail was relatively stable. Based on PNAD full-time employee samples, the 90-50 percentile log differential of the monthly wage changed only 9 log points between 1995 and 2013, whereas the lower tail dispersion measured by the 10-50 percentile log differential changed 51 log points (see Figure 2). This finding suggests the potential importance of convergence of the wage distribution of the minimum wage as an important feature of the lower tail because the usual rationale for a minimum wage is to benefit low wage earners.

The research question of this essay is, "How has the minimum wage impacted the wage distribution in Brazil?" Specifically, how has the minimum wage impacted the wage distribution of both formal and informal employees, and what would the counterfactual wage distribution be in the absence of the increase in minimum wage? The existing studies about the impact of the minimum wage in Brazil primarily focus on its employment effect (Fajnzylber, 2001; Lemos, 2004; Neumark et al., 2006), but its impact on wage distribution is generally neglected. In addition, because it is rational to assume that those with lower education levels and less experience would benefit more from the minimum wage, it is also of interest to know what the relative wage differentials are between workers with different education and experience levels after filtering out the impact of the minimum wage.

To analyze the distributional impact of the minimum wage, the relative minimum wage (which is the log differential of the federal minimum wage and median wage of each state in each year) is defined following Lee (1999), who studied the impact of the minimum wage on wage inequality in the context of the US and proposed a model measuring the impact of the relative minimum wage on log wage differentials. The key assumption of Lee's (1999) identification strategy is that there is no correlation between the average level and variation of latent (when the minimum wage is absent) wage distribution. The Brazilian data demonstrate that this assumption is violated. The conventional strategy to account for this source of bias is to include the state fixed effects; however, this approach is not perfect, as noted by Lee (1999). In addition, because the transitory changes in wages at different percentiles are imperfectly correlated, a transitory increase in the median wage would temporarily increase the lower tail inequality and temporarily decrease the upper tail inequality. When the state fixed effects are included, these temporary changes exhibit a first-order issue that would cause an over-estimation of the impact on both the lower tail and upper tail wage gaps. Autor et al. (2015) proposed employing IV to solve both the mean-variance orthogonality and the first-order issue caused by the transitory fluctuation. The instrument variable employed in this analysis of Brazil is the percentage of employees earning below and equal to 1.2 of the minimum wage in each state and year, which is named "spike and below."

The results demonstrate that a substantial portion of the decline in lower tail wage inequality, and thus the convergence of the entire employee wage distribution between 1995 and 2013, was due to the minimum wage. The counterfactual analysis shows that without the substantial increase in the minimum wage between 1995 and 2013, the wages of workers with education levels lower than secondary school would not have increased as much as we observed, and wages of workers with secondary and tertiary education would have declined more than observed. The minimum wage was also effective in lowering the wage differential between gender, education and experience groups, but its impact on inequality within these groups was negligible.

The remainder of the chapter is organized as follows. Section 2 describes the policy background in Brazil and reviews the relevant research. Section 3 is a discussion of the data employed in this analysis. Section 4 presents the empirical framework, possible confounding factors, and solutions. Section 5 documents the estimation results. Section 6 provides a further counterfactual analysis, and Section 7 concludes the essay.

4.2 Background and Literature

The minimum wage has been an active policy in Brazil since the 1980s. After hyperinflation ended, the minimum wage increased by 150% in real value between 1995 and 2013 and was always binding at the lower tail of the employees' wage distribution, which suggests its potential effectiveness. However, with a few exceptions, the impact of the minimum wage has been largely neglected in the current literature. Theoretically, there are two possible channels for an increase in the minimum wage to impact wage distribution. First, workers with low wages could benefit from an effective minimum wage, which would reduce wage inequality; on the other hand, the minimum wage could reduce employment of the low wage earners if it is set above the “market-clearing price.” Thus, the net impact of the minimum wage on wage distribution depends on the magnitude of those two opposing effects.

For developed countries, the literature has focused on the minimum wage’s impact on employment. Neumark and Wascher (2007) reviewed all analyses of the US and other developed countries and found that most of the empirical evidence demonstrates that a minimum wage has a disemployment effect on low-wage employees. A more recent study by Addison et al. (2008) discovered a positive employment impact in the retail and trade sector of the US. Regarding its impact on wage distribution, Lee (1999) concluded that the decline in federal minimum wage during 1979-1988 caused a larger than observed rise in the 50-10 log differential, which means that if the minimum wage had been unadjusted during the entire period, the wage inequality would have decreased rather than increased. However, DiNardo, Fortin, and Lemieux (1996) concluded that only 40-65% of the increase in the 50-10 log differential observed between 1979 and 1988 was accounted for by the decline in minimum wage and that other factors also played important roles in the movement of wage distribution.

The impact of the minimum wage in the context of Brazil has been largely neglected with only a few exceptions. Neumark et al. (2006) found no positive impact of the minimum wage law on the lower end of the family income distribution in Brazil between 1996 and 2001 using data from 6 metropolitan areas; they also estimated the employment elasticity of the minimum wage, which is -0.07 for household heads but positive for other household members. Fajnzylber (2002) processed a detailed analysis of the impact of minimum wage on wage levels throughout the whole wage distribution. The results demonstrate that for the 1982-1997 period, the minimum wage had an increasing effect on employees' wage levels throughout the entire wage distribution. They also found an employment elasticity of -0.1 for formal sector employees and between -0.25 and -0.35 for informal sector employees. Lemos (2004), considering the period between 1982 and 2000, found little negative impact on employment.

For other Latin American countries, Montenegro and Pages (2004) studied the case of Chile for the 1960-1988 period and found disemployment effects for junior and unskilled workers. Furtado (2005), utilizing 1986-2001 Uruguayan data, demonstrated there was no robust employment effect. Bosch and Manacorda (2010) studied the impact of the sharp decline in the minimum wage on the increase in wage inequality in Mexico between 1989 and 2001. The results suggest that almost all of the growth in lower tail inequality was caused by the sharp decline in the minimum wage. Employing a similar methodology to Bosch and Manacorda (2010), Borraz and Gonzalez Pampillon (2011) analyzed the role of the minimum wage in Uruguay in reducing wage inequality after 2004. The results demonstrate that although the minimum wage increased significantly during this period, that increase was not effective in shifting the wage distribution.

In the presence of an informal labor market, workers displaced from the formal market would move to the informal market, resulting in a decline in the average wages for the informal market and thus an increase in wage inequality. However, this prediction is not supported by some Latin American labor markets which showed increases in the average wages of the informal labor markets after increases in the minimum wages. Maloney and Nunes (2004) and Kristensen and Cunningham (2006) found that the minimum wage impacted both the formal and informal labor sectors in many Latin American countries. Khamis (2009) found the minimum wage has a stronger impact on the informal employees. This is called the "lighthouse effect," which refers to the phenomenon that the minimum wage also serves as a reference wage level in the informal labor sector.

4.3 Data and Descriptive Analysis

4.3.1 Data

The data employed in this analysis comes from a series of the Brazil National Household Survey (PNAD), covering the period between 1995 and 2013. The PNAD survey is collected by Brazilian Institute of Geography and Statistics (IBGE) and covers the general characteristics of the population, including health, education, job characteristics, household income and housing conditions.

Individual samples included in the analysis are full-time employees who have worked at least 140 hours per month. Domestic workers, the self-employed and employers are all excluded, and the first and 99th percentiles are trimmed for each state for each year. (This analysis only considers employees; however, workers displaced due to a higher minimum wage might work as domestic workers or become self-employed. The latent wage distribution is unobservable.) Both formal and informal employees are analyzed, and formal employment is defined by the presence of a formal contract. The wage income measure is the monthly wage income plus the value of goods and products paid for by the primary job. For comparison across years, wage measures of each year are converted into 1995 prices utilizing the consumer price indexes of each year.

In Brazil, the federal minimum wage law varies only by time, not across states, but the research question of interest cannot be answered by exploiting the aggregate time series data. Lee (1999) utilized the variation in the wage level of each state in the US to define the "effective minimum wage" as the log differential of the federal minimum wage and the median wage level of each state. Following Lee (1999), the panel data, which are based on the individual samples and vary by state and year, are constructed for analysis. The weight associated with each sample of the panel data is the frequency of individuals in each state for a specific year.

4.3.2 Descriptive analysis

The data show that the minimum wage was continuously binding during the 1995-2013 period. Figure 3 presents the kernel density estimates of the log relative monthly wage (relative to the median wage of each sample group) of 1995 and 2013 for formal, informal, and total samples, respectively. The vertical lines in each graph are the relative federal minimum wages in both years. The figures suggest that in both

1995 and 2013, the minimum wage had a supporting effect on the lower part of the wage distributions for each sample group. These graphs also demonstrate that most of the change in the relative wage distribution occurred at the lower tail and that the minimum wage is a significant character of the lower tail of the wage distributions. More importantly, the effective minimum wage, which is the log difference between the monthly minimum wage and median wage, increased substantially between 1995 and 2013, being 0.66 log points higher in 2013 than in 1995. The bite of the minimum wage at the lower tail also grew during this period, which suggests the role of minimum wage as a numeraire of the economy.

Various measures of log differentials demonstrate that there was convergence in wage distribution during the 1995-2013 period in Brazil, which was primarily driven by the compression at the lower tail. The variation across years of wage dispersion at the lower and upper tails is depicted in Figure 4, which presents the changes in the 5th, 10th, 20th, 70th and 90th percentiles with respect to the median wage between 1995 and 2013 as well as the change in the effective minimum wage. All measures of wage dispersion and the relative minimum wage in the base year 1995 are normalized to zero, and measures of other years are normalized by subtracting their corresponding measures in 1995. All percentiles are obtained considering sampling weights. Figure 4 demonstrates that the minimum wage continuously increased between 1995 and 2013 by an overall 60 log points. For the 5-50, 10-50 and 20-50 log differentials, a larger measure indicates a smaller lower tail inequality; thus, an upward-sloping trend indicates a decline in inequality. On the contrary, a smaller 70-50 or 90-50 log differential indicates a smaller upper tail inequality; thus, a downward-sloping trend also demonstrates declining inequality in the upper tail. Finally, the graph also demonstrates that the change in lower tail inequality is more significant compared to the change in upper tail inequality for the total employee samples as well as for the formal employee samples.

The previous paragraphs document the variation in the effective minimum wage and wage dispersion across time; the decline in wage dispersion varies among states as well. Figure 5 presents the evolution of the 10-50 log differential between 1995 and 2013 for the three states with the highest average wages (Rio de Janeiro, São Paulo, Distrito Federal) and the three states with the lowest average wages (Alagoas, Piauí, Ceará). There was a greater decline in lower tail inequality in the low wage states compared to the changes in the high wage states. Figure 5 also presents the evolution of the 70-50 log differential for the high wage states and low wage states, which are comparable and relatively stable. In addition, Figure 6 depicts the variation among high, medium, and low wage states (with nine states in each group since there are 27 states in Brazil). As shown, the relative minimum wages are binding for the low wage and medium wage states but not for the high wage states. This graph also demonstrates the significant variations in both the wage dispersion and effective minimum wage among states, these variations provide the resource to answer the research question of interest.

4.4 Methodology

The methodology for identifying the impact of the minimum wage on wage distribution is based on Lee (1999) and Autor, Manning, and Smith (2015), both of whom analyzed the impact of the minimum wage in the context of the US. Lee (1999) proposed that latent wage distribution would be observed in the absence of a minimum wage. It would take a censoring form; that is, people with a latent wage below the minimum would be paid exactly the minimum wage, and others would be unaffected. Assume there is a sufficiently high percentile p and that wages at and above this percentile are not affected by the minimum wage; thus, we have ${w^*}_{st}(r) = w_{st}(r)$ for all $r \geq p$, and the censoring wage distribution can be expressed as the following:

$$\begin{cases} w_{st}(q) - w_{st}(p) = {w^*}_{st}(q) - {w^*}_{st}(p) & if \quad {w^*}_{st}(q) \geq MW_{st} \\ w_{st}(q) - w_{st}(p) = MW_{st} - {w^*}_{st}(p) & if \quad {w^*}_{st}(q) < MW_{st} \end{cases}$$

in which MW_{st} is the log of federal minimum wage, $w_{st}(q)$ denotes the q^{th} percentile of the observed log wage distribution of state s at time t, and ${w^*}_{st}(q)$ denotes the q^{th} percentile of the corresponding log latent wage distribution. Thus, the observed log wage differential can be expressed as a sum of the log differential of the latent wage distribution and the impact of the minimum wage, which can be expressed by the following: $w_{st}(q) - w_{st}(p) = [{w^*}_{st}(q) - {w^*}_{st}(p)] + [\mathrm{f}(w_t^m - w_{st}(p))]$.

Lee (1999) assumed the log differential of the latent wage distribution ${w^*}_{st}(q) - {w^*}_{st}(p)$ would be the same for every state, but this assumption ("mean-variance orthogonality") might be not true according to the Brazil data. According to Figure 6, high wage states usually have a lower effective minimum wage and possess higher inequality. Thus, high wage states would have a more negative wage gap for the lower tail and a more positive wage gap for the upper tail, and the violation of this assumption would cause an overestimation of its impact on the lower tail and an underestimation of its impact on the upper tail. To solve this potential bias, the log differential of the latent wage distribution is assumed to vary across states and years, which can be presented in the following form: ${w^*}_{st}(q) - {w^*}_{st}(p) = STATE_s + TREND_s + YEAR_t$, in which $STATE_s$ represents a series of quantile specific state fixed effects, $TREND_s$ denotes a series of quantile specific time trends for each state, and $YEAR_t$ is a set of quantile specific year dummies.

In addition, the minimum wage effect is assumed to take a quadratic form; thus, the reduced form specification for analyzing the effect of the minimum wage on the wage gap is the following equation in which s denotes state s and t denotes year t:

$$w_{st}(q) - w_{st}(p) = \beta_1(q)[w_t^m - w_{st}(p)] + \beta_2(q)[w_t^m - w_{st}(p)]^2 + \beta_3(q)\, STATE_s + \beta_4(q)\, TREND_s + \beta_5(q)\, YEAR_t + \varepsilon_{st}(q) \qquad (1)$$

Then, the impact of change in the minimum wage on the q^{th} percentile is $\beta_1(q) + 2\,\beta_2(q)[w_t^m - w_{st}(p)]$. In Lee (1999) and Autor et al. (2015), it is assumed that the US wage at and above the 50^{th} percentile is not affected by the minimum wage; thus, p=50, and the proof of $\beta_1(q) = \beta_2(q) = 0$ for all q>=50 guarantees the credibility of the estimation results. However, as argued by Bosch and Manacorda (2010) and Borraz and Gonzalez Pampillon (2011), this might not be an appropriate assumption for Mexico and Uruguay because those countries show evidence of the minimum wage impact spilling over above the median; thus, p=70 is assumed instead. In this essay, the results that assume p=70 are presented in the following sections, but most of the conclusions are robust if assuming p=50.

One confounding factor is that the wage at percentile p appears on both sides of the equation. If there is a shock to the p^{th} percentile and the shock is not passed equally to all other percentiles, a transitory shock to the p^{th} percentile would be negatively correlated with the wage gaps, causing over-estimation on both the lower and upper tails. Autor et al. (2015) proposed employing instrument variables to solve this potential bias. In this essay, the effective minimum wage and its squared term are instrumented utilizing a set of variables that include the log of the percentage of employees earning below and equal to 1.2 of the minimum wage in each state and year ("spike and below") and its squared term, as well as the interaction of the log "spike and below" and the log 70th percentile wage of each state over the entire period. For the IV estimation, the log "spike and below" term identifies the log effective minimum wage, the square of log "spike and below" and the interaction terms are identifying the square of the log effective minimum wage.

4.5 Estimation Results

As we mentioned in the previous section, when a specification suggests a significant relationship between dispersion in the upper tail and the minimum wage, it should be viewed with suspicion while analyzing its impact on the lower tail. Table 1 reports the estimates associated with the effective minimum wage of regressing the effective minimum wage on 75-70, 80-70, 85-70, 90-70 and 95-70 log differentials for three different specifications: 1. Only control for time fixed effects; 2. Control for both time and state fixed effects; 3. Control for time and state fixed effects as well as the state trends, and separately for overall employees, formal employees and informal employees. The instrument employed for these regressions is the percentage of employees earning less than or equal to 1.2 of the minimum wage. The results demonstrate that the specification controlling time and state fixed effects as well as the state trends yields the most trustworthy results for all three sample groups because the estimated impact on percentiles above the 70th percentile is very small and not statistically significant, which guarantees the credibility of the estimation results. All the following reported results are based on the specification in which the time and state fixed effects as well as the state trends are controlled.

Table 2 reports the IV estimation results for overall employees, formal employees and informal employees. For each subsample, the first column documents the annualized trend of the log differentials between each 10th percentile and 70th percentile, that is, the estimates of regressing the log differentials on a linear trend. The negative and statistically significant estimates show that lower tail inequality declined significantly during the entire period. The second columns are the estimated annualized trend of the year coefficient when the effective minimum wage and its square term are controlled. When looking at the estimates documented in the second columns, we found that some of the estimated trends in latent wage dispersion were smaller than the observed wage distribution; some even moved in the opposite direction of the observed trends. For some of the cells, the trend in latent wage dispersion are not statistically different from zero. For almost all cells, a significant proportion of the decline in lower tail inequality disappeared once the minimum wage was controlled for. The third column of each sample set shows the derivatives of the impact of the effective minimum wage, evaluated at the average effective minimum wage across states between 1995 and 2013. For the formal and overall samples, almost all of the decline in the 50-70 and 60-70 log differentials can be explained by the minimum wage. A substantial portion of the decline in the 10-70, 20-70, 30-70 and 40-70 log differentials can be explained by the minimum wage as well. For the informal samples, a substantial proportion of the decline in the lower tail dispersion can also be explained by the minimum wage.

4.6 Counterfactual Analysis

The literature analyzing wage distribution emphasized wage differentials among education, experience and gender groups, which are called “between group” wage inequality, as well as wage inequality “within” each socioeconomic group. It is of interest to know how much of the decline in “between-group” and “within-group” wage inequalities between 1995 and 2013 is accounted for by the minimum wage. The counterfactual analysis is employed to generate the latent wage distribution, assuming the minimum wage of 1995 was in effect in 2013.

Following DiNardo, Fortin, and Lemieux (1996), the latent wage distribution of 2013 is generated in the following way. First, for each state in 2013, we determine each individual observation's percentile in the wage distribution of the specific state. Second, for each individual observation, add an amount to his or her log monthly wage distribution in 2013. For instance, for an individual with wages at the j^{th} percentile of state s in 2013, to simulate how much he or she would earn if the 1995 minimum wage were in effect, the following amount should be added to his or her log monthly wage.

$$\Delta_{s,2013}^{j} = \hat{\beta}_1^j \cdot \left(MW_{s,1995} - MW_{s,2013}\right) + \hat{\beta}_2^j \cdot \left({MW_{s,1995}}^2 - {MW_{s,2013}}^2\right)$$

in which j denotes percentile j and s denotes state s; $\hat{\beta}_1^j$ and $\hat{\beta}_2^j$ are the estimates associated with effective minimum wage and its square in equation 1, and $MW_{s,1995}$ and $MW_{s,2013}$ are the effective minimum wage of state s in years 1995 and 2013.

Table 3 presents various comparisons between the wage levels of the observed 2013 wage distribution and the counterfactual distribution by gender, experience level and education level for the total employees. The average wage measures of each group are reported in the table. The first two columns of the table are average monthly wages calculated from the actual monthly wage data of 1995 and 2013. The third column is the wage measure of the counterfactual distribution found by applying the 1995 minimum wage level to 2013. In a comparison of the second and third columns, we notice that all sub-groups benefited from the increase in the minimum wage because all measures in column 3 are lower than their corresponding measures in column 2 due to the hypothetical lower minimum wage level. In comparing 2013 with 1995, we know the monthly wage of all sub-groups increased except for the complete secondary and tertiary groups; without the increase in the minimum wage, all of them would have experienced a smaller increase, and the complete secondary and tertiary groups would have declined more.

Table 4 reports the changes in wage inequality of the total employees, between-group inequality and within group inequality. Columns 1 and 2 report the inequality measures of the actual wage distribution of 1995 and 2013, and column 3 reports the corresponding measures of the counterfactual distribution generated by applying the 1995 minimum wage to 2013 samples. First, for the change of the total employees, comparison of the 10-50, 25-50, 75-50 and 90-50 log differentials between 1995 and 2013 indicates that there were dramatic declines in wage inequality. The corresponding measures of the counterfactual distribution indicate that without the effective minimum wage policy, the convergence in wage distribution would be smaller. Second, for all measures of between-group inequality, comparison between measures in column 2 and column 3 shows that without the increase in the minimum wage between 1995 and 2013, the between-group inequality would have been larger than what we observed in 2013. Third, the within-group inequality is measured by the log differentials of the residual of regressing the log monthly wage on a set of education level dummies, a quartic of experience, gender dummy and race dummy. The measures in the table indicate that the within-group inequality did not change much between 1995 and 2013, and the minimum wage had a negligible impact on within-group inequality.

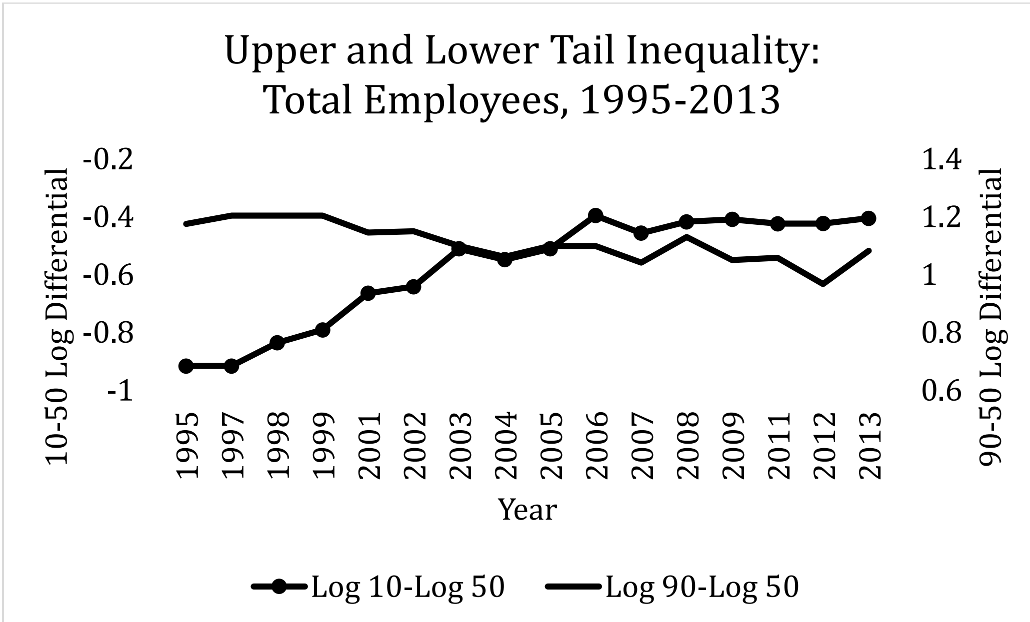
4.7 Conclusions

This essay analyzed how the minimum wage impacted the wage distribution in Brazil after the hyperinflation period. Employing the Brazil National Household Survey 1995-2013 data and the approach proposed in Lee (1999) and Autor et al. (2013), the analysis indicates that a substantial portion of the overall decline in lower tail wage inequality, and thus convergence of the entire employee wage distribution between 1995 and 2013, was due to the minimum wage. The counterfactual analysis demonstrates that without the substantial increase in the minimum wage between 1995 and 2013, the wage of workers with education levels lower than secondary school would not have increased as much as we observed, and the wage of workers with secondary and tertiary education would have declined more than observed. The minimum wage was also effective in lowering the wage differential between gender, education and experience groups but its impact on inequality within these groups was negligible. In addition, the results also indicate that the minimum wage is more effective in shifting the wage distribution of formal employees compared to informal ones.

Figure 1: Brazil Monthly Minimum Wage in 1995 (shown in Brazilian real)

Source: Brazilian Institute of Geography and Statistics (IBGE)

Figure 2: Upper and Lower Tail Wage Inequality: Total Employees, 1995-2013



Note: Based on PNAD 1995-2013 full-time (worked at least 140 hours per month) employee samples (both formal and informal employees are included); the 1st and 99th percentiles are trimmed for each state for each year. The wage income measure is the monthly wage income plus the value of goods and products paid for the primary job. For comparison across years, wage measures of each year are converted into 1995 prices utilizing the consumer price indexes of each year.

Figure 3a: Relative Wage Distribution: 1995 vs. 2013, Total Employees

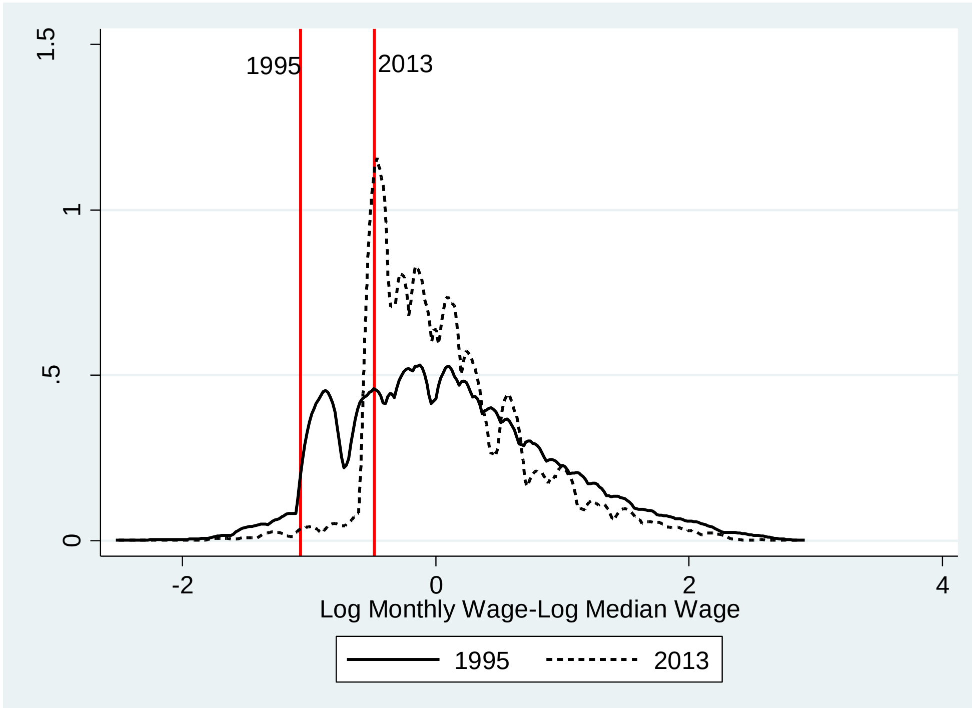


Figure 3b: Relative Wage Distribution: 1995 vs. 2013, Formal Employees

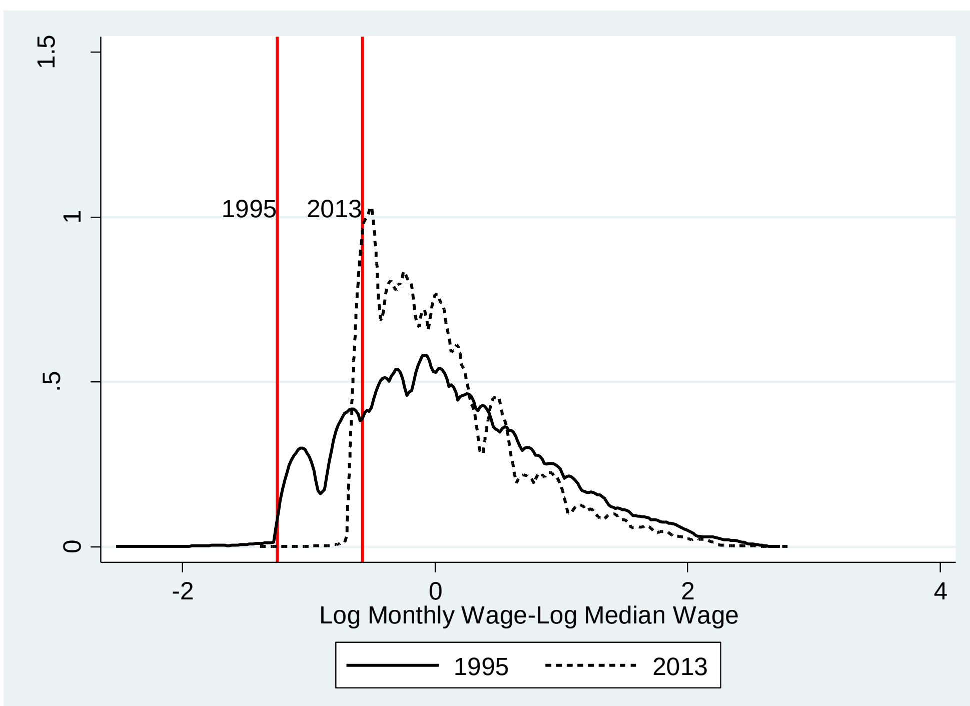
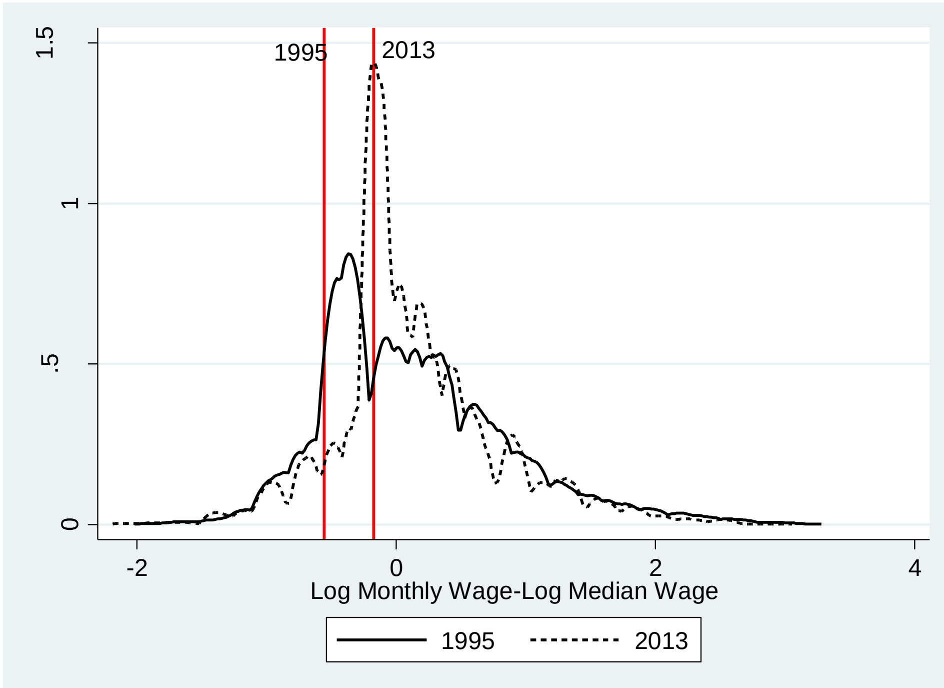


Figure 3c: Relative Wage Distribution: 1995 vs. 2013, Informal Employee Samples



Note: Based on PNAD 1995-2013 full-time (worked at least 140 hours per month) employee samples (the three graphs are for total employees, formal employees, and informal employees, respectively). The wage income measure is the monthly wage income plus the value of goods and products paid for the primary job. For comparison across years, wage measures of each year are converted into 1995 prices utilizing the consumer price indexes of each year. The relative wage distribution is generated by dividing the individual monthly wage distribution of each year by its median wage. The minimum wage of each year shown in this graph is also the relative value.

Figure 4a: Log Differential of Monthly Wage Income: Total Employee Samples, 1995-2013

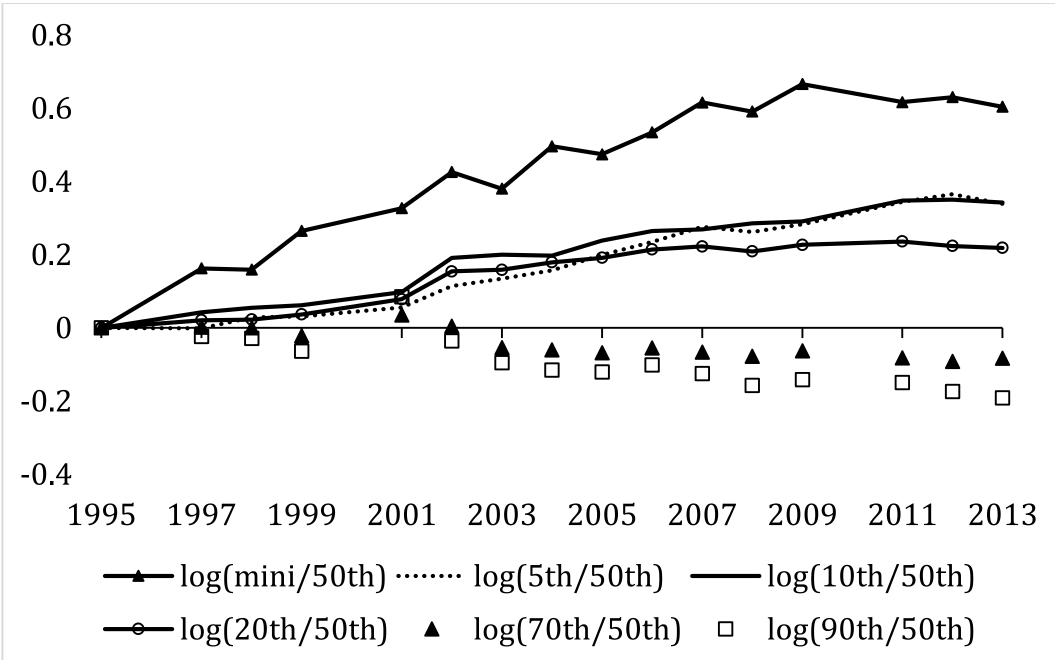


Figure 4b: Log Differential of Monthly Wage Income: Formal Employee Samples, 1995-2013

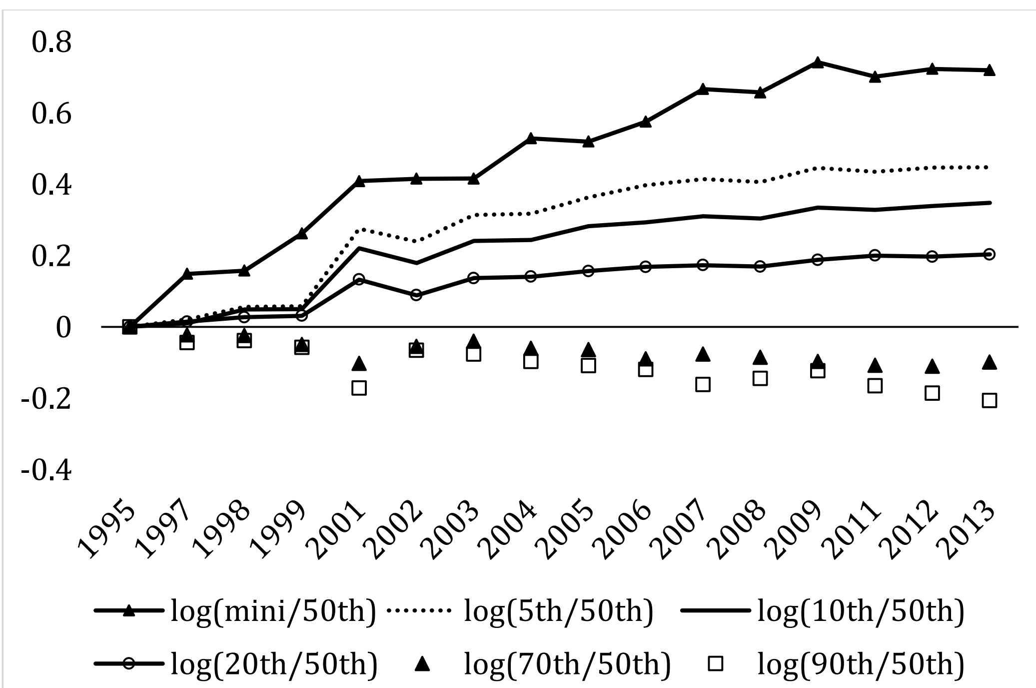
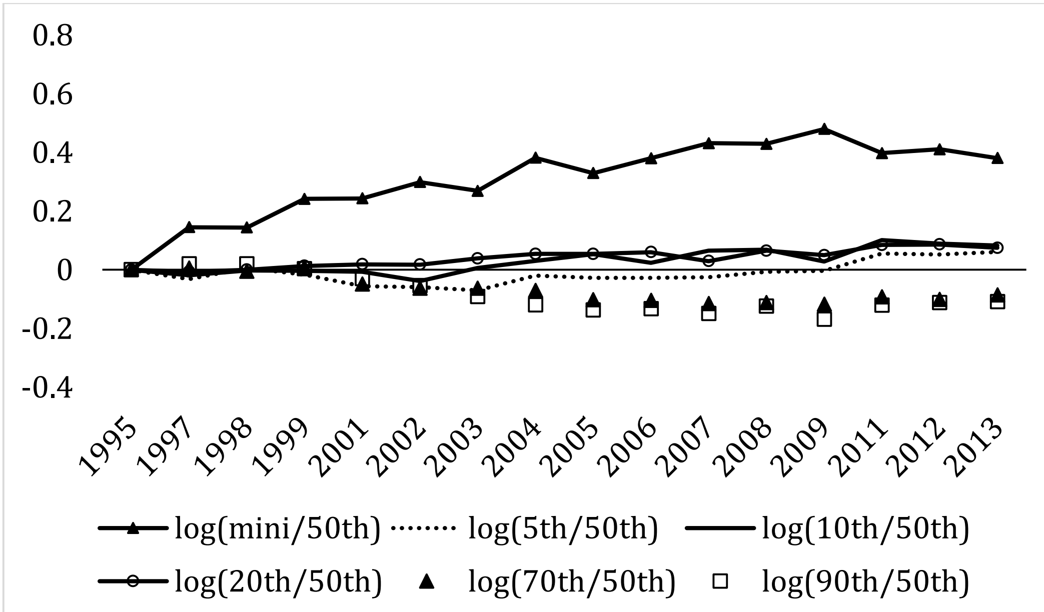


Figure 4c: Log Differential of Monthly Wage Income: Informal Employee Samples, 1995-2013



Note: Based on PNAD 1995-2013 full-time (worked at least 140 hours per month) employee samples (the three graphs are for total employees, formal employees, and informal employees, respectively). The wage income measure is the monthly wage income plus the value of goods and products paid for the primary job. For comparison across years, wage measures of each year are converted into 1995 prices utilizing the consumer price indexes of each year.

Figure 5a: Wage Inequality: High vs. Low Wage States, Total Employee Samples, 1995-2013

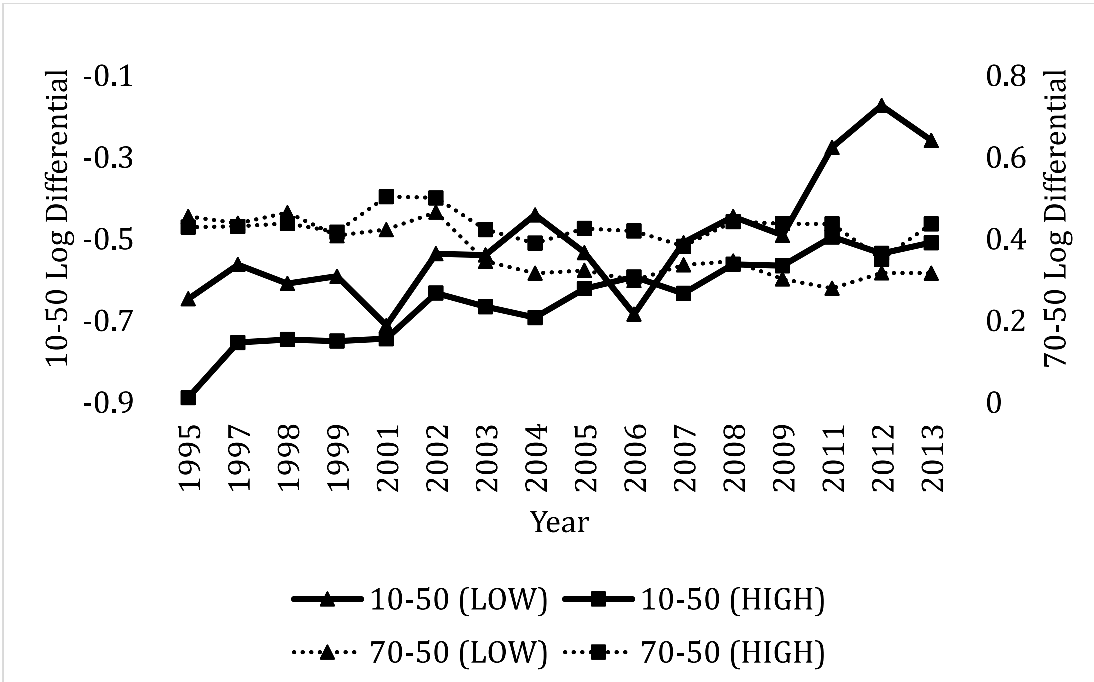


Figure 5b: Wage Inequality: High vs. Low Wage States, Formal Employee Samples, 1995-2013

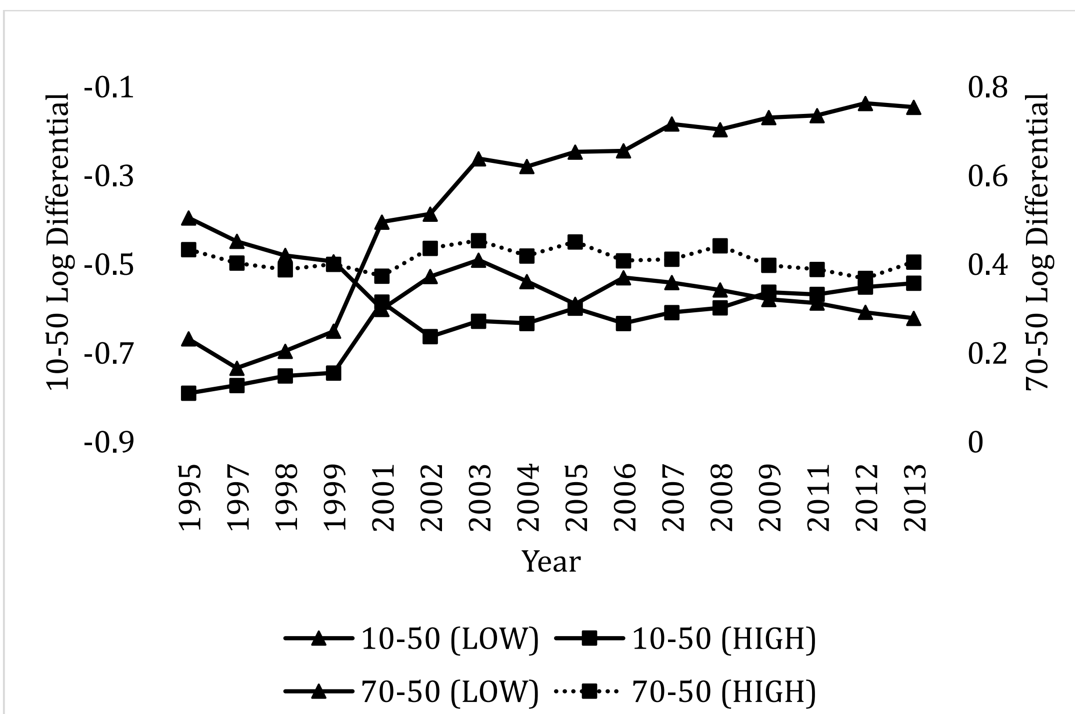
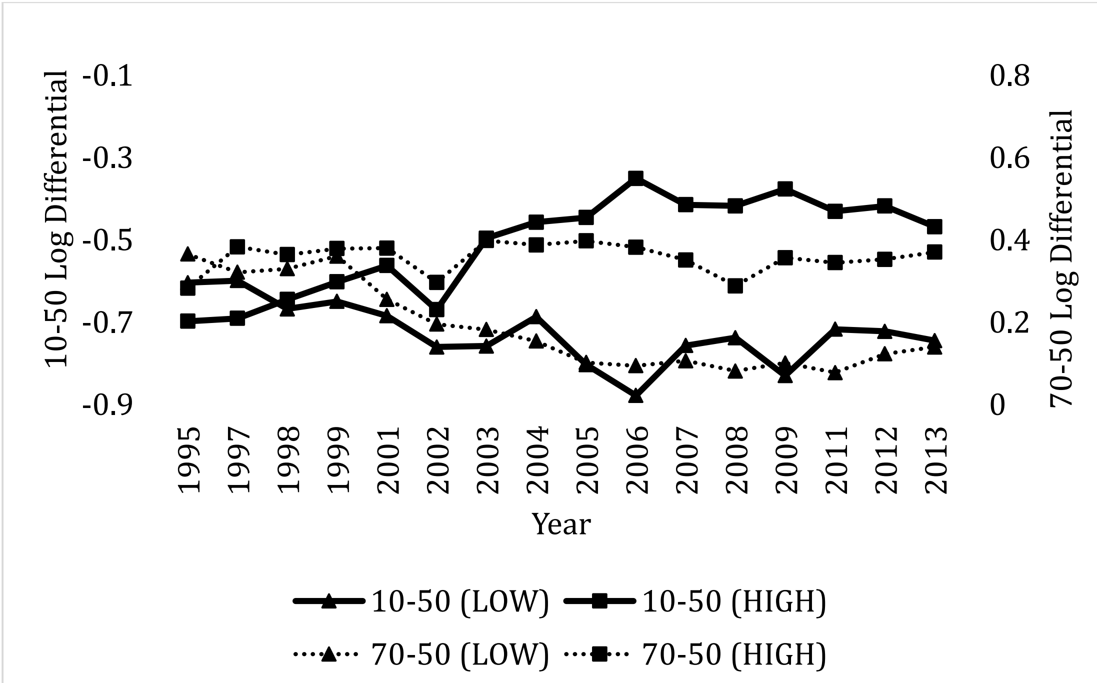


Figure 5c: Wage Inequality: High vs. Low Wage States, Informal Employee Samples, 1995-2013



Note: Based on PNAD 1995-2013 full-time (worked at least 140 hours per month) employee samples (the three graphs are for total employees, formal employees, and informal employees, respectively). The wage income measure is the monthly wage income plus the value of goods and products paid for the primary job. For comparison across years, wage measures of each year are converted into 1995 prices utilizing the consumer price indexes of each year. The 3 states with the highest average wages were Rio de Janeiro, São Paulo, and Distrito Federal; the 3 states with lowest average wages were Alagoas, Piauí, and Ceará.

Figure 6a: Relative Wage Distribution: Low, Medium and High Wage States, Total Employee Samples, 1995

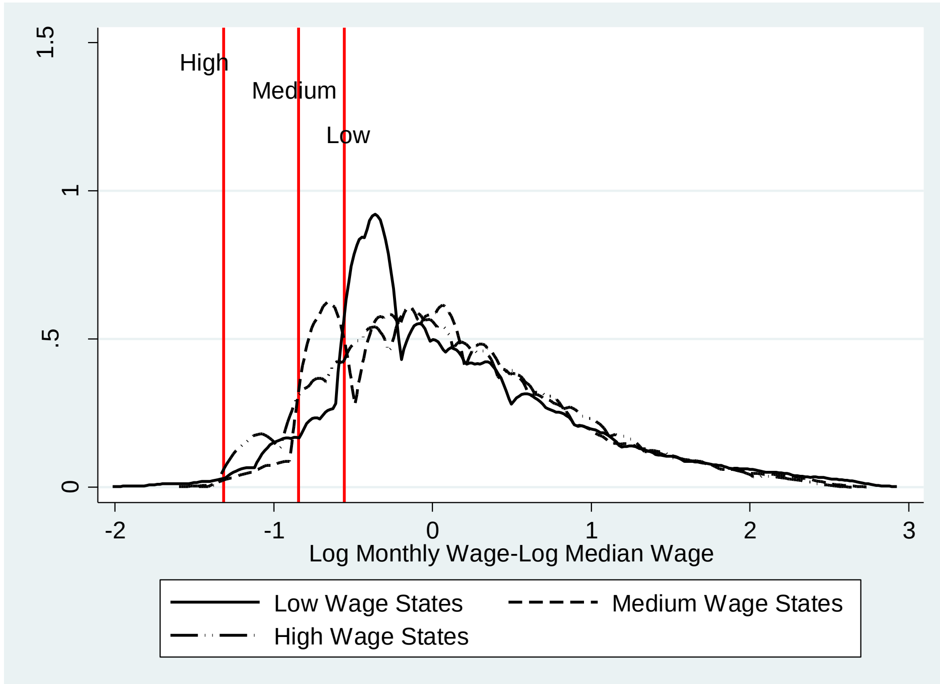


Figure 6b: Relative Wage Distribution: Low, Medium and High Wage States, Formal Employee Samples, 1995

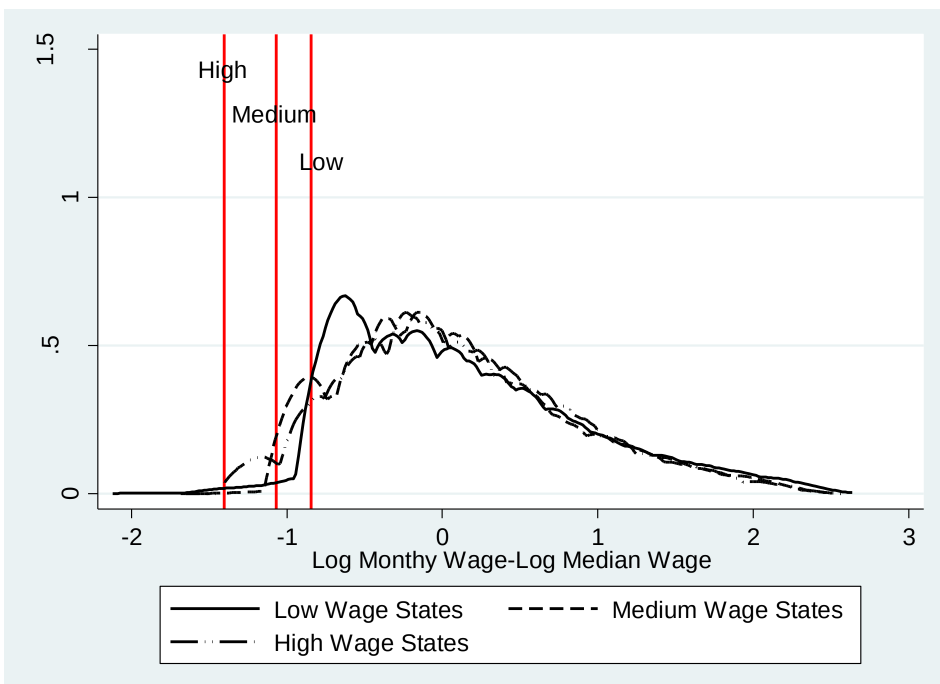
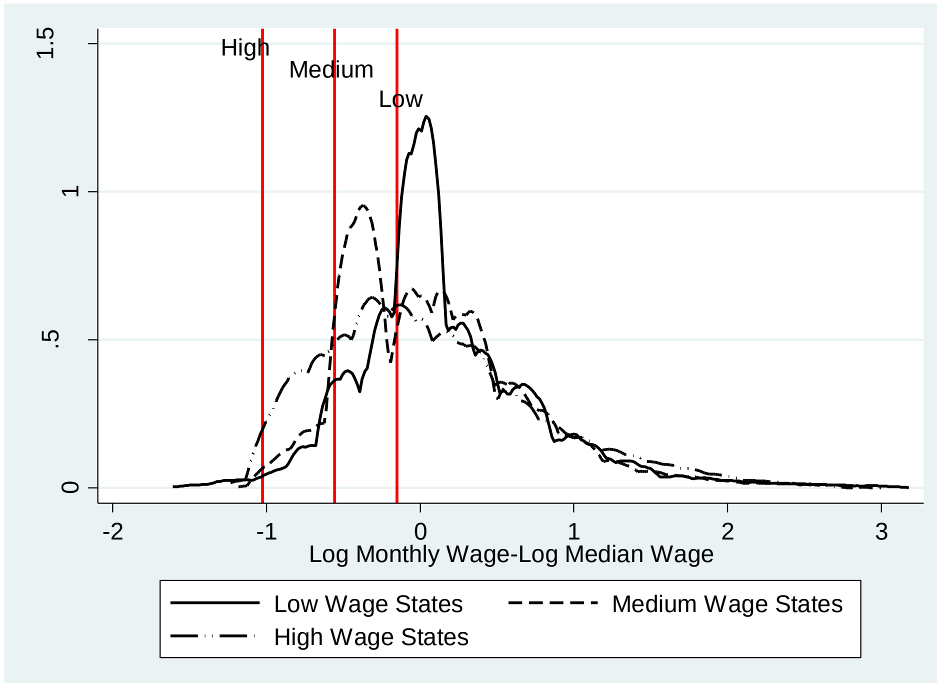


Figure 6c: Relative Wage Distribution: Low, Medium and High Wage States, Informal Employee Samples, 1995



Note: Based on PNAD 1995 full-time (worked at least 140 hours per month) employee samples (the three graphs are for total employees, formal employees, and informal employees, respectively). The wage income measure is the monthly wage income plus the value of goods and products paid for the primary job. The relative wage distribution is generated by dividing the individual monthly wage distribution of each group of states by its median wage. The minimum wage of each group shown in this graph is also the relative value. The total 27 states of Brazil are grouped into low, medium and high wage states based on their average wage levels.

Table 1

Impact of Minimum Wage on Upper Tail Inequality: Brazil, 1995-2013 (50th Percentile as Center)									
	IV: Time Fixed Effect			*IV: Time&State Fixed Effect*			*IV: Time&State Fixed Effect, State Trend*		
Log Differential	All	Formal	Informal	All	Formal	Informal	All	Formal	Informal
60-50	-0.029**	-0.002	-0.144***	0.033	-0.023	0.094*	-0.046	-0.227*	-0.196
	(0.012)	(0.013)	(0.021)	(0.053)	(0.059)	(0.051)	(0.128)	(0.129)	(0.126)
70-50	-0.05**	-0.018	-0.279***	0.174	0.388***	0.296***	-0.341*	-0.094	-0.180
	(0.02)	(0.029)	(0.036)	(0.119)	(0.084)	(0.083)	(0.185)	(0.155)	(0.131)
80-50	-0.033	0.017	-0.377***	0.336***	0.537***	0.398***	-0.228	-0.285	-0.219
	(0.025)	(0.032)	(0.043)	(0.1)	(0.127)	(0.097)	(0.186)	(0.204)	(0.161)
90-50	0.048	0.056	-0.427***	0.464***	0.412**	0.482***	-0.432**	-0.207	-0.368*
	(0.03)	(0.038)	(0.048)	(0.113)	(0.164)	(0.126)	(0.212)	(0.227)	(0.204)
Impact of Minimum Wage on Upper Tail Inequality: Brazil, 1995-2013 (70th Percentile as Center)									
	IV: Time Fixed Effect			*IV: Time&State Fixed Effect*			*IV: Time&State Fixed Effect, State Trend*		
Log Differential	All	Formal	Informal	All	Formal	Informal	All	Formal	Informal
75-70	0.008	0.016	-0.05***	0.122**	0.057	-0.026	0.071	0.003	-0.109
	(0.011)	(0.013)	(0.012)	(0.058)	(0.14)	(0.087)	(0.099)	(0.153)	(0.087)
80-70	0.017	0.034**	-0.076***	0.196***	0.244*	0.145**	0.085	-0.175	-0.033
	(0.014)	(0.014)	(0.014)	(0.067)	(0.136)	(0.065)	(0.094)	(0.173)	(0.093)
85-70	0.045**	0.042***	-0.107***	0.462***	0.116	0.226**	0.139	0.104	-0.159
	(0.020)	(0.016)	(0.015)	(0.085)	(0.14)	(0.111)	(0.12)	(0.169)	(0.103)
90-70	0.093***	0.072***	-0.116***	0.351***	0.041	0.264**	-0.068	-0.104	-0.160
	(0.021)	(0.021)	(0.017)	(0.087)	(0.193)	(0.119)	(0.13)	(0.206)	(0.133)
95-70	0.170***	0.155***	-0.087***	0.614***	0.180	0.126	0.073	-0.020	0.110
	(0.023)	(0.026)	(0.023)	(0.132)	(0.244)	(0.136)	(0.16)	(0.233)	(0.172)

Note: Based on PNAD 1995-2013 total full time (worked at least 140 hours per month) employees (formal and informal employees are both included. The wage income measure is monthly wage income plus value of good and products paid from primary job. Wage measures of each year are in constant 1995 price, the 1st and 99th percentiles are trimmed for each state in each year. The coefficients reported in this table are estimates associated with the effective minimum wage while regressing the effective minimum wage on log differential, seperately for 3 different specifications (1. Only control time fixed effects; 2. Control both time and state fixed effects; 3. Control time and state fixed effects as well as the state trends) and separately for overall employees, formal employees and informal employees. The instrument variable employed is the percentage of employees earning less than or equal to 1.2 of the minimum wage.

Table 2

Impact of Minimum Wage on Lower Tail Wage Inequality: Brazil, 1995-2013, 70th Percentile as Center

	All Employees			***Formal Employees***			***Informal Employees***		
Log Differential	Trend of Differential	Trend of Coefficient	Derivative	Trend of Differential	Trend of Coefficient	Derivative	Trend of Differential	Trend of Coefficient	Derivative
				IV: Time&State Fixed Effects, State Trends					
10-70	-0.075***	-0.015**	0.589***	-0.073***	0.016**	0.94***	-0.073***	-0.031**	0.019
	(0.002)	(0.005)	(0.174)	(0.002)	(0.007)	(0.147)	(0.002)	(0.013)	(0.176)
20-70	-0.061***	-0.002	0.474***	-0.063***	-0.013**	0.533***	-0.057***	-0.019**	0.313*
	(0.002)	(0.002)	(0.097)	(0.002)	(0.004)	(0.128)	(0.002)	(0.008)	(0.164)
30-70	-0.052***	-0.003**	0.433***	-0.054***	-0.018**	0.384***	-0.044***	-0.007***	0.521***
	(0.002)	(0.001)	(0.076)	(0.002)	(0.006)	(0.12)	(0.001)	(0.002)	(0.141)
40-70	-0.043***	-0.016**	0.176*	-0.043***	-0.012***	0.336***	-0.033***	-0.015**	0.067
	(0.001)	(0.006)	(0.093)	(0.001)	(0.004)	(0.13)	(0.001)	(0.007)	(0.129)
50-70	-0.031***	-0.0004	0.406***	-0.031***	0.007	0.45***	-0.023***	-0.007*	0.103
	(0.001)	(0.002)	(0.074)	(0.001)	(0.004)	(0.105)	(0.001)	(0.004)	(0.136)
60-70	-0.017***	0.004	0.373***	-0.017***	-0.001	0.212**	-0.013***	-0.011*	-0.110
	(0.001)	(0.004)	(0.073)	(0.001)	(0.001)	(0.091)	(0.001)	(0.006)	(0.104)

Note: Based on PNAD 1995-2013 total full time (worked at least 140 hours per month) employees (formal and informal employees are both included. The wage income measure is monthly wage income plus value of good and products paid from primary job. Wage measures of each year are in constant 1995 price, the 1st and 99th percentiles are trimmed for each state in each year. For each subsamples, the first column documents the annualized trend of the log differentials between each 10th percentile and the 70th percentile, that is, the estimates of regressing the log differentials on a linear trend. The second columns are the estimated annualized trend of the year coefficient when effective minimum wage and its square are controlled. The third columns of each sample sets are the derivatives of the impact of effective minimum wage evaluated at the average effective minimum wage across states between 1995 and 2013.

Table 3: Log Monthly Wage Change, Actual Distribution and Counterfactual Adjusted for Minimum Wage, Total Employees

Groups	1995 Actual	2013 Actual	2013 Counterfactual (apply 1995 Min Wage)
Total Employees	5.62	5.94	5.65
Status			
Formal	5.75	5.97	5.70
Informal	5.24	5.77	5.44
Gender:			
Male	5.63	5.97	5.71
Female	5.59	5.88	5.56
Education (Male, Formal Employee):			
Incomplete Primary (0-3)	5.39	5.76	5.50
Primary Complete (4)	5.70	5.87	5.61
Secondary Incomplete (5-10)	5.92	5.92	5.66
Secondary Complete (11)	6.16	6.06	5.82
Tertiary Incomplete & Complete (12+)	6.70	6.59	6.36
Experience (Male, Formal Employees):			
1-10 Years	5.72	5.94	5.66
26+ Years	5.78	6.04	5.79
Education and Experience (Male, Formal Employee):			
Exp. 1-10 Years			
Incomplete Primary (0-3)	5.14	5.54	5.26
Primary Complete (4)	5.88	5.94	5.69
Secondary Incomplete (5-10)	5.66	5.77	5.47
Secondary Complete (11)	5.93	5.90	5.62
Tertiary Incomplete & Complete (12+)	6.59	6.53	6.31
Exp. 26+ Years			
Incomplete Primary (0-3)	5.45	5.78	5.51
Primary Complete (4)	5.88	5.94	5.69
Secondary Incomplete (5-10)	6.19	6.05	5.81
Secondary Complete (11)	6.41	6.26	6.04
Tertiary Incomplete & Complete (12+)	6.73	6.66	6.43

Note: Author's calculation based on PNAD 1995 and 2013 total full time (worked at least 140 hours per month) employee samples, the 1st and 99th percentiles are trimmed for each state in each year. The wage income measure is monthly wage income plus value of good and products paid from primary job. For comparison across years, wage measures of each year are converted to be in 1995 price using the consumer price indexes of each year.

Table 4: Wage Inequality Change, Actual Distribution and Counterfactual Adjusted for Minimum Wage, Total Employees

	1995 Actual	2013 Actual	2013 Counterfactual (apply 1995 Min Wage)
Total Employees			
Standard Deviation	0.69	0.51	0.62
10-50	-0.92	-0.41	-0.65
25-50	-0.51	-0.24	-0.38
75-50	0.47	0.39	0.54
90-50	1.03	0.90	0.93
Between Group Inequality			
Informal-Formal	-0.51	-0.21	-0.26
Female-Male	-0.04	-0.09	-0.14
10- Experience-26+ Experience	0.00	-0.07	-0.10
Education Differential:			
Tertiary-Secondary	0.59	0.53	0.60
Tertiary-Secondary Incomplete	0.78	0.65	0.74
Tertiary-Primary	1.00	0.70	0.80
Tertiary-Incomplete Primary	1.35	0.79	0.90
1-10 Years of Experience:			
Tertiary-Secondary	0.70	0.60	0.71
Tertiary-Secondary Incomplete	0.90	0.71	0.83
Tertiary-Primary	1.16	0.82	0.95
Tertiary-Incomplete Primary	1.42	1.00	1.29
26+ Years of Experience:			
Tertiary-Secondary	0.35	0.40	0.43
Tertiary-Secondary Incomplete	0.57	0.59	0.66
Tertiary-Primary	0.87	0.69	0.78
Tertiary-Incomplete Primary	1.33	0.83	0.93
Within Group Inequality (Residual)			
10-50	-0.60	-0.62	-0.62
25-50	-0.32	-0.30	-0.33
75-50	0.34	0.34	0.38
90-50	0.67	0.70	0.72

Note: Author's calculation based on PNAD 1995 and 2013 total full time (worked at least 140 hours per month) employee samples, the 1st and 99th percentiles are trimmed for each state in each year. The wage income measure is monthly wage income plus value of good and products paid from primary job. For comparison across years, wage measures of each year are converted to be in 1995 price using the consumer price indexes of each year.

Chapter 5

General Conclusions

The wage income inequality declined significantly in Brazil during the 1995-2013 period. Coinciding with the change in wage distribution, there were upgrades in the labor force and changes in skill prices in the labor market, the most conspicuous of which were the expansion of tertiary education and the decline in tertiary premium. Additionally, the minimum wage, which is supposed to benefit low-wage earners, increased continuously between 1995 and 2013.

This dissertation studies the decline of wage income inequality in Brazil using the 1995-2013 Brazil National Household Survey data. First, I try to quantify how much of the decline in wage inequality was due to changes in the composition of the labor force and how much was due to changes in the wage structure, with a particular interest in the impact of education expansion. Then, I focus on the tertiary-educated workers to examine whether there is any significant decline in the average quality of the tertiary-educated workers due to the expansion and how the expansion of tertiary education impacted the tertiary premium. In addition, I examine how the minimum wage impacted the lower tail of the employees' wage distribution.

The main conclusions are the following: 1) the changes in wage structure played a fundamental role in decreasing wage inequality over the period under analysis, in which the convergence in return to education had a substantial contribution; 2) the upgrades in the composition of workers' characteristics had a slight unequalizing impact on the wage distribution; 3) the decline in tertiary premium, as an important factor driving the wage distribution change, was mainly caused by the decline in average quality of the tertiary-educated workers of the more recent cohorts in the education expansion process; 4) the minimum wage law was very effective in impacting the lower tail inequality of the employees' wage distribution throughout the entire period between 1995 and 2013.

This research also provides the following policy implications: 1) policies aimed at supporting the labor force's educational advancement would be beneficial in terms of both reducing wage inequality and promoting economic growth; 2) the convergence of the educational premium might discourage people from gaining more education; however, advancing human capital should be fundamentally beneficial to society so the government might use education subsidies or conditional cash transfers to encourage people to maximize their education attainment; 3) the increased relative return to the group with lower education might cause some unemployment among these low-skilled workers so the government should also pay attention to this group and provide the appropriate support. Moreover, the identification of "degraded tertiary hypothesis" suggests that to make the education expansion more efficient and beneficial, the government should guarantee both the quality of basic-level education to ensure all students entering college are well-prepared and the education quality of newly-built (private) universities. The government should also equip public universities with sufficient resources to accommodate the increased number of students.

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Biography

Yang Wang joined the Ph.D. program in Economic Analysis and Policy at Tulane University in 2011. Before joining, she received a Bachelor of Arts in Economics from Hebei University of Economics and Business (Hebei, China) in 2008 and a Master of Arts in Economics from Central University of Finance and Economics (Beijing, China) in 2011. Yang is interested in poverty and inequality, labor economics, and development economics. During her study at Tulane, she published two papers in peer-reviewed journals, The Journal of Economic Inequality and Research in Labor Economics. At Tulane, Yang worked as a team member on the Commitment to Equity (CEQ) project under the supervision of Professor Nora Lustig. She also worked with the World Bank and the Inter-American Development Bank as a short-term consultant. Yang received her Doctor of Philosophy in Economics from Tulane University in May, 2016. She accepted an assistant professorship at Tianjin University of Finance and Economics in China.