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Changes in Returns to Education in Latin America: The Role of Demand and Supply of Skills

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Abstract
Changes in the relative wages of workers with different amounts of education have profound implications for developing countries, where initial levels of inequality are often very high. In this paper we use micro data for five Latin American countries over the 1980s and 1990s to document trends in men's returns to education, and to estimate whether the changes in skill premia we observe can be explained by supply or demand factors. We propose a model of demand for skills with three production inputs, and we allow the elasticity of substitution between the different educational inputs to be different using a nested CES function. Using this model, we show that the dramatic expansion in secondary school in many countries in Latin America depressed the wages of workers with secondary school. We also show that there have been sharp increases in the demand for more skilled workers in the region.

Keywords: returns to education, demand and supply of skills.
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1. Introduction

The rising wage premium for skilled workers in many OECD countries since (at least) the 1980s is a well-documented fact. In the United States, for example, Katz and Autor (1999) estimate that the real wages of High School drop-outs, the least skilled workers, fell over the 1963-1995 period (by about -4.5 percent), while the real wages of College graduates rose sharply (by about 22.4 percent). Considerable controversy exists about the extent to which the increase in the wages of skilled workers can be explained by increases in demand for skill (for example, Katz and Murphy 1992; Katz and Autor 1999) or decreases in relative supply (for example, Card and DiNardo, 2002; Card and Lemieux, 2001a). Authors who have emphasized the role of relative demand have analyzed the determinants of such demand changes, including the computer revolution, Heckscher-Ohlin effects of trade, or outsourcing (Wood 1994; Feenstra and Hanson 1996; Autor, Katz, and Krueger 1998; Berman, Bound, and Machin 1998; Machin and Van Reenen 1998). Those instead who believe that changes in the wage structure can largely be explained by changes in relative supply have concentrated on the deceleration in the supply of College graduates among the baby boom cohort (Card and Lemieux, 2001a, 2001b).

While much analytical work has been done on changes in the wage structure in the United States and Europe, less is known about this matter in developing countries. And yet, changes in the wage structure for workers with different amounts of education are likely to be of great importance in poorer countries. Many developing countries dramatically expanded access to secondary school in the last two decades; under most circumstances, one would expect this to depress the wages of workers with secondary school degrees. In addition, many of these countries have seen substantial increases in import penetration and Foreign Direct Investment (FDI). Trade could decrease the demand for skilled workers through Heckscher-Ohlin effects, but both trade and FDI could result in increases in the demand for skill if they stimulate companies in developing countries to adopt new technologies that are skill-biased.

In this paper we use micro data for five Latin American countries over the 1980s and 1990s to document trends in the returns to education, and to estimate whether the changes in skill premia we observe can be explained by supply or demand factors. The main contributions of the paper are three. First, we provide consistent estimates of changes in relative wages for a group of countries in Latin America. Latin America is the most unequal region in the world. In the 1990s, the Gini coefficient, a widely-used measure of inequality, was between 15 and 19 points higher in Latin America than in North America and Western Europe (Deininger and Squire 1996; Milanovic 2002). Changes in the returns to schooling

could obviously have large effects on income inequality in Latin America, and careful description and explanation for changes in relative wages therefore has considerable value. The countries we analyze—Argentina, Brazil, Chile, Colombia, and Mexico—are the five largest economies in the region, jointly accounting for 85 percent of GDP and 70 percent of population in 2000. Our paper complements multi-country analysis by Berman, Bound and Machin (1998) and Berman and Machin (2000a and 2000b), who use United Nations data on industry shares of production and non-production workers for a sample of developed and developing countries to argue that there has been pervasive skill-biased technological change around the world, including in middle-income countries, and Behrman, Birdsall, and Szekely (2001) and Inter-American Development Bank (2002), who document an increase in the wages of College graduates relative to High School graduates in Latin America, and argue that some of the observed changes can be explained by trade reforms. There are also a number of studies that consider the evolution of relative wages within a given country in the region. For example, papers based on firm-level data for Chile (Pavcnik 2002) and Colombia (Kugler 2002) suggest a complementary relationship between skill-upgrading and adoption of new technology by firms, and papers based on household survey data for Colombia (Attanasio, Goldberg, and Pavcnik 2004) and Brazil (Pavcnik, Blom, Goldberg, and Schady 2004) both attribute an important role to skill-biased technological change transferred through trade as an explanation for the observed changes in the wage distribution.

Second, we assess the role played by changes in relative demand and relative supply of skills in shaping trends in relative wages. Specifically, we estimate the elasticity of substitution between different education inputs and use these coefficients to estimate, in turn, the growth in the demand for skills in each country. Our approach closely follows Card and Lemieux's (2001a) study of the US, UK and Canada. Like Card and Lemieux, we assume that changes in relative demand can be reasonably approximated by a linear time trend. We then assess the extent to which variations in relative supply around this trend can account for the observed changes in relative wages.

The third contribution of this paper is methodological. In order to perform our analysis, we split our sample into three groups, corresponding to individuals with completed primary school, secondary school and college education, and allow for workers of different ages to be imperfect substitutes within each educational group. The breakdown of the sample into three education groups is an important departure from Card and Lemieux (2001a), who only concentrate on the College-High School premium. Our choice is dictated by the observation that, unlike the industrialized countries analyzed by Card and Lemieux, wage

differentials between workers with primary and secondary school education in Latin America changed significantly over the period of observation. As a result, we cannot treat these two groups as perfect substitutes in production. We therefore propose a model of demand for skills with three production inputs, and we allow the elasticity of substitution between the different educational inputs to be different using a nested CES function.

The rest of the paper proceeds as follows. In section 2, we briefly discuss our data sources and present descriptive evidence on the evolution of relative wages and the relative supply of workers with different amounts of education. In section 3 we lay out our basic model of wage determination. In this section we also discuss basic identification of the parameters of interest. Section 4 estimates the parameters of the production function and the trends in demand and supply for skills in the five countries under analysis. Section 5 concludes.

2. Data and basic trends

In this section we present information on wages and labor supply for individuals with different levels of education. We use data from labor force surveys for Argentina, Brazil, Chile, Colombia and Mexico. Because survey coverage varies across countries, we limit the sample to urban areas only to ensure comparability. A detailed description of the data sources as well as information on the criteria we use to construct our sample is provided in the Data Appendix.

We construct wage and labor supply measures for three different education groups: primary (primary school), secondary (high school), and tertiary (college and above). Following Card and Lemieux (2001a) we use different samples to calculate each measure. Wage trends are based on a sample of full-time male employees, ages 26 to 60, who have exactly completed primary, secondary or tertiary education, while supply trends are based on a sample of both female and male workers, ages 26 to 60, with any level of education between incomplete primary and completed tertiary. For the purpose of this second calculation we attribute those with incomplete levels of education to the "nearest" education group, as described in the Data Appendix. On this basis, we obtain labor supply measures for primary-, secondary- and tertiary-educated worker "equivalents".[1]

[1] Using information on both female and male workers to construct supply measures is legitimate if men and women are substitutes in the production function—i.e. an increase in female labor supply has the same impact on wages of male workers as a similar increase in male labor supply. Our results are robust to the exclusion of female workers from all labor supply calculations, although parameter estimates tend to be less precise.

We measure the wage premium using relative returns to education. To calculate average returns we regress (log) weekly wages on age and age squared, two education dummies for secondary and tertiary education, respectively, and year dummies. Our estimates are reported in the first two rows of Table 1. Returns to education are generally high, with each additional year of education being associated with a 10- to 20-percent increase in wages. There is, however, significant variation across countries. Workers with completed secondary education are paid between 45 (Argentina and Colombia) and 83 (Brazil) percent more than their primary-educated counterparts. Similarly, wages of tertiary-educated individuals are 45 (Argentina and Mexico) to 90 (Chile) percent higher than those of workers with secondary education.

We experiment with different average labor supply measures, namely, total hours, total employment, total labor force and total population accounted for by individuals in each education group. We also report employment, unemployment and participation rates by education level. This information is presented in Table 1. The patterns we observe are fairly robust to the choice of supply measure. Workers with primary education account for 50 to 60 percent of labor supply. An additional 25 to 30 percent of the labor supply is secondary-educated, and the remaining 15 to 20 percent has tertiary education. The exception is Chile, where 50 percent of the labor supply has secondary education and only 30 percent is primary-educated. Employment and participation rates increase with education, while unemployment rates are highest among those with primary school and lowest for those with tertiary education.

We next examine changes in relative wages and labor supply over time. Figure 1 plots the returns to tertiary education relative to secondary, and to secondary education relative to primary, by country during the 1980-2000 period. Returns are again estimated from earnings regressions and standardized to zero at the beginning of the period. Relative returns to tertiary education increase and the relative returns to secondary education decrease almost monotonically in all countries—the one exception being the increase in the return to secondary education relative to primary in Mexico. Put differently, wage differences widened at the top of the distribution and narrowed at the bottom. The magnitude of these changes, however, varies across countries. The annual increase in the relative return to tertiary education is lowest in Argentina (around 0.8 percentage points) and highest in Chile (2.1 percentage points). Similarly, the decline in the relative return to secondary education is largest in Chile (-2.7 percentage points) and smallest in Colombia (-0.8 percentage points). Note that each series appears to be the mirror image of the other, suggesting that the return to

tertiary education relative to primary has remained roughly constant over time. In other words, workers with secondary education seem to have lost ground relative to both those with tertiary and primary education during this period in all countries but Mexico.

Figure 2 plots the labor supply of workers with tertiary education relative to those with secondary, and for workers with secondary education relative to those with primary. We here measure labor supply as the percentage of the total population with different education levels, and standardize all series to zero at the beginning of the period. The relative supply of secondary workers increases in all countries, with annual growth rates ranging from 3 percentage points in Mexico to about 5 percentage points for Chile and Colombia. These changes reflect widespread public efforts to increase secondary school enrollment. In contrast, the relative supply of tertiary workers varies significantly across countries. In most countries, relative supply is roughly constant during the 1980s; in the 1990s it grows in Argentina and Chile, declines slightly in Brazil and remains stable in Colombia. Mexico is the only country in the sample where the supply of workers with tertiary education increases faster than that of workers with secondary education throughout the entire period.

Taken together, Figures 1 and 2 indicate that increases in the wage premium of workers with tertiary education occurred at a time when their relative supply was fairly stable or growing. Increases in relative wages that coincide with increases in relative supply are highly suggestive of demand-side changes favoring the most skilled. On the other hand, the wage premium of workers with secondary education fell as their relative supply increased in all countries but Mexico. As a result it is unclear what effect, if any, demand-side changes may have had. Further analysis is necessary to isolate changes in relative demand from changes in relative supply. In the next section we present a theoretical framework that allows us to do this.

3. Model and empirical strategy

We develop a nested model that extends that in Card and Lemieux (2001a) to allow for the treatment of three education groups: primary, secondary and tertiary. Being able to identify changes in relative demand and relative supply separately for three groups rather than for two, as is standard practice in the literature, is key for the purpose of our analysis since we observe a very pronounced increase in the supply of secondary workers and a deterioration in their relative wages compared to both the tertiary and the primary education groups in most countries in our sample.

3.1 Theoretical model

For the sake of clarity and simplicity we construct our model under the assumptions that demand is a function of the marginal productivity of labor, supply is exogenously given, and wages are determined by the interaction of labor demand and supply. In the empirical analysis we test the predictions of this model, as well as those generated by a more flexible formulation with an upward-sloping supply curve.

We assume the representative firm produces under constant elasticity of substitution (CES) technology and uses two labor inputs with different skill levels. For simplicity, we maintain capital in the background. Then:

$$(1) \qquad Y_t=A_t(\alpha_{Lt}N_{Lt}^{\rho}+\alpha_{Ht}N_{Ht}^{\rho})^{1/\rho} \qquad \alpha_{Lt}=1-\alpha_{Ht}$$

where Y is total output, A is skilled-neutral technological change, N is employment (or labor supply), L denotes the unskilled group and H the skilled group, t is time and ρ is a function of the elasticity of substitution between production inputs. We denote this elasticity of substitution by σ_E, where $\sigma_E=1/(1-\rho)$. The parameter α_{Ht} is a measure of the relative productivity of skilled workers at time t.

In addition, we assume that the skilled group (H) is a CES combination of the two top education groups, secondary and tertiary (respectively denoted by 2 and 3), and that the unskilled group (L) represents workers with primary education (denoted by 1, so that L≡1). This implies:

$$(2) \qquad N_{Ht}= B_{Ht}(\alpha_{2t}N_{2t}^{\gamma}+\alpha_{3t}N_{3t}^{\gamma})^{1/\gamma} \qquad \alpha_{2t}=1-\alpha_{3t}$$

where α_{3t} is a measure of productivity of tertiary workers relative to secondary workers and $\sigma_H=1/(1-\gamma)$ is the elasticity of substitution between these two groups.

In constructing the labor supply of each education group we allow for differences in productivity across workers with the same level of education but with different levels of experience, proxied by age. In other words, we define the labor supply of education group e, where e can equal 1, 2 or 3, as a productivity-weighted CES combination of all age groups of individuals with education level e. That is:

$$(3) \qquad N_{et}=(\Sigma_j\beta_j N_{ejt}^{\delta})^{1/\delta} \qquad e=1,2,3 \qquad \Sigma_j\beta_j=1$$

where j denotes a generic age group and δ is a function of the elasticity of substitution between different age groups. We assume that this elasticity of substitution, σ_A, where $\sigma_A=1/(1-\delta)$, is the same across education groups and for any couple of age-specific inputs. Finally, β_j is a measure of the relative productivity of age-group j, which we assume to be time- and education-invariant, thereby ruling out age-biased demand changes.

Under the assumption that labor and product markets are perfectly competitive, we can manipulate (1) to (3) to derive expressions for the wages of individuals of age j and education level e at time t:

(4) $w_{ejt}=\theta_t+\ln\alpha_{et}+\ln\beta_j-1/\sigma_E\, n_{et}-1/\sigma_A(n_{ejt}-n_{et}) \qquad e=1\equiv L$

(5) $w_{ejt}=\theta_t+\ln\alpha_{Ht}+\ln\alpha_{et}+\ln\beta_j-1/\sigma_E\, n_{Ht}-1/\sigma_H(n_{et}-n_{Ht})-1/\sigma_A(n_{ejt}-n_{et}) \qquad e=2,3$

where $\theta_t=(1-\rho)\ln(Y_t)$, $n=\ln N$, $w=\ln W$ and W are wages.

Equations (4) and (5) constitute the basis of our empirical analysis. They illustrate that (log) wages are a function of Total Factor Productivity, represented by θ_t, demand shifts (the αs and βs), and a series of labor supply terms. The first supply term captures the effect of overall changes in the supply of a given skill group, n_{Lt} and n_{Ht}. The coefficient on this term is a transformation of the elasticity of substitution between unskilled (L) and skilled (H) workers, σ_E. The second supply term, which only appears in (5), represents changes in the composition of the supply of skilled (H) workers, i.e. changes in the share of tertiary and secondary workers within the group of skilled workers, $n_{et}-n_{Ht}$. The coefficient on this term is a transformation of the elasticity of substitution between tertiary and secondary workers, σ_H. Finally, the third supply term captures changes in the age composition of each education group, $n_{ejt}-n_{et}$. The coefficient on this term is a transformation of the elasticity of substitution between workers of different ages within each education group, σ_A.

3.2 Empirical strategy.

The main objective of the proposed empirical strategy is to obtain estimates of α_{3t} and α_{2t} and, subsequently, of α_{Ht} and α_{Lt}. The first pair of estimates captures differences in relative productivity and hence relative demand between tertiary and secondary workers, while the second pair captures differences between skilled (H, defined as a composite of tertiary and

secondary workers) and unskilled workers (L, defined as primary workers) or skill-biased technological change.

The variables of interest are, in turn, a function of the parameters included in (4) and (5) above: σ_E, σ_H, σ_A and all β_j. In order to estimate these parameters we follow the strategy proposed in Card and Lemieux (2001a), appropriately modified to account for the fact that our production function is modeled as a nested CES process with three production inputs. The need to fully identify all parameters obliges us to proceed in three steps. Specifically:

Step 1 – The first step produces estimates of the elasticity of substitution between age groups, σ_A, and of all age-specific productivity measures, β_j, that can be used to construct N_{et} as follows. From (4) and (5) and after some manipulation, we obtain:

$$(6) \qquad w_{ejt} = \lambda_{et} + \chi_j - 1/\sigma_A \, n_{ejt} \qquad e=1,2,3$$

where $\chi_j = \ln\beta_j$ represent unrestricted age effects and λ_{et} represent unrestricted time-variant education effects. In particular $\lambda_{1t} = \theta_t + \ln\alpha_{1t} - [(1/\sigma_E - 1/\sigma_A)]n_{1t}$ for e=1 and $\lambda_{et} = \theta_t + \ln\alpha_{et} + \ln\alpha_{Ht} - [(1/\sigma_E - 1/\sigma_H)n_{Ht} + (1/\sigma_H - 1/\sigma_A)n_{et}]$ for e=2, 3.

Further subtracting w_{1jt} from both sides and applying $\delta_{et} = \lambda_{et} - \lambda_{1t}$, we obtain:

$$(7) \qquad (w_{ejt} - w_{1jt}) = \delta_{et} - 1/\sigma_A \, (n_{ejt} - n_{1jt}) \qquad e=2,3$$

To estimate (7) we regress age- and time-specific (log) wage differentials on education dummies fully interacted with time dummies and on age- and time-specific (log) supply differentials, where both wage and supply differentials are constructed using workers with primary education as the base group.

This exercise produces an estimate for σ_A which we then plug back into (6) to obtain:

$$(8) \qquad w_{ejt} + 1/\sigma_A \, n_{ejt} = \lambda_{et} + \chi_j \qquad e=1,2,3$$

where the left-hand side of the equation represents (log) wages corrected for labor supply, measured as $(1/\sigma_A)n_{ejt}$. We next regress corrected (log) wages on education dummies fully interacted with time dummies plus age dummies to produce estimated age effects, χ_j, which we then use to compute the corresponding β_j. Finally, we complete this step by taking these estimates back to (3) to construct N_{et}.

In sum, we estimate the elasticity of substitution across age groups in order to be able to construct aggregate supply measures for each education group that are internally consistent—that is, measures that appropriately aggregate workers of different ages who may not be perfect substitutes for each other in the production function.

Step 2 – The second step produces estimates of the elasticity of substitution between tertiary and secondary workers, σ_H, and of α_{2t} and α_{3t}, which can be used to construct N_{Ht}. We start by assuming that $\ln\alpha_{et}=\phi_{0e}+\phi_{1e}t$, i.e. demand varies linearly over time, and subtract w_{2jt} from w_{3jt} using (5) to obtain:

$$(9) \qquad (w_{3jt}-w_{2jt})+(1/\sigma_A)[(n_{3jt}-n_{2jt})-(n_{3t}-n_{2t})]=\phi_0+\phi_1 t-(1/\sigma_H)(n_{3t}-n_{2t})$$

where the left-hand side of the equation represents (log) wage differentials between tertiary and secondary workers corrected for (log) labor supply differentials, measured as $(1/\sigma_A)[(n_{3jt}-n_{2jt})-(n_{3t}-n_{2t})]$, and where $\phi_0=(\phi_{03}-\phi_{02})$ and $\phi_1=(\phi_{13}-\phi_{12})$. We then regress corrected (log) wage differentials on a constant, a linear trend and (log) relative supply, $n_{3t}-n_{2t}$, to produce estimates of σ_H, α_{3t} and α_{2t}—the last two, under the assumption of a linear demand trend. Finally, we complete this step by taking these estimates back to (2) to compute N_{Ht}.

In sum, we estimate the elasticity of substitution between tertiary and secondary workers in order to construct aggregate supply measures for skilled workers that are internally consistent. That is, measures that appropriately express the quantity of one type of workers, say tertiary, in equivalent units of the other type of workers, say secondary.

Step 3 – The third and final step produces an estimate of the elasticity of substitution between skilled and unskilled workers, σ_E. From (4) and (5) and assuming again that relative demand follows a linear trend over time (i.e. $\ln\alpha_{Ht}-\ln\alpha_{1t}=\kappa_0+\kappa_1 t$), we obtain:

$$(10) \qquad (w_{ejt}-w_{1jt})-\ln\alpha_{et}+(1/\sigma_H)(n_{et}-n_{Ht})=\kappa_0+\kappa_1 t-(1/\sigma_E)(n_{Lt}-n_{1t})-1/\sigma_A[(n_{ejt}-n_{et})-(n_{1jt}-n_{1t})] \qquad e=2,3$$

where the left-hand side of the equation represents (log) wage differentials between secondary/tertiary and primary workers corrected for relative demand for secondary/tertiary workers, measured as $\ln\alpha_{et}$, and for (log) relative labor supply of secondary/tertiary workers, measured as $(1/\sigma_H)(n_{et}-n_{Ht})$. This expression captures changes in the relative wages of skilled workers (H).

We then regress this measure on the supply of skilled workers relative to unskilled workers, and a term capturing variation in labor supply within skill groups and across age groups to produce estimates of σ_E, and a linear time trend in the relative demand for skilled workers. We also obtain a new estimate of σ_A which can be compared to the one produced in Step 1 to check for the internal consistency of the empirical strategy.

4. Results

In this section we implement the empirical strategy described in section 3.2 using the wage and labor supply data described in section 2. Before doing this, however, we present a few simple exercises that clearly illustrate the different sources of variation in the data.

We start by exploring how, if at all, differences in relative supply by education across age groups affect relative wages. In order to get a clearer picture, we group individuals into five-year birth cohorts as described in the Data Appendix and present data on the evolution of cohort-specific returns to education and supply. (When we move on to the regressions, we use three year birth-cohorts in order to retain sufficient variation across observations to identify the parameters in the model.)

Figure 3 plots returns to education measured as the residuals from a regression of cohort X year-specific relative wages on year dummies, country dummies, and a set of full interactions between year and country dummies. Each cohort-specific series captures the within-cohort differential evolution of wages over the life cycle. We attribute differences between cohort-specific series to the effect of relative labor supply coupled with imperfect substitutability across workers of different ages. The top panel presents the returns to tertiary relative to secondary workers and the bottom panel presents the returns to secondary relative to primary workers.

The lower panel of Figure 3 shows that the profiles of younger cohorts are consistently below those of older cohorts. This is evidence that the returns to secondary education relative to primary fall as new cohorts enter the labor market, a fact that is apparent even in Mexico, where the average return to secondary education increased monotonically during 1980-2000. Something similar happens with the returns to tertiary education relative to secondary (top panel), although the picture is more noisy due to the smaller sample sizes.

Figure 4 plots relative supply measured as the residuals from a regression of cohort X year-specific population ratios on year dummies, education dummies and a set of full interactions between year and education dummies. Supply ratios are calculated as the total

number of tertiary (secondary) workers divided by the total number of secondary (primary) workers. As in Figure 3, the top panel presents the returns to tertiary workers relative to secondary, and the bottom panel presents the return to secondary workers relative to primary. Each cohort-specific series captures within-cohort changes in relative supply over time. All cohort profiles are downwards sloping, suggesting that the relative supply of tertiary and secondary workers decreases slightly over time within each cohort. This could be explained by an increase in the number of low-skill immigrants and/or an increase in the number of high-skill outmigrants. Similarly, differences between cohort-specific series can be attributed to increases in the overall level of education of the population—i.e. the relative supply of more educated workers is higher among younger cohorts.

Taken together, Figures 3 and 4 suggest that the relative supply of education across subsequent cohorts rose while relative wages fell in all countries. This point is illustrated more clearly in Figure 5 which plots cohort- and time-specific relative wages (from Figure 3) against cohort- and time-specific relative supply measures (from Figure 4). The data is presented separately for each country, as well as jointly for all five countries. In sum, a first pass at the data indicates that a negative relationship exists between relative wages and supply for different age groups (cohorts). We turn now to formally estimating the parameters of interest in the nested CES model.

Step 1 – This step consists in estimating equation (7) to obtain the elasticity of substitution between workers of different ages within each education group, σ_A. For this purpose, we pool the data from all five countries together, restricting σ_A to be the same across all countries to improve the precision of our estimate. We consider four different labor supply measures: hours worked, employment, labor force and total population. Hours worked and employment are commonly used in the literature for developed countries (Katz and Murphy, 1992; Card and Lemieux, 2001a). These measures are adequate if labor supply is exogenous to wages, i.e. the labor supply curve is perfectly inelastic with respect to wages. However, in countries with high unemployment, including some of the countries in our sample, this assumption may not be realistic. Under these circumstances, labor force participation, or even total population if participation is endogenously determined, can be better measures of labor supply.

Results are presented in Table 2. To account for the fact that relative wages across countries, cohorts and time periods are computed on samples of very different sizes, and hence vary in their precision, all regressions are weighted by the inverse of the sampling variance of the dependent variable—see the Data Appendix. Estimates of σ_A are remarkably

similar across specifications. The coefficient on (log) relative labor supply is negative, and lies between -0.191 for total population and -0.206 for hours worked. As a result, the estimated value of the elasticity of substitution between workers of different ages within each education group ranges from 4.85 (=1/0.206) to 5.23 (=1./0.191), comparable in magnitude to the elasticity of substitution found by Card and Lemieux (2001a) in their analysis of the United States, the United Kingdom, and Canada.

Step 2 – This step consists in estimating equation (9) to obtain the elasticity of substitution between tertiary and secondary workers, σ_H. For this purpose we construct measures of log wage differentials between these groups, net of relative age-specific labor supply changes, using our estimate of σ_A. Here too we present results using four different labor supply measures. Since there is strong evidence in the data of a rise in returns to education in Mexico following the implementation of NAFTA, we also allow wages and labor supply by education for Mexico to vary after the implementation of NAFTA. We do so by including dummy variables for the post-1994 period.

Results are summarized in Table 3. The first panel reports the coefficient on log relative labor supply, i.e. the inverse of the σ_H. As in Step 1, the results are robust to the choice of labor supply measures, although the estimated coefficients are insignificant at conventional levels when employment or labor force participation is used. The coefficient on (log) relative labor supply ranges from -0.204 for employment to -0.231 for hours worked. As a result, the estimated value of the elasticity of substitution between tertiary and secondary workers ranges from 4.3 (=1/0.231) to 4.90 (=1./0.204). The second panel of Table 3 presents the coefficients for the country-specific linear trends, i.e. relative demand for tertiary workers. Here too coefficients are similar across specifications and highly significant, suggesting a generalized increase in the demand for tertiary workers relative to secondary workers in all countries during the period under analysis. Focusing on specifications based on the fraction of the population in different education categories, these results suggest demand-driven changes in log wages that range from 0.9 log points a year in Brazil to around 3.5 log points in Mexico. Argentina and Colombia behave rather similarly, with estimated yearly increases in relative demand of 1.4 and 1.2 log points, respectively, while the coefficient for Chile suggests changes of 2.2 log points.

Step 3 – Finally, we turn to the estimation of equation (11) to obtain the elasticity of substitution between skilled (H) and unskilled (L) workers, σ_E. For this purpose we construct

measures of log wage differentials between these groups, net of changes in demand and relative supply of tertiary versus secondary workers, using our estimate of σ_H.

Results are presented in Table 4. The first panel reports the coefficient on log relative labor supply, i.e. the inverse of the σ_E. Unlike the previous steps, the magnitude of the estimated coefficient is sensitive to the choice of labor supply measure, although the sign remains unaltered. The coefficient varies between -0.622 for labor force participation and -0.269 for hours worked. As a result, the elasticity of substitution between skilled and unskilled workers rages between 1.61 (=1/0.622) and 3.72 (=1/0.269). These values are similar to existing estimates for skilled (tertiary) versus unskilled (secondary and below) workers in the US and other countries. The elasticity of substitution across age groups reported in row 2 of the top panel in Table 4 is remarkably similar to that reported in Table 2, suggesting that the proposed empirical strategy is internally consistent.

The second panel of Table 4 presents the coefficients for the country-specific linear trends, i.e. relative demand for skilled workers. The coefficients again vary across countries and specifications, but the basic message is reasonably similar to that from Table 3. There is an increase in the demand for skilled workers relative to unskilled ones, although this increase is only significant in Colombia and Mexico.

Taken together, the evidence in Figures 3 to 5 and Tables 2 to 4 suggests that the demand for skills rose in all five countries under study during the 1980-2000 period. The magnitude of the changes, however, varies across education groups and across countries. For instance, the rise in the demand for tertiary workers is particularly pronounced in Mexico and Chile, while Argentina, Brazil and Colombia exhibit more modest increases. Similarly, the increase in the demand for skilled workers is more pronounced in Mexico and Colombia than in the other countries.[2]

5. Conclusion

In this paper we use micro data from the urban areas of five Latin American countries over the 1980s and 1990s to document trends in the returns to education, and to estimate the magnitude of demand and supply shifts that affected the wages of three broad educational

[2] Some caution should be exercised in drawing conclusions for Mexico. Although here we find the strongest rise in demand for skills, we have also shown data on Mexico on their own are unlikely to warrant identification of model (5) to (6) since relative supply by education varies linearly over time, with no possibility of identifying this separately from changes in demand. Effectively in our analysis we have used estimates of the elasticity of substitution between different education groups largely coming from the other countries to identify the trends in demand that occurred in Mexico.

groups, corresponding to workers with primary school, secondary school, and tertiary education. Our analysis is based on a nested CES model with three educational inputs. This model allows for different elasticities of substitution across educational groups, and takes into account the fact that workers with different levels of experience are not perfect substitutes in production.

The main empirical findings of the paper are three. First, we estimate the elasticity of substitution of workers with different levels of experience in Latin America. This elasticity, which we estimate to be between 4.9 and 5.2, is comparable in magnitude to that found by Card and Lemieux (2001a) for the US, the UK, and Canada. Ignoring the imperfect substitutability of workers with different amounts of experience is likely to introduce biases into the estimation of the effects of aggregate shifts in demand or supply of workers with different amounts of schooling on wage premia—a point made forcefully by Card and Lemieux.

Second, we show that the dramatic expansion in secondary school in many countries in the region depressed the wages of workers with secondary school. The estimated coefficients imply an elasticity of substitution between tertiary and secondary workers that lies between 4.3 and 4.9. The pattern of falling returns to secondary schooling at a time of sharp increases in the fraction of the workforce with this level of schooling we observe in Latin America is reminiscent of the changes found in the United States after 1910, and especially in the decade beginning in 1940 (Katz and Goldin 1999; Goldin 2001).

Third, we show that there have been sharp increases in the demand for tertiary workers relative to workers with secondary education in Latin America. This has taken place in the five countries we analyze, albeit to different degrees. We also find evidence of demand-side shifts favoring skilled workers, defined as those with tertiary or secondary education—relative to unskilled workers—defined as those with primary education only—although these tend to be estimated less precisely. In comparison with the demand shifts estimated by Card and Lemieux for the United States and the United Kingdom, the demand shifts for Mexico are large, those for Colombia are similar in magnitude, and those found in Argentina, Brazil, and Chile are somewhat smaller.

The paper remains agnostic on a number of issues that certainly deserve further consideration. We do not investigate the determinants of the demand changes that occurred in Latin America, and in particular we are unable to answer whether these demand changes were driven by skill-biased technological change, trade penetration, FDI flows, or other

factors. Similarly, we ignore the role of institutions. Both of these might have played a role in shaping the observed returns to education, and deserve further research.

Data Appendix

The Data used in this paper come from the individual records of five roughly consistent national household surveys. Data refer to urban areas only. Data for Argentina are based on the Enceusta Continua de Hogares (ECH) and refer only to Greater Buenos Aires, since information for provinces other than Buenos Aires is not available in the 1980s. Each year we include both the March and October survey in order to maintain a reasonable sample size. Data for Brazil are based on the Pesquisa Nacional De Amostra de Domicilios (PNAD). We restrict the sample to areas classified as "metropolitan" in the survey. Chilean data are based on the Encuesta de Ocupación y Desocupación de la Universidad de Chile (EOD), and only refer to Santiago. Data for Colombia are based on the Encuesta Nacional de Hogares (ENH), while those for Mexico are based on the Encuesta Nacional de Empleo Urbano (ENEU). For Mexico we limit the sample to municipalities that are sampled each year throughout the survey period. For both Colombia and Mexico we append data from the different rounds of a survey within a year, treating multiple surveys as a single survey. Because the Mexican data have a component of rotating panel, whereby a new sample enters each quarter and stays in the sample for five consecutive quarters, we restrict the sample for our analysis to observations in the third quarter of each year and exclude individuals who have remained in the sample for more than four waves.

As a first step, for each country we have identified the years of education necessary to achieve exactly completed primary school, completed secondary school and completed tertiary education. In order to maintain reasonable sample sizes, tertiary education includes all formal post-secondary schooling, regardless of whether this was acquired in university or technical schools. Table A1 reports this information.

As a second step, and in a manner similar to Card and Lemieux (2001), we construct two samples for each country: a wage sample and a labor supply sample. The wage sample includes exclusively male full-time (at least 20 hours of work a week) employees, aged 26-60 with exactly completed levels of education (primary school, secondary school, tertiary). We restrict the sample to all workers who are salaried employees, i.e. all wage and salary earners, regardless of whether they are in the formal or informal sectors. For all individuals in this wage sample, we construct a consistent measure of weekly wages, obtained as monthly labor income in the main job divided by usual weekly hours of work. We drop from this sample individuals with wages below the 1st percentile or above the 99th percentile of the year-specific wage distribution, those with missing wages, and those with missing years of education.

The labor supply sample includes all individuals in the data aged 26-60. In order to obtain measures of labor supply for primary school, secondary school, and tertiary equivalents we proceed as follows. Workers with more than completed university (i.e. more than completed undergraduate, or college) education are included in the tertiary category with their supply re-weighted by their wage relative to exactly completed college graduates. For example, if those with more than a college degree earn 20 percent more than college graduates, on average, they count as 1.20 times a college worker. Similarly, workers with less than primary school are included in the primary school category with their labor supply weighted by their wage relative to primary school graduates. Workers with incomplete tertiary education are split between the secondary and tertiary categories on the basis of the distance between their wage and the wage of those with exactly completed college and exactly completed secondary. For example, if the difference in wages between those with some college and those with exactly secondary school is 30 percent of the difference in wages between those with exactly a college degree and those with exactly a secondary school degree, we attribute 30 percent of those with some college to the secondary school group and the residual 70 percent to the tertiary group. We proceed in a comparable fashion for secondary school dropouts, i.e. we split them between those with exactly completed secondary school and exactly completed primary school. The only exception is Chile, where secondary school dropouts earn less on average than those with exactly completed primary school. In this case, we assign these individuals entirely to the primary school group. In order to compute these weights we use average relative wages over the whole period of observation.

Information on the yearly size of the wage and supply sample is presented in the last two columns of table A1. The table shows wide variation across countries in sample sizes. The largest surveys are carried out in Brazil (with samples of about 60,000 observations per year), and Mexico (about 50,000); sample sizes are much smaller in Argentina and Chile (about 5,000 each). Colombia displays an intermediate sample size (about 28,000).

When we perform our regression analysis we group individuals into three-year X time-cohort cells. For each country the three-year cells are centered on the following mid points (where data are available): 1981, 1984, 1987, 1990, 1994, 1996, 1999. Similarly, we define three-year birth-cohort cells with midpoints ranging from 1924 to 1972. Age is defined as the difference between these new artificial year and cohort variables. In order to obtain log wage differentials by cell we regress individual log wages for each cell on two education dummies, corresponding to secondary and tertiary education, and a linear term in age. The

differentials are the coefficients on these two education dummies. We use the standard errors of these estimated coefficients as a measure of their precision. In particular, when we run regressions we weight each sample by the reciprocal of the square of its standard error.

Table 1

Wages and Labor Supply by Education

	Argentina	Brazil	Chile	Colombia	Mexico
Returns to education					
Secondary-Primary	0.449	0.827	0.619	0.458	0.578
Tertiary-Secondary	0.449	0.826	0.897	0.691	0.468
% Hours					
Primary	0.530	0.608	0.248	0.482	0.506
Secondary	0.279	0.251	0.526	0.326	0.294
Tertiary	0.191	0.141	0.226	0.191	0.200
% Employment					
Primary	0.524	0.601	0.293	0.532	0.533
Secondary	0.274	0.250	0.506	0.298	0.278
Tertiary	0.202	0.149	0.201	0.170	0.188
% Labor force					
Primary	0.532	0.604	0.302	0.534	0.532
Secondary	0.272	0.251	0.506	0.300	0.278
Tertiary	0.196	0.145	0.192	0.166	0.189
% Population					
Primary	0.574	0.648	0.338	0.581	0.577
Secondary	0.266	0.235	0.511	0.285	0.280
Tertiary	0.160	0.117	0.151	0.133	0.142
Employment to population rate					
Primary	0.584	0.624	0.532	0.610	0.551
Secondary	0.658	0.715	0.609	0.698	0.592
Tertiary	0.806	0.858	0.818	0.849	0.791
unemployment rate					
Primary	0.088	0.055	0.115	0.086	0.022
Secondary	0.070	0.055	0.087	0.087	0.025
Tertiary	0.047	0.027	0.040	0.060	0.029
Participation rate					
Primary	0.640	0.660	0.601	0.667	0.564
Secondary	0.708	0.757	0.667	0.764	0.607
Tertiary	0.846	0.881	0.852	0.903	0.814

Notes. The table reports basic statistics on relative wages by education and the distribution of labor supply by education in the five countries under analysis. The first two rows report time averages of log wage differentials between workers with secondary school and primary school, and workers with tertiary education and secondary education, respectively. Coefficients are conditional on a quadratic in age and year dummies, and refer to male full-time employees with exactly completed primary, secondary or tertiary education. The following rows report the time averages of the distribution of hours, work, employment, labor force and population in terms of education equivalents (primary, secondary and tertiary). Data on supply are obtained pooling all individuals (males plus females) in the sample irrespective of whether they have exactly completed primary, secondary and tertiary education or not. For data sources and definitions see the Appendix.

Table 2

Relative Wages and Relative Supply by Age and Time
Dependent Variable: Relative Wages

	(1)	(2)	(3)	(4)
	Measure of Supply			
	Hours	Employment	Labor Force	Population
Supply Age (All Education Groups)	-0.206***	-0.203***	-0.204***	-0.191***
	(0.010)	(0.009)	(0.009)	(0.009)
Observations	682	682	682	682
Adjusted R-squared	0.967	0.967	0.967	0.968

Notes: the table reports the GLS estimates of a regression of the wages of tertiary and secondary workers relative to workers with primary school education by age and time on their relative supply (equation (7) in the text). Data are three-year birth-cohort X year of observation cells. Regressions also control for the full interaction of education dummies with year dummies and country dummies. Regressions are weighted by the inverse of the sampling variance of the dependent variable. Each column refers to a different measure of labor supply as reported in the top row.

Table 3

Relative Wages and Relative Supply by Time
Tertiary- Secondary Education workers

Dependent Variable: Relative Wages

	(1)	(2)	(3)	(4)
	Measure of Supply			
	Hours	Employment	Labor Force	Population
Supply				
Tertiary - Secondary Education	-0.231*	-0.204	-0.210	-0.224*
	(0.128)	(0.126)	(0.133)	(0.124)
Time Trend				
Tertiary-Secondary Education				
*Argentina	0.013**	0.012*	0.012*	0.014**
	(0.006)	(0.006)	(0.006)	(0.006)
*Brazil	0.008***	0.008***	0.007***	0.009***
	(0.001)	(0.001)	(0.002)	(0.001)
*Chile	0.021***	0.020***	0.021***	0.022***
	(0.004)	(0.004)	(0.004)	(0.005)
*Colombia	0.010***	0.011***	0.010***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)
*Mexico	0.034***	0.032***	0.032***	0.035***
	(0.007)	(0.007)	(0.007)	(0.007)
Observations	341	341	341	341
Adjusted R-squared	0.746	0.751	0.748	0.769

Notes: the table reports the GLS estimates of a regression of wages of tertiary relative to secondary education workers by time on their relative supply (equation (9) in the text). Data are three-year birth-cohort X year of observation cells. Regressions also control for country dummies fully interacted with a linear time trend (reported in the following rows) and for dummies for Mexico post-1994. Regressions are weighted by the inverse of the sampling variance of the dependent variable. Each column refers to a different measure of labor supply as reported in the top row.

Table 4

Relative Wages and Relative Supply by Time
Skilled- Unskilled workers

Dependent Variable: Relative Wages

	(1)	(2)	(3)	(4)
	Measure of Supply			
	Hours	Employment	Labor Force	Population
Supply				
(Tertiary+Secondary)-Primary Education	-0.269	-0.525**	-0.622***	-0.495*
	(0.255)	(0.257)	(0.235)	(0.275)
by Age	-0.238***	-0.228***	-0.229***	-0.200***
	(0.015)	(0.014)	(0.014)	(0.013)
Time Trend				
(Tertiary+Secondary)-Primary Education				
*Argentina	0.005	0.018	0.021	0.018
	(0.016)	(0.015)	(0.013)	(0.017)
*Brazil	0.002	0.010	0.012	0.011
	(0.010)	(0.009)	(0.008)	(0.011)
*Chile	-0.001	0.011	0.017	0.012
	(0.013)	(0.013)	(0.013)	(0.015)
*Colombia	0.009	0.021*	0.025**	0.021
	(0.013)	(0.012)	(0.011)	(0.014)
*Mexico	0.037***	0.047***	0.052***	0.047***
	(0.014)	(0.013)	(0.013)	(0.014)
Observations	682	682	682	682
Adjusted R-squared	0.792	0.807	0.808	0.807

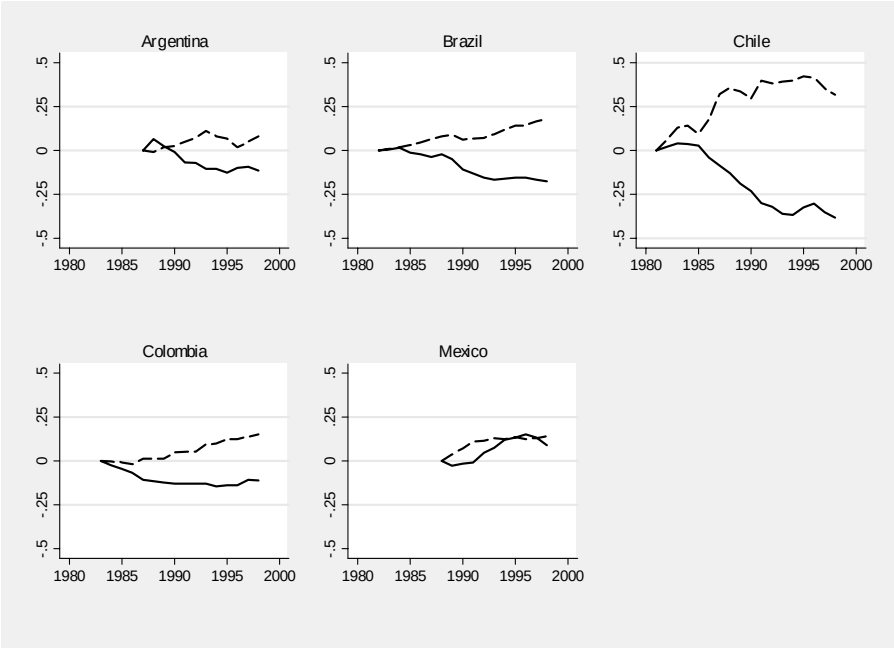
Notes: the table reports the GLS estimates of a regression of log wages of tertiary and secondary education workers relative to primary education workers on the log supply differential between the top two education group (in the first row), and relative supply by age (second row) (equation (10) in the text). Data are three-year birth-cohort X year of observation cells. Regressions also control for country dummies fully interacted with a linear time trend (reported in the following rows) and for dummies for Mexico post-1994. Regressions are weighted by the inverse of the sampling variance of the dependent variable. Each column refers to a different measure of labor supply as reported in the top row.

Table A1
Data Samples

Country	Source	Years of education corresponding to completed levels of education			Period	Yearly sample size	
		Prim.	Prim.	Tert.		Wage sample	Labor supply sample
Argentina	Encuesta Continua de Hogares (Greater Buenos Aires)	7	12	15-18	1986-1999	4,970	864
Brazil	Pesquisa Nacional De Amostra de Domicilios	4	11	14-15	1981-1999[a]	59,445	7,480
Chile	Encuesta de Ocupación y Desocupación de la Universidad de Chile	6	12	15-17	1980-1999	4,630	663
Colombia	Encuesta Nacional de Hogares	5	11	14-16	1982-1999[b]	28,441	3,824
Mexico	Encuesta Nacional de Empleo Urbano	6	12	15-17	1987-1999	51,296	4,287

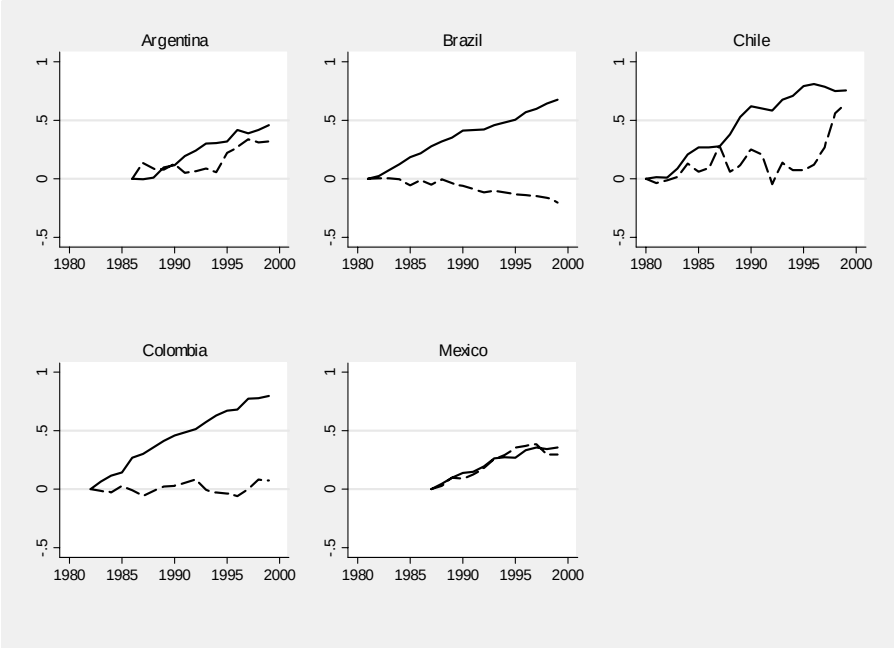
(a) Data are not available in 1991 and 1994.
(b) Data are not available in 1991.

Figure 1
The Evolution of Returns to Education in five Latin American Countries



Notes: the Figure reports the wage returns to tertiary versus secondary school workers (dashed line) and secondary versus primary school workers (solid line) by year, for male full-time employees in each country. The series are obtained from year and country specific regressions of log wages on a constant, a dummy equal one if the individual has at least completed secondary education, a dummy equal one if the individual has at least completed tertiary education, age and age squared. The series in the figure are the coefficients on the two educational dummies. All series are standardized to the first year of observation and are smoothed using a three year moving average.

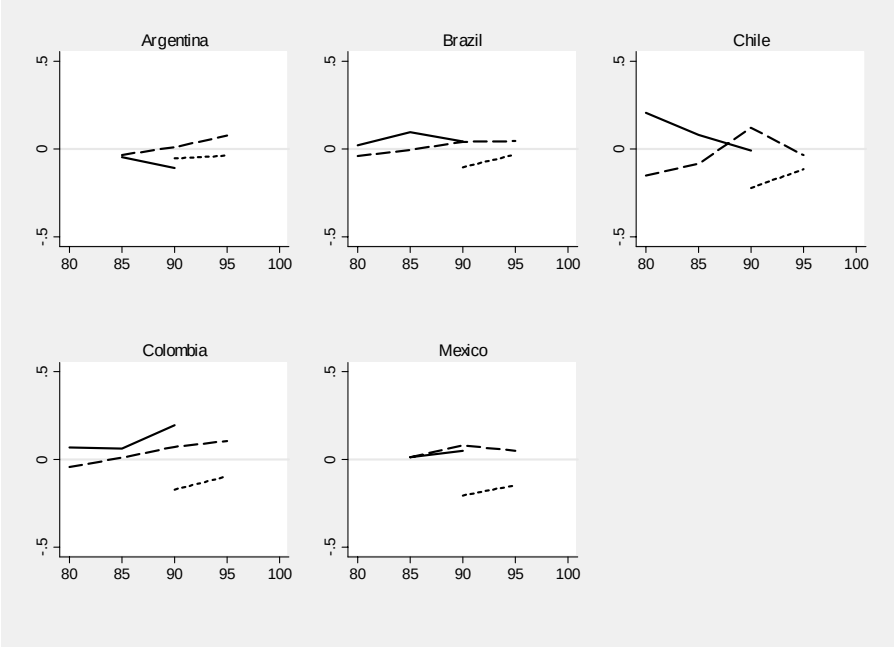
Figure 2
The Evolution of Relative Labor supply by Education in five Latin American Countries



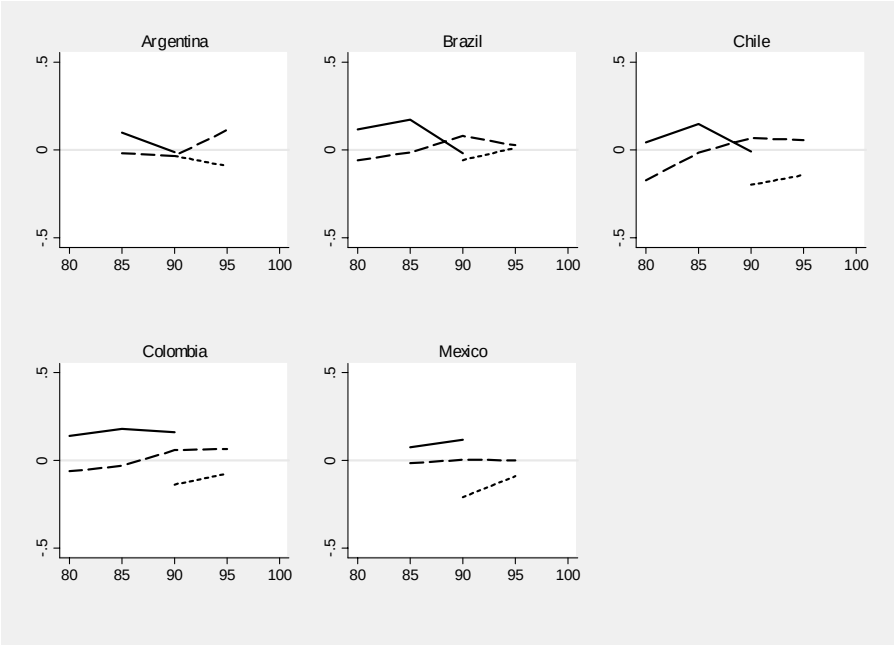
Notes: the Figure reports the relative population of workers with tertiary education versus secondary school (dashed line) and secondary school versus primary school (solid line) by time in each country.

Figure 3
Relative Wages by Cohort and Time

Tertiary-Secondary



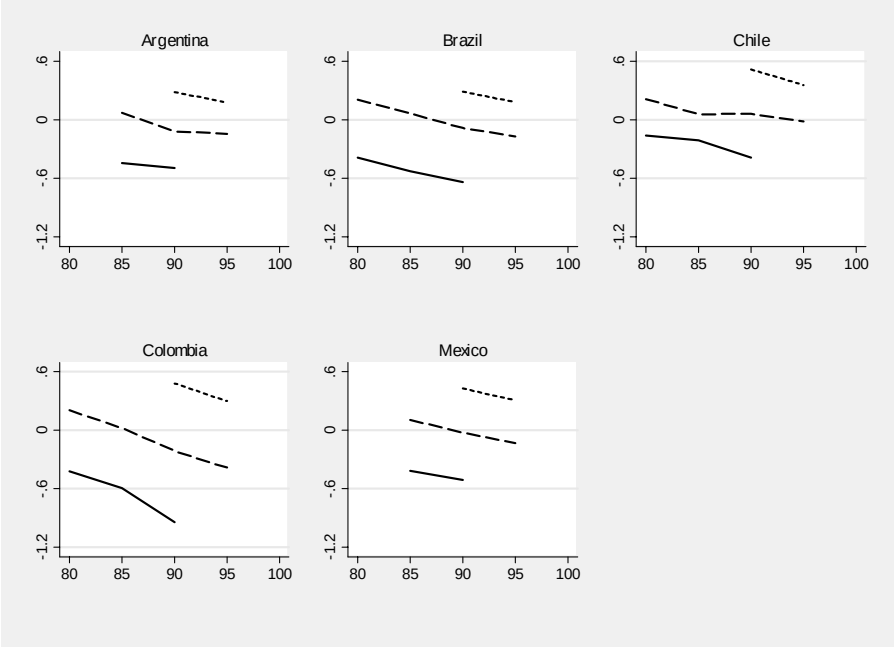
Secondary-Primary



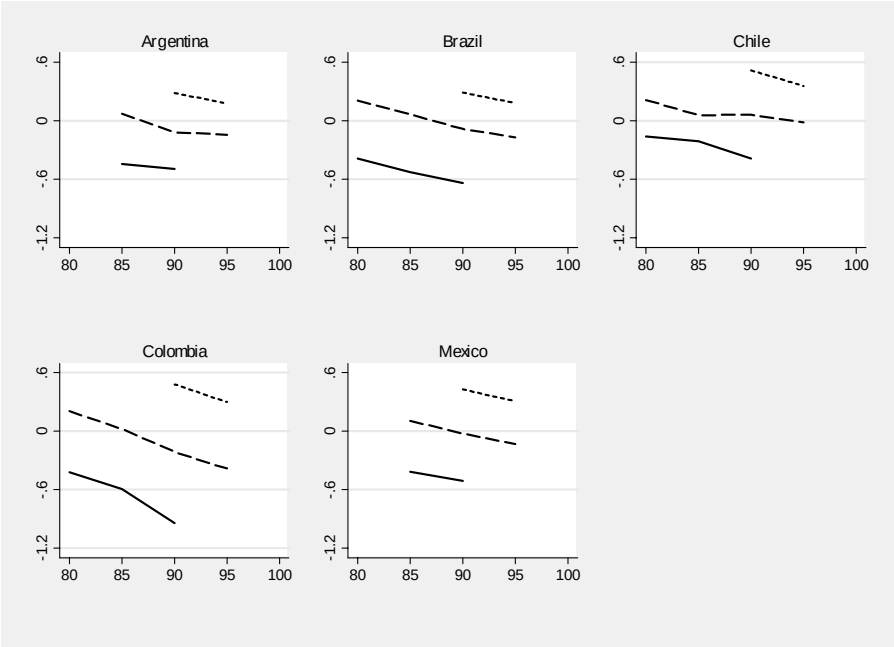
Notes: the Figure reports the wage returns to tertiary versus secondary school (top panel) and secondary school versus primary school (bottom panel) by cohort of birth, time (on the horizontal axis) for male full time employees in each country. Data are grouped by three year birth-cohort X year-of-observation cells. The plotted series are the residuals of log wages by cohort and time on the interaction of country dummies with year dummies separately for each educational differential.

Figure 4
Relative Supply by Cohort and Time

Tertiary-Secondary



Secondary-Primary

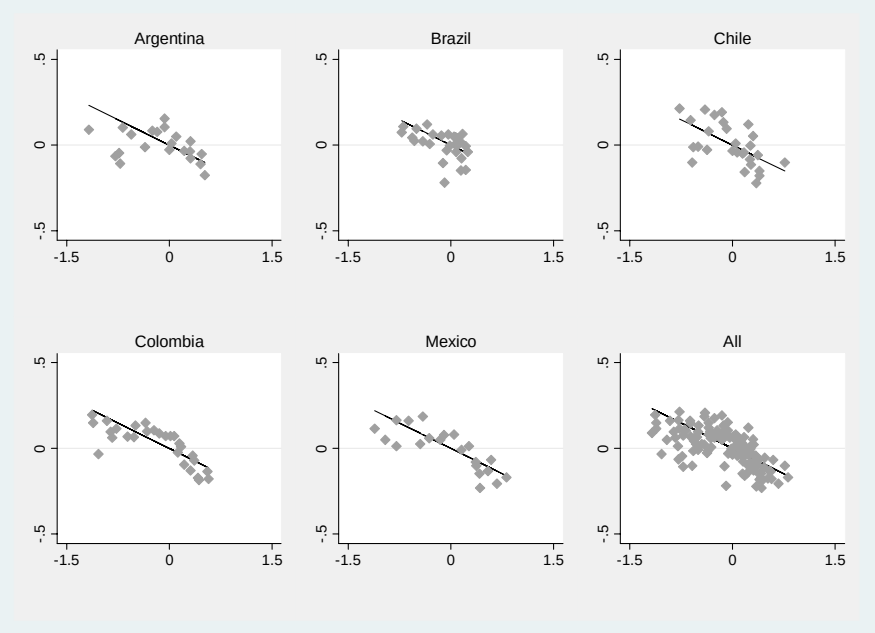


Notes: the Figure reports the relative population of tertiary versus secondary school (top panel) and secondary school versus primary school (bottom panel) by cohort of birth, time (on the horizontal axis) for each country. Data are grouped by three year birth-cohort X year-of-observation cells. The plotted series are the residuals of log relative supply by cohort and time the interaction of country dummies with year dummies separately for each educational differential.

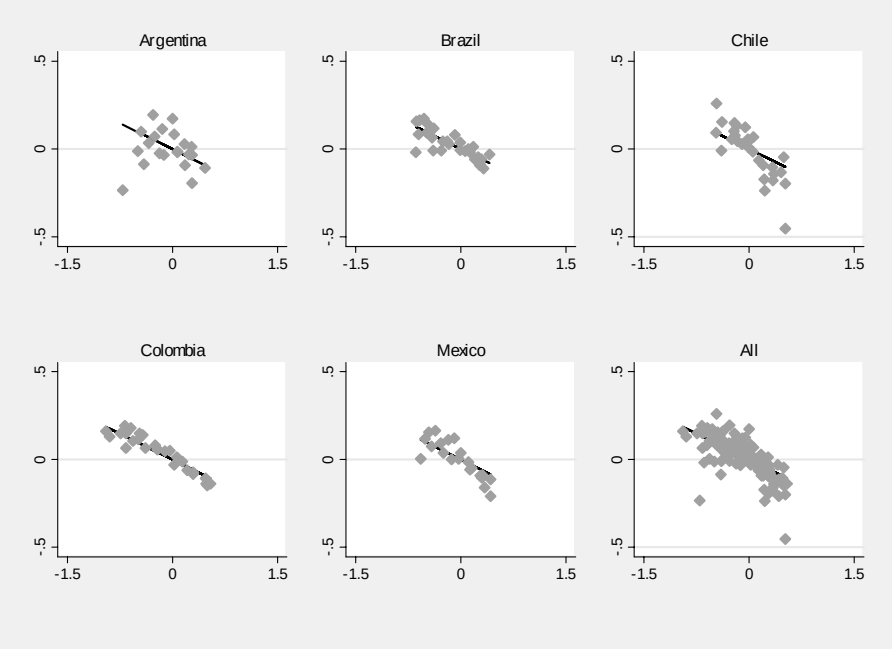
Figure 5

Relative Wages and Relative Supply by Cohort and Time

Tertiary-Secondary



Secondary-Primary



Notes: the Figure plots the wage returns to education by cohort of birth and time (as in Figure 3) on the relative population by education (as in Figure 4) by country. The top panel refers to the tertiary-secondary differential, while the bottom panel refers to the secondary-primary differential. The last graph in each panel pools all countries together. The WLS regression line (Table 2, see column 4) is superimposed to the data. See text for details.

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