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# Trade liberalization and the evolution of skill earnings differentials in Brazil

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**Abstract**

Skilled labor earnings differentials decreased during the trade liberalization implemented in Brazil from 1988 to 1995. This paper investigates the role of trade liberalization in explaining these relative earnings movements. We perform several independent empirical exercises that check the traditional trade transmission mechanism, using disaggregated data on tariffs, prices, earnings, employment and skill intensity. We find that: i) employment shifted from skilled to unskilled intensive sectors, and each sector increased its relative share of skilled labor; ii) relative prices fell in skill-intensive sectors; iii) tariff changes across sectors were not related to skill intensities, but the pass-through from tariffs to prices was larger in skill-intensive sectors; iv) the decline in skilled earnings differentials mandated by the price variation predicted by trade was even larger than the observed one. The results are compatible with trade liberalization accounting for the observed relative earnings changes in Brazil. They also highlight the importance of considering the effects of differentiated pass-through from tariffs to prices.


*Keywords:* Skill earnings differentials; Trade liberalization; Tariffs pass-through; Stolper–Samuelson

*JEL classification:* F13; J31

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## 1. Introduction

From 1988 to 1995 the Brazilian economy underwent a massive trade liberalization. Non-tariff barriers were replaced by tariffs, and tariffs were reduced from an average of 42.6% in 1988 to 13.4% in 1995. Neoclassical trade theory, based on factor endowments differences, has very clear predictions on how relative factor prices should change in response to trade liberalization. Over the same period, a decrease in earnings inequality was observed in Brazil: average earnings of more educated workers declined 15.5% in relation to that of less educated workers. This paper investigates the role of trade liberalization on relative earnings movements in Brazil through a Heckscher–Ohlin-style mechanism.

Brazil is particularly well suited for studying the effects of trade on earnings inequality. First, Brazil moved from being a very protected economy to an open one in a relatively short period of time. Second, earnings inequality *decreased* in Brazil over the liberalization period, contrary to evidence for most other developing countries. Third, relative prices have displayed substantial variation over this period, mostly due to very high inflation rates (the average monthly inflation rate in the 1988–95 period was 20.7%). This is important because Stolper–Samuelson effects work through relative prices changes, and relative prices tend to be more flexible under high inflation. Finally, Brazil has very high-quality and relatively unexplored establishment and household data sets.

One crucial step in relating trade liberalization to wage differentials movements is the link between relative tariffs changes and relative prices changes. This link depends not only on the pattern of relative tariffs changes but also on their pass-through to prices. Even a homogeneous tariff reduction could impact relative prices when pass-through from tariffs to prices differs across sectors. We develop a version of Dornbusch et al. (1980), adding to it import tariffs and aggregating goods into sectors. The model predicts that the pass-through from tariffs to prices depends on the share of imported goods in each sector. The model also delivers the Stolper–Samuelson result that trade liberalization increases the relative price of the relatively abundant production factor. We implement this empirically by adjusting tariffs changes by import penetration. This is an important theoretical feature that has been overlooked in the literature, and proved to be relevant in our empirical analysis.

We perform several independent empirical exercises that check the trade transmission mechanism, using disaggregated data on tariffs, prices, earnings, employment and skill intensity from 1988 to 1995. First, through a decomposition analysis of employment share changes into within- and between-industry effects, we show that employment shifted from skilled to unskilled intensive sectors, and each sector increased its skilled labor relative share. Second, we perform consistency checks on the relationship among relative prices, tariffs and skill intensities. We show that relative prices fell in skill-intensive sectors, and that tariffs changes were unrelated to skill intensities. However, by adjusting for the differentiated pass-through from tariffs to prices across sectors, the trade liberalization pattern with respect to skill intensity was consistent with that of relative prices changes. Finally, we apply a mandated wage analysis. We show that the decline in skilled earnings differentials mandated by the price variation predicted by trade was even larger than the observed one.

There is a wide empirical literature examining the relationship between observed changes in skill premium and international trade. Most of it study the rising skill premium in developed countries (see Slaughter, 2000). For developing countries, the literature is far scantier. Differently from the evidence for Brazil presented in this paper, studies on Mexico (Hanson and Harrison, 1999; Robertson, 2004) and Chile (Beyer et al., 1999) show that these countries have experienced increases in wage differentials after having opened their economies to trade.

A possible problem with the studies for developing countries is the use of the share of nonproduction workers from establishment surveys as a proxy for skill intensity. As we argue in Section 2, we consider education attainment a more adequate measure of skill. Krueger (1997) uses both high education and nonproduction share measures of skill intensity for U.S. data, where both measures are available, and obtains qualitatively the same results. Slaughter (2000) shows that the results of studies that use either measure are comparable. This paper shows that this is not the case for Brazil. When education attainment is used to measure skill intensity, we find a reduction in earnings inequality, while a slight increase is observed for the nonproduction measure. This should be taken as a warning on how to interpret the results of studies for other developing countries.

A competing view attempts to associate the rising skill premium to skill biased technological changes — SBTC (see Acemoglu, 2002). One interpretation in the literature for the findings of an increase in the earnings differentials in developing countries is that SBTC is pervasive in those countries, as in the more developed ones. Some authors have argued that trade opening can induce SBTC in developing countries (see Acemoglu, 2003; Thoenig and Verdier, 2003). Note, however, that, as earnings differentials *decreased* in Brazil, SBTC could not have been its only driving force. Therefore, this paper focuses on the role of trade liberalization in explaining these movements.

This paper is organized as follows. Section 2 presents some stylized facts on earnings differentials and trade liberalization in Brazil. Section 3 discusses the theoretical framework for the empirical exercises, including the role of differentiated pass-through from tariffs to prices across sectors. Section 4 presents the various empirical exercises linking trade liberalization to earnings differentials and Section 5 concludes.

## 2. Stylized facts

### *2.1. Earnings differentials*

We put together data from several different sources. For the education and earnings data we use a particularly rich data set, consisting of repeated cross-sections of an annual household survey (Pesquisa Nacional de Amostras por Domicílio — PNAD) from 1981 to 2001, conducted each September by the Brazilian Census Bureau (IBGE) and used in several studies about the Brazilian labor market. Each cross-section is a representative sample of the Brazilian population and contains about 100,000 observations on households, from which around 330,000 individuals are interviewed.

From the original data, we kept only individuals with positive hours worked in the reference week in the manufacturing sector and with positive monetary remuneration. The main variable used is real hourly earnings, defined as the normal labor income in the main job in the reference month, normalized by normal weekly working hours. The sample also includes self-employed and workers with informal contracts. We measure education by completed years of formal schooling.

Fig. 1 shows the evolution of earnings differentials (in log differences) between skilled and unskilled workers in Brazil between 1981 and 2001 and of average tariffs from 1988 to 1999.[1]

[1] Prior to 1988, there were several quantitative trade restrictions and import tariff waivers that rendered official tariff data uninformative about actual trade barriers. Hence, we do not present these data here.

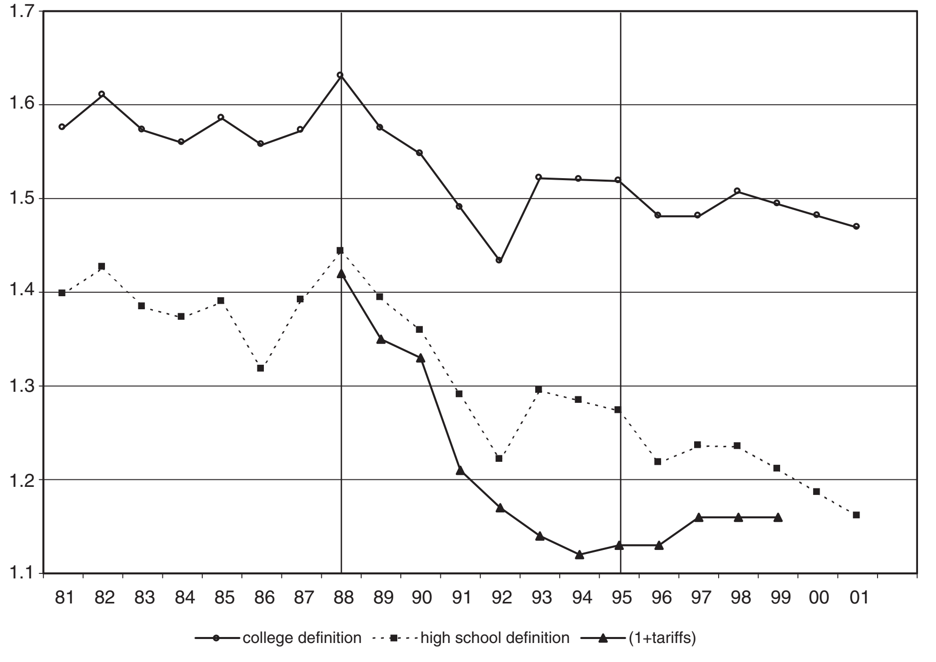


Fig. 1. Tariffs and education earnings differentials.

As the figure illustrates, the bulk of trade liberalization occurred from 1988 to 1995, with minor tariff changes since then. The figure also presents data for two alternative education thresholds to define skill: high-school (at least 11 years of education) and college (at least 15 years of education). For both measures of skill, earnings differentials followed the same pattern from 1981 to 1995. They presented no relevant changes between 1981 and 1988, and dropped from 1988 to 1995. After 1995, earnings differentials remained basically constant for the college skill measure. For the high-school definition, they continued to decrease, but at a lower pace than before.

It is clear that the period of drastic reduction in tariffs (1988–1995) coincided with the period of pronounced decline in earnings differentials for both skill measures.[2] In what follows, we intend to investigate the role of trade liberalization in explaining these relative earnings movements. We use the high-school threshold to define skill in our empirical exercises for two reasons. First, as will be shown in Fig. 3, less than 10% of the workforce had completed college education over the period studied, which is clearly too small a fraction of the labor force when compared to more than 20% of workers with complete high-school. Second, as shown in Fig. 1, both skill measures followed the same pattern over the trade liberalization period.

Behrman et al. (2000) have shown that returns to college education rose in Latin American countries, on average, over the 1990s. Duryea et al. (2002) qualify this evidence, presenting earnings data for tertiary, secondary and primary education groups for each country in the region. They show that, not only the skill premium pattern differs across countries, but also several

[2] Trade liberalization was, of course, not the only event in Brazil during the period studied. A privatization program began in the early 1990s, while the economy experienced periods of high inflation alternated with short-lived inflation stabilization attempts. However, we have no reason to believe that the implications of these other changes to relative prices movements were correlated with those coming from trade liberalization.

countries alternate periods of rising with periods of declining wage differentials. A close look at the data shows that skill earnings differentials in Brazil followed a different pattern from the Latin American average. We analyze the evolution of earnings differentials, splitting the data into three different education groups: workers with primary, high-school (secondary) and college (tertiary) education.

As shown in Fig. 2, college/primary and high-school/primary earnings differentials followed basically the same decreasing pattern during the trade liberalization period. Before 1988, the college/primary earnings gap showed a slight increase, while for the high-school/primary the differential remained unchanged. After 1995, the two measures took different directions. The high-school/primary earnings gap continued its decreasing trend, especially after 1998, and the college/primary remained constant until 1999 and increased steeply afterwards. The difference in patterns between these two measures can be explained by the evolution of the college/high-school earnings differentials, which increased before 1988 and after 1997, and remained constant between 1988 and 1997. The fact that high-school and college skill measures diverged after the trade liberalization period is an indication that other forces affecting those variables may be at play, such as skill biased technological changes and relative skill supply changes. The behavior of earnings differentials after 1995 is not the focus of this paper, since their movements are not related to the effects of trade liberalization.

One could wonder whether the drop in relative earnings of skilled labor during trade opening illustrated in Fig. 1 could have been caused solely by a rise in the relative supply of skilled labor. Fig. 3 shows that, indeed, there was a rise in the share of skilled workers over the same time period, specially for the high-school skill measure. The figure also suggests that, although labor

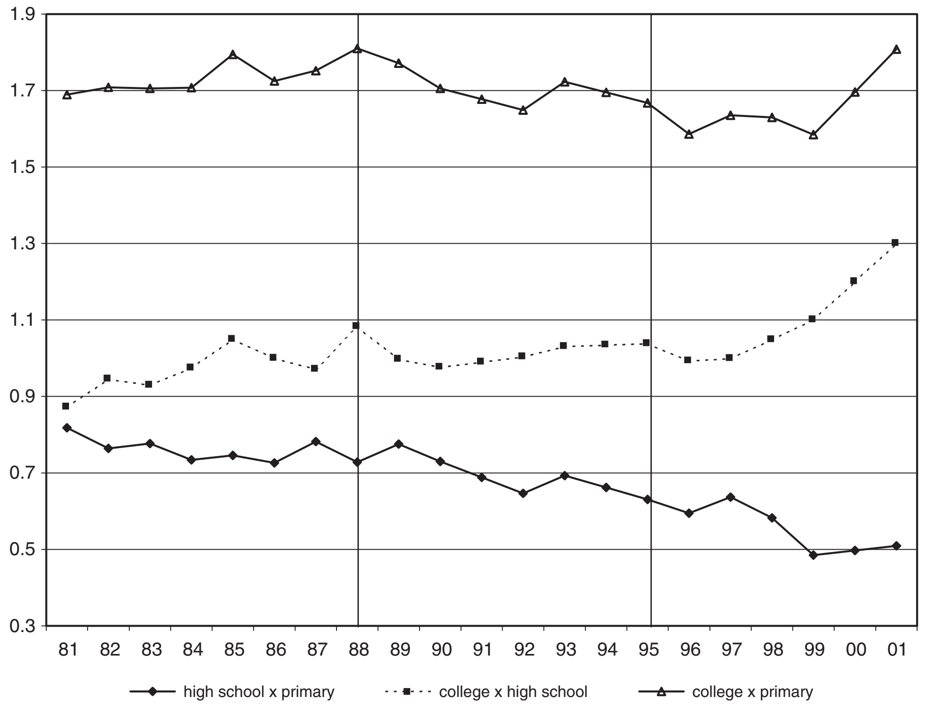


Fig. 2. Education earnings differentials.

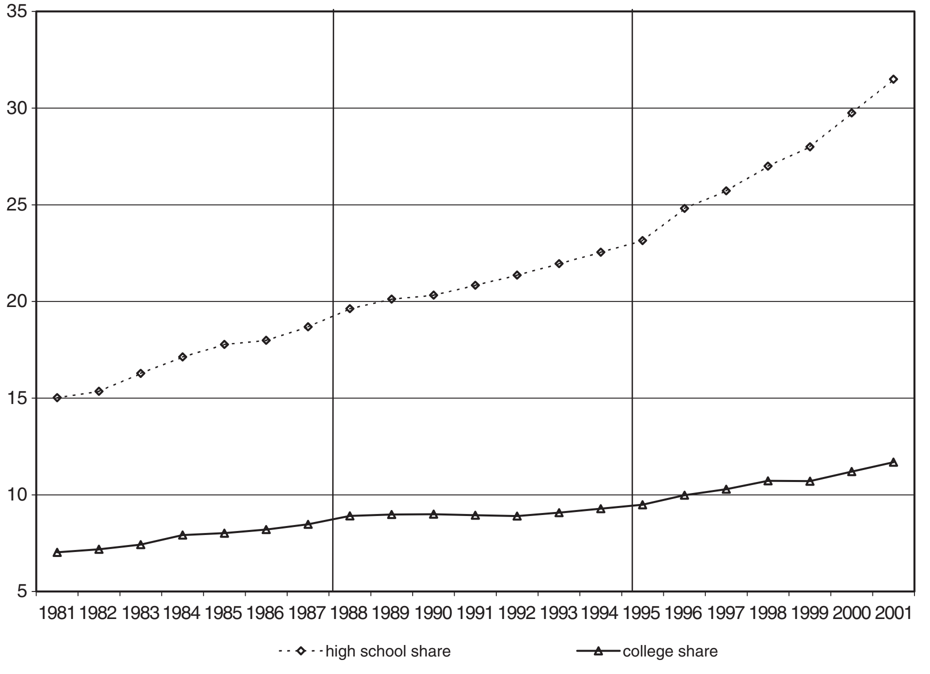


Fig. 3. Education labor supply share (%).

supply could have a say in the decline of earnings differentials, it cannot be its only explanation. The relative supply of skilled workers rose steadily over the period, while earnings differentials started to decline only at the very beginning of the trade liberalization period. This suggests that trade liberalization could be a key factor behind the behavior of earnings differentials. It is also interesting to note that the rate of growth of skilled labor supply increased after 1995, specially for high-school workers. This is compatible with the increase of the college/high-school earnings differentials after trade liberalization observed in Fig. 2.

As we mentioned in the Introduction, most studies that investigated the effects of trade liberalization in developing countries used the share of nonproduction workers as a proxy for skill intensity.[3] Obviously, neither education nor occupation measures perfectly reflect skill intensity, which is unobservable to the econometrician. On the one hand, education attainment fails to reflect skill intensity when, for instance, a highly educated worker is performing tasks that do not require skill. On the other hand, some blue-collar workers can have assignments that demand high skill and they would be misclassified as unskilled workers if one uses the occupation measure as a proxy for skill. The occupation measure is specially problematic in developing countries, since, as unskilled labor wages in these countries tend to be low, firms are more likely to hire workers for nonproduction tasks that do not require skills, such as janitors and phone operators. We believe that education attainment is a more accurate proxy for skill and therefore use it to construct our skill composition measure in the empirical exercises that follow, although we also report results of some experiments using the occupation measure.

[3] Behrman et al. (2000) is a notable exception.

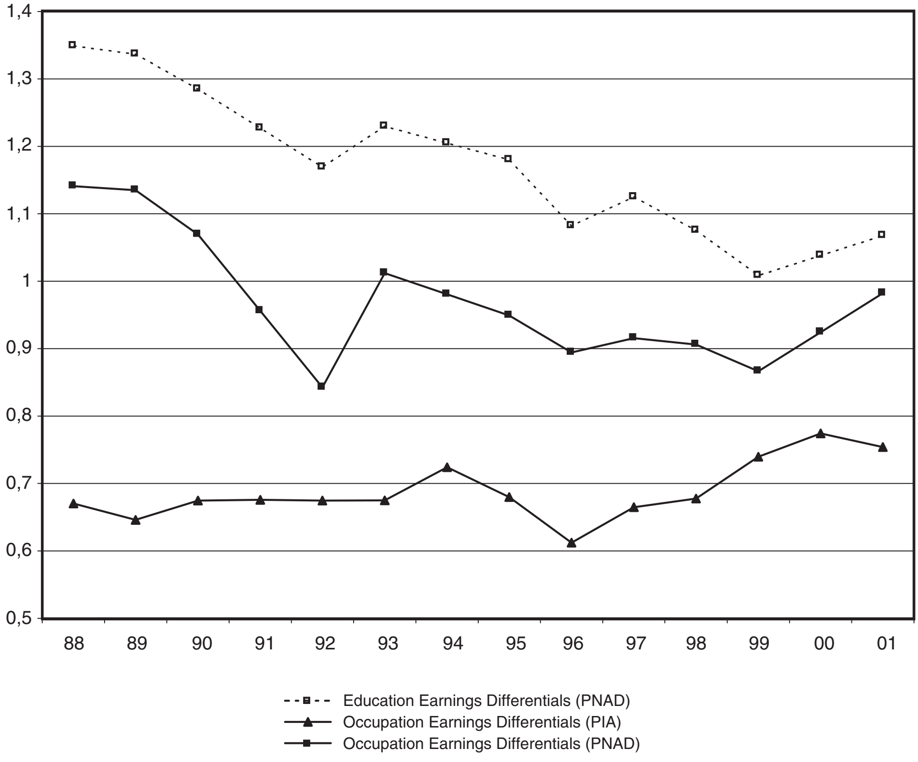


Fig. 4. Earnings differentials: education vs. occupation measures.

Fig. 4 displays the evolution of different measures of the skill earnings differentials, using education and occupation as proxies for skill. We present data on the nonproduction/production earnings differentials from two different sources: i) the Brazilian Industrial Surveys (Pesquisa Industrial Annual — PIA); and ii) the PNAD household surveys.[4] The figure shows that the two earnings differentials computed using occupation as a proxy for skill followed different patterns between 1988 and 1995. The PNAD-defined differentials followed a decreasing pattern, similar to that of the educational earnings differentials described above. In contrast, the PIA-defined differentials slightly rose over the trade liberalization period.

One explanation for this difference could be skill upgrading among nonproduction workers in PIA data. Within-occupation skill upgrading could be the result of outsourcing of service workers that were previously employed in industrial-sector firms, a phenomenon pervasive in Brazil in the early 1990s. In data from establishment surveys, such as PIA, workers that were subcontracted to service-sector firms were removed from the questionnaires answered by the industrial firms. This may not be the case in household surveys, since the worker is the respondent and may perceive herself as still working in the industrial sector, even when subcontracted. These workers are more likely to be in the

[4] In the case of PNAD, we classified workers to production and nonproduction using the classification given by Muendler et al. (2004). The level of disaggregation in the industrial surveys is higher (60 industries) than in the household surveys (21 sectors). The table in Appendix A shows how the data in the two surveys are matched.

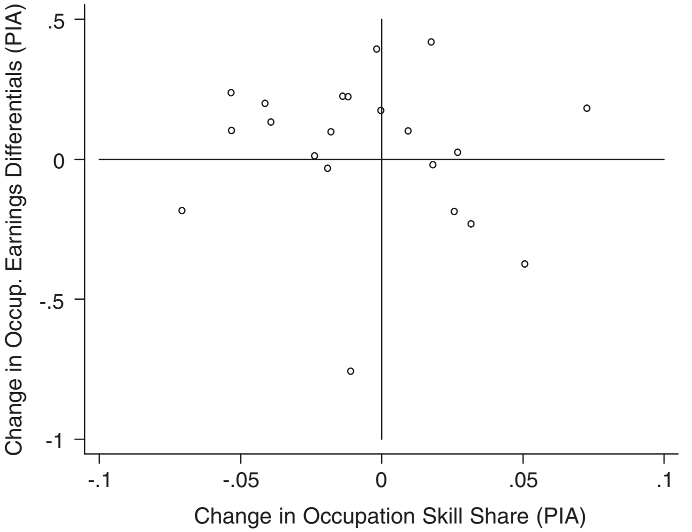


Fig. 5. Occupation earnings differentials and skill share changes (PIA): 1988–95.

nonproduction group, but performing unskilled tasks. Between 1988 and 1995, total industrial employment declined by 31% in PIA data and by only 7.7% in PNAD data, which is compatible with this explanation.

We cannot directly test this hypothesis due to the lack of education data in the industrial surveys, but, as shown in Fig. 5, occupation earnings differentials increased mostly in sectors in which there was a decrease in the share of nonproduction workers. This is consistent with skill upgrading within nonproduction workers due to outsourcing, but it could be consistent with other forms of selection as well. Nonetheless, the evidence presented above challenges the use of occupation wage differentials from industrial surveys as a measure for skill remuneration. The choice of skill proxy turns out to be crucial, since the evolutions of the two measures are very different in Brazil.[5]

## 2.2. Trade liberalization in Brazil

Brazil has a long tradition of restrictive trade policies. Trade barriers were built over several decades, responding to different policy orientations. Trade policy before 1974 was designed as an incentive to selected industries as part of the import substitution strategy. After 1974, the increase in both tariff and non-tariff barriers was a reaction to macroeconomic instability caused first by the oil shocks and later by the debt crisis. By the end of the 1980s a maze of trade policy was in place, distorting price, and, hence, microeconomic incentives.

An important question for our purposes is whether the tariff structure before trade liberalization favored skill-intensive industries. In order to answer this question, we use data on tariffs for 60 industries (PIA classification) between 1988 and 1995, from Kume (2002). We organized them into 21 sectors to match the aggregation level of the education attainment skill

[5] Remember that this was not a problem for U.S. data, as shown by Krueger (1997) and Slaughter (2000).

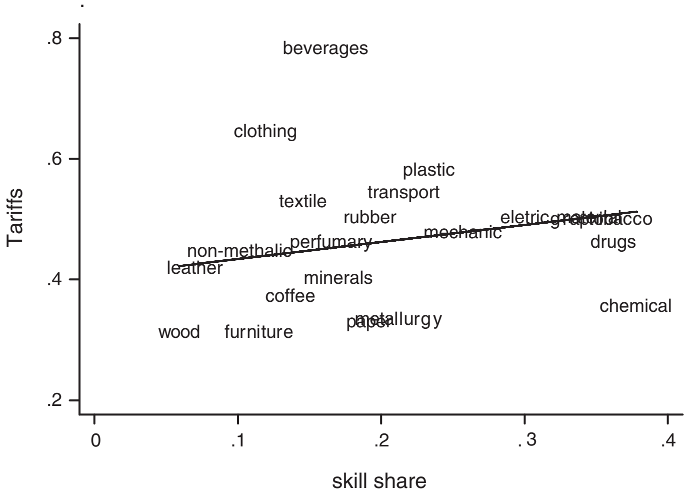


Fig. 6. Tariffs and skill shares (1988).

measure computed from PNAD (see the data matching in Appendix A). Fig. 6 shows that the Brazilian tariff protection pattern in 1988 had only a mildly positive relationship with skill intensity, but with considerable variance. This comes as no surprise, given that trade barriers were raised to cope with macroeconomic problems, and not to protect sectors in which Brazil had no comparative advantage.

Trade liberalization began in 1988, with most non-tariff barriers being replaced by tariffs, and it was intensified by a new government in 1990, in conjunction with the implementation of a regional trade block, Mercosul. The average tariff level was below 14% by November 1995, compared with over 42% in 1988. There has been no major tariffs changes since 1995. Table 1 shows the evolution of nominal tariffs from 1988 to 1999.

Fig. 7 shows that tariffs have declined slightly more in the more skill-intensive sectors, although not dramatically so, a pattern that will be further investigated below.[6] This contrasts sharply with what was observed in Mexico. Hanson and Harrison (1999) and Robertson (2004), for example, show that Mexican tariffs were relatively lower in skill-intensive sectors before trade liberalization, and decreased less in those sectors.

## 3. Theoretical considerations

In a Heckscher–Ohlin world, international trade is completely specialized and countries import only goods in which they have no comparative advantage. Moreover, in these models, trade liberalization affects relative wages through its direct effect on relative domestic prices. However, data are usually collected at the sectorial level, and, in general, sectors are composed of imported, exported and nontraded goods. Hence, sectors do not present complete

[6] Nonproduction–production employment ratios in 1988 are negatively correlated with 1988 tariffs levels, but are not correlated with 1988–1995 tariffs changes.

Table 1
Nominal and effective tariffs, 1988–1995

| Nominal tariffs | 88 | 89 | 90 | 91 | 92 | 93 |
|---|---|---|---|---|---|---|
| Simple average | 42.6 | 35.2 | 33.1 | 21.5 | 17.0 | 14.4 |
| Weighted average[a] | 43.6 | 36.1 | 34.4 | 22.5 | 17.9 | 15.2 |
| Standard deviation | 12.6 | 12.6 | 11.9 | 8.4 | 6.6 | 5.2 |
| Nominal tariffs | 94 | 95 | 96 | 97 | 98 | 99 |
| Simple average | 12.3 | 13.4 | 13.3 | 16.4 | 16.5 | 16.1 |
| Weighted average[a] | 12.6 | 14.4 | 14.6 | 17.8 | 17.7 | 17.0 |
| Standard deviation | 5.6 | 6.2 | 6.6 | 5.6 | 5.5 | 4.7 |

[a] Weighted by the value added in 1988. Source: Kume (2002).

specialization and, more importantly, the impact from tariffs changes to sectorial relative prices is not as straightforward.

In order to investigate the effect of tariffs changes on relative sector prices, we present an H–O type of model with a continuum of goods and no complete trade specialization in each sector, building on a version of Dornbusch et al. (1980) by adding to it import tariffs and by aggregating goods into sectors. The model predicts that the pass-through from tariffs to prices depends on the share of imported goods in each sector. The model also delivers the Stolper–Samuelson result that trade liberalization increases the relative price of the relatively abundant production factor.

Consider two economies, South and North, producing and consuming a continuum of goods, as in Dornbusch et al. (1980), but aggregated into sectors. There is a continuum of sectors in the interval $[u, 1-u]$, $u$ being a constant in the (0, (1/2)) interval. Each sector $k$ comprises a continuum of goods $z$; in the range $[k-u, k+u]$, hence $z \in [0, 1]$. Goods are indexed both by their type, $z$, and by the sector to which they belong, $k$.

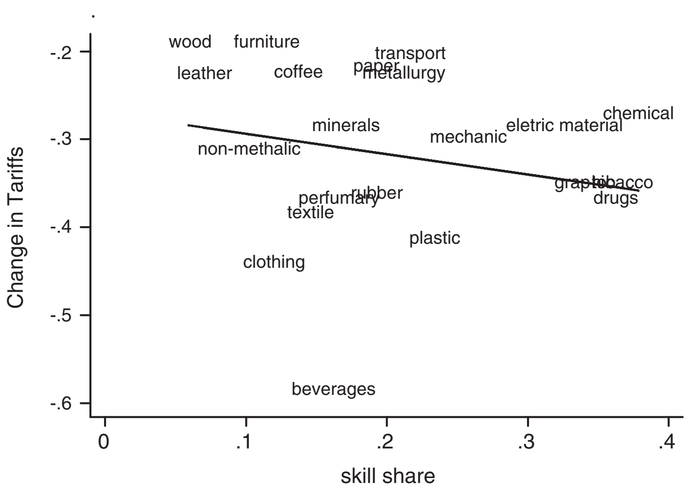


Fig. 7. Tariffs changes (1988–1995) and skill shares (1988).

Following Romalis (2004), we assume Cobb–Douglas production functions with two production factors, skilled and unskilled labor, which are mobile across sectors but not across countries. We assume that South is relatively abundant in unskilled labor. The marginal cost of production of good $z$ from sector $k$ in the South is given by:

$$MgC(q(k,z)) = A(k)s^z w^{1-z}, \tag{1}$$

where $A$ $(k)$ is a technological parameter equal for all goods in sector $k$, $s$ and $w$ are skilled and unskilled labor wages, respectively, and $q$ $(k, z)$ is the quantity produced of good $(k, z)$. Note that the parameter $z$ also represents the skill intensity of the good: goods with higher $z$ are more skill-intensive.

We assume that South imposes import tariffs, $\tau$ $(k)$, which is the same for all goods in sector $k$, but may differ across sectors. South imports a good $(k, z)$ whenever its domestic price exceeds the price in North plus the import tariff, that is, when $p$ $(k, z) \geq (1+\tau(k))$ $p^*$ $(k, z)$, where $p$ $(k, z)$ and $p^*$ $(k, z)$ are domestic and foreign producer prices, respectively. As markets are competitive, prices equal marginal cost, hence the inequality becomes:

$$A(k)s^z w^{1-z} \geq (1 + \tau(k))p^*(k,z), \tag{2}$$

Eq. (2) implicitly defines a cutoff value for $z$, $\bar{z}$ $(k)$, such that all goods $z \geq \bar{z}$ $(k)$ in sector $k$ are imported.[7]

Analogously, South exports a good when $p$ $(k, z) \leq p^*$ $(k, z)$,[8] so that:

$$A(k)s^z w^{1-z} \leq p^*(k,z). \tag{3}$$

Eq. (3) implicitly defines a good $\underline{z}$ $(k)$, such that all goods $z \leq \underline{z}$ $(k)$ in sector $k$ are exported. Clearly, goods $\underline{z}$ $(k) < z < \bar{z}$ $(k)$ are nontraded.[9]

Now we derive the price index in each sector. The wholesale price index is defined as:[10]

$$\log P(k) = \int_{k-u}^{k+u} d(k,z) \log p^d(k,z) dz, \tag{4}$$

where $d$ $(k, z)$ is the share of the good's transactions in total sector's transactions, including both domestically produced and imported products, with $\int_{k-u}^{k+u} d(k,z)dz = 1$. $p^d$ $(k, z)$ is the domestic price, which equals $p$ $(k, z)$ if the good is produced domestically or $(1+\tau$ $(k))$ $p^*$ $(k, z)$ if the good is imported. There are three possible cases. In sectors for which $k+u \leq \bar{z}$ $(k)$, all goods are produced domestically and $p^d$ $(k, z)=p$ $(k, z)$. When $\bar{z}$ $(k) \leq k-u$, all goods in sector $k$ are

[7] Note that $\bar{z}$ $(k)$ is a lower bound for imported goods following our assumption that South is relatively abundant in unskilled labor. Two conditions ensure that $\bar{z}$ $(k)$ is a lower bound. First, $\frac{A(k)s^z w^{1-z}}{p*(k,z)}$ must be increasing in $z$: second, we assume that (s/w)>1, without the need of making further hypotheses regarding the foreign country's technology. Note that these assumptions also guarantee that $\underline{z}$ $(k)$, defined below, is an upper bound for exported goods.

[8] Remember that North does not have import tariffs.

[9] In equilibrium, some goods are exported and others imported. Hence, $0 < \underline{z} \leq \bar{z}$ $(k) < 1$: to satisfy these conditions, equilibrium wages must be such that $p^*$ $(k, z) \in (A$ $(k)$ $w$, $A$ $(k)$ $(s/(1+\tau))$.

[10] We define the price index as the wholesale one because this is the only price index available at the sectorial level in Brazil. Moreover, we employ the same definition for the weight of each good in the price index as in the wholesale price index used in the empirical exercises.

imported. For these sectors, $p^d(k,z)=(1+\tau(k))p^*(k,z)$. Finally, when $k-u\leq\bar{z}(k)\leq k+u$, only a portion of the goods is imported. Thus, the price index can be written as:

$$\begin{aligned}\log P(k) &= \int_{k-u}^{k+u} d(k,z)\log p(k,z)dz \text{ for } k\leq\bar{z}(k)-u \\ &= \int_{k-u}^{\bar{z}(k)} d(k,z)\log p(k,z)dz + \\ &\quad + \int_{\bar{z}(k)}^{k+u} d(k,z)\log[(1+\tau(k))p^*(k,z)]dz \text{ for } \bar{z}(k)-u<k<\bar{z}(k)+u \\ &= \log(1+\tau(k)) + \int_{k-u}^{k+u} d(k,z)\log p^*(k,z)dz \text{ for } k\geq\bar{z}(k)+u \end{aligned} \tag{5}$$

From the sector price indexes in Eq. (5), we can derive the pass-through from tariffs to prices:

$$\frac{\partial \log P(k)}{\partial \log(1+\tau(k))} = \begin{cases} 0 \text{ for } k\leq\bar{z}(k)-u \\ \int_{\bar{z}(k)}^{k+u} d(k,z)dz \text{ for } \bar{z}(k)-u<k<\bar{z}(k)+u \\ \int_{k-u}^{k+u} d(k,z)dz = 1 \text{ for } k\geq\bar{z}(k)+u \end{cases} \tag{6}$$

Eq. (6) shows that the pass-through from tariffs to prices is not equal across sectors. In sectors with no imports ($k\leq\bar{z}(k)-u$), the pass-through is obviously zero. On the other extreme, in sectors where all goods are imported ($k\geq\bar{z}(k)+u$), the pass-through coefficient is one. For sectors with some imports, the pass-through from tariffs to prices is equal to the share of imported goods in total transactions in the sector, that is, $\int_{\bar{z}(k)}^{k+u} d(k,z)dz$, which is the sector's import penetration.

This means that the impact of trade liberalization on relative prices depends not only on the change in relative tariffs, but also on the differentiated pass-through coefficients across sectors. When pass-through coefficients are different across sectors, even a homogeneous tariffs decrease may lead to relative price changes.

Note that sectors in which the country has comparative advantage are the ones with lower import penetration[11], hence, with lower pass-through. As South does not have comparative advantage in skill-intensive goods, a given tariff decrease should have a larger impact on prices of sectors that use skilled labor more intensively.

This model also delivers the Stolper–Samuelson result, as shown in the working paper version of this article (Gonzaga et al., 2005). According to the model, in order to be consistent with the reduction in earnings inequality observed in Brazil, the relative prices of skill-intensive sectors should have decreased, and this decrease should have been induced by trade liberalization. The new relative prices incentives would have led to a shift in production from skill- to unskill-intensive sectors. This would have caused a relative decrease in skilled labor demand, implying a fall in the relative wages of skilled labor. The new factor prices, in turn, would have induced firms in all sectors to increase the proportion of skilled labor used in production.

[11] South has comparative advantage in goods that use skilled labor less intensively, which are goods $z\leq\bar{z}(k)$. At the sectorial level, comparative advantages are not well defined, but they should clearly depend on the share of these goods in the sector.

In the end, under full employment, one should observe higher relative wages for unskilled labor, an increase in employment and production in unskilled-intensive sectors, and an increase in the use of skilled labor in all sectors. The next section investigates whether the comovements of sectorial variables following Brazilian trade liberalization conform to this trade transmission mechanism.

Additionally, according to the model, changes in relative labor supply also affect relative wages: an increase in relative supply of skilled labor decreases its relative earnings. This result is also derived in Gonzaga et al. (2005).

## 4. Empirical results

### 4.1. Within and between industry decomposition

Our empirical exercise begins by analyzing standard decompositions of skilled labor employment shares into *within*- and *between*-industry changes (see Berman et al., 1994; Autor et al., 1998). As discussed below, trade liberalization and skilled labor supply changes have different implications for the evolution of these decompositions changes. In particular, we investigate whether the increase in skilled labor supply could be the only explanation for the drop in skill earnings differentials observed in Brazil.

Changes in skilled labor employment share $\left(\Delta\left(\frac{L_S}{L_U+L_S}\right)\right)$ may be decomposed in two parts:

$$\Delta\left(\frac{L_S}{L_U+L_S}\right) = \sum_k s_k \Delta\left(\frac{L_S}{L_U+L_S}\right)_k + \sum_k \left(\frac{L_S}{L_U+L_S}\right)_k \Delta s_k, \tag{7}$$

which are interpreted as:

1. *within-industry changes*, which are changes in skilled labor employment within each industry $\left(\Delta\left(\frac{L_S}{L_U+L_S}\right)_k\right)$, for given industry employment shares $\left(s_k = \frac{(L_U+L_S)_k}{L_U+L_S}\right)$
2. *between-industry changes*, which are changes in industry employment shares ($\Delta s_k$), for a given skilled labor employment share in each industry $\left(\left(\frac{L_S}{L_U+L_S}\right)_k\right)$.

What would be the results of this decomposition exercise if the increase in relative labor supply were the only significant change in the economy? For a small open economy under full employment, an increase in a factor endowment raises the output of industries that use that factor intensively, and decreases other industries' output. This would generate a positive between-industry effect. If there is no factor price equalization, as may be the case in our model, the resulting fall in skilled labor relative wages would shift labor demand towards skilled workers within each industry, that is, a positive within-industry effect. In terms of Eq. (7), an increase in skilled labor supply is represented by a positive left hand side. The two terms on the right hand side should also be positive, representing the positive within- and between-industry effects.

What would be the results of this exercise if trade were the only source behind the changes in earnings inequality? As described in Section 3, trade opening should have caused a decrease in relative prices of skill-intensive sectors in order to produce the observed decrease in earnings inequality.[12] On the one hand, these price incentives would decrease production in those sectors, which denote a negative between-industry effect. On the other hand, as above, the relative wage incentives would yield a positive within-industry effect. With given factor supplies, the two effects should offset each other.

[12] Note that we are considering an economy that is relatively abundant in unskilled labor.

Table 2
Decompositions of employment shares, 1988–95

| | Total | Within industry | Between industry |
|---|---|---|---|
| Employment share of skilled labor | 0.0267 (100%) | 0.0334 (125%) | −0.0067 (−25%) |

Table 2 presents the results of the decomposition analysis of skilled labor employment shares, using education attainment as a measure of skill from the PNAD data set. Confirming the labor supply movements displayed in Fig. 3, skilled labor employment share (measured by the high-school threshold) increased 2.67% a year between 1988 and 1995, on average. The decomposition reveals that the within effect is positive and the between effect is negative, that is, employment shifted from skilled to unskilled intensive sectors, and each sector increased its relative share of skilled labor. Two important conclusions emerge: (1) labor supply changes alone cannot account for these results, and (2) the results are compatible with the trade explanation.[13]

## 4.2. Consistency checks

We perform some consistency check exercises to examine the causality path predicted by trade theory. As discussed in Section 3, the following relationships should be investigated to determine whether trade liberalization was responsible for the decrease in skilled labor relative earnings observed in Brazil:

1. *What was the pattern of relative price changes?* To be consistent with the decrease in earnings inequality, one should observe a decrease in the relative prices of the sectors that use skilled labor intensively. This should be reflected in the data through a negative correlation between price changes and skill intensity.
2. *What was the pattern of tariff reduction*? If these changes in relative prices, negatively correlated with skill intensity, were induced by trade liberalization, one should observe that the most skill-intensive sectors experienced the largest tariff reductions and/or that in these sectors the tariffs reduction had a larger impact on prices. As Eq. (6) shows, tariffs adjusted by the share of imported goods in each sector is the proper measure to be used to investigate the impact of trade liberalization on prices, since it captures both the tariff changes and the differentiated pass-through effect. Therefore, one should test the correlation between skill intensity and adjusted tariff changes.
3. Was the pattern of price changes induced by tariff changes? This can be examined through the estimation of price changes equations based on the relationship established in Eq. (5).

We investigate each of these questions in turn over the next three sub-sections.

### 4.2.1. Prices and skill intensity

The first step is to check whether the pattern of price changes is consistent with the observed decrease in relative earnings of skilled labor. Fig. 8 suggests that, between 1988 and 1995, relative prices decreased in sectors with a higher proportion of educated workers.

[13] Results not reported here, using nonproduction share from PIA as a proxy for skill, are also compatible with trade. But in that case, they explain the *increase* in earnings differentials observed for that skill measure. There was an average overall annual decrease of 0.7% in nonproduction employment share. This was decomposed into a negative *within-industry* effect (−1.4%), which outweighed a positive *between-industry* effect (0.7%).

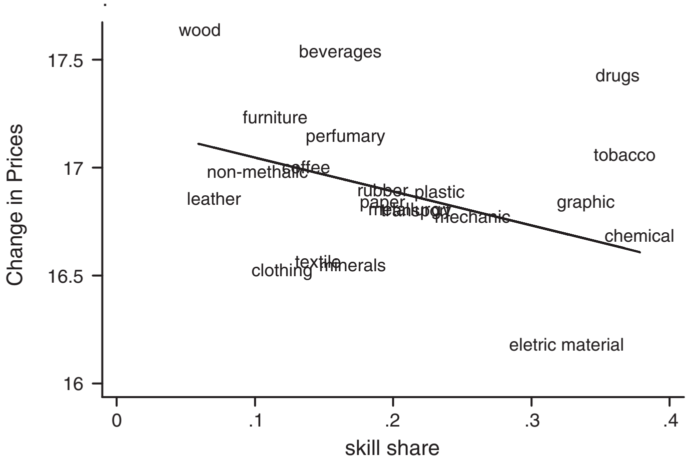


Fig. 8. Price changes (1988–1995) and skill shares (1988).

We test the correlation between prices and the sector skill intensity by estimating:

$$\Delta \log P_{k\tau} = \beta_{0\tau} + \beta_1 \log\left(\frac{L_S}{L_U + L_S}\right)_{k,\tau-1} + v_{k\tau}, \tag{8}$$

where $P_{k\tau}$ is the wholesale price for sector $k$ in year $\tau$, and $\left(\frac{L_S}{L_U+L_S}\right)_k$ is the share of skilled labor employed in sector $k$. The pattern of price changes must deliver a negative value for $\beta_1$, in order to be consistent with the decrease in relative earnings of skilled labor.

Eq. (8) is estimated using yearly observations from 1988 to 1995, for a sample of 60 industries (PIA classification). The Brazilian wholesale price index (Índice de Preços por Atacado-Oferta Global, IPA-OG),[14] collected by the Fundação Getulio Vargas, was matched to the PIA aggregation. The skilled labor share based on education attainment was computed from the 21-sectors' PNAD data set. When this is the skill measure used, we correct the standard errors of all coefficients for the fact that this variable is more aggregated than the dependent variables.

The regression results of Eq. (8) are presented in Table 3. A significant negative correlation between prices and lagged skill intensity (education-based) is observed in column (1), which uses panel data, showing that relative prices changed in favor of less skill-intensive sectors. Since there is not much variation in skill intensity over time, we estimate a cross-section of the changes in prices from 1988 to 1995 on the skill intensity in 1988. The estimated coefficient, in the second column, is about seven times higher (in absolute value), as expected. In the third column, results of an unweighted regression are presented, which are very similar to those of column (2).

Since most of the empirical literature uses the share of nonproduction workers as a measure of skill intensity, we also estimate Eq. (8) using that measure. Consistent with the slight rise in occupation wage differentials, the skill intensity coefficient in column (4) is positive, yet not significant. Finally, in column (5) we aggregate the skill definition based on the occupation measure to the 21-sector level (the same of the education-based definition). The results do not

[14] The weight of each good in IPA-OG is given by the share of the good's transactions in total sector's transactions. The latter is defined as the sum of the sector's total production and imports.

Table 3
Prices and skill intensity, 1988–95

| | Dependent variable: change in prices | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| High education employment share | −0.043 (0.020) | −0.338 (0.061) | −0.299 (0.131) | – | – |
| Nonproduction employment share | – | – | – | 0.036 (0.239) | 0.062 (0.285) |
| Constant | 3.489 (0.039) | 16.240 (0.257) | 16.320 (0.241) | 16.913 (0.292) | 16.947 (0.355) |
| Observations | 420 | 60 | 60 | 60 | 60 |
| Weighted | Yes | Yes | No | Yes | Yes |
| Time dummies | Yes | No | No | No | No |

Notes: Panel regression of yearly changes in column (1) and cross-section of 1988–1995 changes in columns (2) to (5). In column (5), nonproduction share is aggregated to sector level. Sector employment shares are used as weights. Robust standard errors are in parentheses.

change, so that the differences in the level of aggregation do not seem to be driving the different results for the two skill measures.[15]

These results verify the first consistency check: there is a negative and significant correlation between relative price changes and skill intensity. This is true when we use education attainment as a proxy for skill, which is a more accurate proxy for skill than occupation, as discussed in Section 2. Hence, the pattern of relative price changes is consistent with the observed decline in earnings differentials.

#### *4.2.2. Tariffs and skill intensity*

If the changes in relative prices, which were shown to be negatively correlated with skill intensity, were induced by trade liberalization, one should observe either that the largest tariff reductions occurred in the most skill-intensive sectors or that the pass-through from tariffs to prices was larger in these sectors.

We first estimate the correlation between tariff changes and skill intensity using the following equation:

$$\Delta\log(1 + t_{k\tau}) = \gamma_{0\tau} + \gamma_1 \log\left(\frac{L_S}{L_U + L_S}\right)_{k,\tau-1} + \eta_{k\tau}, \tag{9}$$

where $t_k$ is the average import tariff for sector $k$.

The results for cross-section long changes (1988–1995) regressions are presented in columns (1) and (2) of Table 4. Neither skill intensity measure is significantly correlated with the changes in tariffs. Therefore, as already suggested by Fig. 7, there is no clear pattern of tariff reductions with relation to skill intensity in Brazil.

According to Eq. (6), the proper measure to be used to investigate the impact of trade liberalization on prices is tariffs adjusted by the share of imported goods in each sector. This measure captures both the tariff changes and the differentiated pass-through from tariffs to prices. We, then, test the correlation between adjusted tariff changes and skill intensity, using $\alpha_k\ \Delta\log\ (1+t_{k\tau})$ as the dependent variable in Eq. (9), where $\alpha_k$ is the import penetration. This is measured as the ratio of imports over the sum of imports and total production in each sector in the initial year (1988).

[15] A variance decomposition analysis suggests that about 50% of the price variation occurs within sectors (between industries) and 50% occurs between sectors.

Table 4
Tariff changes and skill intensity, 1988–95

| | Dependent variable | | | | | |
|---|---|---|---|---|---|---|
| | Change in tariffs | | Change in tariffs * Import shares | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| High education employment share | −0.015 (0.023) | – | −0.002 (0.001) | −0.012 (0.004) | −0.015 (0.005) | – |
| Nonproduction employment share | – | 0.002 (0.039) | – | – | – | −0.008 (0.004) |
| Constant | −0.258 (0.038) | −0.252 (0.045) | −0.004 (0.001) | −0.031 (0.008) | −0.036 (0.009) | −0.019 (0.007) |
| Observations | 60 | 60 | 420 | 60 | 60 | 60 |
| Weighted | Yes | Yes | Yes | Yes | No | Yes |
| Time dummies | No | No | Yes | No | No | No |

Notes: Panel regression of yearly changes in column (3) and cross-section of 1988–1995 changes in the other columns. Sector employment shares are used as weights. Robust standard errors are in parentheses.

Columns (3) and (4) of Table 4 report the regression results for a panel of yearly changes and for a cross-section of long changes, respectively. Both skill intensity coefficients are negative and significant, with the long changes coefficient being about six times larger (in absolute value) than the panel one as expected. The unweighted regression yields the same result, as shown in column (5). Interestingly, the use of nonproduction employment share as an alternative explanatory variable also delivers a negative and statistically significant coefficient (see column (6)). These results indicate that adjusted tariffs fell relatively more in more skill-intensive sectors.

Note that these last results contrast with those obtained in columns (1) and (2), where tariff changes were not adjusted by import penetration. These two sets of results together imply that: (i) tariff changes had no relationship with skill intensity, and (ii) import penetration was larger in more skill-intensive sectors, which, according to the arguments in Section 3, entails a higher pass-through from tariffs to prices in these sectors.

This exercise establishes the second consistency check for the causality from trade liberalization to earnings differentials: adjusted tariff changes are negatively correlated with skill intensity.

### *4.2.3. Prices and tariffs*

We now investigate the relationship between tariff and price changes. Based on Eq. (5), we estimate:

$$\Delta \log P_{k\tau} = \delta_{0\tau} + \delta_1 \alpha_k \Delta \log(1 + t_{k\tau}) + \delta_2 \beta_k \Delta \log P_{k\tau}{}^* + \varepsilon_{k\tau} \tag{10}$$

$\alpha_k$ captures the differentiated pass-through impact from tariffs to prices in sector $k$, measured by import penetration in 1988. As we do not have data on the international prices of goods, we use the international prices of sectors $P^*_{k\tau}$ instead, proxied by U.S. prices.[16] $\beta_k$, the differentiated pass-through of international prices to domestic sector prices, is measured by the ratio of imported plus exported goods over the sum of production and total imports in the sector, which we denote trade exposure.[17]

[16] Note that Eq. (5) considered international prices as measured by the same currency as domestic prices. Were they measured by another currency, any nominal exchange rate changes would be captured by the time dummies $\delta_{0\tau}$.

[17] In Eq. (5), we split the sector into domestically produced and imported goods. However, the domestically produced goods include both nontraded and exported goods, and the prices of the latter also depend on international prices.

Table 5
Price changes and tariff changes, 1988–95

| | Dependent variable: price changes | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Tariff changes | 0.457 (0.237) | 0.125 (0.775) | – | – | – |
| Tariff changes × import penetration | – | – | 4.221 (2.194) | 5.173 (3.821) | 4.035 (2.011) |
| U.S. price changes | 0.105 (0.182) | 1.446 (0.915) | – | – | – |
| U.S. price changes × trade exposure | – | – | 0.378 (0.155) | 2.031 (1.919) | 1.001 (0.472) |
| Constant | 2.882 (0.018) | 16.684 (0.215) | 2.874 (0.018) | 16.857 (0.075) | 16.869 (0.070) |
| Observations | 350 | 50 | 350 | 50 | 50 |
| Weighted | Yes | Yes | Yes | Yes | No |
| Time dummies | Yes | No | Yes | No | No |

Notes: Panel regression of yearly changes in columns (1) and (3) and cross-section of 1988–1995 changes in the other columns. Sector employment shares are used as weights. Robust standard errors are in parentheses.

We have assumed away export subsidies and quantitative trade restrictions.[18] Hence, changes in the rents generated by other trade barriers should be captured by an error term, $\varepsilon_{k\tau}$. The effects of other omitted variables are in the time dummies and the error term.

Eq. (10) is estimated using a panel of yearly observations from 1988 to 1995, for a sample of 50 industries. The level of aggregation is lower here because we could only match 50 U.S. industries to the PIA classification. U.S. producer price data are from the Bureau of Labor Statistics. In order to identify the causal effect of tariffs on prices, we must assume that the tariffs reductions are exogenous, that is, not correlated to other (omitted) determinants of price changes. Note, however, that this was a period of substantial policy change in Brazil. We argue that the introduction of time dummies in Eq. (10) absorbs the contemporaneous correlation between variations in tariffs and the other policy changes, which is true as long as there is no within-sector correlation among these changes.

We first estimate Eq. (10) without considering the differentiated pass-through coefficient, that is, we regress price changes on unadjusted tariff changes and U.S. prices changes (with $\alpha_k = 1$ and $\beta_k = 1, \forall k$). The first column of Table 5 presents the estimation results using panel data. The estimated tariff coefficient is positive and statistically different from zero at conventional significance levels. The coefficient for U.S. prices is not precisely estimated in this specification. In the long differences regression, presented in the second column, neither coefficient is significantly different from zero.

Next, we take into account the differentiated pass-through coefficients from tariffs and from international prices to domestic industry prices, as in Eq. (10). We regress the prices changes on the tariffs changes multiplied by import penetration, $\alpha_k$, and U.S. price changes times trade exposure, $\beta_k$. Both $\alpha_k$ and $\beta_k$ are measured by 1988 levels. The results of the panel regression, reported in column (3), show that the coefficient of adjusted tariff changes is also positive and statistically significant. Moreover, adjusted international prices turned out to be positive and significant.[19] In column (4) we use the long differences specification and find that the coefficient of adjusted tariffs is positive but not significant at conventional levels. In an unweighted regression, in column (5), the coefficients of both the adjusted tariffs and adjusted international prices changes are positive and significant.

[18] As discussed in Section 2.2, most non-tariff barriers were replaced by tariffs in the outset of trade liberalization.

[19] One cannot compare the magnitude of the estimated coefficients because of the differences in the units of measurement between the two variables.

These results are in accordance with the predictions of the model presented in Section 3: relative price changes are positively correlated with tariff changes adjusted by import penetration and with international prices adjusted by trade exposure.[20]

### 4.3. Mandated wage equations

While the pattern of price changes is consistent with that of relative earnings and correlated with tariff changes, we have not as yet examined how much of the drop in skill earnings differentials could be attributed to price changes mandated by trade liberalization. We therefore follow another vein of the trade literature and estimate mandated wage equations (see Baldwin and Cain, 1997; Haskel and Slaughter, 2003; Robertson, 2004). According to the Stolper–Samuelson theorem, price changes should equal factor price changes, weighted by the factor cost share. If the only factors of production used were skilled and unskilled labor, it is easy to show that price changes could be decomposed in two terms:

$$\Delta\log p_k = \frac{\theta_k^S}{\theta_k}(\Delta\log w_S - \Delta\log w_U) + \Delta\log w_U, \tag{11}$$

where $\theta_k^S$ is the cost of skilled labor and $\theta_k$ is the total cost in sector $k$. Therefore, regressing price changes on the cost share of skilled labor should yield an estimate of the economy-wide returns to skill changes.

Our estimation is based on the following regression:

$$\Delta\log p_k = \phi_0 + \phi_1\left(\frac{w_S L_S}{w_U L_U + w_S L_S}\right)_k + \eta_k, \tag{12}$$

where the estimated coefficient $\phi_1$ is interpreted as the changes in skill earnings differentials associated with price changes.[21]

Since we are interested in the effect of prices that resulted from trade liberalization, we follow Haskel and Slaughter (2003) and estimate Eq. (12) in two steps. First, we estimate the change in prices predicted by the change in tariffs. For this step, we compute two alternative sets of predicted prices that result from the estimation of Eq. (10): (i) not adjusting tariffs and international price changes for differentiated pass-through across sectors, and (ii) with the adjustments, using both weighted and unweighted regressions. These results were presented, respectively, in columns (2), (4) and (5) of Table 5. In the second step, we estimate Eq. (12) using the predicted prices, instead of actual prices, as the dependent variable. The estimated

[20] There is one caveat in interpreting the results of this regression. The composition of goods within each sector may change over time, and this change may be correlated with changes in trade policy. On the one hand, trade liberalization may reduce or even eliminate domestic production of goods with relatively high domestic production costs. On the other hand, new products may be introduced due to the reduced cost of imported goods. Even though this is a drawback, there is nothing we can do to correct for possible measurement errors caused by it.

[21] The general form for Eq. (11) when there are $l$ factors of production is:

$$\Delta\log p_j = \frac{\theta_j^1}{\theta_j}(\Delta\log w_1 - \Delta\log w_2) + \frac{\theta_j^1 + \theta_j^2}{\theta_j}\Delta\log w_2 + \sum_{k=3}^{l}\left(\frac{\theta_j^k}{\theta_j}\Delta\log w_k\right).$$

In this case, one could still use Eq. (12), but the coefficient $\phi_1$ should equal $\frac{\theta_j^S+\theta_j^U}{\theta_j}(\Delta\log w_s - \Delta\log w_U)$, which would be well estimated if the share of labor in total cost is time invariant. An analogous argument applies for the constant term in Eq. (12).

Table 6
Mandated wages

| | Dependent variable: change in prices | | |
|---|---|---|---|
| | Predicted by tariff changes | Predicted by tariff changes, adjusted by differentiated pass-through | |
| | (1) | (2) | (3) |
| High-education cost share | −0.048 (0.039) | −0.294 (0.085) | −0.268 (0.088) |
| Constant | 16.88 (0.021) | 16.93 (0.087) | 16.94 (0.033) |
| Auxiliary regression in Table 5 | Column (2) | Column (4) | Column (5) |
| Actual change in log earnings differentials | −0.168 | −0.168 | −0.168 |
| Observations | 60 | 60 | 60 |
| Weighted original regressions | Yes | Yes | No |

Notes: Robust standard errors are in parentheses.

coefficient of the cost share of high-education is interpreted as the changes in skill earnings that are mandated by price changes induced by trade liberalization.

The results are presented in Table 6. The actual fall in skill earnings differentials observed in Brazil from 1988 to 1995 was 15.5% (which corresponds to the −0.168 log difference). The first column shows that the decline in earnings differentials mandated by the price variation predicted by the (unadjusted) change in tariffs was estimated at 4.7%, but was not significantly different from zero. When we use the price changes predicted by tariffs, allowing for differentiated pass-through coefficients across sectors, weighted in column (2) and unweighted in column (3), we find mandated annualized skill earnings differential declines of 25.5% (−0.294 log difference) and 23.5% (−0.268), respectively.

These results indicate that, if trade were the only change in the Brazilian economy from 1988 to 1995, skill earnings differentials would have fallen by even more (8–10 percentage points) than what was actually observed. Other changes in the economy were responsible for this difference. In particular, skill biased technological changes would have had a positive impact on the differentials. Note, however, that the labor supply changes observed in Brazil might have reinforced the decline in earnings differentials. It is beyond the scope of this paper to disentangle the contribution of these other factors on the evolution of the skill premium. Nevertheless, this result provides compelling evidence that trade liberalization played a major role in explaining the decrease in relative earnings of skilled labor in Brazil.

## 5. Conclusion

During the trade liberalization implemented in Brazil from 1988 to 1995, earnings of workers with at least complete high-school decreased with respect to earnings of less educated workers. In this paper we present evidence compatible with trade liberalization having played a role in explaining these relative earnings movements.

First, a decomposition analysis of changes in the employment share of skilled labor over this period reveals that employment shifted from skilled- to unskilled-intensive sectors, and that each sector increased its relative share of skilled labor. Second, we show that relative prices fell in skill-intensive sectors, and that tariffs reductions, adjusted by import penetration, were larger in those sectors. Furthermore, we find not only that prices and tariffs were positively correlated, but also that the impact of tariffs changes on prices was higher in sectors with larger import penetration. Finally, we show that the decline in skilled earnings differentials mandated by the price variation predicted by trade, allowing for differentiated pass-through coefficients across sectors, was even larger than the observed one. In summary, all steps of the trade transmission mechanism were tested, and the results are compatible with trade liberalization playing an important role in the changes of relative earnings observed in Brazil.

Our results highlight the importance of considering the effects of differentiated pass-through from tariffs to prices across sectors in order to adequately investigate the effects of trade liberalization on relative prices. We develop a theoretical foundation for this through a modified version of Dornbusch et al. (1980), which shows that the pass-through from tariffs to prices in each sector depends on the sector's import penetration.

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## Appendix A

### *A.1. Data matching*

Data matching: PIA vs. PNAD

| Industry: PIA | Sector: PNAD |
|---|---|
| 1 Metal ore mining | Minerals |
| 2 Cement manufacturing | Minerals non-metallic |
| 3 Cement, concrete and gypsum product manufacturing | Minerals non-metallic |
| 4 Glass and glass product manufacturing | Minerals non-metallic |
| 5 Nonmetallic mineral product manufacturing | Minerals non-metallic |
| 6 Iron production and processing | Metallurgy |
| 7 Nonferrous metals production and processing | Metallurgy |
| 8 Steel production and processing | Metallurgy |
| 9 Other metal products manufacturing | Metallurgy |
| 10 Machinery, equipment and commercial installation Manufacturing | Mechanic |
| 11 Road construction machinery and tractor manufacturing | Mechanic |
| 12 Machinery maintenance, repairing and installation | Mechanic |
| 13 Electrical products manufacturing for power generation and distribution | Electrical material |
| 14 Electric conductor and other electrical device manufacturing | Electrical material |
| 15 Electric appliance and equipment manufacturing (including household appliances) | Electrical material |
| 16 Electronic components, electronic equipment and communication apparatus manufacturing | Electrical material |
| 17 Audio and video equipment manufacturing | Electrical material |
| 18 Automobile, truck and bus manufacturing | Transport |
| 19 Motor vehicle engine and parts manufacturing | Transport |
| 20 Ship and boat building (including repairing) | Transport |
| 21 Railroad rolling stock manufacturing and repairing | Transport |
| 22 Other transportation equipment manufacturing | Transport |
| 23 Wood sawing and wood products manufacturing | Wood |

**Appendix A** (*continued*)

Data matching: PIA vs. PNAD

| Industry: PIA | Sector: PNAD |
|---|---|
| 24 Furniture manufacturing | Furniture |
| 25 Pulp and paper production | Paper |
| 26 Pulp, paper and paperboard products manufacturing | Paper |
| 27 Printing, publishing and allied industries | Graphic |
| 28 Rubber product manufacturing | Rubber |
| 29 Non-petrochemical chemical manufacturing | Chemicals |
| 30 Alcohol production | Chemicals |
| 31 Petroleum refining | Chemicals |
| 32 Basic and intermediate petrochemical manufacturing | Chemicals |
| 33 Resins, artificial and synthetic fibers and elastomers manufacturing | Chemicals |
| 34 Fertilizer manufacturing | Chemicals |
| 35 Miscellaneous chemical product manufacturing | Chemicals |
| 36 Pharmaceutical manufacturing | Drugs |
| 37 Perfumes, detergents and candles manufacturing | Perfumery |
| 38 Laminated plastics plate and pipe manufacturing | Plastic |
| 39 Plastics products manufacturing | Plastic |
| 40 Natural fabric processing, weaving, knitting and finishing | Textile |
| 41 Artificial and synthetic fabric weaving, knitting and coating | Textile |
| 42 Other textiles manufacturing | Textile |
| 43 Apparel and apparel accessories manufacturing | Clothing |
| 44 Leather and hide products and luggage manufacturing | Leather |
| 45 Footwear manufacturing | Leather |
| 46 Coffee manufacturing | Food |
| 47 Rice milling and processing | Food |
| 48 Wheat milling | Food |
| 49 Fruit and vegetable processing and canning | Food |
| 50 Other grains and seeds milling and plant product manufacturing | Food |
| 51 Tobacco product manufacturing | Tobacco |
| 52 Animal (except poultry) slaughtering and meat processing | Food |
| 53 Poultry slaughtering and processing | Food |
| 54 Fluid milk and dairy product manufacturing | Food |
| 55 Sugar manufacturing | Food |
| 56 Oilseed milling | Food |
| 57 Seed oil refining and food fats and oils processing | Food |
| 58 Animal feeds manufacturing | Food |
| 59 Other food manufacturing | Food |
| 60 Beverage manufacturing | Beverages |

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