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TRADE LIBERALIZATION AND THE RETURNS TO EDUCATION: A PSEUDO-PANEL APPROACH

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Abstract

We investigate the impact of trade liberalization on wages and the returns to education in Brazil. Our pseudo-panel estimates of the returns are significantly lower than OLS estimates, signifying omitted ability bias in traditional cross-section estimated returns in developing countries. Trade liberalization impacted on wages and the returns to education in both traded and non-traded sectors, suggesting important spill-over effects. Wages in both sectors fell in the period immediately after trade reform, with some compression of the skilled wage premium especially at the top of the distribution. Subsequently, there has been some recovery in wages, especially in the non-traded sector.

JEL Classification: J31, C23

Keywords: Trade Liberalization; Returns to Education; Pseudo-Panel

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1. Introduction

The use of standard Mincerian earnings functions to estimate the rate of returns to education has given rise to a plethora of studies for both developing and developed countries (see Psacharopoulos, 1994, and Ashenfelter *et al*, 1999, for a survey). Data limitations, especially for developing countries, has led to the widespread utilization of least squares regression on cross-section datasets in order to estimate these rates of return. One consequence is that the estimated returns are likely to be contaminated by so-called 'ability bias': if ability is only imperfectly observed, then OLS estimated returns to education will be biased upwards by the positive correlation between schooling and unobserved ability (Ashenfelter *et al*, 1999; Card, 1999). Various techniques have been employed in an attempt to mitigate these biases, including trying to explicitly control for ability, the use of longitudinal (panel) data, the study of identical twins, and instrumental variable estimation exploiting variation caused by exogenous changes in schooling (e.g. changes in the compulsory leaving age as in Harmon and Walker, 1995). Empirical results have confirmed that returns to education are typically over-estimated by OLS because of ability bias (Card, 1999).[1]

Comparative analyses show that wage equations have a greater explanatory power for developing than for developed countries, and that their coefficients reflecting rates of return to education can be as much as three times larger (Lam and Levison, 1992a, 1992b;

[1] However, some more recent estimates for developed countries suggest that measurement error which may bias OLS estimated returns downwards may be at least as important (Ashenfelter *et al*, 1999).

Psacharopoulos, 1994). These differences may reflect omitted variables related to institutional arrangements, high concentration of wealth, poverty, parental education, family background and family connections among other variables that play an especially important role affecting educational participation and attainment, the distribution of schooling and labor market opportunities in developing countries.

In this paper we estimate the returns to education in Brazil during the 1980s and 1990s while attempting to control for unobserved factors which might bias the rate of return.[2] Due to the lack of longitudinal data, we construct a 'pseudo-panel' (Deaton, 1985) from the successive Pesquisa Nacional por Amostras por Domicilio (PNAD) cross-sectional data sets. We are thereby able to compare conventional OLS estimates of the returns to education with those obtained using pseudo-panel methods which can control for certain unobservables. The magnitude of the differences gives an indication of the extent of the bias in cross-section OLS estimates of rates of return for Brazil, and also perhaps for developing countries more generally.

We also investigate the impact on wages and the returns to education of the trade reform that took place in Brazil at the beginning of the 1990s. Two clear predictions emerge from considering the relationship between trade liberalization, wages and the returns to education in developing countries. First, increased international trade may have a significant impact on returns to education in countries which have experienced long periods of trade protection. Previously protected industries will experience falling rents in the face of international

[2] For a discussion on some possible omitted variables that may affect returns to education in Brazil, see Psacharopoulos and Arriagada (1989) and Lam and Schoeni (1993).

competition. Hence trade liberalization may lead to a decline of the relative wages of traded sector industries most affected by international competition. Whether such effects will spill-over into the non-traded sector depends on the fraction of workers affected by trade and their impact on local labor markets. Second, according to the traditional Stolper-Samuelson theorem, trade liberalization should raise the price of developing countries' abundant factor (less educated labor), thus reducing the skilled wage premium and, by extension, wage inequality. Trade liberalization in developing countries may therefore produce gainers and losers across different industrial sectors and educational groups.

Somewhat curiously, and in contradistinction to the standard theory, the extant empirical evidence on the effects of trade liberalization indicates that the skilled wage premium has increased rather than decreased in a number of countries following liberalization, including Mexico (Hanson and Harrison, 1999; Robertson, 2000), Chile (Beyer *et al*, 1999), Morocco (Currie and Harrison, 1997), Costa Rica (Robbins and Grindling, 1999), and Colombia (Robbins, 1996a).[3] There are a number of possible explanations for these findings. First, trade reform in developing countries may generate increased demand for more educated workers through a stimulus to capital inflows which may be directly complementary with skilled labor.[4] Second, technology transfer entails high skills so that even if the transferred technology were skill-neutral, there would be a temporary increased demand for skilled labor

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[3] Robbins (1996b) surveys similar conclusions applying to Argentina, Malaysia, the Philippines, Taiwan and Uruguay.

[4] In-flowing capital embodies in-flowing technology, which is assumed to be skill-biased because the new technology is mainly designed in the industrialised world which is skill intensive and, *a fortiori,* because there is evidence that new technology is skill-biased within the industrialised world (Berman *et al*, 1998). Robbins (1996b) has termed this effect as the 'Skill-Enhancing-Trade Hypothesis'. Where the gap between existing and newly imported technology is large, trade reform could have a relatively greater effect on skill demand in a developing country than it does in an industrialised country (O'Connor and Lunati, 1999).

while the new machinery and technology is being installed post-liberalization (Pissarides, 1997).[5] Third, the increased skill premium may be a consequence of the exposure of unskilled labor-intensive industries in these countries to very low pay competition from countries such as China. This argument may be particularly relevant for Brazil, Mexico and other Latin American countries which occupy not the lowest, but an intermediate position in the global division of labor (Wood, 1999).[6] Finally, there is the effect of outsourcing (to 'Maquiladoras') which are restricted to a few areas and segmented from the rest of the economy (Feenstra and Hanson, 1997).

The impact of trade liberalization on wages and the returns to education is ultimately an empirical issue, and the case of Brazil is particularly well suited to this purpose for a number of reasons. First, one of the main features of the Brazilian labor market is its wide wage and income distribution. Indeed, Brazil is consistently ranked amongst the most iniquitous countries in the world (Psacharopoulos, 1991; Li *et al*, 1998). The main causal factors underpinning this inequality are the unequal distribution of education together with its high rates of return (Ram, 1990; Lam and Levison, 1992a; Barros, 1995). Second, trade liberalization took place over a relatively short period of time, and the reductions in trade protection were widespread and substantial. They followed a century-long era of import substitution strategies that left Brazil an especially closed economy by the end of the 1980s. Third, Brazil benefits from the availability of a long and reliable series of individual-level data

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[5] An additional argument suggesting that the increase in the skill premium might be temporary is that the elasticity of supply of skilled labour is likely to be much greater in the long than in the short run, whereas the elasticity of supply of unskilled labour is said to be high even in the short-run.

[6] Whether this effect will predominate will depend on whether the country is located in a developing country cone of specialisation or a developed country cone (Davis, 1996).

covering most years from 1981 to the present and thus encompassing the periods before, during and after trade liberalization. The PNADs are nationally representative samples, including both urban and rural populations. In other countries where the issue of trade and inequality has been investigated, the available individual-level data is typically much less comprehensive. A fourth reason why Brazil's case is of particular interest is that, at least from the point of view of the average worker, Brazil remains thoroughly rooted in the developing world. Unlike in Mexico and Chile where increases in wage inequality were accompanied by generally strong labor demand and consequent wage rises, average real wages in Brazil, after a period of growth in the 1970s, have remained largely stable since 1980 (Green *et al*, 2001).

The three principal questions that this paper addresses are therefore as follows:

(a) How do pseudo-panel estimates of the returns to education in Brazil compare with their traditional OLS counterparts? What are the implications, if any, for conventional OLS estimates based on cross-sections?

(b) What is the impact of trade liberalization on wages and the returns to education in both the traded and non-traded sectors?

(c) Can we identify the gainers and losers from increasing international trade?

The remainder of the paper is organized as follows. Section 2 discusses previous estimates of the returns to education in Brazil and charts the progress of trade liberalization over the last two decades. Section 3 discusses the data series and methodology. Section 4 presents our analyses of these data. Finally, section 5 concludes.

2. Returns to Education and Trade Liberalization in Brazil

2.1 Returns to Education

The investigation of Brazilian rates of return to education has received considerable attention due to the widely acknowledged close relationship between education and income inequality. Since Langoni (1973) reported that education differentials contributed around 58 percent of the increase in income inequality between the 1960s and 1970s, many papers have emphasized the role of education in the explanation of the very unequal distribution of income in Brazil. Standard Mincerian wage equations can account for as much as 60 percent of overall wage dispersion, and the returns to education are very high, even when compared to other developing countries (Psacharopoulos, 1994). Barros (1995) reports that education can explain between 35 and 50 percent of the total distribution of income. Thus, the labor market in Brazil appears to value education extremely highly.

The very unequal distribution of education between different groups and regions is another feature of the Brazilian labor market. Lam and Levison (1992a) show that the variance of schooling can be more than six times greater than that of the US. Greater inequality in educational attainment tends to increase income inequality, *ceteris paribus*. For example, having different levels of education by region, say, produces different returns to education among regions. However, more recently, some decline in schooling inequality has been noted, with a resulting positive impact on income inequality (Lam and Levison, 1992b).

In the last two decades, there has been a steady and noticeable increase in average educational attainment of the work-force in Brazil. Using the PNADs, Green *et al* (2001) calculate that average years of education rose from just over 5 years in 1981 to almost 7 years in 1999, an increase of over 30 percent in this comparatively short period. International comparisons show

that the level of education attainment in Brazil, however, is still well below that of developed and many developing countries (Barro and Lee, 1996). As reported by Menezes-Filho *et al* (2000), one expected consequence of this increase in schooling is a fall in the average return to education. However, underlying this fall, the returns to education may vary across different education levels according to changes in the distribution of education and with economic changes that affect the structure of labor demand. Green *et al* (2001) find decreasing returns to education since the 1980s for all educational levels except for the college-educated group which experienced a marked increase, especially after the turn of the decade. Coupled with the increase in the supply of college-educated workers over the period, the interpretation of this increased return is that there has been an increase in the relative demand for more highly educated workers. This coincides with the period of trade reform.

2.2 Trade Liberalization

Prior to 1990, the Brazilian economy was highly protected and regulated, and public sector companies dominated a variety of infrastructure activities and other industries. Successive administrations followed a vigorous import substitution industrialization strategy aimed at protecting the domestic market. Trade barriers were expanded through tariffs, import licenses, different exchange rate regimes for imports and exports, and other measures such as taxes and subsidies. More than half of all industrial products were in the 'Anexo C', a list of items that could not be imported.

Some modest reduction in tariffs and the lifting some redundant barriers commenced in 1988. However, the major break with the import substitution strategy began in 1990, under the incoming President Collor administration, when efforts to contain inflation were combined with drastic trade liberalization. The new government introduced a four-year schedule to

reduce the degree of protection, but, in practice, it was completed in only three years. By the middle of 1993, most of the complex and bureaucratic non-tariff barriers had been removed, and a new tariff structure was imposed which substantially reduced the degree of protectionism.

In 1987, the weighted average nominal tariff was 55 percent; by 1992 it had been reduced to 14 percent. This was accompanied by a sharp reduction in the modal tariff, reducing the standard deviation to about one third of the previous figure. The weighted average effective tariff[7], which remained fairly unchanged in the 1980s, dropped from 68 percent in 1987, to 18 percent in 1992, while the standard deviation declined from 54 percent to 17 percent (Kume *et al*, 2000). As a result of the new economic policy and the overvaluation of exchange rate from 1990 to 1996, imports increased by 257 percent, while exports increased by 151 percent. As a result, by 1995, the trade balance began to display increasing deficits.

While the tariff reduction itself was not severe by international standards, the removal of the non-tariff barriers shifted the pattern of protection. Given that Brazil was largely closed to trade prior to the reforms, the new policy was extremely significant, especially for the manufacturing sector, and signaled that the long period of protectionism was coming to an end. In contrast to many other developing countries in which trade reforms were gradually introduced and had a moderate impact (Adriamananjara and Nash, 1997), the change in trade policy in Brazil seems to have been rather more radical in its impact as can be seen by the very

[7] The computation of effective tariffs includes the tariff of the good itself and the tariffs of all intermediate goods employed in its production (for more details, see Corden, 1974, and Kume *et al*, 2000). Thus, effective tariffs more appropriately measure the degree of protection than nominal tariffs.

rapid rise in the import penetration ratio in the manufacturing sector, and by the index of quantum of aggregate imports. By 1996, the import penetration ratio reached 11.5 – more than twice the figure for 1990 - and the index of quantum of imports increased almost three-fold over this period. These changes suggest significant allocative adjustments in the economy with potentially large effects on the wage structure.

3. Data and Methodology

3.1 Data

Our main data source, the PNADs, is a series of nationally representative cross-section household surveys, which have been carried out every year since 1976, excepting 1980, 1991 and 1994.[8] They are conducted using a consistent methodology by the government's statistical agency, Instituto Brasileiro de Geografia e Estatistica (IBGE). We use data from 1981 to 1999, during which time a consistent education classification is available, thus giving a series of nearly a decade each side of the initiation of trade reform. Each PNAD contains data on roughly 350,000 individuals in about 100,000 randomly selected households, following face-to-face interviews conducted in the third week of September. We restrict our analysis to employed individuals earning a positive wage, aged between 18 and 65 inclusive. This yields an average of almost 125,000 individuals per annum, and a total across the 17 PNADs that we utilize of over 2 million observations.

[8] In 1980 and 1991 there was a national census. In 1994, the survey was cancelled due to a shortage of funds.

We compute the hourly wage as monthly pay at the time of interview in the respondent's main job divided by weekly hours multiplied by 4.33; to obtain real hourly wages we deflate hourly wages by the CPI of September in each year, based in 1998 *reais*. Although the quality of PNAD data is known to be high (Sawyer, 1988), as a further precaution we eliminate outliers that might be due to measurement or misreporting error by trimming the top and bottom of the real wage distribution by 0.1 percent.

We define potential work experience in the conventional way as age minus years of study minus six. The basic education variable gives the number of years of completed education, which is then used to classify education into six levels:[9]

Level 1: Illiterate (less than one year of study)
Level 2: Some elementary education
Level 3: Completed elementary, no or some primary
Level 4: Completed primary, no or some secondary
Level 5: Completed secondary, no or some college
Level 6: Completed college

For the purposes of this paper, we match the PNAD data at the two-digit industry level with data on trade. The trade variable we employ is effective tariffs taken from Kume *et al* (2000). Where trade data are available at a greater degree of industry disaggregation than PNAD, in order to obtain commensurability with the PNAD industry codes we compute average values of the trade data weighted by industry output. In other cases where PNAD has the more disaggregated industry classification, we simply combine the PNAD individuals across industries to match the trade data sources. The result is a two-digit classification of 31 industries, of which 20 are in the traded-goods sector and 11 in the non-traded sector.

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[9] There was a technical change in the recording of this variable between the 1980s and 1990s. An algorithm, available on request from the IBGE, was used to make education levels commensurate across years.

3.2 Methodology

A key methodological issue is that the PNADs are only cross-section, while ideally we would like a panel of individuals or households that we could trace through time in order to investigate the changing wage structure and the returns to education as trade was liberalized. In addition, as noted in the introduction, estimation with cross-section data can be seriously affected by unobserved individual heterogeneity. For example, there is some evidence that much of the degree of the inter-industry dispersion in wages (which is also important for our analysis here) might be attributable to unobserved individual heterogeneity (Carruth *et al*, 1999; Keane, 1993; Gibbons and Katz, 1992). Other estimates may also not be immune to unmeasured differences between individuals, and this could be a particular problem when, over a long period, the composition of workforce changes substantially as it does here. This problem can be circumvented, or at least mitigated, by tracking cohorts as suggested by Deaton (1985), and estimating relationships based on cohort means.

To illustrate with a simple model, suppose that our basic panel regression equation could be written as:

$$y_{it} = x_{it}^{'}\beta_t + \alpha_i + \varepsilon_{it}, \qquad t = 1,...,T, \tag{1}$$

where *i* indexes individuals and *t* time periods. Unfortunately, in the PNADs, we do not observe the same individuals in every time period, and hence we do not have genuine panel data available to estimate such an equation. In such circumstances, the approach first advocated by Deaton (1985) proceeds as follows. Define a set of *C* cohorts, based on age (year-of-birth) say, such that every individual *i* is a member of one and only one cohort for each *t*. Averaging over the cohort members, we obtain:

$$\overline{y}_{ct} = \overline{x}_{ct}^{'}\beta + \overline{\alpha}_{ct} + \varepsilon_{ct}, \qquad c = 1,\ldots,C, \tag{2}$$

where $\overline{y}_{ct}$ is the average of the y_{it} for all members of cohort *c* at time *t*. This is a so-called 'pseudo-panel'. Note that the 'cohort fixed effects', $\overline{\alpha}_{ct}$, will, in fact, vary with *t* since they comprise different individuals in each cohort *c* at time *t*, but can be treated as constant if the number of individuals per cohort is large. Then estimation can proceed with the standard fixed-effects estimator on the cohort means, thus eliminating any unobserved (fixed) differences between individual cohorts.

Deaton argues that there is a potential measurement error problem arising from using $\overline{y}_{ct}$ as an estimate of the unobservable population cohort mean and an adjustment based on errors-in-variables techniques is therefore needed. However, this is typically ignored by researchers if the number of observations per cohort is reasonably large (see, for example, Browning *et al*, 1985 and Blundell *et al*, 1993). More explicitly, Verbeek and Nijman (1992) suggest that when the cohort size is at least 100 individuals, and the time variation in the cohort means is sufficiently large, the bias in the standard fixed-effects estimator will be small enough that the measurement error problem can be safely ignored. Although this issue will be considered in the analysis, given the size of the PNADs, suitably chosen cohorts should fulfill this size criterion and hence this is the approach used in this paper.

We construct our pseudo-panel data by computing cohort- or cell-means in each available cross-section, where the cells are defined by the two-digit industry classification described above and seven year-of-birth cohorts taken at ten-year intervals.[10] The first birth cohort

[10] We choose to use the two-digit industry classification to define the cohorts because we want to investigate the traded and non-traded sectors separately, and because the trade data are only available at this level of disaggregation. The other dimension of the cohorts - year-of-birth at

comprises individuals born between 1916 and 1925, since the oldest workers from this cohort will just be included in the sample data as they will be 65 years old in 1981. The second birth cohort runs from 1926-35, and so on through to the seventh cohort, which comprises individuals born since 1976. For each of the seven birth cohorts, we divide the individuals according to the 31 two-digit industries we identify based on the PNAD and trade data. Thus, in total, we have a theoretical maximum of (31×7=) 217 groups in our pseudo-panel.[11]

For each of these 217 groups, we compute observations based on cell means from the PNAD data which can then be matched with the trade data for each industry at each point in time. However, not all birth cohorts are observed in every year of the PNAD data. For birth cohorts 2, 3, 4 and 5, we derive observations for each of the 17 PNAD datasets we have available. But, for the first birth cohort (born between 1916 and 1925) the youngest individual will be 65 years old in 1990 and thus we have no further observations for this birth cohort after this date. Similarly, the oldest individual in the sixth cohort (born between 1966 and 1975) was only 18 years old in 1984 and hence we have no observations from this cohort until then. Finally, the oldest individual in birth cohort 7 (those individuals born since 1976) was 18 years old in

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ten-year intervals - allows for unobserved differences between these similar individuals (loosely half a generation) such as differences in the quality of their education, their skills and attitudes, unionisation levels etc to be controlled for in the wage equations via the fixed effects.

[11] The choice of 10 year intervals for the birth cohorts is essentially arbitrary, but meets the requirements for the cell sizes to be reasonably large (on average) so that the measurement error problem discussed above is negligible. It also ensures that individuals within each cell are relatively homogeneous while individuals in different cells are relatively heterogeneous (Deaton, 1985). Of course, a myriad of other methods for defining the cells are available (for example, based on gender, race, region etc), but for the purposes here – investigating the determinants of earnings across industries – deriving cells based on age seems to be the most sensible since age-earnings profiles capture much of the variation in earnings over the life-cycle.

1994 (when there was no PNAD conducted) and hence there are no observations from this cohort in our pseudo-panel dataset until 1995.

A second limitation on the number of observations in our pseudo-panel analysis is that, while for most PNADs, we observe individuals from each of the 31 two-digit industries, for the oldest two cohorts (youngest two cohorts), there are no individuals observed in a few industries in the latest (earliest) years because of small sample sizes for the very oldest (youngest) workers.

Due to these two limitations, our pseudo-panel dataset is an unbalanced panel of 2,974 observations. The overall distribution of industry observations for each birth-cohort group and PNAD is given in the Appendix, Table A1 while the average size of each of the industry-birth-cohort cells is given in Table A2. These average cell sizes are large by the standards typically employed for pseudo-panel analyses which ignore the measurement error issue described above. So, for example, Browning *et al* (1985) have an average cell size of 190, while Blundell *et al* (1993) have cell sizes of 300-400 individuals. As can be seen in Table A2, our average cell size is 707 individuals and hence we feel confident that we too can safely discount this problem.

However, this average disguises a large variance between cells; the median cell size is only 181 and some cells are rather small.[12] Hence, even where the average cell size is very large, as in birth cohorts 3, 4, 5 and 6, the minimum for some industry-birth-cohort cells may be rather

[12] Of course, where there are less than 31 observations in the entries in Table A1, the missing cells are where the number of observations for that industry-birth-cohort cell is zero.

insufficient. Thus, as seems fairly standard practice (e.g. Propper *et al*, 2001), we estimate by weighted least squares to accommodate the differences in cohort sizes.

4. Results and Discussion

4.1 Basic Descriptives

We first investigate whether the episode of trade liberalization that began around 1990 had a noticeable effect on average wages. Figure 1 shows that across the whole of the period, the average real hourly wage was almost unchanged: it was 2.96 *reais* in 1981 and 2.81 *reais* in 1999.[13] However, the mean wage disguises movements in the ratio of non-traded to traded sector wages which was fairly constant throughout the 1980s but, following the most rapid period of trade liberalization, rose from 1.39 in 1992 to 1.45 in 1995, and increased further to 1.55 by 1999. This increase in the raw traded to non-traded sector wage differential may be perhaps be linked to the consequences of increased competition in traded sector following trade reform. As can be seen, almost all of the increase in dispersion since 1992 is a result of increases in wages in the non-traded sector.

Of course, movements in average wages and raw wage differentials can occur for a number of reasons in addition to any impact of trade liberalization. Perhaps the most pertinent during the period under investigation are the significant increase in the average levels of education of the Brazilian workforce together with the substantive changes in the gender composition of

[13] The figures in this sub-section are also weighted by cell size and so reflect the underlying individual PNAD data. The 'blip' in 1986, known as the 'Plano Cruzado effect', is genuine. It resulted from a wage and price freeze program, which allowed wages to rise 8 percent faster than prices.

employment. Figure 2 documents these two trends. Average years of schooling increased from 5.28 years in 1981 to 6.94 years by 1999, an increase of 31 percent. At the same time, the proportion of employees who are female increased from just over 30 percent to almost 40 percent.[14]

The education composition of employment is depicted in Figure 3. It is evident that the increase in mean schooling years in Figure 2 is dominated by a fall in the proportion of illiterates (level 1), and an increase, in particular, in the proportion that completed secondary or some college level education (level 5). There are also significant differences in the educational composition of employment by sector. Table 1 reveals that the non-traded sector is relatively skilled compared to the traded sector, employing a much greater share of more educated workers both pre- and post-liberalization. Since 1992, however, the proportionate increase in the share of more educated workers is greater in the traded sector.[15]

4.2 Returns to Education and Trade Liberalization

To disentangle the multifarious changes in the composition of employment over time and their impact on wages separate from any impact attributable to trade liberalization clearly requires a multivariate approach. Table 2 presents estimates of standard Mincerian earnings functions for our industry-cohort cell means, in which we regress log wages on experience and its square, indicators recording the highest level of education achieved (level1 - level6 as defined in section 3 with level 1 as the base), and gender. While these regressions are based on cell

[14] There was a steady change in the raw gender wage gap over the whole period, with the ratio of female to male wages increasing from 70 percent in 1981 to 85 percent in 1999; see Green *et al* (2001) for further details.

[15] However, this increase is from a much lower base, and the traded sector still employs workers with much lower average education than the non-traded sector.

means, the interpretation of the coefficients is standard. In order to investigate the consequences of trade liberalization on wages, we define a (0,1) dummy (lib) which takes a value of 1 for the period after liberalization. We define this to be from 1992 onwards since most of the reduction in tariffs, for example, had taken place by 1992. We examine the impact of liberalization separately for the traded and non-traded sectors by creating the appropriate interactions. Column 1 of Table 2A presents a simple OLS regression which decomposes the mean (log) wage between sectors and trade regime. This shows that, on average, workers in the traded sector were paid 12.5 percent[16] less than workers in non-traded sector pre-liberalization. As perhaps anticipated from Figure 1, in the post-liberalization period, average wages in the traded sector fell further behind those in the non-traded sector; the magnitude of the reduction being some 6.7 percent after 1992.

A standard pooled OLS Mincerian earnings function is presented in column 2 of Table 2A. The coefficient estimates appear sensible; there is a hump-shaped experience-earnings profile, women earn significantly less than equivalently experienced and qualified men, and the returns to education are monotonically increasing in education level.[17] Moreover, as discussed in Section 2 above, the returns to education in Brazil are very high, and the wage equation explains a large proportion of the total variation in earnings. A comparison of columns 1 and 2 reveals that, although average wages are lower in the traded sector, this is entirely due to the lower human capital in that sector. In the pre-liberalization period, workers in the traded

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[16] Computed as $\{\exp(\beta)-1\}\times 100$, where β is the coefficient on the dummy variable.

[17] The phrase 'return' is potentially misleading, as the calculation is strictly speaking not a return to education investment. We simply reflect conventional terminology is using the phrase. No calculation of lost wages or other education costs is included, and it is implicitly assumed that the length of time required to complete each education level remains stable throughout the period.

sector were, in fact, paid ($\exp(0.097)-1=$) 10.2 percent more than similar workers in the non-traded sector once experience, education attainment and gender are controlled for. This can perhaps be interpreted as *prima facie* evidence of workers in that sector enjoying some of the rents accruing to industries which befitted from the high levels of protectionism in that period. Post-liberalization, wages in both sectors fell significantly, and thus there would appear to be important spill-over effects results from trade reform. However, the fall in wages in the traded sector was considerably larger than in the non-traded sector. Interestingly, conditional on human capital, trade reform appears to have approximately completely eliminated the wage advantage that workers in the traded sector enjoyed pre-liberalization.[18]

Column 3 exploits the pseudo-panel nature of our data and estimates the same Mincerian earnings function as in column 2 but using a fixed-effects estimator. As shown in section 3, this eliminates any unobserved (and observed) fixed industry-cohort factors.[19] As can be seen, the OLS estimated returns to education in column 2 appear to be biased upwards for every education category, perhaps signifying the impact of unmeasured variables associated with education attainment (such as ability) that also affect productivity and wages. All of the OLS estimated coefficients are substantially larger than their fixed-effects counterparts, and some are more than double in size. Hence, unmeasured ability appears to be especially important in wage formation in Brazil, and previous estimates of the returns to education were probably considerably over-estimated. Moreover, these results suggest that the estimation of returns to education using pseudo-panel data would appear to be a particularly useful alternative and/or

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[18] Post-liberalization, we can compare $0.097-0.258=-0.161$ for the traded sector with -0.165 for the non-traded sector.

[19] Note that the construction of the pseudo-panel controls for fixed industry (and cohort) differences and thus we cannot now compare the traded and non-traded sectors, only changes *within* each sector.

complimentary technique for developing countries where coefficients of education are typically found to be very high (Psacharopoulos, 1994).[20]

The results in column 3 indicate rather smaller net changes in wages post-liberalization once we control for fixed industry-cohort effects. Column 4 decomposes the post-liberalization period and compares wages in the period immediately after trade reform with the second half of the 1990s when trade policy remained fairly unchanged. The dummy variable D9599 takes a value of 1 for the years 1995-1999 inclusive and is interacted with the sectoral dummies. As can be seen, following significant falls in wages in both sectors in the 1992-1994 period (-11.4 percent and -8.1 percent in the traded and non-traded sectors respectively), there was a substantial recovery in both sectors in the late 1990s. Wages in the non-traded sector fell less and increased more in the second half of the 1990s, thus explaining the widening gap between traded and non-traded wages even accounting for differences in human capital. One possible explanation of this result is the fall in rents and the reduction in the bargaining power of unions in industries most affected by trade (Hay, 1998; Arbache, 2000).

Table 2B focuses more explicitly on the returns to education pre- and post-liberalization by allowing the estimated rates of return to differ between the two periods. This allows us to identifying possible gainers and losers following trade liberalization among workers with different education levels. Column 5 restricts the returns in the traded and non-traded sectors to be the same and simply differentiates the returns pre- and post-liberalization, while

[20] The fixed-effects estimates of the returns to education are still large however, particularly for those with level 5 (completed secondary) and level 6 (completed college) qualifications.

column 6 allows for the returns to be additionally differentiated in each sector as well as pre- and post-liberalization.

A number of interesting findings are apparent. First, those with level 5 education (secondary, or some college education) saw their (relative) wages fall most in the period after trade reform. This is also the group that experienced the largest increase in its relative supply as noted previously (and shown clearly in Figure 3) and clearly these two factors may be related in a manner not captured by the cohort fixed-effects. Second, incremental returns to higher levels of education in the non-traded sector are much greater than those in traded sector. Third, there is evidence of some compression in the wage distribution post-liberalization in the non-traded sector. There was a substantial increase in the returns to level 1 education[21] and a fall in the returns to level 2 education. Indeed, the former effectively caught up with the latter. This was coupled with a significant fall in the incremental returns to level 5 education. Hence we seem to have identified liberalization as an equalizing influence on dispersion of wages in the non-traded sector. While there is also some evidence of compression at the top of the education-wage distribution in the traded sector, the differences are not significant at conventional levels from their pre-liberalization rates of return.

In the results presented above, the liberalization dummy simply records trade liberalization as a 0-1 event. In practice, trade reforms affected different industries to different degrees and at different times. In order to more accurately reflect the timing and extent of trade liberalization therefore, Table 3 presents estimates of the impact of the reforms using a measure of the

[21] Although these comprise a small group – only 8.1 percent of employees in that sector - as seen in Table 1.

degree of liberalization as captured by the level of effective tariffs in the industry. Let e_{jt} denote the (proportionate) rate of effective tariffs in industry *j* at time *t*. Then we define our measure of 'openness' for industry *j* at time *t* as:

$$\text{open}_{jt} = \begin{cases} \exp(-e_{jt}) & \text{if } e_{jt} > 0 \\ 0 & \text{if } j \text{ is a non-traded sector industry} \end{cases} \quad (3)$$

Thus, within the traded sector, lower effective tariff rates imply a greater degree of openness, while in the non-traded sector, openness is defined to be zero. The advantage of this specification is that openness is defined continuously over the (0,1) range for both traded and non-traded industries. Moreover, smaller values of open_{jt} imply higher tariffs (effectively infinite tariffs for the non-traded sector), while larger values imply greater potential for external competition since they reflect lower values of tariffs. Hence the metric has a sensible interpretation.

Column 2 of Table 3 reports the results of adding this measure of the degree of liberalization to our pseudo-panel fixed effects equation given in column 1.[22] As can be seen, its coefficient is negative and significant, implying that a greater average degree of openness is associated with significantly lower average wages, *ceteris paribus*. This average is taken across both traded and non-traded sectors despite the fact that the non-traded sector is unaffected directly by trade liberalization (and thus has a value of $\text{open}_{jt} = 0 \; \forall \; j \text{ and } t$). Of course, to simply attribute this fall in average wages to competition resulting from greater openness in the traded sector together with spill-over effects in the non-traded sector would be naïve since

[22] Note that the sample period now runs from 1987 to 1998 since, while we have effective tariff data for 1999, we do not have data on the value of production for 1999 which we need to combine industries to match the industrial aggregation that is present in the PNADs.

there will have been other - particularly perhaps cyclical - changes over time which may have also affected the overall level of wages. But the general trends revealed by the estimates are perhaps not unsurprising.

The specification in column 3 includes interactions between the measure of openness and each of the different education levels in order to ascertain whether the impact of greater openness is borne disproportionately by different education groups. All education groups receive lower wages the higher the degree of openness that they face. Similar to the results in Table 2, we find that the wages of the education group most affected by trade liberalization is level 5 (secondary or some college education), although the compression at the lower end of the education distribution is also again apparent.

5. Conclusions

This paper has documented the sectoral distribution of wages and the returns to education in a major developing country over a period surrounding a substantive trade reform. Interest in changing wages and returns to education has been motivated by the potential for trade theory to explain changing income distribution in both the developing and the developed world. The implications for the developed countries of this and other studies of developing countries are unclear, in light of a range of theories which predict increasing inequality due to transfer of skill-biased technology. Nevertheless, for developing countries an improved understanding of the consequences of trade liberalizing measures is important. The case of Brazil is especially valuable because trade reform was concentrated into just a few years during which trade liberalization measures were the key economic policy taking place, predating other, lesser,

liberalization measures by several years and also because of the availability of good individual-level data over a long period spanning the major reforms.

Using pseudo-panel techniques, we have found that the returns to education, though high, are substantially lower than those obtained through traditional OLS methods on cross-sectional data. On the basis of the evidence in this paper, we would therefore suggest that previous estimates of rates of returns for developing countries might be biased upwards, and perhaps to a considerable degree. We have also investigated the structure of wages both before and after trade reform. Our descriptive analysis reveals that there was some widening of the non-traded to traded sector wage differential post-liberalization. However, once we condition for the human capital composition of the workforce, both sectors saw reductions in wages in the period after trade reform. Moreover, we saw that wages in the traded sector appear to have been squeezed by increasing openness in the immediate post-liberalization period, with the largest squeeze in those industries with the greatest exposure as measured by this index. There was a concurrent squeeze in wages in the non-traded sector too, and it is tempting to argue that this is due to significant spill-over effects. Such effects have seldom been investigated in the literature on trade liberalization since it typically focuses on the traded sector only. These findings provide fruitful opportunities for further research.

From the policy perspective, one may conclude that trade liberalization had a slightly equalizing influence on wages in accordance with Stolper-Samuelson theorem, but that this has come at the expense of reducing the (conditional) level of wages. Moreover, there is some evidence that this equalizing effect appears to have been more at the expense of reducing the returns to those with secondary education rather than increasing the pay of the less educated. It is important to note that such effects are not a consequence of the increasing supply of

educated workers since we use a multivariate approach which explicitly controls for such compositional factors (as well as unobserved differences) between industries and individuals' cohorts.[23] One caveat to this conclusion is that in the last few years there appears to have been some recovery in wages, and thus the documented reductions in wages in the period immediately after trade reforms may have reflected only transitional effects.

[23] See also Green *et al* (2001) who document the increase in *demand* for skilled labour in Brazil throughout the sample period.

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TABLE 1

The Composition of Employment: 1981-1991, 1992-1999

	Proportion with highest education level					
Sector and Period:	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
Non-traded						
pre-1992	0.111	0.159	0.312	0.144	0.193	0.082
post-1992	0.081	0.124	0.300	0.164	0.237	0.094
Mean	0.099	0.144	0.307	0.152	0.211	0.087
Traded						
pre-1992	0.270	0.238	0.306	0.088	0.075	0.023
post-1992	0.210	0.199	0.332	0.121	0.111	0.027
Mean	0.250	0.225	0.315	0.099	0.087	0.025
Overall Mean	0.148	0.171	0.310	0.134	0.171	0.066

Notes:
1. These are row proportions in each case.
2. Education classification:
   - Level 1: Illiterate (less than one year of study)
   - Level 2: Some elementary education
   - Level 3: Completed elementary, no or some primary
   - Level 4: Completed primary, no or some secondary
   - Level 5: Completed secondary, no or some college
   - Level 6: Completed college

TABLE 2A

Returns to Education Attainment and Trade Liberalization: 1981-1999

	Column 1 OLS	Column 2 OLS	Column 3 Fixed-effects	Column 4 Fixed-effects
traded	-0.133	0.097		
	(0.027)**	(0.010)**		
traded×lib	-0.069	-0.258	-0.099	-0.121
	(0.032)*	(0.011)**	(0.014)**	(0.015)**
non-traded×lib	0.004	-0.165	-0.005	-0.084
	(0.029)	(0.010)**	(0.013)	(0.014)**
experience		0.060	0.043	0.032
		(0.001)**	(0.002)**	(0.002)**
experience^2×10^{-3}		-0.623	-0.621	-0.607
		(0.024)**	(0.031)**	(0.029)**
female		-0.845	-0.490	-0.462
		(0.015)**	(0.077)**	(0.072)**
level2		1.026	0.469	0.354
		(0.109)**	(0.121)**	(0.113)**
level3		1.952	1.071	0.864
		(0.050)**	(0.107)**	(0.100)**
level4		2.239	1.662	1.360
		(0.087)**	(0.125)**	(0.117)**
level5		3.524	2.261	1.867
		(0.066)**	(0.115)**	(0.109)**
level6		3.556	2.988	2.548
		(0.077)**	(0.134)**	(0.127)**
traded×D9599				0.179
				(0.015)**
non-trade×D9599				0.257
				(0.014)**
constant	0.648	-2.053	-1.048	-0.608
	(0.019)**	(0.049)**	(0.096)**	(0.092)**
N	2974	2974	2974	2974
R^2	0.02	0.89	0.94	0.94

Notes:
1. Standard errors in parentheses.
2. + significant at 10%; * significant at 5%; ** significant at 1%.

TABLE 2B

Returns to Education Attainment and Trade Liberalization: 1981-1999

	Column 5	**Column 6**	
	Fixed-effects	**Fixed-effects**	
		traded	**non-traded**
experience	0.044	0.047	
	(0.002)**	(0.002)**	
$experience^2 \times 10^{-3}$	-0.646	-0.689	
	(0.037)**	(0.038)**	
female	-0.465	-0.444	
	(0.078)**	(0.077)**	
level2	0.532	0.451	1.077
	(0.142)**	(0.157)**	(0.301)**
level3	1.045	0.875	1.415
	(0.114)**	(0.132)**	(0.209)**
level4	1.472	1.353	2.171
	(0.142)**	(0.173)**	(0.246)**
level5	2.255	1.810	3.076
	(0.128)**	(0.168)**	(0.209)**
level6	3.166	2.724	3.945
	(0.148)**	(0.207)**	(0.229)**
level1×lib	0.010	-0.008	0.834
	(0.081)	(0.087)	(0.204)**
level2×lib	-0.059	-0.216	-0.638
	(0.127)	(0.140)	(0.287)*
level3×lib	-0.023	-0.056	0.179
	(0.068)	(0.078)	(0.141)
level4×lib	0.090	0.133	-0.137
	(0.127)	(0.156)	(0.214)
level5×lib	-0.238	-0.197	-0.219
	(0.084)**	(0.141)	(0.111)*
level6×lib	-0.050	-0.370	-0.094
	(0.108)	(0.227)	(0.125)
constant	-1.044	-1.293	
	(0.102)**	(0.117)**	
N	2974	2974	
R^2	0.93	0.94	

Notes:
1. Standard errors in parentheses.
2. + significant at 10%; * significant at 5%; ** significant at 1%.

TABLE 3

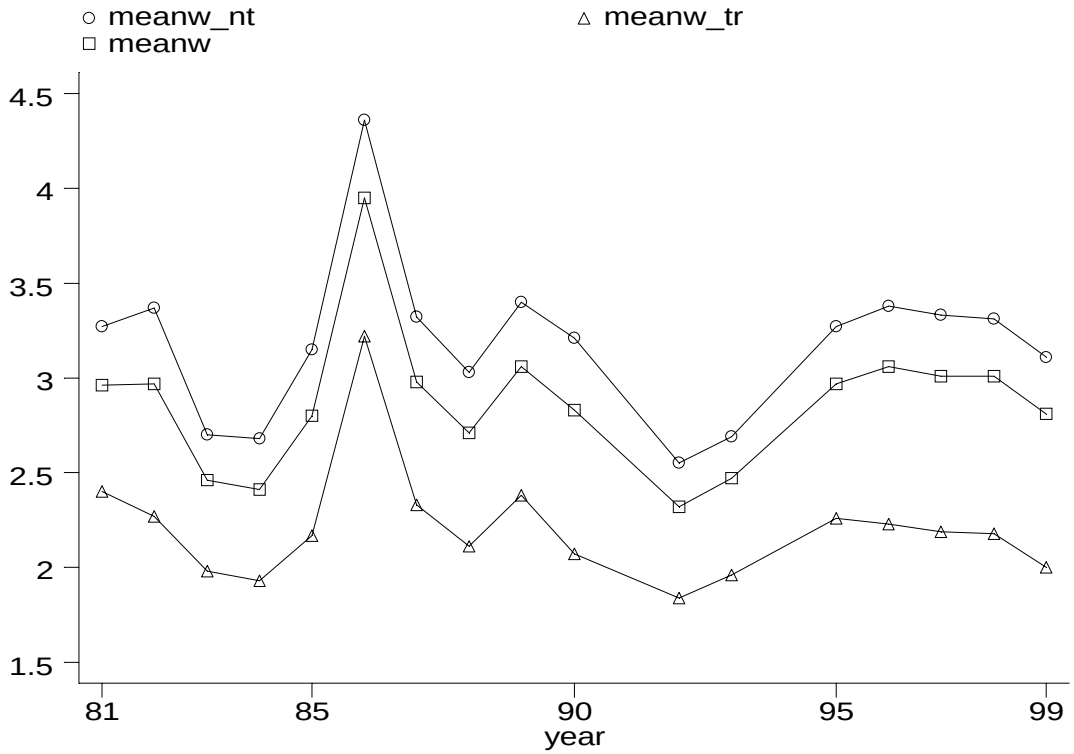
Returns to Education and Degree of Openness: 1987-1998

	Column 1 Fixed-Effects	Column 2 Fixed-Effects	Column 3 Fixed-Effects
experience	0.047	0.051	0.051
	(0.003)**	(0.003)**	(0.003)**
experience$^2\times10^{-3}$	-0.570	-0.570	-0.572
	(0.045)**	(0.044)**	(0.047)**
female	-0.452	-0.446	-0.464
	(0.083)**	(0.081)**	(0.081)**
level2	0.579	0.566	0.645
	(0.124)**	(0.121)**	(0.220)**
level3	1.049	1.045	0.927
	(0.115)**	(0.112)**	(0.170)**
level4	1.610	1.669	1.616
	(0.135)**	(0.132)**	(0.191)**
level5	2.166	2.247	2.503
	(0.123)**	(0.121)**	(0.171)**
level6	3.029	3.001	3.043
	(0.146)**	(0.143)**	(0.188)**
open		-0.314	
		(0.037)**	
level1×open			-0.279
			(0.173)
level2×open			-0.407
			(0.212)+
level3×open			-0.061
			(0.128)
level4×open			-0.127
			(0.210)
level5×open			-0.907
			(0.154)**
level6×open			-0.492
			(0.236)*
constant	-1.256	-1.278	-1.286
	(0.100)**	(0.098)**	(0.144)**
N	1771	1771	1771
R^2	0.96	0.96	0.96

Notes:
1. Standard errors in parentheses.
2. + significant at 10%; * significant at 5%; ** significant at 1%.

FIGURE 1

Mean Wages in the Traded and Non-traded Sectors



Note:

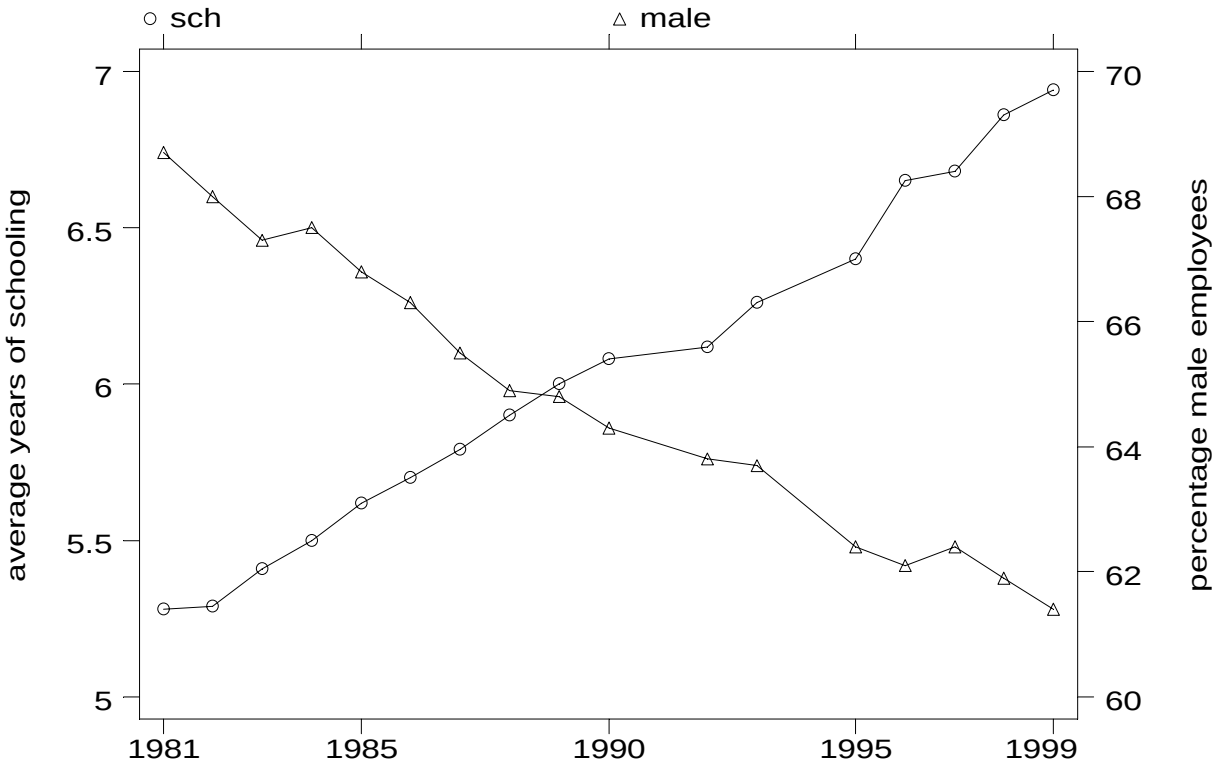
Δ average wages in the traded sector industries

□ average wages

○ average wages in the non-traded sector industries

FIGURE 2

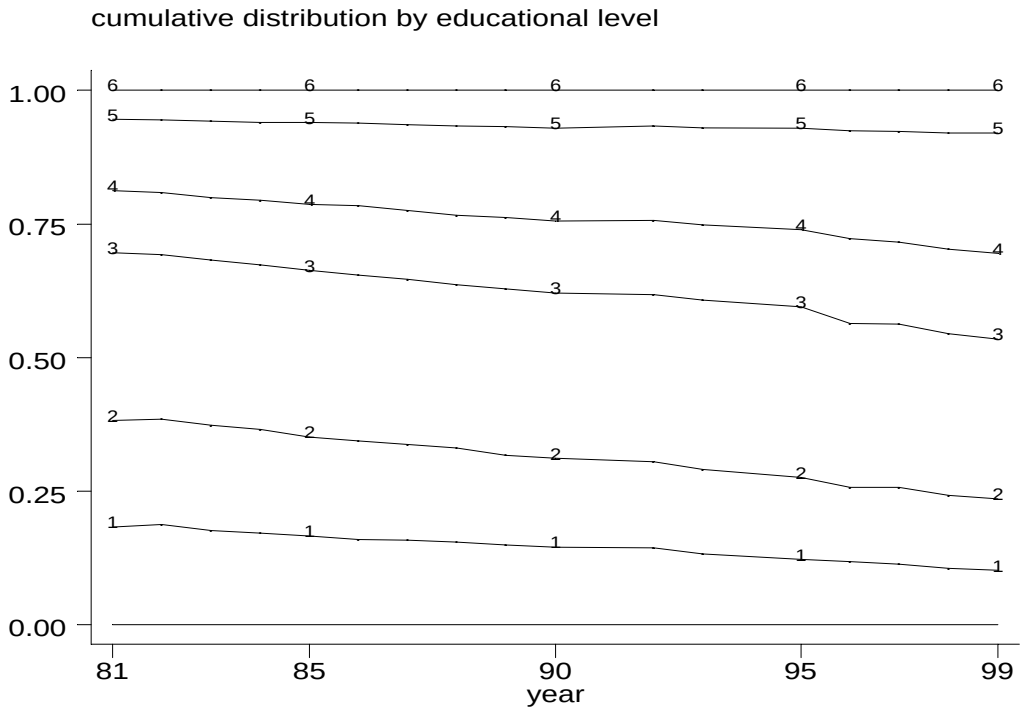
Mean Schooling and Gender Composition of Employment



Note:
Δ percentage male employees (right hand scale)
○ average years of schooling (left hand scale)

FIGURE 3

Education Composition of Employment



Note:
The graph depicts the cumulative proportion of workers who have attained each education level, where education levels are defined as follows:

Level 1: Illiterate (less than one year of study)
Level 2: Some elementary education
Level 3: Completed elementary, no or some primary
Level 4: Completed primary, no or some secondary
Level 5: Completed secondary, no or some college
Level 6: Completed college

APPENDIX

TABLE A1

Number of Cohort-Industry Observations by PNAD Year and Birth Cohort

	Birth cohort and year of birth							
	1	2	3	4	5	6	7	
PNAD	1916-25	1926-35	1936-45	1946-55	1956-65	1966-75	1975-81	**Total**
1981	31	31	31	31	31			155
1982	31	31	31	31	31			155
1983	31	31	31	31	31			155
1984	31	31	31	31	31	29		184
1985	31	31	31	31	31	31		186
1986	31	31	31	31	31	31		186
1987	29	31	31	31	31	31		184
1988	29	31	31	31	31	31		184
1989	28	31	31	31	31	31		183
1990	24	31	31	31	31	31		179
1992		29	31	31	31	31		153
1993		30	31	31	31	31		154
1995		31	31	31	31	31	31	186
1996		29	31	31	31	31	30	183
1997		29	31	31	31	31	30	183
1998		27	31	31	31	31	31	182
1999		27	31	31	31	31	31	182
Total	296	512	527	527	527	432	153	2974

TABLE A2

Average Size of Cohort-Industry Cells by PNAD Year and Birth Cohort

	Birth cohort and year of birth							
	1	2	3	4	5	6	7	**Average**
PNAD	1916-25	1926-35	1936-45	1946-55	1956-65	1966-75	1975-81	
1981	292.9	632.1	1011.3	1412.4	1330.8			935.9
1982	265.3	639.5	1044.3	1504.9	1612.6			1013.3
1983	223.9	605.9	1017.2	1481.9	1766.5			1019.1
1984	192.0	576.2	982.8	1471.4	1813.4	167.8		874.9
1985	165.9	551.0	987.2	1507.8	1905.4	352.0		911.5
1986	71.1	284.4	530.6	816.3	1059.0	313.7		512.5
1987	65.5	281.9	536.2	844.6	1081.3	424.5		544.1
1988	47.3	270.1	510.7	827.5	1046.9	533.6		544.7
1989	34.1	252.7	495.9	817.1	1063.0	647.0		560.1
1990	19.0	239.5	486.5	822.4	1061.9	749.9		584.5
1992		203.6	428.4	796.5	1077.6	943.5		696.3
1993		167.8	418.1	786.6	1082.6	1055.4		705.6
1995		115.9	399.1	787.5	1130.3	1145.9	190.0	628.1
1996		91.5	357.1	742.6	1076.2	1109.5	308.8	621.7
1997		75.8	351.0	748.8	1127.1	1183.4	430.9	660.4
1998		57.0	325.6	709.3	1102.6	1155.0	518.2	657.5
1999		36.8	312.9	698.4	1104.9	1186.0	650.9	678.8
Average	142.7	305.2	599.7	986.8	1261.3	786.2	420.4	707.2