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Trade Liberalization and the Demand for Skilled Labor in Brazil

Over the past three decades, labor markets in developing countries went through important changes in terms of wage differentials and the employment composition of their workforce. One of these changes was the fast rise in the supply of workers with intermediate levels of education, both in absolute terms and relative to the supply of workers with higher and lower education levels. Moreover, the wage differentials between college-educated workers and those with intermediate levels of education rose, while the differentials between the latter and workers with up to elementary education fell. These changes had important implications for poverty and inequality.[1]

Many Latin-American countries also went through trade liberalization processes in the 1980s and 1990s as part of a package of market-orientated reforms. These reforms induced important changes not only in their product markets, by changing relative prices and increasing the productivity of manufacturing firms, but also in the labor markets, by spurring labor reallocation and transition into the informal sector.[2] A significant body of research links the changes in the wage differentials reported above to the trade liberalization process, following a literature that first examined the impact of trade liberalization on inequality in the United States and other developed countries.[3]

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1. See, for example, Schady and Sánchez-Páramo (2003); Gonzaga, Menezes-Filho, and Terra (2006).

2. On the effects of trade liberalization on productivity, see Pavcnik (2002); Muendler (2003); Fernandes (2007). On its effect on labor market transitions, see Menezes-Filho and Muendler (2006).

3. See Acemoglu (2002) for a survey of the impact of trade liberalization in developed countries.

The theoretical framework used by most of these studies is the traditional Heckscher-Ohlin model. According to this model, since skill is a relatively scarce resource in most Latin American countries, opening up trade with more developed countries should raise the prices of low-skill-intensive goods. The production of these goods would therefore increase, intensifying the demand for unskilled workers and generating a decline in the skill premium. Many researchers were thus surprised when the data revealed that the wage differentials between college-educated workers and workers with up to secondary education in developing countries were actually rising.

One explanation for this apparent rejection of the Heckscher-Ohlin model is that countries do not move instantaneously from a closed economy to an open one, but from a pattern of high tariffs to one of low tariffs. Moreover, the changes in tariffs tend to vary substantially across sectors, depending on the structure of protection that prevailed before trade liberalization. In several cases, this structure was unrelated to the pattern of comparative advantages across industries. The changes in relative prices during a trade liberalization process therefore follow the changes in tariffs, and the impact of trade liberalization on inequality depends on the correlation between the changes in tariffs and the skill intensity across manufacturing sectors. Using this framework, Hanson and Harrison, as well as Robertson, find that trade liberalization was associated with a rise in wage inequality in Mexico, whereas Gonzaga, Menezes-Filho, and Terra report that the predictions of the Heckscher-Ohlin model are actually consistent with the decline in the wage differentials between workers with secondary education or more and workers with less than secondary education in Brazil in the early 1990s.[4]

An important limitation of these papers is that the framework they use only allows for two skill groups, while the descriptive evidence summarized above consistently points to different movements in the wage differentials between skilled and semiskilled workers, on the one hand, and between semiskilled and unskilled workers, on the other. How can trade opening explain both the rise in returns to college education and the fall in returns to secondary education that took place in many developing countries in the 1980s and 1990s? Two hypotheses were put forward to explain these trends. First, the movements in wage differentials may reflect the decline in the relative supply of college-educated workers, which did not increase as quickly as the supply of workers with secondary education. Second, the relative demand for college-educated workers may have risen. Schady and Sánchez-Páramo find

4. Hanson and Harrison (1999); Robertson (2004); Gonzaga, Menezes-Filho, and Terra (2006).

that the relative demand for college-educated workers has indeed risen in Argentina, Chile, Colombia, and Mexico, with mixed results for Brazil.[5] Fernandes and Menezes-Filho allow for a more general pattern of substitutability between the three skill groups; they find that the demand for college-educated workers relative to semiskilled workers has risen in Brazil in the last two decades, as has the demand for the semiskilled workers relative to unskilled workers.[6]

One reason for this process of skill upgrading in developing countries, especially in the case of college-educated workers, may be that trade creates a tendency for the price of skill-intensive goods to increase in developed countries, which increases the profitability of innovations in these goods and may raise the demand for skilled workers in both developed and developing countries, depending on how skill abundant the latter are.[7] Moreover, trade liberalization could bias innovations toward skill-intensive goods in developed countries because of the threat of technological imitation, which would increase wage inequality in both developed and developing countries.[8] Finally, the outsourcing of input production by firms in developed countries could raise the demand for skilled labor in both developed and developing countries, since the outsourced activities are not skill intensive from the developed countries' point of view, but they are skill intensive from the developing countries' perspective.[9]

Empirically, Feenstra and Hanson find that foreign direct investment increased the relative demand for skilled labor in Mexico and can account for a substantial fraction of the rise in the skilled-labor wage share.[10] Pavcnik argues that capital-skill complementarities can partly explain the process of skill upgrading in Chile, while the share of imported materials, foreign technical assistance, and patented technology are not statistically significant once she controls for plant fixed effects.[11] Schady and Sánchez-Páramo indicate that changes in the volume of imports and the intensity of research and development at the sectoral level tend to increase the demand for skilled labor in Chile, Colombia, and Mexico.[12]

In this paper, we put forward a different hypothesis. The reduction in tariffs that accompanies trade liberalization causes a decline in the price of

5. Schady and Sánchez-Páramo (2003).
6. Fernandes and Menezes-Filho (2003).
7. Acemoglu (2003).
8. Thoenig and Verdier (2003).
9. Feenstra and Hanson (2003).
10. Feenstra and Hanson (1997).
11. Pavcnik (2003).
12. Schady and Sánchez-Páramo (2003).

domestically produced skill-intensive traded goods, as well as in the price of foreign inputs used by domestic firms. If the foreign inputs embody advanced technology, a process of technological diffusion will take place and the production function of domestic firms will shift outward.[13] Our hypothesis is that this process of diffusion of new technologies through capital and intermediate goods increases the relative productivity of skilled workers. If skilled workers are gross substitutes with respect to semiskilled workers, this will also increase the relative demand for skilled workers.

The paper is organized as follows. The next section presents background information on wage differentials and skill composition in Brazil, outlines the process of trade liberalization, and describes the data used in this paper. The subsequent section presents evidence that the relative demand for college-educated workers has shifted to the right in the period analyzed. We then test the skill-biased technological diffusion hypotheses, and a final section concludes.

Background Information and Data Description

As background for the empirical exercises carried out below, we present some stylized facts on the Brazilian labor market. We start by defining our education groups. Workers with between zero and four years of schooling are classified as unskilled; those with between five and eleven years as semiskilled; and those with over eleven years as skilled. This criterion is commonly used in Brazil for dividing workers into three skill groups when the proxy for qualification is years of schooling.

Figure 1 presents the evolution of the relative supply of skilled workers with respect to semiskilled workers and of the latter with respect to unskilled workers, for the period 1980 to 1998. The figure shows that the relative supply of semiskilled workers increased substantially over the period, while that of skilled workers remained stable or even declined slightly. Figure 2 shows that wage differentials between skilled and semiskilled workers increased after 1992, while the opposite occurred with wage differentials between semiskilled and unskilled workers after 1990. The fact that the wage differentials behave consistently with supply raises the question of whether demand shocks

13. Evidence supporting this view is presented by Schor (2004); Lisboa, Menezes-Filho, and Schor (2003); and Fernandes (2007).

FIGURE 1. Relative Supply of Skilled Labor

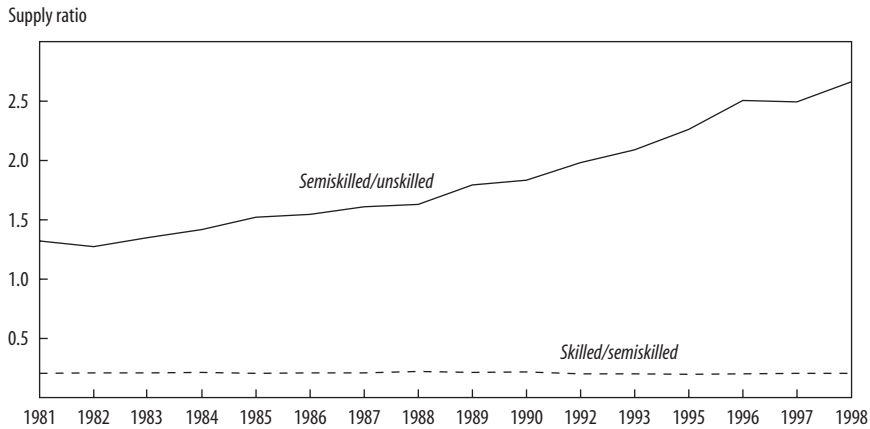
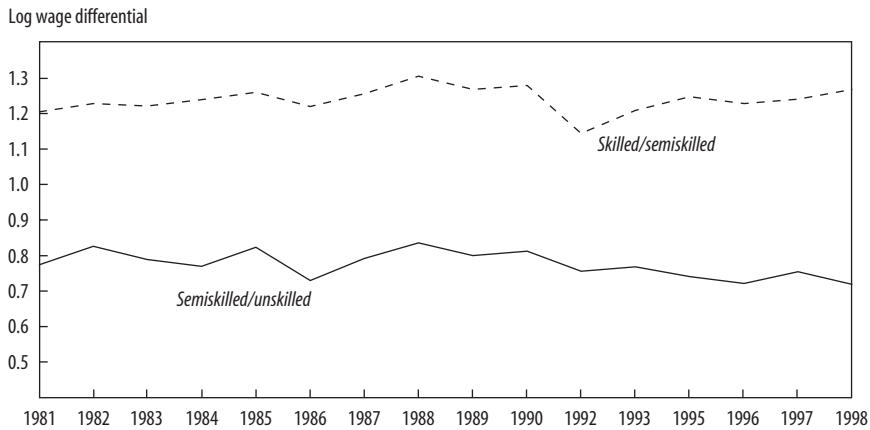


FIGURE 2. Wage Differentials over Time



can still play a role. Fernandes and Menezes-Filho show that for any plausible values of the elasticities of substitution between skilled and semiskilled workers and between semiskilled and unskilled workers (which are allowed to be different in their model), relative demand has, in fact, risen in Brazil for both the skilled and the semiskilled.[14]

14. Fernandes and Menezes-Filho (2003).

FIGURE 3. Unemployment Rate by Skill Level

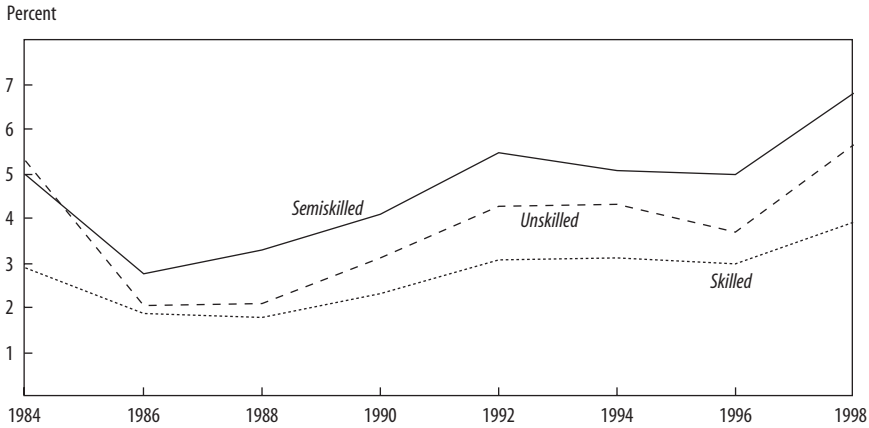


Figure 3 compares the evolution of the relative unemployment rates of workers with different skill levels. Unemployment increased for all types of workers, with a somewhat higher rise for semiskilled workers than for the other two categories. Traditional trade models do not include a role for unemployment, but if there are any rigidities or frictions in the labor market, such as the difficulty of adjusting workers' aspirations to the new availability of jobs, then wages for semiskilled labor would not adjust instantaneously to the rise in supply, leading to unemployment.

In terms of the sectoral composition of the workforce, manufacturing employment declined steadily over the period, even before trade liberalization, while the employment share of the service sector expanded significantly (see figure 4). This trend occurred in several countries and may be related to a secular rise of income or to the rapid increase in labor productivity that took place first in manufacturing. Since this paper uses only data from formal sector firms, we need to understand the trends in the labor market as a whole. Figure 5 shows that the share of workers in the formal sector also shrank steadily after 1990, with a corresponding rise in all other labor market categories. Menezes-Filho and Muendler show that this can partly be explained by the trade liberalization process.[15]

15. Menezes-Filho and Muendler (2006).

FIGURE 4. Sectoral Composition of the Workforce

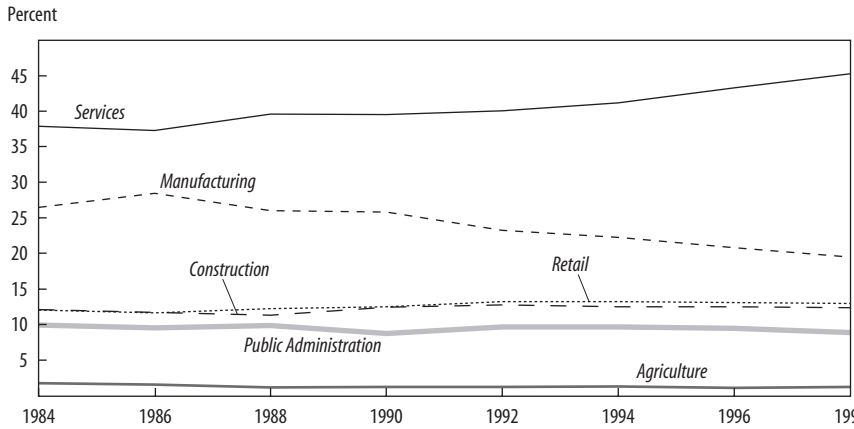
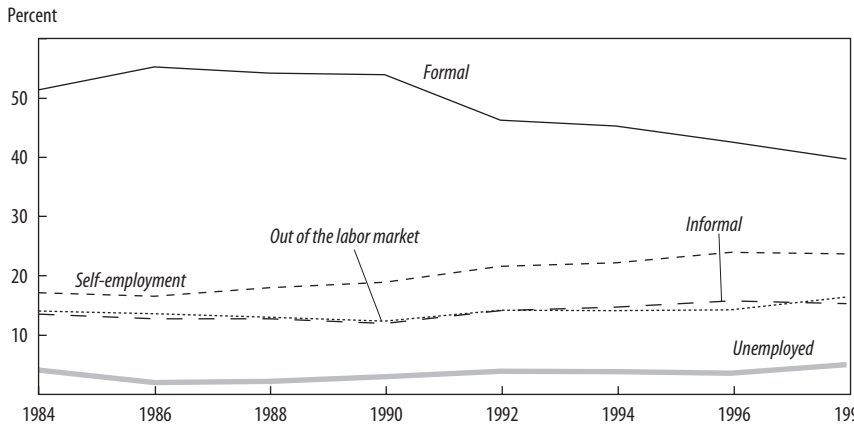


FIGURE 5. Occupation Composition of the Workforce



Trade Liberalization

Until the end of the 1980s, Brazilian trade policy included very high nominal tariffs and significant nontariff barriers. Nominal tariffs were generally redundant, as the price wedge between domestic and international prices tended to be lower than that suggested by tariffs. Imports were restricted mainly by nontariff barriers, such as lists of prohibited goods, difficult access to government import authorization, and limits on imports for each firm. At the same

time, several exceptions softened both tariff and nontariff barriers on some specific goods.

The first attempt to rationalize trade policy so that tariffs would express the actual degree of trade protection occurred in 1988. Most of the nontariff barriers were abolished, and nominal tariffs were reduced slightly. In 1990 the newly elected government announced a move toward a more open trade regime. First, all but a few nontariff barriers were to be eliminated. Trade policy thereafter would rely mostly on tariffs and on exchange rate management (although the exchange rate regime was much more flexible than before). Second, the government announced a four-year schedule of tariff reductions. At the end of this period, tariffs would range between 0 and 40 percent. The government largely followed through on its announced promises: the average tariff declined from over 50 percent in 1989 to 14 percent in 1994.

Our information on tariffs is from Muendler.[16] Data on tariffs are available at the product level, so we matched each product to the equivalent two-digit sector definition to construct the output tariffs. To construct the input tariff series for each industry, we used data from the input-output tables (that is, each industrial sector's purchases of intermediate and capital goods from other sectors, per unit of output) for various years to construct weights and compute a weighted average of the tariffs prevailing in each of these sectors over time.

Figures 6 and 7 describe the distribution of input and output tariffs across sectors for 1988, 1990, and 1994. The dispersion of input tariffs was quite high in 1988; the industries with highest input tariffs were automobiles, rubber, pharmaceuticals, other foods, and especially apparel, which had a tariff rate of 90 percent. Between 1988 and 1990, there was a small across-the-board tariff reduction, on the order of 10 percent. Tariff reductions were massive between 1990 and 1994, so that by 1994 most sectors had tariff rates fluctuating between 10 and 20 percent. Tariffs in the apparel sector, for example, were reduced from 70 percent to about 20 percent in this period.

Descriptive Statistics

The database constitutes one of the innovations of this study, as it allows us to work with disaggregated data, which is crucial for the quality of the results. We used administrative data from the Labor Ministry's Annual Social Information Report (*Relação Anual de Informações Sociais,* or RAIS) and the

16. Muendler (2003).

FIGURE 6. Input Tariffs across Sectors and Time

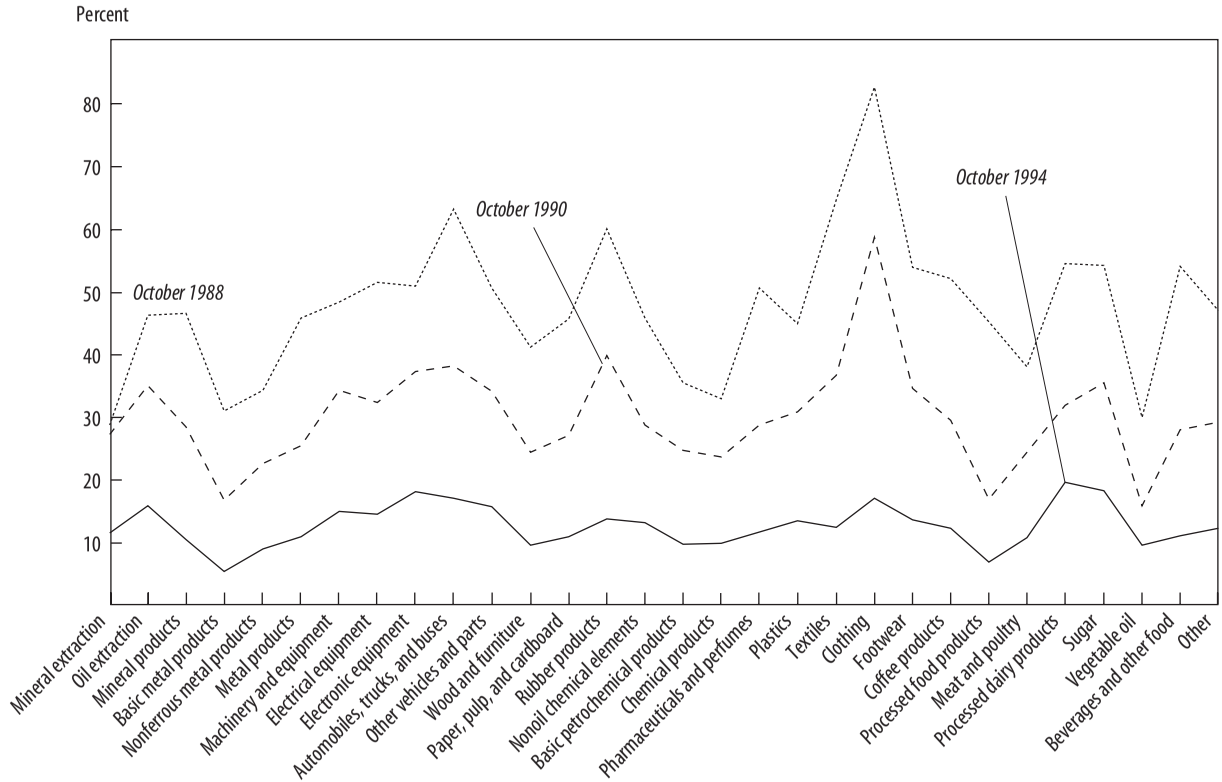
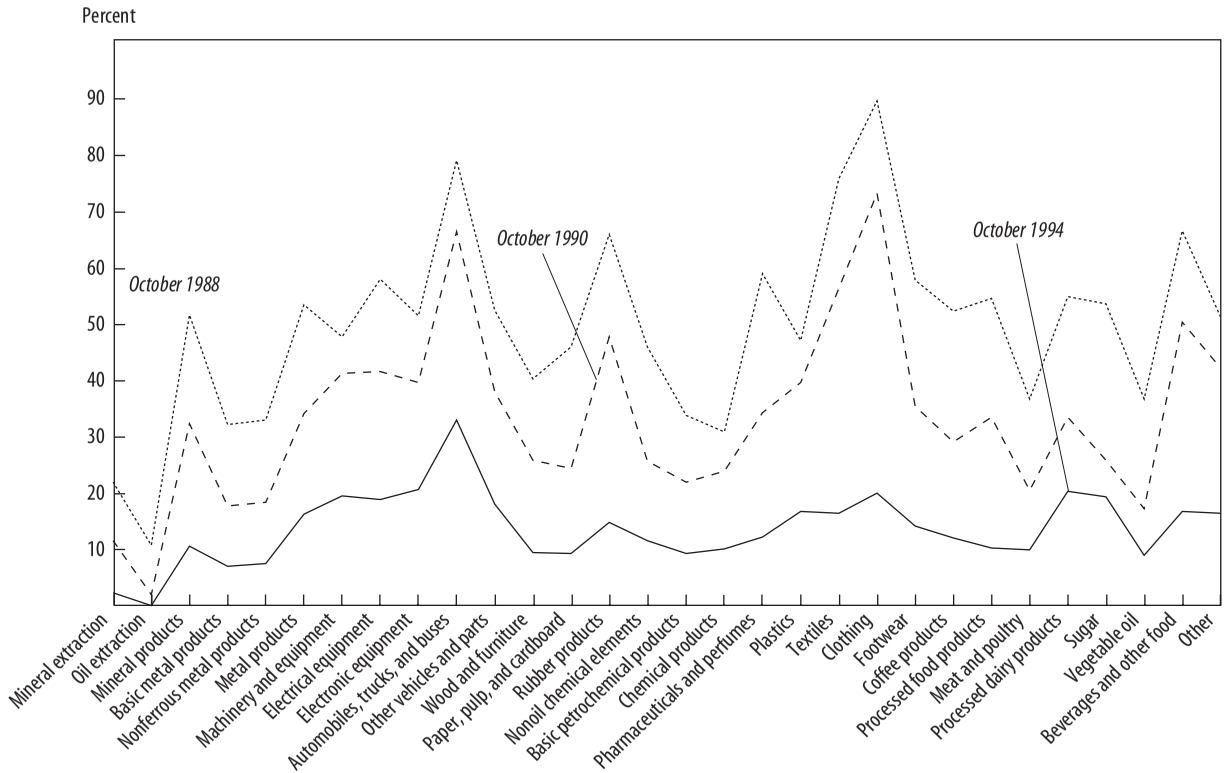


FIGURE 7. Output Tariffs across Sectors and Time



Annual Industrial Survey (*Pesquisa Industrial Anual,* or PIA) from the Brazilian Institute of Geography and Statistics (IBGE). Both data sets cover the manufacturing sector in the state of São Paulo for the period 1990–98.[17]

To examine our hypothesis of skill-biased technological transfer, we intersect the RAIS and PIA databases to obtain information on both workers and establishments. The PIA data were assembled by Menezes-Filho, Muendler, and Ramey to meet the IBGE's requirement of confidentiality.[18] The PIA data are collected at the firm level, but this information is confidential. We therefore put together cells of three to five firms, identifying which firms belong to each cell. Initially, the firms were separated into groups with some characteristics in common, namely, the years the firm appears in the PIA; the industrial sector (two-digit classification) to which the firm belongs; and the state in which the firm is located. The cells were then generated randomly within each group. The cells are invariant over time, that is, they have data on the same firms in all years, which makes it possible to identify a fixed effect per cell. Finally, we matched each RAIS firm to the cells of PIA firms. The cells that have variations in their composition owing to information gaps in the RAIS were excluded from the sample.

Preliminary Evidence

Wages and employment per education group were obtained from the RAIS, while data on output and capital stock are from the PIA. Data on tariffs are from Muendler.[19] Table 1 presents descriptive statistics at the cell level for the main variables used in the analysis. Figures 8 and 9 describe the evolution of relative employment share by skill level. The figures clearly show that both skill-based employment ratios increased in the period, from 0.26 in 1990 to 0.32 in 1998 in the skilled/semiskilled case and from 1.39 to 3.73 in the semiskilled/unskilled case. These trends closely mimic the behavior of the labor supply in the economy as a whole, especially in the semiskilled case. Figures 10 and 11 show the evolution of relative wages by skill groups in the period. The wage ratio between skilled and semiskilled workers generally grew in the period (from 2.66 in 1990 to 3.04 in 1998), while the ratio between semiskilled and unskilled workers was practically stable (at 1.19 in

17. The PIA was not conducted in 1991, producing a gap in that data set.
18. Menezes-Filho, Muendler, and Ramey (2004).
19. Muendler (2003).

TABLE 1. Descriptive Statistics of the Cell-Level Data

Variable	*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Number of skilled workers	0	802	33.75	71.00
Number of semiskilled workers	0	3152	146.48	287.63
Number of unskilled workers	0	2311	79.42	179.85
Proportion of skilled workers	0	1	0.2051	0.2477
Proportion of semiskilled workers	0	1	0.5511	0.2382
Proportion of unskilled workers	0	1	0.2437	0.2303
Number of workers	1	4335	259.65	489.09
Ln(value added)	5.21	86.01	44.75	9.68
Ln(capital)	0	78.30	37.98	15.03
Number of cells	654			

FIGURE 8. Temporal Evolution of Relative Employment between Skilled and Semiskilled Workers

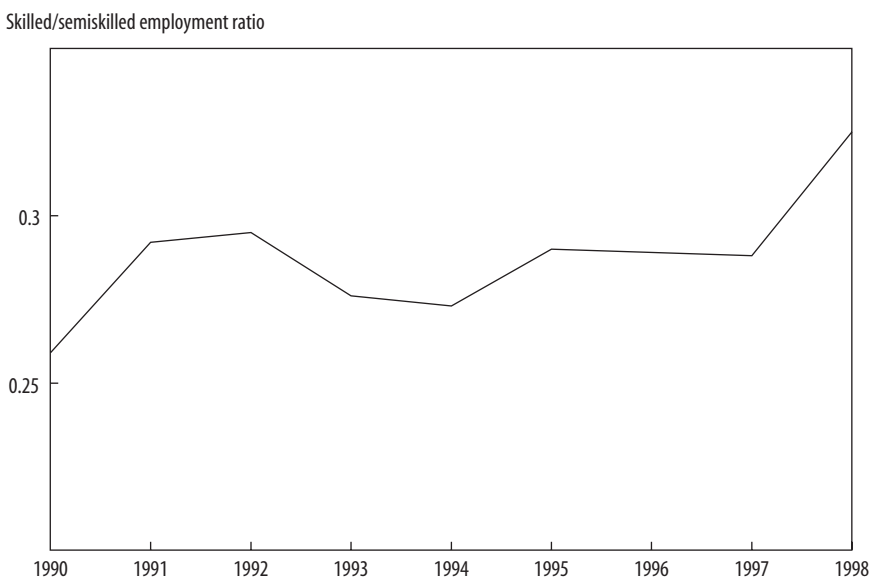


FIGURE 9. Temporal Evolution of Relative Employment between Semiskilled and Unskilled Workers

FIGURE 10. Temporal Evolution of the Relative Wage between Skilled and Semiskilled Workers

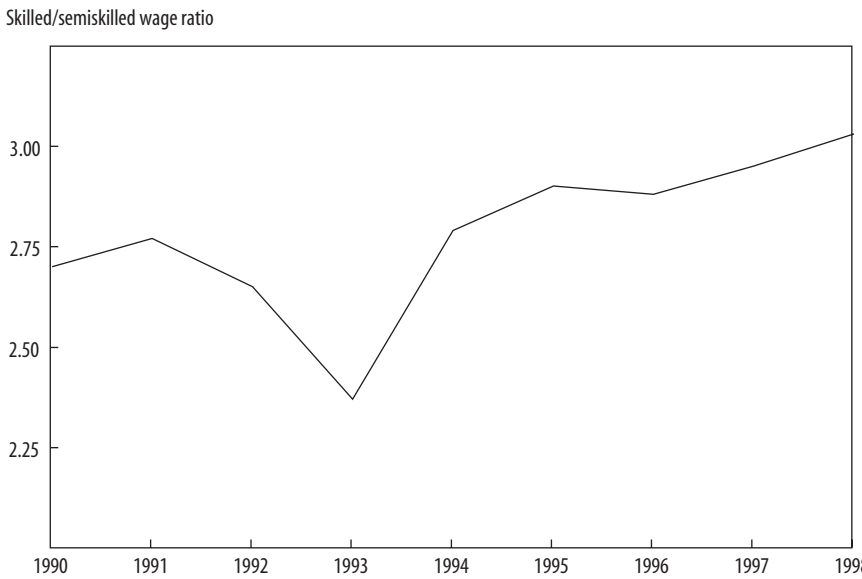
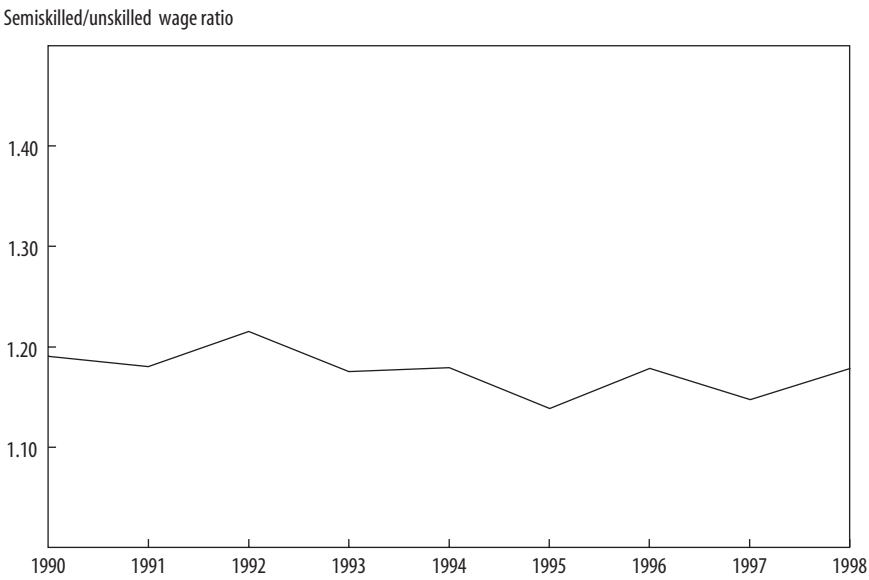


FIGURE 11. Temporal Evolution of the Relative Wage between Semiskilled and Unskilled Workers



1990 and 1.18 in 1998). The labor market trends in the formal sector were thus very similar to the stylized facts for the economy as a whole.

To explore the evolution of skilled employment, we decompose the trends as proposed by Berman, Bound, and Griliches:[20]

$$\Delta s \equiv \underbrace{\sum_i \overline{e}_i \Delta s_i}_{\text{within}} + \underbrace{\sum_i \overline{s}_i \Delta e_i}_{\text{between}},$$

where s is the share of skilled workers in the economy; e_i is the participation of firm i in total industrial employment; s_i is the share of skilled workers in the total employment of firm i; Δ is the difference operator between two points in time; and a bar above the variable denotes its temporal mean in the period in question.

This expression decomposes the variation in the share of a determined skill group between two moments in time into two components: the variation

20. Berman, Bound, and Griliches (1994).

TABLE 2. Decomposition within and between Groups, 1990–98
(in percent)

Segment of decomposition	*Skilled labor*	*Semiskilled labor*
Total variation		
Total	8.19	13.13
Annual	0.68	1.09
Within-group variation		
Total	11.07	9.80
Annual	0.92	0.82
Between-group variation		
Total	–2.88	3.33
Annual	–0.24	0.28
Between/total	–0.3516	0.2536

within firms and the variation between firms. If the predictions of the traditional Heckscher-Ohlin model were valid for explaining at least part of the alterations in employment composition described here, the between component would have a significant negative sign, since economic opening would have caused establishments producing low-skill-intensive goods to increase their production and their share in total employment.

Table 2 presents the results of this decomposition for the variation in the relative employment of skilled and semiskilled workers between 1990 and 1998. The results show that the participation of skilled workers grew 8.19 percent in the period. However, firms that use skilled labor intensively decreased their relative participation in total employment, since the between term was negative (–2.88 percent). The increased participation of skilled workers in manufacturing was thus driven by the variation within firms (11.07 percent), which was partly offset by traditional Heckscher-Ohlin-type considerations.

The change in the between component for semiskilled workers, on the other hand, is positive and accounts for 25.36 percent of the total change. Here, the between component acted in opposition to the Heckscher-Ohlin prediction, although it is consistent with the fact that Brazil is abundant in semiskilled labor relative to its trade partners.[21] The finding that most of the rise in skilled employment occurred within firms is remarkable in that it is in line with the evidence from developed countries, and it heightens the need to explain the process of skill upgrading that took place in Brazil.[22]

21. See Gonzaga, Menezes-Filho, and Terra (2006).

22. The results of this decomposition are, in principle, consistent with Feenstra and Hanson (2003), who would argue that this process of skill upgrading is the result of outsourcing of input production among Brazilian firms.

Results

The approach used here closely follows that proposed by Machin and van Reenen, which minimizes a cost function that has wages (W), capital (K), and technology (TEC) as arguments.[23] We include a noncorrelated random error (μ_{it}), time dummies (D), and a firm-specific effect (a_i), thereby obtaining the following equation:

$$(1) \qquad W_{it}^{q/(q+s+n)} = \alpha + \beta_0 1nY_{it} + \beta_1 1nK_{it} + \beta_2 \mathrm{TEC}_{it} + \beta_3 D_t + \alpha_i + \mu_{it},$$

where q stands for skilled workers, s for semiskilled workers, and n for unskilled workers. Although it does not result directly from microeconomic theory, we also estimate the model with wages excluded from the explained variable, that is, transforming it into the proportion of skilled workers in the total labor force:

$$(2) \qquad L_{it}^{q/(q+s+n)} = \alpha_1 + \beta_0 1nY_{it} + \beta_1 1nK_{it} + \beta_2 \mathrm{TEC}_{it} + \beta_3 D_t + \alpha_i + \mu_{it}.$$

When we expand equations 1 and 2 to include the technology proxy—namely, tariffs on imported intermediate goods (T_{it}^{in})—we obtain the equations to be estimated:

$$(3) \qquad W_{it}^{q/(q+s+n)} = \alpha + \beta_0 1nY_{it} + \beta_1 1nK_{it} + \beta_2 T_{it}^{in} + \beta_3 D_t + \alpha_i + \mu_{it};$$

$$(4) \qquad L_{it}^{q/(q+s+n)} = \alpha_1 + \beta_0 1nY_{it} + \beta_1 1nK_{it} + \beta_2 T_{it}^{in} + \beta_3 D_t + \alpha_i + \mu_{it}.$$

We also estimate similar equations for semiskilled workers.

Because tariffs are the main variables in this analysis, the political economy of tariff reduction is pertinent. From the policy perspective, the choice of which industries are more protected and which ones face more competition could be nonrandom. Tariffs might then be correlated with productivity performance before (and perhaps during) the trade liberalization period, so that $E[\mu_{it}/T_{it}^{in}] \neq 0$ in equation 4. However, since the government policy was to reduce all tariffs to a common low level, the differences in the changes in tariffs across sectors were mostly driven by the initial distribution of tariffs across sectors. At any rate, we control for the history of the political economy of trade protection up to 1990 by including firm-specific fixed effects in the equation to be estimated.

Table 3 presents the results at the cell level for the full period (1990–98). Columns 1 and 3 were estimated by weighted least squares (weighting the observations by the share of each firm in total industrial employment), and

23. Machin and van Reenen (1998).

TABLE 3. Demand for Skilled Labor: Share of Skilled and Semiskilled Workers in Total Employment[a]

	Skilled workers			*Semiskilled workers*		
		Fixed effects			*Fixed effects*	
Explanatory variable	*WLS* (1)	(2)	(3)	*WLS* (4)	(5)	(6)
ln(*Y*)	0.000	−0.001**	−0.001**	0.001***	0.000	0.000
	(0.0004)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
ln(*K*)	0.001***	0.001***	0.001***	−0.001***	−0.002***	−0.002***
	(0.0002)	(0.0004)	(0.0004)	(0.0002)	(0.0004)	(0.0004)
ln(tariff on intermediate goods)	−0.131***	−0.036**	−0.105***	−0.140***	0.031*	0.020
	(0.1230)	(0.0180)	(0.0270)	(0.0120)	(0.0180)	(0.0270)
ln(tariff on final goods)			0.056***			0.009
			(0.0160)			(0.0150)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. The dependent variable in columns 1, 2, and 3 is the share of skilled workers in total employment; in columns 4, 5, and 6, it is the share of semiskilled workers in total employment. Columns 1 and 4 were estimated by weighted least squares (weighting the observations by the share of each firm in total industrial employment); columns 2, 3, 5, and 6 include firms' fixed effects. Standard errors are in parentheses.

columns 2, 3, 5, and 6 include firms' fixed effects. We focus first on the share of skilled workers in total employment (columns 1, 2, and 3). The WLS regressions provide evidence of capital-skill complementarity and, more important, of a negative correlation between input tariffs and the share of skilled workers. The fixed effects regressions confirm the above results: tariffs affect the evolution of the share of skilled workers even after we control for firm-specific heterogeneity. The estimated coefficient is statistically significant at conventional levels. The third column includes tariffs on final goods as a control in the regressions, since this variable is likely to be correlated with tariffs on intermediate goods, which would bias the coefficient of the latter. This increases the coefficient of input tariffs, while output tariffs present a positive coefficient.[24] The results of column 4 indicate that a reduction in input tariffs also increases the demand for semiskilled workers. The fixed effects regressions, however, show that this effect is not robust to the inclusion of firm-level heterogeneity, since the effect of input tariffs is now insignificant. The coefficient on capital is negative and significant across all specifications, suggesting that capital and semiskilled labor are substitutes.

24. Output tariffs are introduced in the model only as a control. We do not intend to test any trade theory, since this would have to take general equilibrium effects into consideration (see Gonzaga, Menezes-Filho, and Terra, 2006).

Table 4 presents the results of the regressions using the wage bill share as the dependent variable. The results do not change qualitatively with respect to the employment share regressions. Reductions in input tariffs raise the demand for skilled workers, but they do not have a significant impact on the demand for semiskilled workers.

Table 5 implements a robustness test to verify that the effects of input tariffs on the demand for skilled labor are indeed capturing the impact of technological diffusion. If this is the case, we would expect the effect to be strongest in industries that use inputs that are likely to be affected by technological innovation, such as computers, machines, and so forth. We therefore use the input-output tables to construct input weights for each sector, computing a weighted average of years of education by industry on the input side and interacting this variable with the input tariffs. The impact of input tariffs on the demand for skilled labor should be highest in firms that use inputs that are themselves produced in skill-intensive sectors. The results indicate that this is indeed the case, since the interaction term is negative and statistically significant, meaning that a decline in tariffs increases the demand for skilled labor most in sectors that use inputs that are skill intensive.

We also test the robustness of the results using a different proxy for skill level (see table 6). The PIA has information on workers' occupation, defined as blue-collar and white-collar employment. Blue-collar workers, who work

TABLE 4. Demand for Skilled Labor: Share of Skilled and Semiskilled Workers in Total Wages[a]

	Skilled workers			*Semiskilled workers*		
		Fixed effects			*Fixed effects*	
Explanatory variable	*WLS* (1)	(2)	(3)	*WLS* (4)	(5)	(6)
ln(*Y*)	0.001***	−0.001**	−0.001**	0.001***	0.001	0.001
	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0004)
ln(*K*)	0.002***	0.000	0.000	−0.002***	−0.001**	−0.001**
	(0.0003)	(0.0004)	(0.0004)	(0.0002)	(0.0004)	(0.0004)
ln(tariff on intermediate goods)	−0.142***	−0.041*	−0.124***	0.133***	0.022	0.022
	(0.0150)	(0.0220)	(0.0330)	(0.0120)	(0.0180)	(0.0270)
ln(tariff on final goods)			0.066***			0.000
			(0.0190)			(0.0160)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. The dependent variable in columns 1, 2, and 3 is the wage bill share of skilled workers; in columns 4, 5, and 6, it is the wage bill share of semiskilled workers. Columns 1 and 4 were estimated by weighted least squares (weighting the observations by the share of each firm in total industrial employment); columns 2, 3, 5, and 6 include firms' fixed effects. Standard errors are in parentheses.

TABLE 5. Input Tariffs and Human Capital Inputs[a]

	Share of total employment		*Share of total wage bill*	
Explanatory variable	*Skilled workers (1)*	*Semiskilled workers (2)*	*Skilled workers (3)*	*Semiskilled workers (4)*
ln(*Y*)	−0.001*	0.0003	−0.001***	0.0004
	(0.0003)	(0.0003)	(0.0004)	(0.0003)
ln(*K*)	0.001***	−0.002***	−0.0002	−0.0006
	(0.0004)	(0.0004)	(0.0005)	(0.0004)
ln(input tariffs)	−0.027	0.028	−0.025	0.012
	(0.0180)	(0.0180)	(0.0350)	(0.0199)
ln(input tariffs)*	−0.1965***	0.063**	−0.254***	0.139***
Human capital inputs	(0.0260)	(0.0260)	(0.0354)	(0.0299)
Year dummies	yes	yes	yes	yes

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. The dependent variable in column 1 is the share of skilled workers in total employment; in column 2, the share of semiskilled workers in total employment; in column 3, the wage bill share of skilled workers; in column 4, the wage bill share of semiskilled workers. All regressions include firms' fixed effects. Standard errors are in parentheses.

directly in the production process, can be used as a proxy for unskilled workers, while white-collar workers, who are not directly involved in the production process, provide a proxy for skilled labor. The regression results are very similar to our results using education as a measure of skill: input tariffs are negatively correlated with skill level, even after controlling for firm-specific

TABLE 6. Occupation as the Qualification Proxy[a]

	Skilled workers			*Semiskilled workers*		
	WLS	*Fixed effects*		*WLS*	*Fixed effects*	
Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
ln(*Y*)	0.003***	0.004***	0.004***	0.003***	−0.002***	−0.002***
	(0.0004)	(0.0007)	(0.0007)	(0.0001)	(0.0007)	(0.0007)
ln(*K*)	0.000	0.001***	0.001***	−0.001***	−0.0004*	0.000
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0002)
ln(tariff on intermediate goods)	−0.013**	−0.296***	−0.318***	−0.013**	−0.038***	−0.011
	(0.0055)	0.0094	(0.0122)	(0.0055)	(0.0095)	(0.0110)
ln(tariff on final goods)			0.022***			−0.027***
			(0.0077)			(0.0070)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.
a. The dependent variable in columns 1, 2, and 3 is the share of skilled workers in total employment; in columns 4, 5, and 6, it is the share of semiskilled workers in total employment. Columns 1 and 4 were estimated by weighted least squares (weighting the observations by the share of each firm in total industrial employment); columns 2, 3, 5, and 6 include firms' fixed effects. Standard errors are in parentheses.

fixed effects. We can thus credibly affirm that technological shocks, caused by the fall in tariff levels, are skill biased.

Conclusions

This paper has examined the impact of trade liberalization on demand for skilled labor in Brazil by examining the impact of input tariffs on the employment share of college-educated workers, using matched employee-employer data. We find that the decline in input tariffs has an important impact on skill upgrading in Brazil, even after we control for capital deepening, output tariffs, and fixed effects. This effect is stronger among firms that use inputs that are themselves skill intensive and thus likely to be affected by technological diffusion. Trade liberalization thus appears to have perverse impacts on inequality, counter-acting Heckscher-Ohlin type considerations. This problem can only be solved with increased investments in human capital.