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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, wages, 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 is very close to the observed one. The results are compatible with trade liberalization accounting for the observed relative earnings changes in Brazil.

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1 Introduction

Brazil has one of the most unequal income distributions in the world. According to the Human Development Report (United Nations Development Program, 2000), Brazil tops the ranking of income concentration for 86 countries in the world. The ratio between the mean income appropriated by the 20% richest families and by the 20% poorest is about 33 in Brazil, compared, for example, to 8 in the U.S., 9 in the U.K., 14 in Russia, 4 in Sri Lanka and Nepal, 18 in Kenya and 30 in Guatemala (the country with the second highest ratio). Also, Squire and Zou (1998) present data on Gini coefficients for several countries, which show Brazil on the top of the list with an average (over time) coefficient of 0.578 relative to a sample mean (s.d.) of 0.362 (0.092).

In Brazil, as well as in many other less developed countries, education is often seen as the main source of inequality. Barros *et al.* (2000), for example, show that the distribution of education and its returns account for about half of the wage inequality explained by observed sources in Brazil. This occurs because education is very unequally distributed and because returns to education are quite high in Brazil.[1]

Although income inequality has not changed much over the past fifteen years, education earnings differentials *fell* during the trade liberalization period. Brazil carried out a massive trade liberalization from 1988 to 1995. Non-tariff barriers were first gradually substituted by tariffs, and then tariffs were reduced from an average of 39.6% in 1988 to 13.1% in 1995. Earnings of workers with at least high school diplomas were 3.85 times higher than those for less educated workers in 1988, and this ratio decreased to 3.28 in 1995. This paper investigates the role of trade liberalization in explaining these relative earnings movements,

[1] Menezes-Filho *et al.* (2002) compare 17 countries from Latin America and the Caribbean and find that returns to education are highest in Brazil. Lam and Levinson (1992) report that returns to education are much higher in Brazil than in the U.S.

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.[2] Second, relative prices have displayed substantial variation over this period, mostly due to very high inflation rates (the average monthly inflation rate for 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.

There is a wide empirical literature examining the causes of the rising skill premium in the U.S. and other OECD countries. A large part of this literature investigates the role of international trade, mostly based on the Heckscher-Ohlin model (see Slaughter, 2000, for a survey of trade studies using U.S. data). A competing view attempts to associate the rising skill premium to skill biased technological changes - SBTC (see Acemoglu, 2002, for a review of the evidence on SBTC and some alternative explanations). Although some papers have been successful in relating trade induced relative product prices changes to wage differentials movements, most of the available evidence favors the SBTC view.

With respect to less developed countries, the literature is far scantier (see Slaughter, 2000, for a survey on the effects of trade liberalization on labor markets in developing countries). Studies on Mexico and Chile show that these countries have also experienced increases in wage differentials, despite having opened their economies to trade. Hanson and Harrison (1999) argue that trade protection was skewed towards low-skilled workers in Mexico prior to the reform,

[2] Trade liberalization was, of course, not the only change in Brazil during the period studied. To name the most important changes, a privatization program began in the early 1990's and 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.

so that the tariffs decline was deeper in those sectors, which could have led to the increase in wage differentials observed in this country. However, the authors did not find any correlation between price changes and skill intensity. Robertson (2003) shows that, following Mexico's entrance to the GATT, the relative price of skill-intensive goods rose and so did the relative wages of skilled workers. However, following the creation of NAFTA, the opposite took place. Beyer *et al.* (1999) find that a fall in the relative price of labor intensive goods in Chile helps to explain the simultaneous rise in wage inequality. Behrman *et al.* (2000) found that trade flows, on average, did not affect the wage differentials in a sample of several Latin American countries.

A possible problem with other studies for developing countries is the use of the share of nonproduction workers 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 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 for how to interpret the results of studies for other developing countries.

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 well as in the more developed ones. Some authors have argued that trade opening can induce SBTC in developing countries, either because these countries use U.S. technologies, which are becoming more skill-biased (Acemoglu, 2003), or because firms in developing countries may respond to a threat of technological leapfrogging by biasing the direction of their innovations towards skilled-labor-intensive technologies (Thoenig and Verdier, 2003).

Note that earnings differentials *decreased* in Brazil between 1988 and 1995, contrary to the evidence found for other developing countries. This implies that SBTC could not have been the driving force of the observed changes in earnings differentials in Brazil. Therefore, this paper focuses on the role of trade liberalization in explaining these movements.

According to traditional trade theory, in order to be consistent with the reduction in earnings inequality, the relative prices of skill-intensive sectors should have decreased, and this decrease should have been induced by trade liberalization. The new relative prices 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 price incentives, in turn, would have induced firms in all sectors to increase the proportion of skilled labor used in production.

One crucial step in relating trade liberalization to wage differentials movements is the link between 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 an homogeneous tariff reduction could impact relative prices when pass-through from tariffs to prices differs across sectors. We argue that the impact of tariffs on prices should be higher in sectors with a larger share of import competing goods. We implement this by adjusting tariffs changes by import penetration, a proxy for the share of importable goods. This is an important theoretical feature that has been overlooked in the literature, and proved to be relevant in our empirical exercises.

We perform several independent empirical exercises that check the trade transmission mechanism, using disaggregated data on tariffs, prices, wages, employment and skill intensity from 1988 to 1995. First, the decomposition of changes in skilled-labor employment share into within- and between-industry effects shows that employment shifted from skilled to unskilled intensive sectors, and each sector increased its relative share of skilled labor.

Second, we show that relative prices fell in skill-intensive sectors. Although tariffs changes are found to be unrelated to skill intensity, import penetration was larger in more skill-intensive sectors, suggesting a higher pass-through from tariffs to prices in these sectors. Furthermore, we find not only that prices and tariffs are positively correlated, but also that the impact of tariff changes on prices is higher in sectors with larger import penetration. This is consistent with trade liberalization being responsible for the relative fall in prices of skill-intensive sectors.

Finally, we apply a mandated wage equation analysis. We show that the decline in skilled earnings differentials mandated by the price variation predicted by trade is very close to the observed one. The predicted price variation is obtained by regressing price changes on tariff changes, allowing for differentiated pass-through coefficients across sectors.

In sum, all steps of the trade transmission mechanism are tested, and the results are compatible with trade liberalization playing a role in explaining the observed decrease in earnings inequality in Brazil. The empirical exercises also highlight the importance of considering differentiated pass-through from tariffs to prices across sectors in order to properly investigate the effects of trade liberalization on relative prices.

This paper is organized as follows. Section 2 presents the data and some stylized facts. Section 3 discusses the theoretical framework for the empirical exercises, including the role of differentiated pass-through from tariffs to prices across sectors. The Brazilian trade liberalization process is briefly described in Section 4. Section 5 presents the various empirical exercises linking trade liberalization to earnings differentials and Section 6 concludes.

2 Data and Stylized Facts

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), 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 and with positive monetary remuneration. The main variable used in this analysis 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.

We split individuals into two education groups: the skilled (those that have at least completed high school, that is, 11 years of education) and the unskilled (those with less than complete high school education). As we show below, 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, compared with more than 20% of workers with complete high school. Therefore, we choose to use the high school threshold to define skill in all empirical exercises that follow.

Figure 1 shows the evolution of earnings differentials between skilled and unskilled workers in Brazil between 1981 and 1997. The dotted line uses our preferred measure of skill (high school or more) and refers to the manufacturing sector only. It shows that wage differentials remained basically constant between

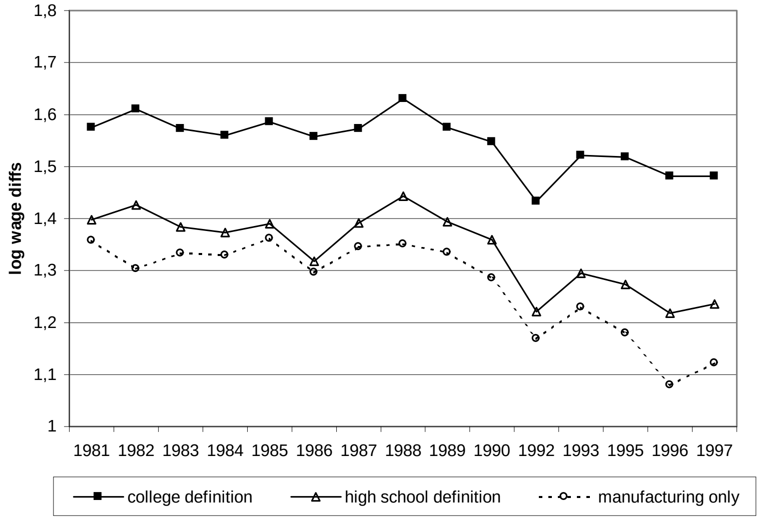

Figure 1: Education Earnings Differentials

1981 and 1988, dropping continuously afterwards. It is important to note that trade liberalization started in 1988. The continuous line with triangles shows that the behavior for the economy as a whole followed a similar path, which is expected, as workers can move between sectors. Finally, the line with squares shows what happens if we use college education to define a skilled worker. The drop in earnings differentials can still be noted in this case, but it is smaller in magnitude and concentrated in the 1988-1992 period[3].

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[4]. In order to compare our results with those using this alternative definition, we used data on occupation from the Brazilian Industrial Surveys (Pesquisa Industrial Anual-PIA), also collected

[3] It is important to note that the wage differential between college educated and high school educated workers rose over the 1990s in Brazil, but this was outweighted in our sample by the decline in the high school-primary school wage differential.

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

by the Brazilian Census Bureau over the same time period, and matched them to the education definitions described above. As the sectors in the industrial surveys are defined at a more disaggregated level than in the household surveys, we would obtain efficiency gains by using the nonproduction definition of skill if the results using the two definitions of skill were compatible.

Figures 2 and 3 show that, while there is a strong association between the high education and the nonproduction employment share across the manufacturing sectors, the correlation between the skill earnings differentials computed using the two definitions is much weaker. More importantly, Figure 4 shows that the earnings differentials computed using nonproduction occupation as a proxy for skill slightly *rose* along the sample period. This behavior contrasts with the fall of relative earnings observed when education attainment is used as a proxy for skill. Obviously, neither measure perfectly reflects skill intensity, which is unobservable to the econometrician. Education attainment fails to reflect skill intensity when, for instance, a highly educated worker is performing a task that does not require skill. On the other hand, some blue-collar workers can have highly skill demanding assignments.[5] We believe that education attainment is a more accurate proxy for skill and use education to construct our skill composition measure in the empirical exercises that follow. We also report results of some experiments using the occupation measure.

The drop in skilled-labor relative earnings observed in Figure 1 could have been caused solely by a rise in skilled labor relative supply. Figure 5 indeed shows that there was a rise in the share of skilled workers over the same time period, both in the manufacturing sector (line with triangles) and in the economy as a whole (dotted line). The line that uses the college definition of skill (continuous with squares) also trended upwards, but at a slower pace. Note

[5] Moreover, in developing countries, where unskilled labor wages are low, firms are more likely to hire workers for nonproduction tasks that do not require skills, such as janitors, phone operators, etc.

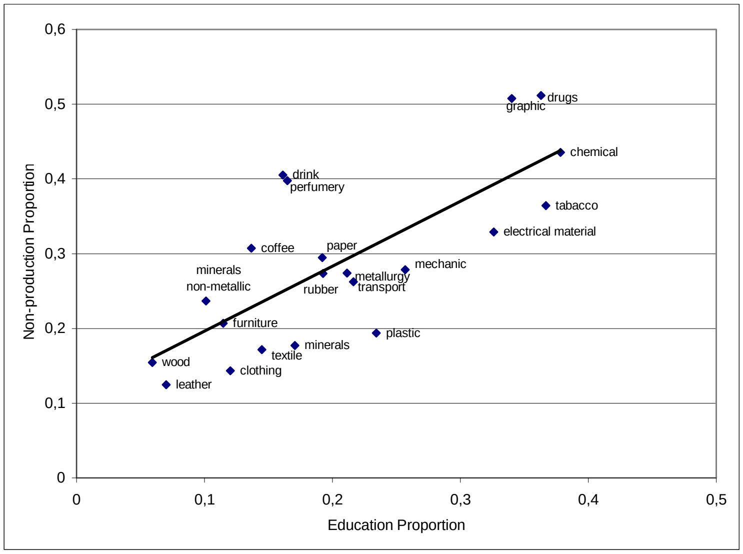

Figure 2: Employment Shares: Education vs. Occupation Measures

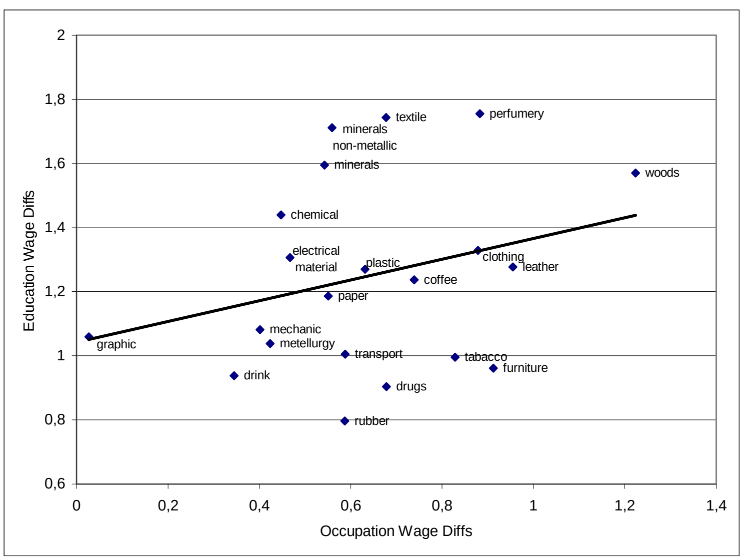

Figure 3: Earnings Differentials: Education vs. Occupation Measures

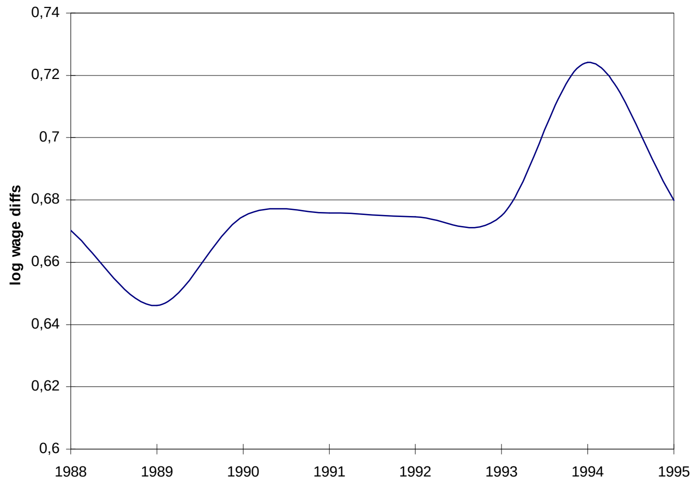

Figure 4: Earnings Differentials: Nonproduction Occupation Measure

that, according to the college definition, only about 9% of the workforce, on average, was skilled in 1988-1995.

While labor supply could have a say in the decline of wage differentials observed above, it is worth noting that the relative supply of skilled workers rose steadily over the period, with minor fluctuations. By contrast, Figure 1 shows that wage differentials remained relatively stable until 1988, starting to decline at the very beginning of the trade liberalization period. This suggests that other factors are behind the behavior of wage differentials. We now try to uncover these factors.

3 Theoretical Considerations

In traditional trade models, international trade is based on differences among countries, which may be either in their factor endowments, as in the Heckscher-Ohlin (H-O) framework, or in the technology they possess, as in Ricardian models. A common feature in these models is that, in a small open economy, relative

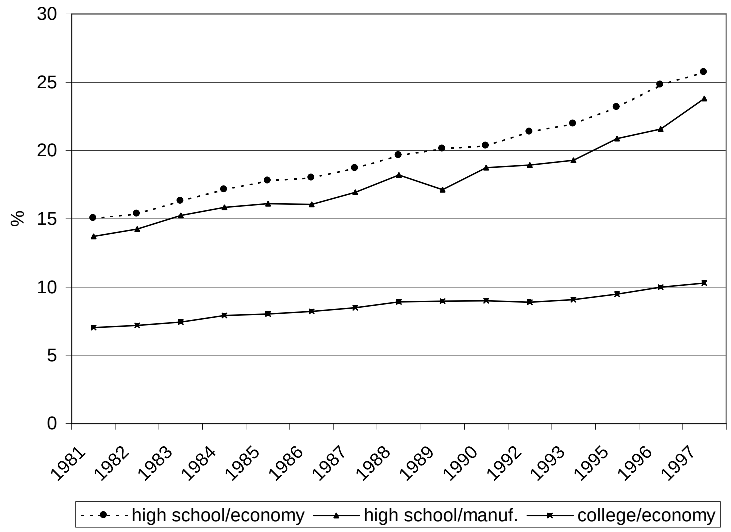

Figure 5: Education Relative Labor Supply

wages are a function only of technological parameters and relative prices. The intuition for this result is the following. In a small open economy, relative prices of tradable goods are determined abroad, and any excess supply or demand is fulfilled by trade of goods. Wages, in turn, are equal to the value of the factors' marginal productivity. As prices are exogenous, and marginal productivity depends solely on technological parameters, wages depend only on prices and technological parameters, and not on factors' supply or goods' demand parameters.[6]

The crucial point in these models is that trade liberalization affects relative wages through its effect on relative domestic prices. In a small open economy,

[6] More precisely, if the economy is in the cone of diversification and the number of goods is greater or equal to the number of factors, then factor relative prices depend only on relative prices of tradable goods being produced, and technological parameters. If the economy is outside the diversification cone, or the number of goods is smaller than the number of factors, then relative factor prices will depend not only on technology and relative prices of goods being produced, but also on taste parameters and factor supplies. The existence of non-tradable goods does not alter the main implications of the analysis. The only effect of non-tradables is to decrease the size of the diversification cone.

domestic goods prices are distorted by trade constraints, so that:

$$p_i = (1 + r_i)\, E p_i^*, \tag{1}$$

where p_i represents the domestic price of good i; r_i represents import tariffs, export subsidies or any type of rents generated by trade barriers, such as quantitative restrictions; E is the nominal exchange rate; and p_i^* is the international price of good i.

In a H-O world, economies' trade is completely specialized, that is, countries should import only goods in which they do not have comparative advantage. However, prices are observed only at the sectorial level, and, in general, sectors are composed of both importable and exportable goods. In fact, the price level in a sector is a weighted average of prices of all goods in that sector, as in:

$$P_j = \prod_{i=1}^{n_j} (p_i)^{\alpha_i}\,, \tag{2}$$

where P_j is the price level in sector j, n_j is the number of goods in sector j, and α_i is the weight of good i in the sector's price index.

Since some of the goods in the sector are importable while others are exportable, each sector price can be written as:

$$P_j = \left[\prod_{i=1}^{k_j} (p_i)^{\alpha_i}\right] \left[\prod_{i=k_j+1}^{n_j} (p_i)^{\alpha_i}\right], \tag{3}$$

where goods 1 to k_j are importable and goods $k_j + 1$ to n_j are exportable. Using equation (1), ignoring quantitative restrictions, and noting that importable goods are affected by tariffs (t_i) whereas exportable goods are affected by export subsidies (s_i), equation (3) becomes:

$$\begin{aligned} P_j &= \left[\prod_{i=1}^{k_j} \left[E p_i^* (1 + t_i)\right]^{\alpha_i}\right] \left[\prod_{i=k_j+1}^{n_j} \left[E p_i^* (1 + s_i)\right]^{\alpha_i}\right] \\ &= E P_j^* \left[\prod_{i=1}^{k_j} (1 + t_i)^{\alpha_i}\right] \left[\prod_{i=k_j+1}^{n_j} (1 + s_i)^{\alpha_i}\right], \end{aligned}$$

where $P_j^* = \prod_{i=1}^{n_j} (p_i^*)^{\alpha_i}$.

If all tariffs were equal across goods in each sector, export subsidies were inexistent, then the sector price would be:

$$P_j = EP_j^* (1 + t_j)^{\alpha^j}, \tag{4}$$

where $\alpha^j = \sum_{i=1}^{k_j} \alpha_i$.

Equation (4) states that the pass-through from tariffs to prices is directly related to the share of importable goods in each sector, α^j. This implies that, in empirical tests of the model, one should use differentiated pass-through from tariffs to prices, with coefficients in each sector depending on the proportion of importable goods. We explore this implication of the theory, which has not been considered in the previous empirical literature.

For any two sectors m and n, domestic relative prices are, thus, given by:

$$\frac{P_m}{P_n} = \frac{P_m^* (1 + t_m)^{\alpha^m}}{P_n^* (1 + t_n)^{\alpha^n}}. \tag{5}$$

Equation (5) shows that a fall in trade barriers across sectors may cause changes in relative prices. This depends on the change in relative tariffs and on the pass-through coefficients. If the pass-through is the same for all sectors, trade liberalization affects relative prices only if tariff reductions are heterogeneous across sectors. However, even a homogeneous tariffs decrease may lead to relative price changes, which happens when pass-through coefficients are different.[7]

If falling tariffs had a larger impact on prices of sectors that use skilled labor more intensively, the new price incentives would then induce a shift of production from skill- towards unskill-intensive sectors, increasing the demand for unskilled labor and decreasing that for skilled labor. In this case, for a given

[7] Note that changes in relative tariffs only affect relative prices when they are not prohibitive. For sufficiently high tariffs, a good seizes to be importable. In this case, its domestic price becomes independent of international prices and tariffs. That is, equation (1) no longer holds for that good.

labor supply, relative skilled-labor wages would decline in order to restore labor market equilibrium.

The new relative wages, in turn, would induce producers to decrease the use of the production factor that became relatively more expensive. Hence, producers in each sector would change the mix of factors, using more skilled and less unskilled labor relative to the pre-liberalization choice. This last effect would offset the original relative demand increase for unskilled labor. In the end, 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 empirical section of this paper, Section 5, investigates whether the comovements of sectorial variables following Brazilian trade liberalization conform to this trade transmission mechanism.

4 Trade Liberalization in Brazil

In this section we briefly describe the process of trade liberalization in Brazil. Brazil has a long tradition of restrictive trade policies. From World War II to 1973 the country pursued an import substitution strategy, following the trend among Latin American countries. This strategy was based on domestic market protection and subsidies to chosen industries. From 1960 to 1973 there was a gradual import liberalization, combined with export promotion policies, including frequent exchange rate devaluations. As a result of these policies, Brazilian exports became considerably more diversified. For example, coffee exports, which accounted for 40% of total exports in 1964, fell to only 20% in 1973. The impact on imports was not as significant. There was some import substitution in intermediate and capital goods, but imports remained highly concentrated in those goods, as well as in oil, which accounted for 20% of total imports in 1974.

The two oil crises of the 1970s brought about large trade imbalances. The Brazilian government chose to use restrictive trade policy instead of letting exchange rate devaluations restore trade balance. Tariffs and non-tariff barriers were imposed, along with export promotion policies to compensate for the anti-export bias generated by the import restrictions. The debt crisis of the 1980s called for large trade surpluses, which were attained by the intensification of trade restrictions and an industrial policy that gave fiscal incentives and cheap credit to selected firms.

In sum, trade barriers were built over several decades, but responding to different policy orientations. Trade policy before 1974 was designed as an incentive to selected sectors 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 by the oil shocks and the debt crisis. The effect of these policies on relative prices distorted microeconomic incentives. By the end of the 1980's a maze of policy incentives was in place.

An important question for our purposes is whether the tariff structure before trade liberalization favored skill-intensive sectors. In order to answer this question, we use data on tariffs for 60 sectors between 1988 and 1995, from Kume (2002). Figure 6 shows that the Brazilian tariff protection pattern in 1988 had virtually no relation with skill-intensity (using education as a measure of skill). 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.

The trade liberalization process was initiated in 1988 and intensified by a new government in 1990, in conjunction with the implementation of a regional trade block, Mercosul.[8] Trade liberalization was even deeper than planned. However,

[8] The Mercosul agreement established a customs union between Brazil, Argentina, Uruguay and Paraguay.

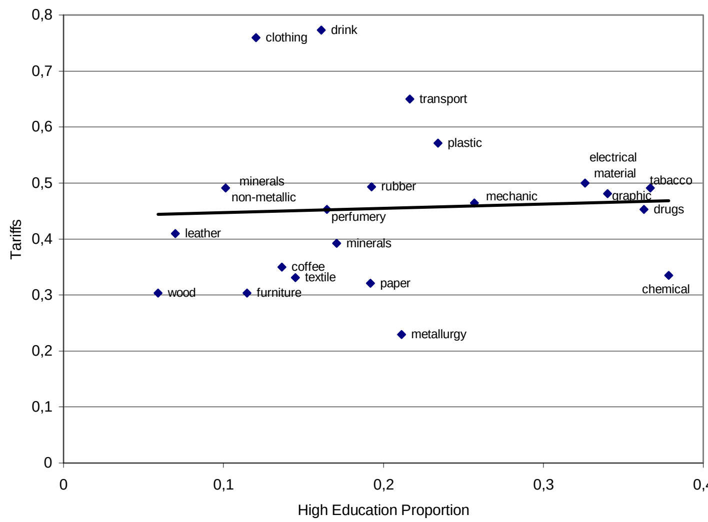

Figure 6: Tariffs and Skill Proportion (Education Measure)

after the 1994 Mexican crisis, there was a partial reversal of the process. Some quantitative import restrictions were temporarily re-introduced, and some tariffs were raised. Nonetheless, the average tariff level was below 14% by November 1995, compared with almost 40% in 1988. The bulk of trade liberalization occurred from 1988 to 1995, with minor tariff changes since then. Table 1 shows the evolution of nominal and effective tariffs from 1988 to 1995.

Nominal tariffs	1988	1989	1990	1991	1992	1993	1994	1995
Simple average	39.6	32.1	30.5	23.6	15.7	13.5	11.2	13.1
Weighted average*	37.7	29.4	27.2	20.9	14.1	12.5	10.2	12.2
Standard deviation	14.6	15.8	14.9	12.7	8.2	6.7	5.9	8.6
Effective tariffs	1988	1989	1990	1991	1992	1993	1994	1995
Simple average	52.1	46.5	47.7	34.8	20.3	16.7	13.6	20.1
Weighted average*	46.8	38.8	37.0	28.6	17.7	15.2	12.3	15.6
Standard deviation	36.6	44.5	60.6	36.5	17.2	13.5	8.4	37.2

(*) Weighted by value added.
Source: Kume (2002).

Table 1: Nominal and effective tariffs, 1988-1995

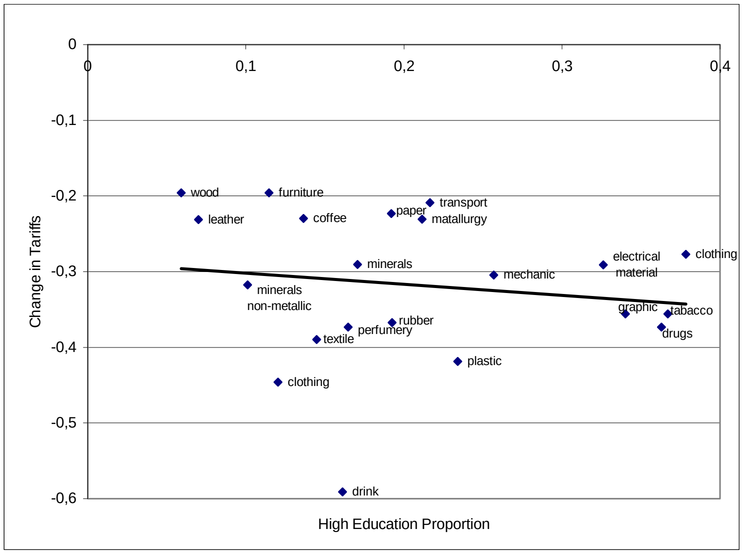

Figure 7: Changes in Tariffs and Skill Proportion (Education Measure)

Figure 7 shows that tariffs seem to have declined slightly more in the more skill-intensive sectors, although not dramatically so, a pattern that will be further investigated below. This contrasts sharply with what was observed in Mexico. Hanson and Harrison (1999) and Robertson (2003), for example, show that Mexican tariffs were relatively lower in skill-intensive sectors before trade liberalization, and decreased less in those sectors.

5 Empirical Results

5.1 Within and Between Industry Decomposition

Our empirical exercise begins by investigating whether the increase in skilled labor supply could be the only explanation for the drop in skill earnings differentials observed in Brazil. As discussed below, trade liberalization and skilled labor supply changes have different implications for the results of standard decompositions of skilled-labor relative employment and wage bill shares into *within* and *between* industry changes (see Berman, Bound and Griliches, 1994 and Autor, Katz and Krueger, 1998).

Changes in skilled-labor employment share ($\Delta\left(\frac{L^S}{L^U+L^S}\right)$) may be decomposed in two parts:

$$\Delta\left(\frac{L^S}{L^U+L^S}\right)=\sum_j s_j\Delta\left(\frac{L^S}{L^U+L^S}\right)_j+\sum_j\left(\frac{L^S}{L^U+L^S}\right)_j\Delta s_j, \qquad (6)$$

which are interpreted as:

1. *within industry changes*, which are changes in skilled-labor employment within each industry ($\Delta\left(\frac{L^S}{L^U+L^S}\right)_j$), for given industry employment shares ($s_j=\frac{\left(L^U+L^S\right)_j}{L^U+L^S}$);
2. *between industry changes*, which are changes in industry employment shares (Δs_j), for a given skilled-labor employment share in each industry ($\left(\frac{L^S}{L^U+L^S}\right)_j$).

What would be the results of this decomposition exercise if the increase in relative labor supply were the only significant change in the economy? According to the Rybczynski theorem, for a small open economy, an increase in a factor endowment raises the output of sectors that use that factor intensively, and decreases other sectors' output, without changing the factor proportion used in each industry. In terms of equation 6, an increase in skilled-labor supply is represented by a positive left hand side. Since factor proportions do not change in each industry, the first term on the right hand side, which represents the *within industry* effect, should be zero. The whole effect should lie in the second term, the *between industry* effect, which should be positive.

What would be the results of this exercise if trade were the only source behind the changes in wage inequality? As described in Section 3, trade should have caused a decrease in relative prices of skill-intensive sectors in order to produce the observed decrease in wage inequality. On the one hand, these price incentives would decrease production in those sectors, which denote a negative *between industry* effect. On the other hand, the relative wage incentives would shift labor demand towards skilled workers within each industry, that is, a positive *within industry* effect. With given factor supplies, the two effects should offset each other.

It is important to note that SBTC would have the same impact as the trade effect described in the previous paragraph: a negative *between industry* effect and a positive *within industry* effect. SBTC represents, by definition, a positive *within industry* effect, since each industry should use relatively more of the skilled labor. With given labor supply, a negative *between industry* effect should also be observed. Therefore, the results of the decomposition exercise cannot distinguish between these two competing explanations for wage differential changes.[9]

Table 2 presents the decomposition results for skilled-labor employment and wage bill shares, using education attainment as a measure of skill. Confirming the labor supply movements displayed in Figure 5, skilled-labor employment share 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 either the trade and SBTC explanations.[10]

[9] Note that SBTC and trade yield the same decomposition results when trade induces a fall in relative prices of skill-intensive goods. In developed countries trade is usually followed by a rise in relative skill-intensive goods prices, which would produce a positive *between industry* effect and a negative *within industry* effect. Hence, in the case of developed countries, SBTC and trade should have opposite decomposition effects.

[10] Results not reported here, using nonproduction share as a proxy for skill, are also compatible with trade. But in that case, they explain the *increase* in earnings differentals 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 outweighted a positive *between industry* effect (0.7%).

	Total	Within Sectors	Between Sectors
High Education	0.0267	0.0334	-0.0067
Employment Share	(100%)	(125%)	(-25%)
High Education	0.0084	0.0256	-0.0172
Wage Bill Share	(100%)	(304%)	(-204%)

Table 2: Employment and Wage Bill Shares Decompositions, 1988-95

Table 2 also shows that the wage bill share of skilled workers increased over the period. However, it increased on average less than the employment share, 0.84% by year. This is compatible with the observed decrease in skilled labor relative wages. Consequently, the skilled worker wage bill share *between sector* effect is larger compared to that of employment share. The employment share decomposition presents a negative *between effect*, which means that, on average, employment share decreased in skilled labor intensive sectors. As these sectors use more of the factor that had its remuneration decreased, it is logical that their overall wage bill share should decrease by a larger proportion than the employment share.

5.2 Consistency Checks

In this sub-section, consistency checks 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. Indeed, equation (4) shows that tariffs adjusted by the share of importable 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 equations based on the relationship established in equation (4).

We will investigate each of these questions in turn over the next three subsections.

5.2.1 Prices and Skill Intensity

The first step is to check whether the pattern of price changes is consistent with the observed decrease in skilled labor relative wages. We test the correlation between prices and sector skill intensity by estimating:

$$\Delta \log P_{i\tau} = \beta_{0\tau} + \beta_1 \log \left(\frac{L^S}{L^U + L^S} \right)_{i,\tau-1} + \nu_{i\tau}, \tag{7}$$

where $P_{i\tau}$ is the wholesale price for sector i in year τ, and $\left(\frac{L^S}{L^U+L^S} \right)_i$ is the share of skilled labor employed in sector i. The pattern of price changes must deliver a negative value for β_1, in order to be consistent with the decrease in skilled-labor relative earnings. Before turning to the estimated equations, Figure 8 suggests that, between 1988 and 1995, relative prices decreased in sectors with a higher proportion of educated workers.

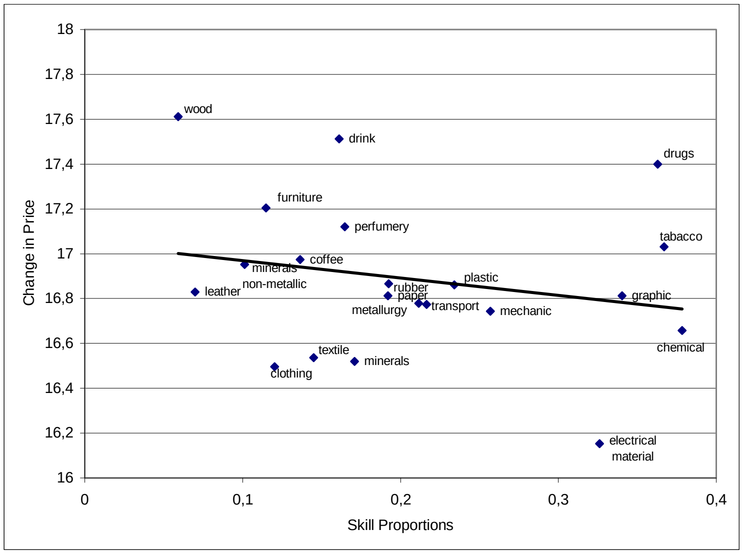

Figure 8: Price Changes and Skill Proportion

Equation (7) is estimated using a panel of yearly observations from 1988 to 1995, for a sample of 60 sectors, defined according to the Brazilian Industrial Surveys (PIA). The Brazilian wholesale price index (*Índice de Preços por Atacado*, IPA) was collected by the *Fundação Getulio Vargas* and was made compatible with the PIA sectorial definitions. We correct the standard errors of all coefficients here and in the following sub-sections for the fact that our independent variable (share of educated workers) is more aggregated than the dependent variables we use.

The regression results of equation (7), controlling for time effects, are presented in Table 3. A significant negative correlation between prices and lagged skill intensity was observed, showing that relative prices changed in favor of less skill-intensive sectors. In the second column, we include the share of nonproduction workers as an additional control, which has a positive and significant coefficient. The inclusion of this variable significantly raises (in absolute value) the estimated education share coefficient. This suggests that, although the two skill measures are positively correlated with each other, relative prices moved in opposite directions with respect to them, so that the exclusion of one measure biases the coefficient of the other.[11]

These results verify the first consistency check: there is a negative correlation between relative price changes and skill intensity. Hence, the pattern of relative price changes are consistent with the observed change in earnings differentials.

	Dependent Variable: Change in Prices			
	(1)	(2)	(3)	(4)
Education Employment Share	-0.043 (0.020)	-0.338 (0.061)	-	-
Nonproduction Employment Share	-		0.006 (0.034)	0.036 (0.239)
Constant	3.489 (0.039)	16.240 (0.257)	1.556 (0.054)	16.913 (0.292)
N	420	60	420	60

Notes: Weighted regressions, using the sector employment shares as weights. Time dummies are included. Robust standard errors are in parentheses.

Table 3: Prices and Skill Intensity, 1988-95

5.2.2 Tariffs and Skill Intensity

In the previous sub-section we showed that relative prices are negatively correlated with skill intensity. If these changes in relative prices 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

[11] Unweighted regressions yield the same qualitative results.

using the following equation:

$$\Delta \log (1+t)_{i\tau} = \gamma_{0\tau} + \gamma_1 \log \left(\frac{L^S}{L^U + L^S} \right)_{i,\tau-1} + \eta_{i\tau}. \tag{8}$$

The results are presented in columns (1) and (2) in Table 4. Neither skill intensity measures are significantly correlated with the changes in tariffs. Therefore, as suggested by Figure 7, there is no clear pattern of tariff reductions with relation to skill intensity in Brazil.

According to equation (4), the proper measure to be used to investigate the impact of trade liberalization on prices is tariffs adjusted by the share of importable goods in each sector. As discussed above, this measure captures both the tariff changes and the differentiated pass-through from tariffs to prices. We, then, test the correlation between skill intensity and adjusted tariff changes, using the following equation:

$$\alpha^i \Delta \log (1+t)_{i\tau} = \lambda_{0\tau} + \lambda_1 \log \left(\frac{L^S}{L^U + L^S} \right)_{i,\tau-1} + u_{i\tau}.$$

As a proxy for the share of importable goods (α^i), we use import penetration, which is the ratio of imports over the sum of imports and total production in each sector in the initial year (1988).

The coefficient of education employment share is negative and significant, as reported in column (3) of Table 4. Moreover, as shown in column (4), the inclusion of nonproduction employment share as an additional explanatory variable does not change the estimated education employment share coefficient, and its coefficient is not significant. These results indicate that adjusted tariffs fell relatively more in more skill intensive sectors. Note that these 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 relation 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 were negatively correlated with skill intensity.

	Dependent Variable							
	Change in Tariffs				Ch Tariffs*Import			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education Employment Share	-0.002 (0.004)	-0.015 (0.023)	-		-0.002 (0.001)	-0.012 (0.004)	-	
Nonproduction Employment Share	-		-0.002 (0.004)	-0.014 (0.030)	-		-0.001 (0.0006)	-0.008 (0.004)
Constant	-0.026 (0.013)	-0.258 (0.038)	-0.095 (0.011)	-0.252 (0.045)	-0.003 (0.001)	-0.031 (0.008)	-0.004 (0.001)	-0.019 (0.007)
N	420	60	420	60	420	60	420	60

Notes: Weighted regressions, using the sector employment shares as weights.
Time dummies are included. Robust standard errors are in parentheses.

Table 4: Tariff Changes and Skill Intensity, 1988-95

5.2.3 Prices and Tariffs

We showed that relative price changes and tariff changes, once adjusted by import penetration, are consistent with relative wage changes. In this subsection we investigate the relation between tariff and price changes.

From equation (4), domestic prices changes are related to changes in tariffs and international prices as follows:

$$\Delta \log P_{j\tau} = \Delta \log E_{\tau} + \Delta \log P^{*}_{j\tau} + \alpha^{j} \Delta \log \left(1 + t_{j\tau}\right). \qquad (9)$$

When deriving equation (4), we have assumed that export subsidies and quantitative trade restrictions did not exist. Hence, for estimating equation (9), changes in the rents generated by other trade barriers should be captured by an error term, $\varepsilon_{j\tau}$. Moreover, all sectors are equally affected by changes in the nominal exchange rate, which are captured by time dummies $\delta_{0\tau}$. These time dummies and the error term may also capture the effect of other omitted variables. The equation to be estimated takes the following form:

$$\Delta \log P_{j\tau} = \delta_{0\tau} + \delta_1 \Delta \log P^*_{j\tau} + \delta_2 \alpha^j \Delta \log (1 + t_{j\tau}) + \varepsilon_{j\tau}, \qquad (10)$$

where U.S. prices are used as a proxy for international prices P^*_j, t_j is the average import tariff for sector j, and α^j captures the differentiated pass-through impact from tariffs to prices in sector j.[12] As in the previous sub-section, we use import penetration in 1988 as a proxy for this measure.

Equation (10) is estimated using a panel of yearly observations from 1988 to 1995, for the sample of 60 sectors.[13] In order to identify the causal effect of tariffs on prices, we must assume that the changes in tariffs are exogenous, that is, not correlated to other (omitted) determinants of price changes. Note, however, that this was a period of substantial policy changes in Brazil (see Behrman *et al* , 2000). We argue that the introduction of time dummies in equation (10) absorbs the contemporaneous correlation between changes in tariffs and the other policy changes, which is true as long as there is no within-sector correlation among these changes.[14]

We first estimate equation (10) without considering the differentiated pass-through coefficient, that is, we regress price changes on unadjusted tariff changes ($\alpha^j = 1$, $\forall j$) and U.S. prices changes. The first column of Table 5 presents the estimation results. The estimated tariff coefficient is positive and statistically different from zero at conventional significance levels. However, the coefficient for U.S. prices is not precisely estimated. This might indicate that U.S. prices are a poor proxy for international prices. Therefore, in column (2) we drop U.S.

[12] Note that the pass-through from tariffs to prices in each sector is $\delta_2 \alpha^j$.

[13] U.S. producer price data were drawn from the Bureau of Labor Statistics Website, but we could only match 50 U.S. sectors to the equivalent Brazilian sectors.

[14] The previous sub-section results, that tariff changes are uncorrelated with skill intensity, reinforce the exogeneity of tariff changes assumption.

prices to gain efficiency, but the results do not change qualitatively.

Next, we take into account the differentiated pass-through coefficient from tariffs to prices, by regressing the prices changes on the tariffs changes multiplied by the initial levels of import penetration, α^j. The results, reported in column (3), show that the coefficient of adjusted tariff changes is also positive and statistically significant.[15] This means that the impact of tariff changes on prices is higher in sectors with larger import penetration.

In column (4) we include both the tariffs and the interaction between tariffs and import penetration as explanatory variables of prices changes, and find that both effects are positive and (marginally) significant. In column (5) we run an unweighted regression and only the coefficient of the adjusted tariffs changes is found to be statistically different from zero. This suggests that the combination of tariffs changes and their differentiated pass-through coefficients is the driving force of prices changes.

The results of this sub-section confirm the third consistency check: relative price changes are positively correlated with tariff changes adjusted by import penetration.[16]

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

[16] 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.

Dependent Variable: Prices Changes				
	(1)	(2)	(3)	(4)
Tariff Changes	0.457	0.125	0.478	0.459
	(0.237)	(0.775)	(0.233)	(0.900)
Tariff Changes * Import Penetration	-		-	
US Price Changes	0.105	1.446	-	-
	(0.182)	0.915		
Constant	2.882	16.68	2.315	16.93
	(0.018)	(0.215)	(0.023)	(0.233)
N	350		420	
Weighted Regression	yes		yes	

Notes: Robust standard errors are in parentheses.
Weights are the sector employment shares. Time dummies are included.

Table 5: Price Changes and Tariff Changes, 1988-95

	(5)	(6)	(7)	(8)	(9)	(10)
Tariff Changes	-		0.426	-1.343	0.297	-0.765
			(0.233)	(1.343)	(0.217)	(1.072)
Tariff Changes * Import Penetration	3.733	4.184	2.889	4.447	3.867	3.205
	(1.699)	(2.656)	(1.667)	(2.710)	(1.347)	(1.640)
US Price Changes	-	-	-		-	
Constant	2.302	16.89	2.315	16.91	0.646	16.96
	(0.022)	(0.086)	(0.024)	(0.087)	(0.015)	(0.064)
N	420	60	420	60	420	60
Weighted Regression	yes		yes		no	

5.3 Mandated Wage Equations

While the pattern of price changes is consistent with the pattern of relative earnings evolution and seems to be determined by 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 (see Baldwin and Cain, 1997, Haskel and Slaughter, 2002, and Robertson, 2003) and estimate mandated wage equations. 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:

$$\Delta \log p_j = \frac{\theta_j^S}{\theta_j}\left(\Delta \log w^S - \Delta \log w^U\right) + \Delta \log w^U, \tag{11}$$

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

Our estimation is based on the following regression:

$$\Delta \log p_{j\tau} = \phi_{0\tau} + \phi_1 \left(\frac{w^S L^S}{w^U L^U + w^S L^S}\right)_{j\tau} + \eta_{j\tau}, \tag{12}$$

where the estimated coefficient ϕ_1 is interpreted as the changes in skill earnings differentials associated with price changes.[17]

Since we are interested in the effect of prices that resulted from trade liberalization, we follow Haskel and Slaughter (2002) and estimate equation (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: those that result from the estimation of equation (10) with and without adjusting tariffs changes for differentiated pass-through across sectors, presented, respectively, in columns (2) and (3) of Table 5. In the second step, we estimate equation (12)

[17] The general form for equation (11) when there are l factors of production is:

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

In this case, one could still use equation (12), but the coefficient ϕ_1 should equal $\frac{\theta_j^S+\theta_j^U}{\theta_j}\left(\Delta \log w^S - \Delta \log w^U\right)$, 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 equation (12).

using the predicted prices, instead of actual prices, as the dependent variable. In this case, the estimated coefficient ϕ_1 is interpreted as the changes in returns to skill that are mandated by price changes induced by trade liberalization.

Dependent Variable: Change in Prices				
	Predicted by tariff changes		Predicted by tariff changes, adjusted by import penetration	
	(2)	(3)	(4)	(5)
Education Cost Share	-0.007	-0.048	-0.030	-0.224
	(0.006)	(0.039)	(0.007)	(0.082)
Constant	2.300	16.88	2.309	16.91
	(0.003)	(0.021)	(0.003)	(0.087)
Auxiliary Regression	Table , col. (2)		Table , col. (3)	
Actual Change in Wage Diffs	-0.024	-0.168	-0.024	-0.168
N	420	60	420	60

Notes: Weighted regressions, using the sector employment shares as weights.
Robust standard errors are in parentheses. Time dummies are included.

Table 6: Mandated Wages

The results are presented in Table 6. The actual annualized fall in skill earnings differentials observed in Brazil from 1988 to 1995 was 2.4% on average. 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 0.7%, but was not significantly different from zero.

When we use the price changes predicted by tariffs, allowing for differentiated pass-through coefficients across sectors (column 2), we find a mandated annualized skill earnings differential decline of 3.0%, which is very close to the observed one.[18] This result provides compelling evidence that trade liberalization played a major role in explaining the decrease in skilled labor relative earnings in Brazil.

[18] The use of non-weighted regressions, not reported here, results in a coefficient of -5.9%, with a standard error of 0.007.

6 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.

According to traditional trade theory, the mechanism through which trade liberalization could have caused the observed reduction in relative earnings of skilled workers in Brazil is the following. First, the relative prices of skill-intensive sectors should have decreased, in order to be consistent with the decrease in earnings inequality. These changes in relative prices could have been induced by trade liberalization depending not only on the change in relative tariffs but also on their pass-through to prices. Even an homogeneous tariff reduction would impact relative prices when pass-through from tariffs to prices differs across sectors.

Second, the new relative prices 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 price incentives, in turn, would have induced firms in all sectors to increase the proportion of skilled labor used in production.

We perform several independent empirical exercises that check this trade transmission mechanism, using disaggregated data on tariffs, prices, wages, employment and skill intensity from 1988 to 1995. First, a decomposition analysis of changes in skilled-labor employment share over this period reveals a positive *within industry* effect and a negative *between industry* effect. This means that employment shifted from skilled to unskilled intensive sectors, and that each sector increased its relative share of skilled labor. These results are compatible with relative wage change being caused by either the trade liberalization or a SBTC, but not by labor supply changes alone.

Second, a panel regression of prices on skill intensities delivers a negative coefficient, which implies that relative prices indeed fell in skill-intensive sectors. Tariffs changes are found to be unrelated to skill intensities. However, the pass-through from tariffs to prices may be differentiated across sectors, being directly related to the share of importable goods in each sector. Therefore we adjust tariffs changes by import penetration, a proxy for the share of importable goods. We find that tariffs changes adjusted by import penetration were stronger in skill-intensive sectors. Furthermore, we find not only that prices and tariffs are positively correlated, but also that the impact of tariffs changes on prices is higher in sectors with larger import penetration. This is consistent with trade liberalization being responsible for the relative fall in prices of skill-intensive sectors.

Finally, we apply a mandated wage equation analysis. We show that the decline in skilled earnings differentials mandated by the price variation predicted by trade is very close to the observed one. The predicted price variation was obtained by regressing price changes on tariff changes, allowing for differentiated pass-through coefficients across sectors.

In sum, all steps of the trade transmission mechanism were tested, and the results are compatible with trade liberalization accounting for the observed relative earnings changes in Brazil. Our results also 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.

The results described above were obtained when we use education attainment as a proxy for skill. Most of the literature for developing countries uses the share of nonproduction workers instead. We show that one obtains opposite results when this alternative measure is used for Brazil: nonproduction workers relative earnings *increased* over the period. This should be taken as a warning for studies on countries that do not have an education attainment measure, and are restricted to the use of the nonproduction measure as a proxy for skill.

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