CHANGES IN RETURNS TO EDUCATION IN LATIN AMERICA: THE ROLE OF DEMAND AND SUPPLY OF SKILLS

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Using micro data for the urban areas of Argentina, Brazil, Chile, Colombia, and Mexico, the authors document trends in men's returns to education during the 1980s and the 1990s and estimate the role of supply and demand factors in explaining the changes in skill premia. They propose a model of demand for skills with three production inputs, corresponding to workers with primary-, secondary-, and university-level education. Further, the authors demonstrate that an unprecedented rise in the supply of workers having completed secondary-level education depressed their wages relative to workers with primary-level education throughout Latin America. This supply shift was compounded by a generalized shift in the demand for workers with tertiary education.

The rising wage premium for skilled workers since (at least) the 1980s is a well documented fact in many developed countries. Much less is known about the evolution of skill premia in developing countries and, in particular, about the extent to which changes have occurred because of shifts in the relative demand for or the relative supply of workers with different levels of completed education. For a variety of reasons, understanding the determinants of relative wage growth in Latin America is important. First, Latin America is the region with the most unequal distribution of wealth 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). Since labor earnings are the largest income source for most households in Latin America, changes in education wage premia have important implications for the evolution of inequality. However, without an understanding of whether any observed shifts are largely a result of changes in the relative demand for skilled workers or, rather, changes in the relative supply of workers with different levels of education, it is hard to design appropriate policies. For example, if the evolution of wages in the region were largely a result of supply-side shifts, policies that facilitate the quality of or access to schooling at various levels might be appropriate. Alternatively, if changes in wage premia were largely a result of shifts in the demand for workers who had completed different levels of education, the focus would logically be on policies that affect relative demand, such as trade or technological change.

In order to study changes in the returns to education in the 1980s and 1990s, we use micro data from five countries in Latin

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Industrial and Labor Relations Review, Vol. 63, No. 2 (January 2010).
0019-7939/00/6302 $01.00

America: Argentina, Brazil, Chile, Colombia, and Mexico. These are five of the six largest economies in the region, accounting for 85 percent of the Gross Domestic Product (GDP) and 70 percent of the region's population. Building on a model originally developed by Card and Lemieux (2001), we analyze the role of supply and demand in explaining changes in wages for workers with primary, secondary, and university education.

Our paper makes two important contributions to the literature, the first methodological and the second substantive. The model developed by Card and Lemieux (2001) considers two education classes—"skilled" (college) and "unskilled" (high school or less). In Latin America, however, the latter group accounts for a relatively large share of the population, and treating it as a single aggregate might be misleading. In many countries in the region, the relative supply of workers having completed primary and secondary education has changed substantially over the last two decades. For example, in Mexico, the fraction of workers having completed some secondary education more than doubled between 1980 and 2000 (increasing from 11.8 to 29.0 percent) while the fraction of workers completing only primary-level education or less fell by more than one-third (decreasing from 82.2 to 59.7 percent) (Barro and Lee 2000, cited in Sánchez–Páramo and Schady 2003). It is important to take into account these changes when estimating the demand for workers with different skill levels. In order to do so, we extend Card and Lemieux's basic framework to a nested model with constant elasticity of substitution (CES) where we abandon the assumption that workers with primary and secondary education are perfect substitutes in production.

The second and more important contribution of our paper is substantive. On the basis of the nested CES model, we estimate the elasticity of substitution between workers having completed primary and secondary education, between workers of different ages, and between workers having completed tertiary and less than tertiary (primary plus secondary) education. We use the nested CES model to estimate the extent to which there were demand–side changes favoring skilled workers in Latin America.

Related Literature

The literature on the effects of supply and demand factors on the evolution of the relative wages of skilled and unskilled workers in economically developed countries, in particular the United States, is extensive. Important contributions include Katz and Murphy (1992), Katz and Autor (1999), Feenstra and Hanson (1996), Autor et al. (1998), Berman et al. (1998), Machin and Van Reenen (1998), Card and Lemieux (2001), and Card and DiNardo (2002). While there is no consensus among these researchers, most agree that a combination of skill–biased technological change, trade and outsourcing reforms, and the deceleration in the supply of college graduates among the baby boom cohort, led to a dramatic increase in the wage premium paid to skilled workers, especially in the 1980s. For example, the figures summarized in Katz and Autor (1999) reveal that between 1979 and 1995, the real wages of high school dropouts in the USA fell by 19 percent while those of workers with postgraduate education increased by 14 percent.

A substantial literature also exists that considers the evolution of wages in the developing world, including in Latin America. Most of these studies have been country–specific, and they generally consider the impact of a particular set of reforms. Many of the better–known and more convincing studies have focused on the impact of trade liberalization. For example, Attanasio et al. (2004) analyzed the effects of trade liberalization in Colombia while Pavcnik et al. (2005) studied the effects of tariff reductions on the evolution of industry wage premia, including premia to skills, in Brazil. In a similar vein, Revenga (1997) analyzed the relationship between trade liberalization and wage inequality in Mexico, while Galiani and Sanguinetti (2003) focused on Argentina. Feenstra and Hanson (1997), meanwhile, analyzed the effects of Foreign Direct Investment (FDI) on wages in the *maquiladora* (assembly plant) sector in Mexico. Other papers investigated the role played by technology: Pavcnik (2002) and

Kugler (2002) suggested a complementary relationship between skill-upgrading and adoption of new technology by firms in Chile and Colombia, respectively.

Behrman et al. (2007) is an important exception to these country-specific studies. They used household surveys for a large number of Latin American countries to trace out the evolution of the tertiary-secondary and tertiary–primary wage gaps in the region and to relate the evolution of these wage gaps to indices of policy reforms, developed by Lora (2001), including trade policy, privatization, capital account policy, and tax policy. On the basis of a series of cross-country regressions with these data, Behrman et al. concluded that liberalizing policy changes increased wage dispersion in Latin America, although the effects tend to become weaker over time. However, unlike our paper, Behrman et al. did not attempt to identify the contribution of changes in the supply and the demand for skills on the evolution of wages.

Data and Basic Trends

In this section, we present information on wages and labor supply for individuals with different levels of education using data from labor force surveys for Argentina, Brazil, Chile, Colombia and Mexico. Because survey coverage varies across countries, the sample is limited to urban areas only to ensure comparability. A detailed description of data sources and information on the criteria used to construct the sample are 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). All calculations are based on data for both formal and informal salaried workers. Following Card and Lemieux (2001), we use different samples to calculate each measure. Wage trends are based on a sample of full-time male employees who have completed primary, secondary, or tertiary education while supply trends are based on a sample of both female and male workers having completed any level of instruction between incomplete primary and completed tertiary. For the purpose of this second calculation, we attribute those with incomplete levels of instruction 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," as is common in the literature (see, for example, Katz and Murphy 1992; Card and Lemieux 2001).

To calculate average wage premia, (log) earnings are regressed on age and age squared, education dummies for secondary and tertiary education, and year dummies. The coefficients on the education dummies 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 having completed secondary education are paid approximately 45 percent more than those having completed primary education in Argentina and Colombia, and 83 percent more in Brazil. Similarly, wages of individuals having completed college are approximately 90 percent higher than those of workers with secondary education in Chile, but only 45 percent higher than the wages of workers in Argentina and Mexico.

Table 1 reports averages for a number of labor supply measures, including total population, labor force, employment, and hours accounted for by individuals in each education group. The patterns observed are fairly robust to the choice of supply measure. The table also reports employment, unemployment, and participation rates by education level. Workers with a primary school education account for 50 to 60 percent of the labor supply. An additional 25 to 30 percent of the labor supply has a secondary school education, and the remaining 15 to 20 percent has a college education. The exception is Chile, where 50 percent of the labor supply has completed high school but only 30 percent has completed solely primary school. Employment and participation rates increase with education; that is, unemployment rates are highest among those with a primary school education and lowest for those with a college education.

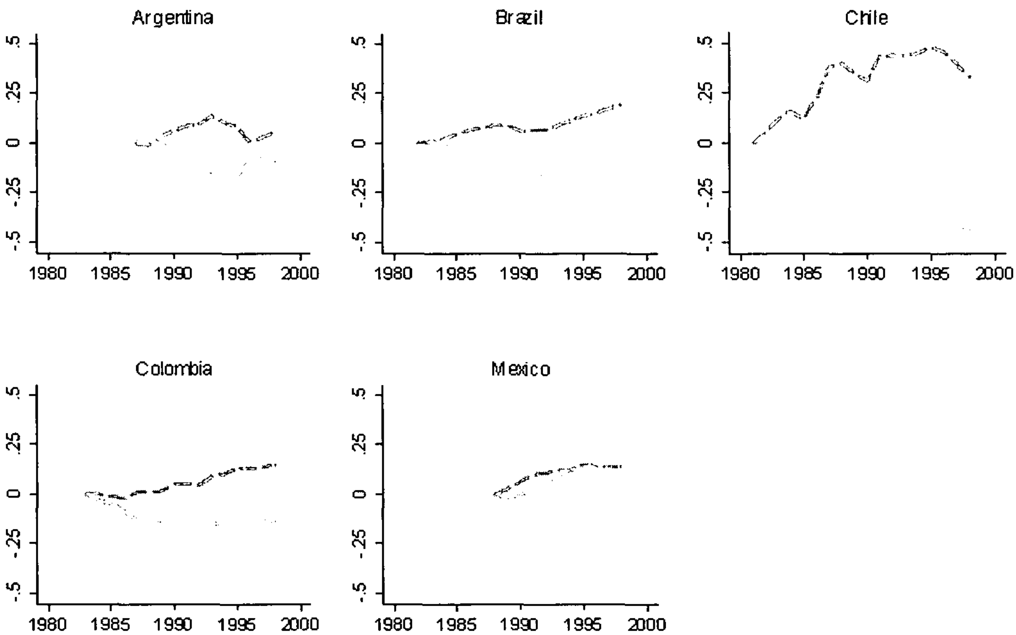
Table 1. Wages and Labor Supply by Education

	Argentina	*Brazil*	*Chile*	*Colombia*	*Mexico*
Returns to education					
Secondary-Primary	0.479	0.832	0.636	0.470	0.575
Tertiary-Secondary	0.448	0.837	0.896	0.701	0.474
% Population					
Primary	0.557	0.635	0.352	0.569	0.571
Secondary	0.277	0.240	0.492	0.293	0.283
Tertiary	0.166	0.126	0.157	0.137	0.146
% Labor Force					
Primary	0.522	0.595	0.319	0.527	0.529
Secondary	0.279	0.251	0.482	0.303	0.278
Tertiary	0.199	0.154	0.199	0.170	0.193
% Employment					
Primary	0.513	0.592	0.309	0.523	0.53
Secondary	0.281	0.25	0.482	0.303	0.277
Tertiary	0.206	0.158	0.209	0.174	0.193
% Hours					
Primary	0.519	0.614	0.312	0.536	0.538
Secondary	0.282	0.244	0.489	0.300	0.275
Tertiary	0.198	0.142	0.199	0.163	0.187
Employment to population rate					
Primary	0.608	0.655	0.561	0.634	0.570
Secondary	0.668	0.734	0.626	0.712	0.603
Tertiary	0.817	0.882	0.849	0.876	0.814
Unemployment rate					
Primary	0.086	0.053	0.109	0.082	0.021
Secondary	0.063	0.052	0.080	0.079	0.024
Tertiary	0.042	0.024	0.035	0.051	0.024
Participation rate					
Primary	0.665	0.691	0.629	0.691	0.582
Secondary	0.713	0.774	0.681	0.773	0.618
Tertiary	0.853	0.903	0.880	0.923	0.834

Note: Table 1 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 having completed secondary and primary education, 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 who have completed precisely primary, secondary, or tertiary levels of education. The following rows report the time averages of the distribution of population, labor force, employment, and hours worked in terms of education equivalents (primary, secondary and tertiary). Data on supply are obtained pooling all individuals (males plus females) in the sample whether or not they have completed primary, secondary and tertiary education. For data sources and definitions see the Data Appendix.

We next examine changes in relative wages and labor supply over time. For each country, Figure 1 plots the returns to tertiary education relative to secondary, and returns to secondary education relative to primary, during the years between 1980 and 2000. Returns are estimated from earnings regressions and are standardized to zero at the beginning of the period. Relative returns to tertiary education generally increase and relative returns to secondary education decrease over time in all countries—the one exception being the increase in the return to secondary education relative to primary education in Mexico. 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 education

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 to one if the individual has completed at least secondary education, a dummy equal to one if the individual has completed at least 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.

has remained roughly constant over time. In other words, workers with a secondary school education seem to have lost ground relative both to those with tertiary and to those with primary school education during this period in all countries but Mexico. This pattern is similar to what Autor et al. (2006, 2008) have reported for the United States over the last decade or so, with increases in wage inequality at the top of the distribution, and no changes (or possibly even declines) at the bottom. Autor et al. argued that the demand for skills has become increasingly "polarized," to the detriment of workers with intermediate skill levels.

Figure 2 plots the labor supply of workers with tertiary education relative to those with secondary education, and workers with secondary education relative to those with primary education. Here, we measure labor supply as a percentage of the total population with different levels of education and standardize all series to zero at the beginning of the period. The relative supply of workers having completed secondary school increases in all countries, with annual growth rates ranging from 3 percent in Mexico to about 5 percent in both Chile and Colombia. These changes reflect widespread public efforts to increase secondary school enrollment. In contrast, changes in the relative supply of college-educated workers vary significantly across countries. In most countries, the supply of workers with tertiary education relative to that of workers with secondary school education remained roughly constant during the 1980s; in the 1990s, this relative supply grew in Argentina and Chile, declined slightly in Brazil, and remained stable in Colombia. Mexico is the only country in the sample where the supply of college-educated workers increased faster than that of workers with a secondary school 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 the relative supply of these workers was fairly stable or growing (Brazil is an exception). Increases in relative wages that coincide with increases in relative supply clearly suggest demand-side changes favoring the most skilled. On the other hand, the wage premium of workers with a secondary school education fell as their relative supply increased in all countries except 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.

Model and Empirical Strategy

In order to allow for the treatment of three education groups—primary, secondary and tertiary—we develop a nested model that extends that of Card and Lemieux (2001). Being able to identify changes in relative demand and supply for these groups is crucial for our analysis since we have observed some deterioration in the relative wages of secondary workers compared to *both* the tertiary and the primary education groups in most of the countries in our sample.

In defining "skilled" workers as those with a college education, we follow Card and Lemieux (2001) and virtually all of the literature on the United States. Further, this is the approach taken by the bulk of studies on Latin America (for example, Pavcnik et al. 2005, and Green, Dickerson, and Arbache 2001 for Brazil; Galiani and Sanguinetti 2003 for Argentina; Robbins and Gindling 1999 for Costa Rica; see also a recent review on developing countries by Goldberg and Pavcnik 2007, who focused on this breakdown). Unlike Card and Lemieux, however, we allow for primary and secondary workers to be imperfect substitutes in production.

Theoretical Model

Whereas factor demand is a function of the marginal productivity of labor, we assume that supply is exogenously given and that wages are determined by the interaction of a downward sloping labor demand curve and a vertical labor supply curve. The representative firm produces under constant elasticity of substitution (CES) technology and uses two labor inputs with different skill levels. For simplicity, capital is maintained in the background. Then:

$$Y_t = A_t(N_{Ut}^{\rho}+\alpha_t N_{St}^{\rho})^{1/\rho} \tag{1}$$

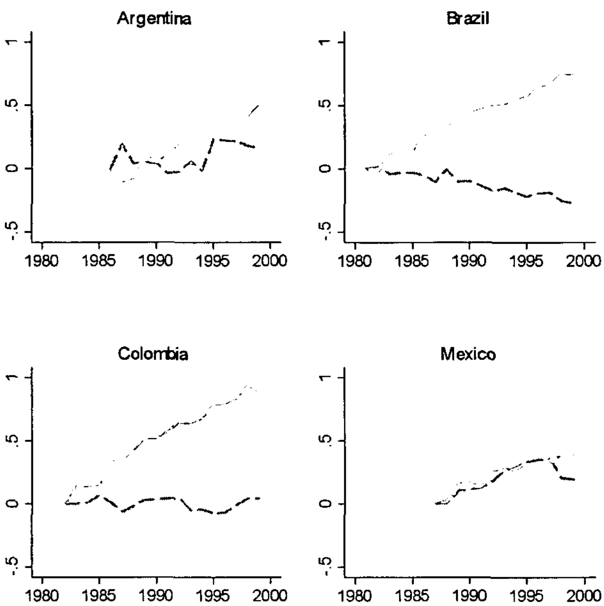
where Y is total output; A is skill-neutral technological change; N is employment; U denotes workers with less than tertiary education to whom, for consistency with Card and Lemieux and many others, we refer as "unskilled"; S is "skilled" labor; t is time, and $\rho < 1$ is a function of the elasticity of substitution between skilled and unskilled labor. Denote this elasticity of substitution by σ_E, where $\sigma_E = 1/(1-\rho)$. The parameter α_t is a measure of the relative productivity of skilled workers relative to unskilled workers at time t. The coefficient on N_{Ut} is normalized to be one—an innocuous transformation that defines the units of measurement of A_t.

In constructing the employment measures for each skill group, we allow for differences in productivity across workers with the same level of education but of different ages, and we define the employment of each skill group as a productivity-weighted CES combination of all age groups of individuals in that skill level. That is:

$$N_{jt} = (\Sigma\beta_{ja}N_{jat}^{\delta})^{1/\delta} \quad j = S,U \tag{2}$$

where a denotes a generic age group and δ is a function of the elasticity of substitution between different age groups. This elasticity of substitution, σ_A, where $\sigma_A = 1/(1-\delta)$, is assumed to be the same across skill groups and for any pair of age-specific inputs. β_{ja} is a measure of the relative productivity of

Figure 2. The Evolution of Relative Labor Supply by Education in Five Latin American Countries



Notes: Figure 2 reports the relative supply of workers with tertiary education versus secondary education (dashed line) and secondary education versus primary education (solid line) by time in each country. See text for details.

age-group a with skill level j, which is taken to be time-invariant, thereby ruling out age-biased demand changes.

So far, the model is identical to Card and Lemieux (2001). In contrast with Card and Lemieux, however, the model allows for the age-specific supply of unskilled labor to be a CES combination of the two low-level education groups—primary- and secondary-level (respectively denoted by 1 and 2)—while the skilled group (S) represents workers with a tertiary education (denoted by 3, so that $S \equiv 3$ and $N_{Sat} \equiv N_{3at}$). This implies:

$$(3) \qquad N_{Uat} = (\gamma_a N_{1at}^{\theta} + N_{2at}^{\theta})^{1/\theta}$$

where γ_a is a measure of the relative productivity of primary workers relative to secondary workers and $\sigma_U = 1/(1-\theta)$ is the elasticity of substitution between these two groups. Note that when $\theta = 1$, workers with primary- and secondary-school education are perfect substitutes for each other. This is, in effect, the model used by Card and Lemieux (2001).

Under the assumption that labor and product markets are perfectly competitive, (1) to (3) can be manipulated to derive expressions for the wages of individuals of age a and of education level e ($e = 1, 2, 3$) at time t:

$$(4) \qquad w_{3at} = X_t + ln\alpha_t + ln\beta_{3a} - 1/\sigma_E n_{3t} - 1/\sigma_A(n_{3at} - n_{3t})$$

$$(5) \qquad w_{2at} = X_t + ln\beta_{Ua} - 1/\sigma_E n_{Ut} - 1/\sigma_A(n_{Uat} - n_{Ut}) - 1/\sigma_U(n_{2at} - n_{Uat})$$

$$(6) \qquad w_{1at} = X_t + ln\beta_{Ua} + \ln\gamma_a - 1/\sigma_E n_{Ut} - 1/\sigma_A(n_{Uat} - n_{Ut}) - 1/\sigma_U(n_{1at} - n_{Uat})$$

where $X_t = \rho\ln(A_t) + (1-\rho)\ln(Y_t)$, $n = \ln N$, $w = \ln W$ and W denotes wages.

Equations (4) to (6) constitute the basis of our empirical analysis. They illustrate that (log) wages are a function of Total Factor Productivity, represented by X_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_{3t} ($\equiv n_{Ht}$) and n_{Ut}. The coefficient on this term is a transformation of the elasticity of substitution between unskilled (U) and skilled (S) workers, σ_E. The second supply term captures changes in the age composition of each skill group, $n_{jat} - n_{jt}$ ($j = S, U$). The coefficient on this term is a transformation of the elasticity of substitution between workers of different ages within each skill group, σ_A. Finally, the third supply term, which only appears in (5) and (6), represents changes in the composition of the supply of unskilled (U) workers within each age–time cell, $n_{eat} - n_{Uat}$ ($e = 1, 2$). The coefficient on this term is a transformation of the elasticity of substitution between workers with primary and secondary education, σ_U.

Empirical strategy

The main objective of our empirical strategy is to obtain estimates of α_t that capture differences in relative productivity and hence relative demand between skilled and unskilled workers. To estimate these parameters we follow the strategy proposed in Card and Lemieux (2001), appropriately modified to account for the fact that our production function is modeled as a nested CES process with three production inputs. In practice, this is a three–step process:

Step 1–The first step produces estimates of the elasticity of substitution between primary and secondary workers, σ_U, and the efficiency of primary workers relative to secondary workers γ_a, which can be used to construct N_{Uat}. Subtracting w_{2at} from w_{1at} using (5) and (6) one obtains:

$$(7) \qquad w_{1at} - w_{2at} = d_a - 1/\sigma_U (n_{1at} - n_{2at})$$

where d_a is a set of unrestricted age dummies, which account for log relative productivity of primary to secondary workers ($\ln \gamma_a$). In practice, log wage differentials between primary and secondary workers by age and time are regressed on their relative labor supply plus age dummies to obtain estimates of γ_a and σ_U. Since there is strong evidence in the data of a dramatic shift in the wage structure in Mexico following the implementation of NAFTA, this and the following regressions include unrestricted year-age-education interaction dummies for Mexico post–1993.[1] Finally, we complete this step by taking these estimates back to (3) to compute N_{Uat}.

Step 2–The second step produces estimates of the elasticity of substitution between age groups, σ_A, and of all age-specific productivity measures, β_{ja}, that can be used to construct N_{jt} ($j = S, U$). From (4) to (6) and after some manipulation, we obtain:

$$(8) \qquad w_{eat} - w_{3at} = d_t + d_{ea} - 1/\sigma_A (n_{Uat} - n_{3at}) - 1/\sigma_U (n_{eat} - n_{Uat}) \quad e = 1,2$$

where d_{ea} represent unrestricted age–education effects and d_t represent unrestricted time effects. In particular $d_{2a} = \ln\beta_{Ua} - \ln\beta_{3a}$, $d_{1a} = d_{2a} + \ln\gamma_a$ and $d_t = -\ln\alpha_t - (1/\sigma_E - 1/\sigma_A)(n_{Ut} - n_{3t})$.

This exercise produces an estimate for σ_A (as well as a new estimate of σ_U) which can then be plugged back into (5) and (6) to obtain:

$$(9) \qquad w_{3at} + 1/\sigma_A \, n_{3at} = d_{3t} + ln\beta_{3a}$$

$$(10) \qquad w_{2at} + 1/\sigma_A \, n_{Uat} + 1/\sigma_U (n_{2at} - n_{Uat}) = d_{Ut} + ln\beta_{Ua}$$

$$(11) \qquad w_{1at} + 1/\sigma_A \, n_{Uat} + 1/\sigma_U (n_{1at} - n_{Uat}) - ln\gamma_a = d_{Ut} + ln\beta_{Ua}$$

where the left-hand side of each equation represents (log) wages corrected for labor supply, $d_{3t} = X_t + \ln\alpha_t - (1/\sigma_E - 1/\sigma_A)\, n_{3t}$ and $d_{Ut} = X_t - (1/\sigma_E - 1/\sigma_A)\, n_{Ut}$. In practice, the adjusted (log) wages are regressed on skill ($j = S, U$) dummies interacted with age dummies to produce the estimated age effects β_{ja}. Finally, we complete this step by taking

[1]Results are essentially unchanged if we exclude Mexico from the sample. Indeed, the additional controls for Mexico post-1993 imply that Mexico does not really contribute to the identification of the regression parameters.

Table 2. First Step Estimates
Dependent Variable: Relative Wages by Age and Time
Primary Relative to Secondary Workers

	(1)	*(2)*	*(3)*	*(4)*
		Measure of Supply		
	Population	*Labor Force*	*Employment*	*Hours*
$-1/\sigma_U$	−0.350***	−0.352***	−0.350***	−0.325***
	(0.024)	(0.024)	(0.024)	(0.023)
Observations	248	248	248	248
Adjusted R^2	0.84	0.83	0.83	0.83

Notes: Table 2 reports the GLS estimates of equation (7) in the text. The reported coefficient is the negative of the inverse of the elasticity of substitution between primary and secondary workers. 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.
*Statistically significant at the .10 level; **at the .05 level; ***at the .01 level (two-tailed tests).

these estimates back to (2) together with σ_A to construct N_{St} and N_{Ut}.

Step 3 – The third and final step produces an estimate of the elasticity of substitution between skilled and unskilled workers, σ_E. From (4) to (6) and assuming that the relative demand for skilled versus unskilled workers follows a linear trend over time, so that $\ln\alpha_t = f_0 + f_1 t$, we obtain:

$$(12) \quad w_{eat} - w_{3at} = f_0' - f_1\, t + d_{ea} - 1/\sigma_E (n_{Ut} - n_{3t}) - 1/\sigma_A [(n_{Uat} - n_{Ut}) - (n_{3at} - n_{3t})] - 1/\sigma_U (n_{eat} - n_{Uat}) \qquad e = 1,2$$

where the left-hand side of the equation represents (log) wage differentials of (unskilled) workers possessing primary- and secondary-level education relative to those (skilled) workers possessing tertiary-level education; the coefficient f_1 captures demand-side changes favoring skilled workers. The coefficient on the first labor supply term provides an estimate of σ_E. The coefficients on the other terms provide new estimates of σ_A and σ_U.

Results

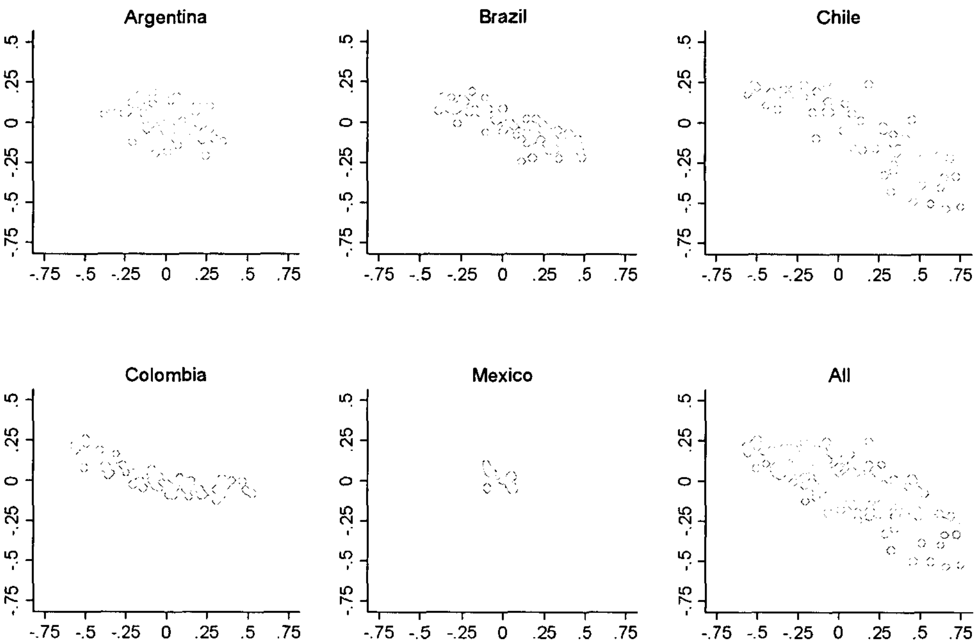
Implementing the empirical strategy described above and using the wage and labor supply data described in the section on basic trends, we present both regression results and graphs that illustrate the different sources of variation in the data. Individuals are grouped into three–year birth cohorts. The Data Appendix describes in detail how wage and supply differentials are computed based on the micro data and how the aggregation into cells is performed. To improve the precision of the estimates, data from all five countries are pooled together, restricting σ_E, σ_A and σ_U (but not the γ_as, the β_{ja}s and f_1) to be the same across all countries. We consider four labor supply measures: total population, labor force, employment, and hours worked, the latter two of which are commonly used in the literature for developed countries (Katz and Murphy 1992; Card and Lemieux 2001). These measures are adequate if labor supply is exogenous, so that the labor supply curve is completely inelastic with respect to wages. In countries with high unemployment, however, including some of the countries in our sample, this assumption may not be realistic. Under these circumstances, labor force, or even total population, can be better measures of labor supply.[2]

Main results

Step 1: Results from estimating equation (7) are presented in Table 2. To account for the

[2]If this is the case, though, the estimated coefficients, despite being consistent, are a combination of labor supply and labor demand parameters.

Figure 3. First Step Estimates
Regression-Adjusted Relative Wages and Relative Supply by Age and Time
Primary Relative to Secondary Workers



Note: Figure 3 shows the fit of equation (7) in the text. See text for details.

fact that relative wages by cell are computed on samples of 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). Standard errors are clustered at the country level throughout.

Estimates of σ_U are remarkably similar across specifications, demonstrating that workers with primary and secondary education are not perfect substitutes for each other in Latin America. For example, when population is used as a measure of supply, the coefficient on $-1/\sigma_U$ is -0.350 (s.e. 0.024), which implies that the elasticity of substitution between workers with primary and secondary education is 2.29 (= 1/0.350).

Figure 3 illustrates how well the model fits the data. The figure plots the residuals from country-specific regressions of log wage differentials between workers having completing primary- and secondary-level education ($w_{1at} - w_{2at}$) on age dummies on the vertical axis, and the residuals of country-specific regressions of log relative supply of the same groups ($n_{1at} - n_{2at}$) on the age dummies on the horizontal axis (equation 7). Labor supply in this figure is defined in terms of population, as in column (1) of Table 2. The figure also includes the GLS regression line. The last graph pools observations from all countries. There is clear evidence of a negative relationship between the relative wages of workers with these two levels of schooling and their relative employment across all countries; results do not appear to be driven by specific observations or countries.

Step 2: Table 3 demonstrates that the coefficient on $-1/\sigma_A$ in equation (8) is very small and not significant at conventional levels. In contrast to what has been found in the United States, the United Kingdom, and Canada

Table 3. Second Step Estimates
Dependent Variable: Relative Wages by Age and Time
Primary and Secondary Workers Relative to Tertiary Workers

	(1)	(2)	(3)	(4)
	Measure of Supply			
	Population	*Labor Force*	*Employment*	*Hours*
$-1/\sigma_U$	−0.367***	−0.369***	−0.366***	−0.342***
	(0.036)	(0.037)	(0.037)	(0.035)
$-1/\sigma_A$	−0.002	0.004	−0.006	−0.024
	(0.040)	(0.041)	(0.042)	(0.043)
Observations	496	496	496	496
Adjusted R^2	0.96	0.96	0.96	0.96

Notes: The table reports the GLS estimates of equation (8) in the text. The coefficient in the second row is the negative of the inverse of the elasticity of substitution between workers of different ages. The first row reports the second step estimate of the coefficient in Table 2. See also notes to Table 2.

(where this elasticity is estimated to be on the order of 5), it appears that different age inputs are close to being perfect substitutes in production in Latin America.

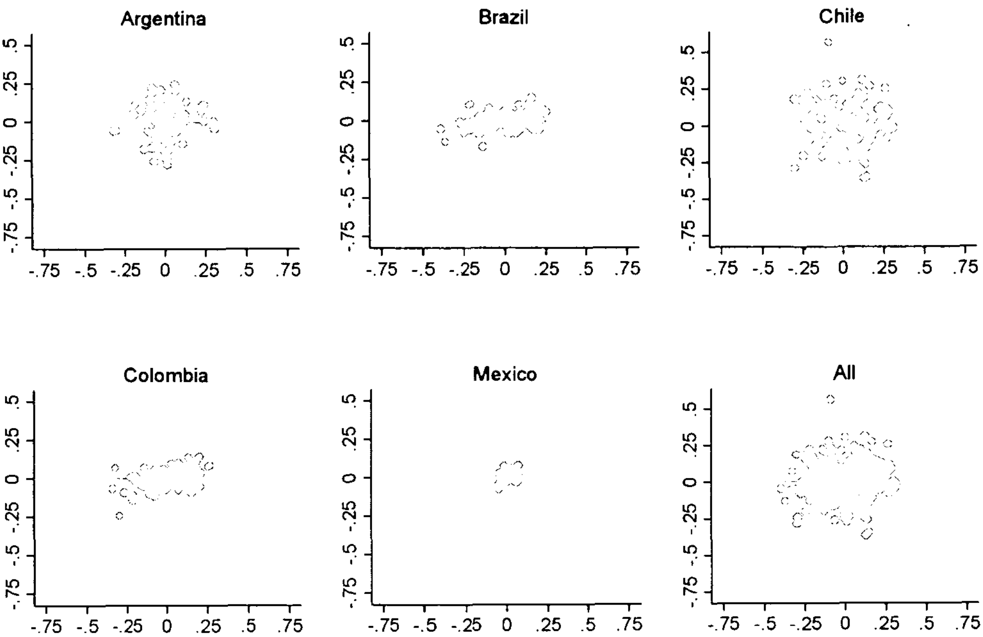
This correlation is also evident in Figure 4, which summarizes the regression-adjusted correlation between wages by age and time of unskilled (or less educated) workers relative to skilled (or more educated) workers. These figures are obtained as residuals from regressions of relative wages ($w_{eat} - w_{3at}$, on the vertical axis) and relative skilled to unskilled supply ($n_{Uat} - n_{3at}$, on the horizontal axis) on year dummies, age-education interaction dummies and within-unskilled relative labor supply ($n_{eat} - n_{Uat}$) (see equation 8). Figure 4 clearly illustrates that relative wages remain essentially constant though relative supply varies.

Estimates of the coefficient $-1/\sigma_U$ in the first row of Table 3 are similar to those in Table 2, which provides an internal consistency check. We use these estimated coefficients to obtain estimates of the β_{ja} based on equations (9) to (11) (regressions not reported). These values of σ_U and σ_A are then used to compute N_{jt}, based on equation (2).

Step 3: Finally, we turn to the estimation of equation (12) to obtain the elasticity of substitution between skilled (S) and unskilled (U) workers, σ_E, and a measure of demand-side changes favoring skilled workers, $\ln\alpha_t$. These results are presented in Table 4. The first two rows of the table illustrate that workers with primary- and secondary-level education are imperfect substitutes (as in Tables 2 and 3), but there is no evidence of imperfect substitution across workers of different ages (as in Table 3). The third row in the table contains estimates of σ_E, the elasticity of substitution between skilled and unskilled workers. These estimates range from approximately 2.6 when *hours* is used as the measure of supply, to approximately 5 with the measures of labor force or population. The lower panel of the table suggests that there have been significant trends in the demand for skilled workers in every country in the region, regardless of the measure of supply that is used. For example, with the measure of population, the annual trends in demand favoring skilled workers range from 0.004 in Brazil to 0.035 in Mexico.

Figure 5 shows the time-series correlation between relative wages and the relative labor supply of unskilled to skilled workers. To obtain these series, we regressed the relative wages of skilled to unskilled workers by age and time ($w_{eat} - w_{3at}$) on a linear time trend; age-education interaction dummies; the supply of unskilled workers relative to skilled workers by age and time, standardized to the overall relative supply by time ($n_{Uat} - n_{3at} - (n_{Ut} - n_{3t})$); and the supply of workers with primary and secondary education relative to the overall supply of unskilled labor ($n_{eat} - n_{Uat}$), explained by equation (12). As before,

Figure 4. Second Step Estimates
Regression-Adjusted Relative Wages and Relative Supply by Age and Time
Primary and Secondary Workers Relative to Tertiary Workers



Note: Figure 4 shows the fit of equation (8) in the text. See text for details.

we use population as a measure of labor supply. The residuals from these regressions are averaged across age groups using the same weights used in the regressions; these average residuals are plotted on the vertical axis. We proceed in a comparable fashion for the relative supply of unskilled to skilled workers ($n_{Ut} - n_{3t}$). These residuals are then plotted on the horizontal axis. The sample is split into three sub-periods 1981–1986 (denoted by 83), 1987–1993 (denoted by 90), and 1994–1999 (denoted by 97). Figure 5 demonstrates a negative correlation between wages and the supply of skilled to unskilled workers. Broadly speaking, observations for the early 1980s and late 1980s through the early 1990s are located around the origin or to the southeast of it while observations for the late 1990s are located to the northwest of it. The results suggest that the growth in the relative supply of skilled versus unskilled labor tended to accelerate in the late 1990s while relative wages tended to decelerate.[3]

In sum, the data show clear evidence of a rise in the relative demand for skilled workers, which was only partly compensated by a rise in their relative supply. Workers with secondary-level education experienced a deterioration in their relative position in their labor market due to adverse supply and demand shocks.

Robustness checks

We performed a large number of robustness checks to our basic estimates, all of which are summarized in Table 5. In all of these regressions we use the shares of the population with different education levels (rather

[3]Recall that the regressions condition on a linear time trend, so only variations around this trend can be identified.

Table 4. Third Step Estimates
Dependent Variable: Relative Wages by Age and Time
Primary and Secondary Workers Relative to Tertiary Workers

	(1)	(2)	(3)	(4)
	Measure of Supply			
	Population	*Labor Force*	*Employment*	*Hours*
$-1/\sigma_U$	−0.348***	−0.349***	−0.347***	−0.325***
	(0.041)	(0.042)	(0.041)	(0.039)
$-1/\sigma_A$	−0.061	−0.061	−0.056	−0.073
	(0.044)	(0.045)	(0.046)	(0.046)
$-1/\sigma_E$	−0.222**	−0.194	−0.334***	−0.390***
	(0.106)	(0.121)	(0.114)	(0.108)
Trends in demand				
Skilled – Unskilled				
*Argentina	0.006*	0.004	0.006*	0.007**
	(0.003)	(0.003)	(0.003)	(0.003)
*Brazil	0.004**	0.003	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
*Chile	0.017***	0.015***	0.017***	0.018***
	(0.003)	(0.003)	(0.003)	(0.003)
*Colombia	0.008***	0.007***	0.008***	0.008***
	(0.003)	(0.002)	(0.002)	(0.002)
*Mexico	0.035***	0.032**	0.037***	0.040***
	(0.014)	(0.013)	(0.013)	(0.013)
Observations	496	496	496	496
Adjusted R-squared	0.94	0.94	0.94	0.94

Notes: Table 4 reports the GLS estimates of equation (12) in the text. The coefficient in the third row is the negative of the inverse of the elasticity of substitution between skilled and unskilled labor. The first and second rows report step 3 estimates of the coefficients in Table 3. The following rows reports country-specific trends in the relative demand for skilled labor. See also notes to Table 2.

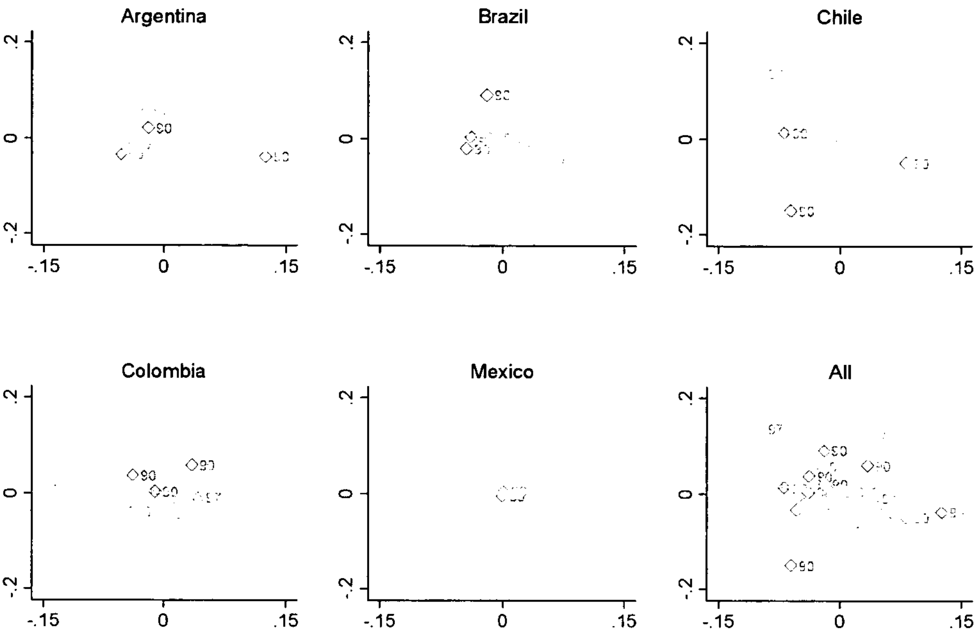
than labor force, employment, or hours) to define labor supply, and we report only the last step of the estimation, just as we did in column 1 of Table 4. Below, we discuss several potential concerns regarding our methods and interpretation.

The first concern relates to the way in which we measure labor supply. Following Card and Lemieux (2001), we use both men and women. Simply adding up data for male and female workers to construct supply measures is legitimate if these workers are perfect substitutes in production, so that an increase in male and female labor supply has the same impact on wages of male workers. This assumption, however, may be problematic; for example, Topel (1994) argued that highly skilled women might be substitutes for less skilled men in the United States. As a robustness check, we present estimates that assume that the elasticity of substitution between men and women is 2, 10, or 20.[4] Results based on these different measures of labor supply are reported in columns 1 through 3 of Table 5. These results show that our estimates are very similar, no matter what we assume the elasticity of substitution between men and women to be.

Second, it could be argued that demand and supply changes are correlated with institutional changes in the labor market. There is considerable evidence that labor market institutions affect the distribution of wages in OECD countries (see Blau and Kahn 1996 and 1999). In Latin America, minimum wages appear to affect wage inequality at the bottom of the distribution (Maloney and Nunez

[4]An alternative approach would be to estimate this parameter based on the data, but this would imply using female wages, with the well known problems related to endogenous participation of women in the labor market.

Figure 5. Third Step Estimates
Regression Adjusted Relative Wages and Relative Supply by Time
Unskilled Relative to Skilled Workers



Note: Figure 5 shows the fit of equation (12) in the text. See text for details.

2004; Bosch and Manacorda 2008). This raises the possibility that we could be confounding demand-side changes with the deregulation of the labor market that took place in much of Latin America beginning in the 1980s.

To test this proposition, we include in our regressions an index of labor market reforms developed by Lora (2001), which comprises four aspects of policy reforms: ease of hiring, ease of layoff, flexibility of work day, and social security contributions as a proportion of salaries. A higher value of the index implies a more "flexible" labor market. Because this index is only available from the mid-1980s, we run regression on a restricted sample for which the index is available. In column 4, we include the index of labor market flexibility instead of a time trend. The coefficient on this index is 0.005 and is nowhere near conventional levels of significance. In column 5, we add a linear trend that is the same across countries. We therefore identify the effect of labor market institutions based on the deviation in country policies from a common regional trend. Once again, although the coefficient on the index is positive, it is not significant, whereas the common trend is positive and significant. More importantly, the other parameters are similar to those in column 4 (as well as to those in column 1 of Table 4). We conclude from these checks that the institutional changes in the labor market are likely to have had only a modest effect on the evolution of wage differentials between skilled workers (with tertiary education) and unskilled workers (less than tertiary education—perhaps because labor market institutions have an effect primarily at the bottom of the wage distribution in Latin America.

A third concern regarding our estimates is that our sample is restricted to urban areas. In many developing countries (including in

Table 5. Robustness Checks
Dependent Variable: Relative Wages by Age and Time
Primary and Secondary Workers Relative to Tertiary Workers

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
	Different values of elasticity of substitution between men and women			*Including index of labor market flexibility*		*2SLS (using Census data)*
	2	*10*	*20*			
$-1/\sigma_U$	−0.215***	−0.283***	−0.290***	−0.378**	−0.375**	−0.332**
	(0.030)	(0.033)	(0.035)	(0.128)	(0.133)	(0.099)
$-1/\sigma_A$	−0.058	−0.071	−0.070	0.048	−0.026	−0.127
	(0.163)	(0.136)	(0.133)	(0.080)	(0.076)	(0.587)
$-1/\sigma_E$	−0.214**	−0.362**	−0.381**	−0.048	−0.221	−0.288
	(0.076)	(0.117)	(0.122)	(0.058)	(0.113)	(0.389)
Trends in demand Skilled – Unskilled						
					0.007*	
					(0.003)	
*Argentina	0.015**	0.010*	0.010			0.007
	(0.004)	(0.005)	(0.005)			(0.009)
*Brazil	0.011***	0.005**	0.005**			0.007
	(0.002)	(0.001)	(0.001)			(0.009)
*Chile	0.024***	0.023***	0.023**			0.031**
	(0.004)	(0.005)	(0.005)			(0.001)
*Colombia	0.019**	0.011*	0.010*			0.007
	(0.005)	(0.004)	(0.004)			(0.019)
*Mexico	0.050***	0.045***	0.045***			0.006
	(0.008)	(0.009)	(0.009)			(0.009)
Labor reform index				0.005	0.290	
				(0.308)	(0.374)	
Observations	448	448	448	448	448	160
Adj. R^2	0.94	0.94	0.94	0.94	0.95	0.98

Notes: Table 5 reports similar regressions to those in Table 4, column 1. Columns 1 to 3 use different values of the elasticity of substitution between men and women to compute the overall supply of labor. Columns 4 and 5 control for Lora (2001) index of labor market reforms. Column 5 instruments population in urban areas with population in both urban and rural areas using census data. See also notes to Table 4. Supply is given by the share of the population with different amounts of education.

Latin America), the proportion of workers in urban and rural areas changes over time as a result of differences in fertility rates and migration. If urban areas attract a selected sample of workers—in particular, if migration responds to returns to skills—our estimates could be biased by this margin of endogenous selection. There is no perfect solution for this possible problem: the surveys for Argentina, Chile, and Mexico cover only urban areas, and even for those countries where the sample covers the entire country, the measures of "wages" and "earnings" in rural areas are likely to be very poor—a well known problem with these data in developing countries.

To test whether selective migration is a source of serious concern for our estimates, we have integrated our analysis with micro data from the Integrated Public Use Microdata Series (IPUMS) version of the population censuses of the five countries under study (Minnesota Population Center 2008).[5]

[5]We used data from the following censuses: Argentina: 1991 and 2001; Brazil: 1980, 1991 and 2000; Chile: 1982, 1992, 2002; Colombia: 1985 and 1993, Mexico: 1990 and 2000.

Population censuses refer to the universe of the population (whether in urban or rural areas). However, because census data typically do not provide information on wages, we use these data to measure supply (in the entire country) and use survey data to measure wages (in urban areas). The basic model is then estimated by Two Stage Least Squares, with population in urban areas instrumented by the overall (urban plus rural) population in each cell. This process should rid the measure of supply of any potential correlation with the regression error term that arises from endogenous migration or changing composition of the urban sample. One drawback of this approach, however, is that the number of observations is substantially reduced because censuses are conducted on a decennial basis. The number of observations falls, therefore, by nearly two-thirds, from 496 to 160. Nevertheless, the results from these estimations, reported in the last column of Table 5, are in line with those reported in the main body of the paper. (They are less precise though, because of the smaller sample sizes and the mechanical loss of precision associated with the IV estimator.) The cofficient on $-1/\sigma_U$ is now estimated to be −0.332, and that on $-1/\sigma_E$ is −0.228 (though this is not significant). The coefficients on the trends for skilled workers are all positive although they are only significant for Chile. We conclude that although it is hard to rule out decisively that endogenous migration and compositional changes could introduce some biases, estimates that attempt to correct for this source of endogeneity are reasonably similar, and well within the confidence intervals, of our basic (uncorrected) estimates.

To test the robustness of our estimates even further, we performed a number of additional checks, which for the purposes of brevity we have not reported. First, we derived country-specific (rather than common) estimates of $1/\sigma_E$, $1/\sigma_A$, and $1/\sigma_U$ in an attempt to see whether pooling the data across countries is acceptable. These estimates tend to be quite noisy because of the small sample sizes. However, we can never reject the null that the $1/\sigma_E$ and $1/\sigma_U$ estimates are the same in the pooled and country-specific regressions. The $1/\sigma_A$ coefficients are different, although this is driven by only one country, Chile, where the results from the country-specific regressions suggest that workers of different ages are imperfect substitutes. We conclude from this check that pooling the data across countries, as we do, is reasonable, although some caution should be exercised given the lack of precision in the country-specific estimates.

One final concern is that our estimates might be affected by compositional effects induced by variations in unemployment along the business cycle. This is potentially a problem in Latin America, where unemployment is high. Our "baseline" measure of labor supply is based on population shares with different levels of education, so this margin of endogenous selection should not be an issue for these estimates. Nevertheless, as an additional check, we used a non-parametric strategy to derive bounds for the estimated coefficients under, respectively, perfect negative and positive selection. In practice, building on Johnson et al. (2000), we assume that all non-employed workers come from either the bottom or the top of the wage distribution in their cell. Assuming symmetry of wage distribution, this allows us to recover selection-adjusted mean log wages by cell.

Results lead to conclusions that are similar to those based on Table 4. That is, workers whose education consists of primary and secondary school are imperfect substitutes in production. The demand for skills has grown in all countries under study (with coefficients on the time trends between 0.01 and 0.51), while the elasticity of substitution between skilled and unskilled labor takes on a value between 3 and 4.

Conclusion

We have documented trends in returns to education in the urban areas of five Latin American countries during the 1980s and 1990s in order to estimate the magnitude of demand and supply shifts that have affected the wages of three broad educational groups corresponding to workers with primary, secondary, and tertiary education. Based on a nested CES model that allows for different elasticities of substitution across educational groups, our analysis takes into account the fact that workers of different ages are potentially imperfect substitutes in production and allows for a trend in relative demand for skilled versus unskilled workers. In contrast with results for the United States, the U.K., and Canada, we find that workers with primary-and secondary-level education are imperfect substitutes in production in Latin America. We estimate the elasticity of substitution between these two labor inputs to be on the order of 3, which explains why, as the share of workers with secondary education rose, their relative wages deteriorated sharply relative to those workers who possessed only primary education. We also find that workers of different ages (within each skill group) are very close substitutes in Latin America.

We build on these estimates to assess the role that changes in the demand and supply of skills have played in shaping the returns to education in Latin America. Our estimates of the elasticity of substitution between skilled and unskilled workers in the countries under study range from 2.6 to 5.2, depending upon the measure of labor supply used. Similar to findings for the United States, U.K., and Canada, our results suggest a generalized increase in the demand for skilled workers, which was only partly compensated by an increase in relative supply, so that skill premia increased in every country. Our results are robust to a number of checks that control for variations in unemployment along the business cycle, different degrees of substitution between men and women, endogenous migration, and explicit controls for labor market reforms.

Like many who have studied changes in the wage structure in the United States, we remain agnostic on a number of issues that deserve further consideration. For example, we do not investigate the reasons for the demand changes that occurred in Latin America; in particular, we do not analyze whether they were driven by skill-biased technological change, trade penetration, FDI flows, or other factors. We note, however, that extensive literature does exist, for the region, on the relationship between trade reforms and the evolution of relative wages. Much of this literature, in fact, suggests that trade openness is one of the reasons for the increased demand for skilled workers in Latin America, both because unskilled sectors were more protected prior to reforms (Attanasio et al. 2004; Revenga 1997), and because trade has been a conduit for the transmission of skill-biased technologies from North to South (Attanasio et al. 2004; Pavcnik et al. 2005; Sánchez-Páramo and Schady 2003).

Several areas besides changes in wage structure deserve further research. One such area includes possible changes in the quality of education, which could also have affected the evolution of relative wages. Indeed, changes in the returns to education might confound true changes in the price of skills with shifts in the levels of skills associated with each level of education. This inability to control adequately for changes in the quality of education is a common problem in the literature, and we note that our estimates therefore need to be interpreted with some caution. Finally, another area deserving further study is an analysis of the reason why demand-side trends favoring skilled workers appear to have been stronger in Mexico and Chile than they were in Argentina and Brazil. Being able to answer these and other questions would help round out the analysis in this (and other) papers. Notwithstanding these issues, we conclude from our analysis that it is likely that shifts in demand and supply of skills to the overall detriment of secondary school workers go a long way in explaining trends in the wage structure in Latin America in the 1980s and 1990s.

DATA APPENDIX

The Data used in this paper come from the individual records of five roughly consistent national household surveys and refer to urban areas only. Data for Argentina are based on the *Encuesta Continua de Hogares* (ECH) and refer only to Greater Buenos Aires since information for provinces other than Buenos Aires is not available for the 1980s. For 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), with the sample being restricted 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 refer only 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 limited the sample to municipalities that are sampled each year throughout the survey period. For both Colombia and Mexico, we appended 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 restricted the sample for our analysis to observations in the third quarter of each year and excluded individuals who have remained in the sample for more than four waves.

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

As a second step, and similar to Card and Lemieux (2001), we constructed 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 per week) employees, aged 26 to 56, who have completed specific levels of education (primary-, secondary-, or tertiary-level). We restricted the sample to all *salaried* employees, that is, all wage and salary earners, whether or not they are employed in formal or informal sectors. For all individuals in this wage sample, we constructed a consistent measure of earnings, obtained as monthly labor income in the main job divided by usual weekly hours of work. We dropped from this sample individuals whose wages were below the 1st percentile or were 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 26–56. In order to obtain measures of labor supply for primary- and secondary-school and tertiary equivalents, we proceeded as follows. Workers with more than completed tertiary (undergraduate) education are included in the tertiary category with their supply re-weighted by their wage relative to those who have (precisely) completed college. 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-level education are included in the primary school category with their labor supply weighted by their wage relative to those having completed primary school. 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 having completed college and those having completed secondary school. For example, if the difference in wages between those with some college and those with a secondary-level education is 30 percent of the difference in wages between those with a college degree and those with 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. In other words, we divide them between those who have completed secondary school and those who have completed primary school. The only exception is Chile, where secondary school dropouts earn less on average than those who have completed primary school only. In order to compute these weights, we use average relative wages over the entire 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, with the largest surveys 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 performed our regression analysis we grouped individuals into three-year time-cohort cells. For each country, we centered the three-year cells on the following mid points (where data are available): 1981, 1984, 1987, 1990, 1993, 1996, 1999. Similarly, we defined three-year birth-cohort cells with midpoints ranging from 1927 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 regressed 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 used the standard errors of these estimated coefficients as a measure of their precision. In particular, when we ran regressions, we weighted each variable by the reciprocal of the square of its standard error. In order to give the same weight to different countries, we standardized these weights to the total sum of weights in each country.

Table A1. Data Samples

Country	Source	Years of education corresponding to completed levels of education: Prim.	Sec.	Tert.	Period	Average yearly sample size: Labor supply sample	Wage 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.

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