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ON THE EVOLUTION OF TOTAL FACTOR PRODUCTIVITY IN LATIN AMERICA

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Because of several policy distortions, including import-substitution industrialization, widespread government intervention, and both domestic and international competitive barriers, there has been a general presumption that Latin America has been much less productive than the leading economies in the last decades. In this paper we show, however, that until the late 1970s Latin American countries had high productivity levels relative to the United States. It is only after the late 1970s that we observe a fast decrease of relative total factor productivity (TFP) in Latin America. We also show that the inclusion of human capital in the production function makes a crucial difference in the TFP calculations for Latin America. (*JEL* O11, O47, O54)

I. INTRODUCTION

Because of several policy distortions, including import-substitution industrialization, widespread government intervention, and both domestic and international competitive barriers, there has been a general presumption that Latin America has been much less productive than the leading economies in the last decades. Recent papers have provided evidence that is consistent with this hypothesis. In particular, Cole et al. (2005) found that average total factor productivity (TFP) in Latin America corresponded to roughly 50% of U.S. productivity between 1950 and 2000. The authors also argued that competitive barriers may explain why TFP is low in Latin America relative to the United States.

Some studies have documented a negative TFP growth rate in Latin America in the 1980s. Bosworth and Collins (2003) and Loayza, Fajnzylber, and Calderón (2005) show that average TFP in Latin America declined during this decade. Other studies have confirmed this finding for some specific countries, including Kydland and Zarazaga (2002) and Hopenhayn and Neumeyer (2006) for Argentina, Bergoing et al. (2002) for Mexico, and Bugarin et al. (2007) for Brazil.

In this paper we show, however, that until the late 1970s Latin American countries had high productivity levels relative to the United States. On average, TFP in Latin America corresponded to 82% of the United States between 1960 and 1980. It is only after the late 1970s that we observe a fast decrease of relative TFP in Latin America, which fell to 54% of U.S. TFP in 2007.

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ABBREVIATIONS

GDP: Gross Domestic Product
GGDC: Groningen Growth and Development Centre
LAP: Labor-Augmenting Productivity
TFP: Total Factor Productivity

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Blyde and Fernandez-Arias (2006) also presented some evidence that Latin America had high TFP relative to the United States in the 1960s and 1970s, and that it was lower in the 1990s.[1] Our main contribution is to document more systematically this stylized fact—this point was just one among many in their article—and examine to what extent this result is robust to the use of different methodologies and data sources. In particular, we consider the role of natural resources and human capital.

We first address the possibility that natural resources might account for the high relative TFP in Latin America between 1960 and 1980. We compute a measure of TFP adjusted for natural resources for the seven largest Latin American countries, for which there is detailed sectorial data available from the Groningen Growth and Development Centre 10-Sector Database (Timmer and de Vries 2009). Despite being lower than our baseline measure in every year, the adjusted relative TFP displays the same pattern. In particular, it was high between 1960 and 1980 and then it fell sharply.

We consider next the importance of including human capital as a factor of production. In this paper we include human capital in the production function, as has become standard in the growth and development accounting literature (see Klenow and Rodriguez-Clare 1997; Hall and Jones 1999). We show that the inclusion of human capital makes a crucial difference in the TFP calculations for Latin America. When we do not include human capital we obtain a value of 53% for Latin America relative TFP between 1960 and 1980. It then declines and reaches 43% in 2007.

This paper is organized as follows. In Section II we present the methodology used to construct our measure of relative TFP. Section III presents the stylized facts about relative TFP in Latin America and several robustness exercises. In particular, we examine the role of natural resources and human capital. Section IV concludes.

1. We arrived at this finding independently. A first version of Ferreira, Pessôa, and Veloso (2008), presented in the Society for Economic Dynamics Meeting of 2004 (http://ideas.repec.org/p/red/sed004/576.html), already made the point that relative TFP in Latin America was high in the 1960s and 1970s. This subsection was removed from that paper and transformed, after many additions, into the first version of the current article, in 2005 (http://ideas.repec.org/p/fgv/epgewp/620.html).

II. METHODOLOGY AND DATA

Let the production function in terms of output per worker be given by:

$$y_{it} = A_{it} k_{it}^{\alpha} h_{it}^{1-\alpha}, \tag{1}$$

where y_{it} is the output per worker of country i at time t, k stands for physical capital per worker, h is human capital per worker, and A is TFP. Estimates in Gollin (2002) of the capital share of output for a variety of countries fluctuates around 0.40, so we set α at this value.

In our exercises we follow Bils and Klenow (2000) to model human capital and set:

$$h = \exp \phi(s) = \exp\left((\theta/1-\psi)s^{1-\psi}\right), \tag{2}$$

where s stands for schooling. We measured s using average years of schooling of the population aged 15 years and over, taken from Barro and Lee (2010), interpolated (in levels) to fit an annual frequency. According to the calibration in Bils and Klenow (2000), we set $\psi = 0.58$ and $\theta = 0.32$.

The physical capital series is constructed with investment data in international prices from the Penn World Table 6.3 using the perpetual inventory method.[2] As usual in the literature, we assume that all economies were in a balanced growth path at time zero and compute the initial capital stock, K_0, according to the expression $K_0 = I_0/[(1+g)(1+n)-(1-\delta)]$, where I_0 is the initial investment expenditure, g is the rate of technological progress, n is the growth rate of the population, and δ is the rate of capital depreciation.

To minimize the impact of economic fluctuations we used the average investment of the first 5 years as a measure of I_0. In order to reduce the effect of K_0 in the capital stock series, we started this procedure taking 1950 as the initial year.[3] We used the same depreciation rate for all economies, which was calculated from U.S. census data. We employed the capital stock at market prices, investment at market prices, I, as well as the law of motion of capital to estimate the implicit depreciation rate according to:

$$\delta = 1 - (K_{t+1} - I_t)/K_t.$$

2. See Heston, Summers, and Atten (2009) for a description of Penn World Table 6.3.

3. For Chile, Dominican Republic, Ecuador, and Paraguay we have investment data since 1951, so we set this as the initial year to compute capital stocks for these countries.

FIGURE 1
Latin America Relative TFP (U.S. = 1)

From this calculation, we obtained $\delta = 3.5\%$ per year (average of the 1950–2007 period). To compute k, we divided K by the number of workers, obtained from Penn World Table 6.3. We calculated the rate of technological progress by adjusting an exponential trend to the U.S. output per worker series, correcting for the increase in the average schooling of the labor force and obtained $g = 1.53\%$. The population growth rate, n, is the average annual growth rate of population in each economy between 1960 and 2007, calculated from population data in the Penn World Table 6.3.

Data on output per worker in international prices were obtained from the Penn World Table 6.3. In order to compute the value of A_{it}, we used the observed values of y_{it} and the constructed series of k_{it} and h_{it} so that the productivity of the ith economy at time t was obtained as:

$$A_{it} = y_{it}/(k_{it}^{\alpha} h_{it}^{1-\alpha}). \tag{3}$$

III. STYLIZED FACTS

A. Baseline Results

Figure 1 shows the evolution between 1960 and 2007 of the (geometric) mean and the median of TFP of 18 Latin American countries[4] relative to U.S. TFP.[5] Until the late 1970s, mean TFP in Latin America was close to that of the leading economy, corresponding to 82% of U.S. TFP between 1960 and 1980. The median Latin America TFP relative to the United States averaged 79% between 1960 and 1980. However, since the late 1970s both the mean and the median TFP in Latin America have fallen continuously, declining to 54% and 60% of U.S. TFP in 2007, respectively.

In absolute values, TFP grew on average 0.58% per year in Latin America between 1960 and 1980, above the U.S. TFP growth rate of 0.32%. Between 1980 and 2007, however, while U.S. productivity growth accelerated, growing at 0.89% per year, Latin America TFP collapsed, declining at an average annual rate of 0.88%.[6] As a result, in the entire 1960–2007 period TFP

4. The Latin American countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.

5. For each country i and year t, relative TFP is given by: A_{it}/A_{USt}. We then computed the unweighted average of this ratio across countries for every year to calculate the Latin America relative TFP.

6. The fall was even higher between 1980 and 2003: −1.23% annually.

in Latin America fell in absolute terms 0.26% per year, with 14 out of 18 countries of our sample presenting zero or negative growth.

Table 1 presents data on relative TFP for the seven largest economies in Latin America. In some countries, such as Venezuela, Mexico, Argentina, and Brazil, TFP surpassed that of the United States during most of the period before 1980. This contrasts drastically with the situation in 2007, when TFP in these countries ranged between 61% and 73% of the United States. Only Chile had an increase in relative TFP between 1960 and 2007. When we consider the sample of 18 Latin American countries, in 10 of them TFP was at least 80% of the United States between 1960 and 1980. However, in 2007 relative TFP in Latin America was above 0.80 only in Chile.

We have thus identified two general patterns: relative TFP in Latin America was high until the late 1970s and since then it has fallen continuously in the region. Is this a general fact observed in other regions? Figure 2 shows that this is not the case. From 1960 to 1980 average TFP in Latin America was close to that of Western Europe and 25% higher than East

TABLE 1
Relative TFP (U.S. = 1)

	1960	1965	1970	1975	1980	1985	1990	1995	2000	2007
Argentina	1.04	0.95	1.01	1.02	1.00	0.76	0.66	0.73	0.68	0.73
Brazil	0.91	0.93	1.06	1.37	1.44	1.05	0.94	0.80	0.66	0.64
Chile	0.73	0.66	0.77	0.64	0.83	0.62	0.70	0.87	0.84	0.86
Colombia	0.83	0.77	0.85	0.90	0.96	0.75	0.75	0.71	0.57	0.60
Mexico	1.11	1.10	1.15	1.16	1.20	1.03	0.89	0.65	0.70	0.61
Peru	0.56	0.61	0.69	0.77	0.71	0.52	0.39	0.40	0.36	0.40
Venezuela	1.22	1.36	1.49	1.46	1.14	0.87	0.89	0.88	0.75	0.73
Latin America	0.81	0.78	0.83	0.88	0.87	0.68	0.62	0.60	0.54	0.54

FIGURE 2
Relative TFP, Region, and Continent Averages (U.S. = 1)

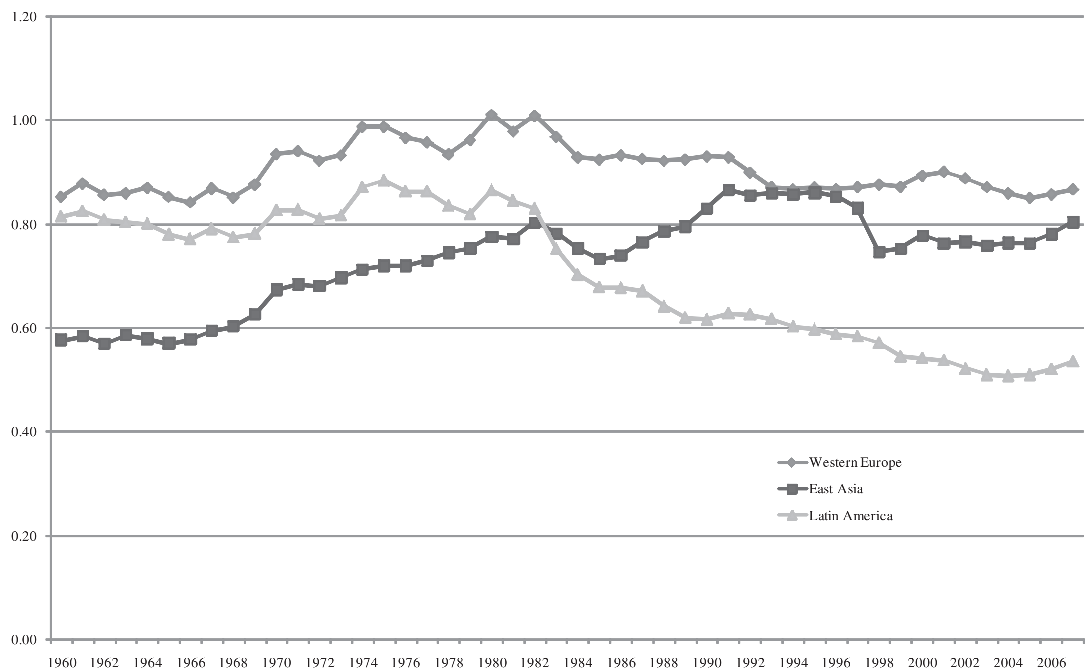


TABLE 2
Relative TFP (U.S. = 1)—δ = 10%

	1960	1965	1970	1975	1980	1985	1990	1995	2000	2007
Argentina	1.03	0.93	1.00	1.01	0.99	0.78	0.70	0.76	0.71	0.78
Brazil	0.87	0.89	1.02	1.27	1.33	0.99	0.91	0.79	0.67	0.67
Chile	0.71	0.64	0.79	0.67	0.91	0.67	0.75	0.88	0.83	0.83
Colombia	0.80	0.75	0.84	0.88	0.94	0.72	0.74	0.69	0.57	0.60
Mexico	1.04	1.03	1.08	1.10	1.13	0.98	0.88	0.64	0.70	0.62
Peru	0.54	0.60	0.69	0.81	0.75	0.55	0.42	0.44	0.38	0.42
Venezuela	1.15	1.33	1.48	1.44	1.10	0.88	0.93	0.95	0.81	0.79
Latin America	0.78	0.75	0.81	0.86	0.84	0.67	0.63	0.61	0.55	0.55

Asia TFP.[7] However, while in East Asia we observe convergence to the U.S. productivity level between 1960 and 2007, in Latin America there was increasing divergence relative to U.S. TFP since the late 1970s. In 2007 both regions surpassed Latin America TFP by more than 50%.

We observe the same qualitative patterns if we compare Latin America TFP with average TFP in a larger sample of 83 developed and developing countries.[8] In particular, mean TFP in Latin America was 6% above the average world TFP between 1960 and 1980. However, in 2007 it was 23% below average world TFP. Only Sub-Saharan Africa fares worse in terms of TFP reduction in the period.

B. Basic Robustness Exercises

It could be the case that our results are driven by measurement error in the TFP series. In particular, if our capital stock is measured with error due, for instance, to the procedure used to construct the initial capital stock or to our hypothesis about the depreciation rate, our TFP calculations could be biased.[9]

In order to verify the sensitivity of the results to the initial capital stock, we reconstructed the capital stock series using a 10% depreciation rate and the same methodology as above. We then generated a new TFP series according to Equation (3). This exercise is important because a higher depreciation rate reduces the importance of the initial capital stock. Results did not change much, as shown in Table 2. Between 1960 and 1980, average TFP in Latin America was close to 82% of U.S. TFP. After this date, it fell continuously and in 2007 it corresponded to only 55% of U.S. TFP.

We also repeat our exercises using capital and output data from Nehru and Dhareshwar (1993). This is important because Cole et al. (2005) used this data to conclude that Latin America TFP during the post-war period corresponded to only 50% of the U.S. TFP. The data set spans the period 1950–1990. We use Equation (3) to construct TFP measures for Latin America, Western Europe, and East Asia.

As shown in Figure 3, from 1950 to 1975 average TFP in Latin America fluctuates a little above 80% of U.S. TFP. Mean relative TFP in Latin America fell continuously after the mid-1970s and in 1990 it amounted to only 55% of U.S. TFP. Hence, we conclude that our previous findings are confirmed using the Nehru and Dhareshwar (1993) data set.

C. The Role of Natural Resources

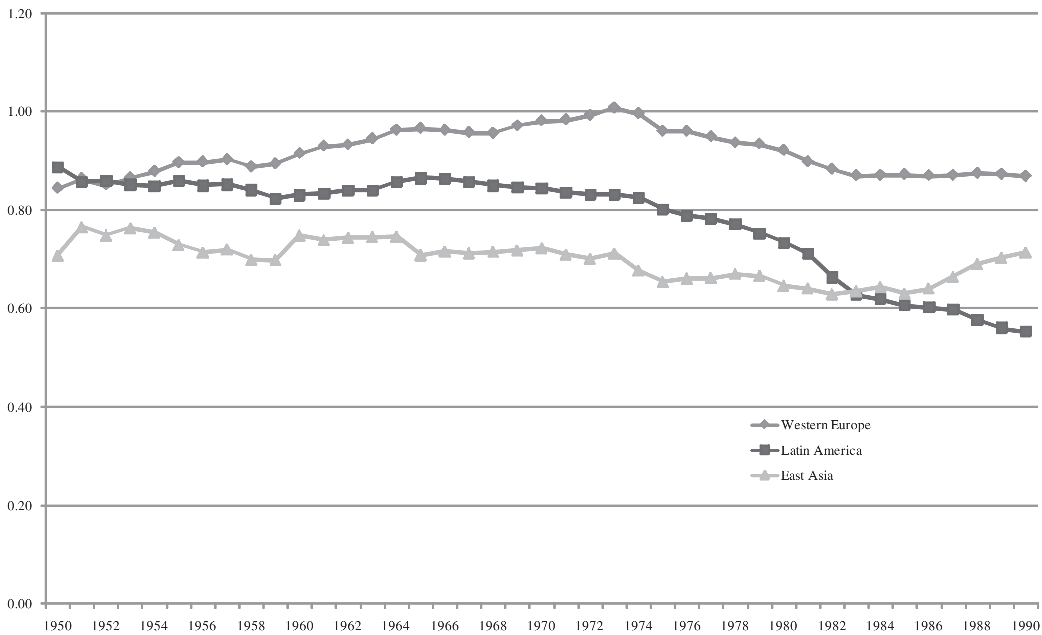
All these exercises consider only physical capital, labor, and human capital as factors of production. In particular, we do not consider the contribution of factors that might be important in Latin America, such as natural resources. It could be the case that the methodology we use attributes to productivity the contribution of natural resources and thus overestimates relative TFP in Latin America. Moreover, the reduction of the importance of natural resources in production might account for the decline in relative TFP in Latin America since 1980.

7. The countries included in our comparison are as follows. Western Europe: Austria, Italy, Finland, Belgium, France, Norway, Iceland, Denmark, Germany, Netherlands, Sweden and Switzerland. East Asia: Taiwan, Hong Kong, Korea, Singapore, Thailand, and Japan.

8. See the Appendix for a list of the countries included in the sample.

9. It is important to remind, however, that for 14 of the 18 Latin American countries included in our sample, the initial year for the capital stock series is 1950, whereas for the other four countries we have investment data since 1951. This reduces the impact of the initial capital in the capital stock series.

FIGURE 3
Relative TFP, Latin America and Other Regions (U.S. = 1)—Nehru-Dhareshwar Data



In order to address this possibility, we use two approaches. First, we exclude Venezuela from the sample. Figure 4 compares the results for Latin America relative TFP in our benchmark case (including Venezuela) to those we obtain when we exclude Venezuela from the sample. We can observe that when we exclude Venezuela, relative TFP in Latin America is slightly smaller between 1960 and 1980, averaging 80% during this period. Between 1980 and 2007, the two series are very similar.

Our second approach is to subtract from gross domestic product (GDP) the value added in natural resource-related sectors in computing our measure of output. This is a coarse correction, since it assigns all of the value added in these sectors to natural resource inputs and neglects capital and labor inputs in these sectors. It should be noted, in particular, that this procedure underestimates the value of TFP for resource-rich countries.[10] In any case, it gives a rough estimate of the bias that natural resources may create for our observed TFP measure. This is the same procedure used by Hall and Jones (1999) to correct for natural resources. The difference is that, in addition to the mining industry, we also make a correction for value added in agriculture, forestry, and fishing.

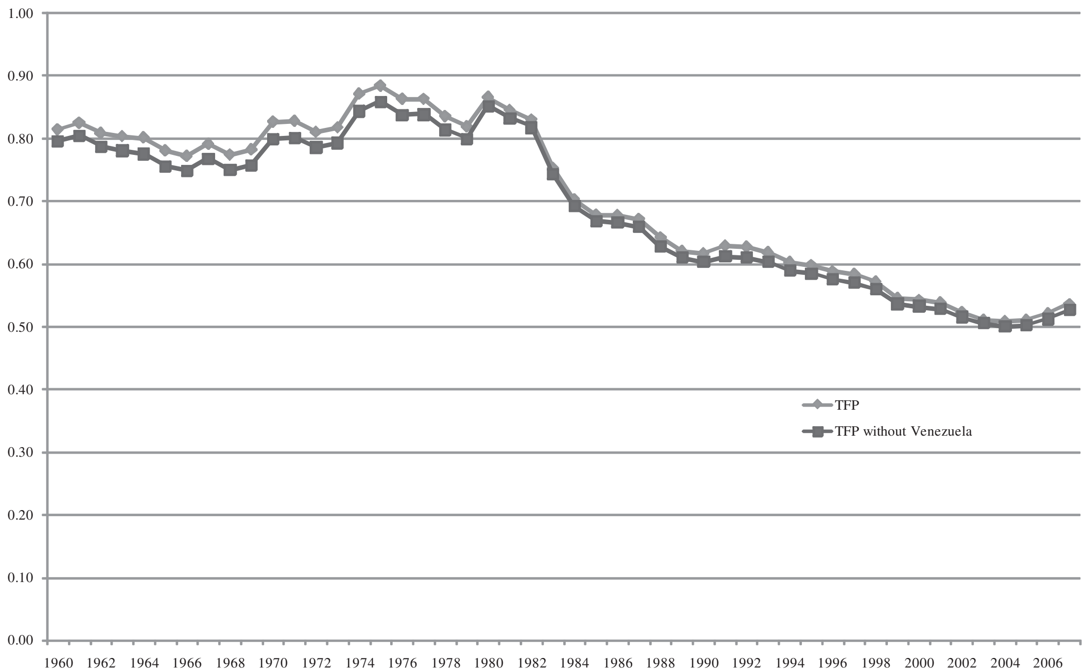
We use data on sectorial value added obtained from the Groningen Growth and Development Centre 10-Sector Database (GGDC).[11] There is data for nine Latin American countries for the period 1950–2005. The measure we use for the production from mineral resources is the value added in the mining and quarrying sector. We also subtract from GDP the value added in the agriculture, forestry, and fishing sector. Specifically, for each country we calculate the proportion of natural resources output in total value added using data from GGDC. Then we apply these proportions to output per worker data in international prices from the Penn World Table to obtain a measure of adjusted output per worker. The last step is to use this measure of output per worker and our baseline physical and human capital per worker to compute a measure of TFP adjusted for natural resources according to Equation (3).

One caveat is that the GGDC sectorial data is measured in domestic prices rather than international prices. To our knowledge, there is no

10. See Caselli (2005).

11. See Timmer and de Vries (2009) for a description of the data set.

FIGURE 4
Latin America Relative TFP (U.S. = 1), with and without Venezuela



time-series data available on natural resources production measured in international prices for Latin American countries.[12] Hence we assume in this exercise that the proportion of natural resources output in total value added is the same whether it is measured in domestic or international prices. Since this is a tradable sector, we believe this is a reasonable first approximation.

In order to make the results more readily comparable to previous tables, we calculated the relative adjusted TFP measure for the seven largest Latin American economies: Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela. Figure 5 compares our baseline results for these seven Latin American countries with the measure of TFP adjusted for natural resources. Without the adjustment, mean relative TFP for the seven Latin American economies was 94% between 1960 and 1980, and fell to 61% in 2007. Despite being lower than our baseline measure in every year, the adjusted relative TFP displays the same pattern. In particular, it was high between 1960 and 1980, corresponding on average to 76% of U.S. TFP during this period. It then declined sharply, falling to only 51% of U.S. TFP in 2005.

Table 3 presents results for each of the seven Latin American countries. Venezuela was the country most affected by the adjustment, since the mineral sector makes a large contribution to its GDP. The Appendix presents separate TFP results for adjustments because of the mineral sector, and the agriculture, forestry, and fishing sectors.

D. The Role of Human Capital

As mentioned in the introduction, Cole et al. (2005) provided evidence that TFP in Latin America stood around 50% of U.S. TFP between 1950 and 2000. They consider only physical capital and labor as factors of production. In this paper, we include human capital in the production function, as has become standard in the growth and development accounting literature (see Klenow and Rodriguez-Clare 1997; Hall and Jones 1999). Figure 6 compares our

12. Restuccia, Yang, and Zhu (2008) construct international dollar prices of agricultural products using data from Food and Agriculture Organization, but they only have data for a particular year.

FIGURE 5
Latin America Relative TFP, with Adjustment for Natural Resources (U.S. = 1)

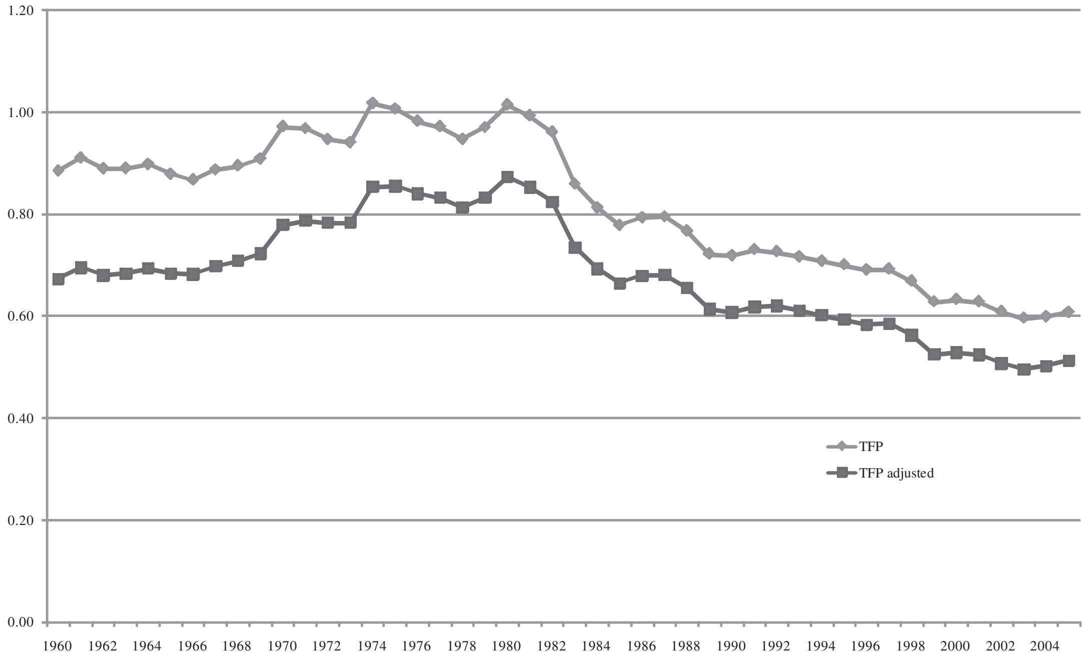


TABLE 3
Relative TFP (U.S. = 1)—Adjusted for Natural Resources

	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005
Argentina	0.94	0.86	0.93	0.94	0.92	0.70	0.60	0.66	0.62	0.61
Brazil	0.78	0.80	0.94	1.25	1.33	0.95	0.85	0.72	0.59	0.54
Chile	0.63	0.58	0.68	0.55	0.73	0.52	0.59	0.75	0.71	0.70
Colombia	0.58	0.56	0.64	0.70	0.76	0.59	0.57	0.56	0.45	0.46
Mexico	0.93	0.95	1.01	1.05	1.09	0.93	0.81	0.60	0.65	0.56
Peru	0.43	0.49	0.57	0.68	0.61	0.44	0.33	0.34	0.30	0.31
Venezuela	0.58	0.67	0.80	1.04	0.86	0.68	0.66	0.64	0.52	0.51

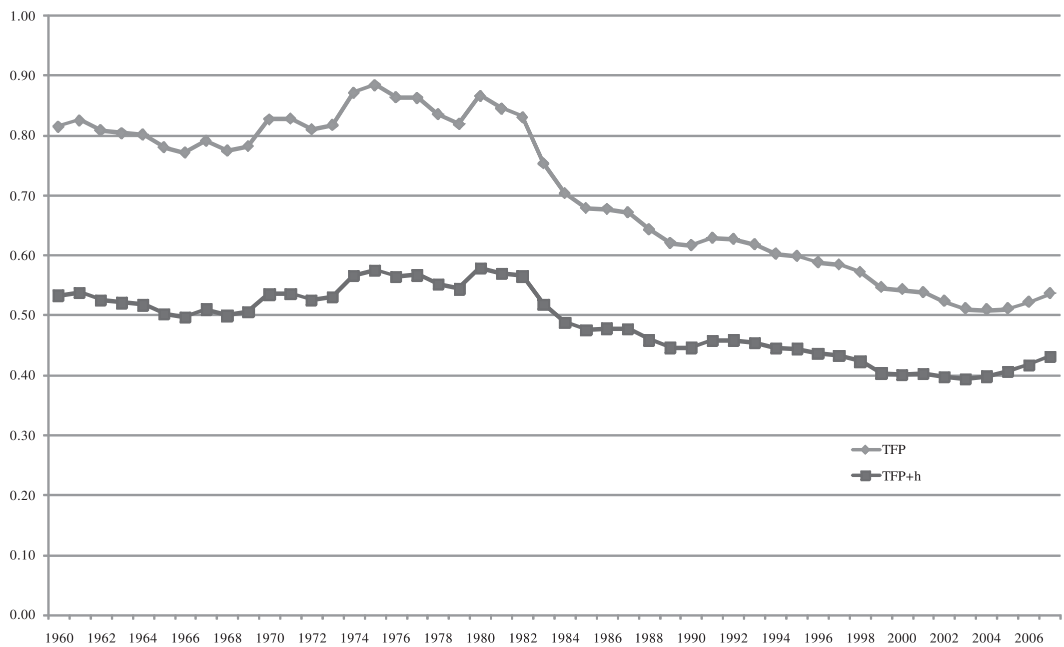
results for TFP in Latin America relative to the United States (TFP) with the ones we obtain when we disregard human capital and attribute differences in relative human capital to relative TFP (TFP + h).

Figure 6 shows that the inclusion of human capital in the production function makes a great difference in the TFP calculations for Latin America. When we do not include human capital, following Cole et al. (2005)'s procedure, we obtain a value of 53% for Latin America relative TFP between 1960 and 1980. It then declines to reach 44% in the 1990s and 43% in 2007. Since human capital in Latin America averaged less than 40% of U.S. human capital between 1960 and 1980, the fact that Cole et al. do not account for relative human capital differences and consequently attribute it to relative TFP leads them to significantly underestimate Latin America relative TFP until 1980.[13] Moreover, they also underestimate the decline in Latin America relative TFP since 1980, since Latin America relative human capital increased between 1980 and 2007.

Cole et al. (2005) argue that a large TFP gap between the United States and Latin America remains after adjusting for human capital

13. Figure A1 in the Appendix presents schooling data for Latin America and the United States.

FIGURE 6
Latin America Relative TFP, with and without Human Capital in the Production Function (U.S. = 1)



differences. In order to support their claim, the authors argue that, after adjusting for human capital, Hall and Jones (1999) find an average productivity level of 58% of the United States in 1988 for a comparable group of Latin American countries. They also report that Klenow and Rodriguez-Clare (1997) find a comparable Latin American relative productivity of 67%, using 1985 data and a different procedure to adjust for human capital. Taking the average of the two estimates gives a Latin American relative productivity of 62.5%.

However, Cole et al. do not take into account the fact that Hall and Jones and Klenow and Rodriguez-Clare calculate a measure of labor-augmenting productivity (LAP) instead of TFP. As is well known, relative TFP is always higher than relative LAP. If we computed TFP values based on Hall and Jones'and Klenow and Rodriguez-Clare's LAP values and production function parameters, the average Latin America relative TFP would be 77% in the second half of the 1980s.[14] Since TFP in Latin America collapsed in the early 1980s, their measure of the relative TFP would be even larger in the 1970s. Hence, the fact that we include human capital in the production function in large measure explains the differences between our results and those presented by Cole et al. (2005).[15]

Because of the importance of human capital for TFP calculations in Latin America, we checked if our results depend on the schooling data that we used, obtained from Barro and Lee (2010). To verify the robustness of our results to the schooling series, in Figure 7 we present the results for relative TFP in Latin America when we use education data from Cohen and Soto (2007).

14. Hall and Jones use a production function given by $Y = K^{\alpha}(AH)^{1-\alpha}$, where $LAP = A$ and $\alpha = 1/3$. In this case relative TFP $= (0.58)^{1-\alpha} = (0.58)^{1-1/3} = 0.695$. Klenow and Rodriguez-Clare use as the production function $Y = K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta}$, where $LAP = A$, $\alpha = 0.3$ and $\beta = 0.28$. In this case relative TFP $= (0.67)^{1-\alpha-\beta} = (0.67)^{1-0.3-0.28} = 0.845$. Taking the average between the two numbers, we obtain relative TFP = 0.77. We thank a referee for suggesting these calculations.

15. A recent paper by Restuccia (2008) includes human capital in the production function and calculates that TFP in Latin America corresponded to 60% of U.S. TFP around 2005, which is similar to our result. Restuccia (2008) does not calculate Latin America relative TFP for the period 1960–1980.

FIGURE 7
Latin America Relative TFP, using Cohen and Soto (2007) Schooling Data (U.S. = 1)

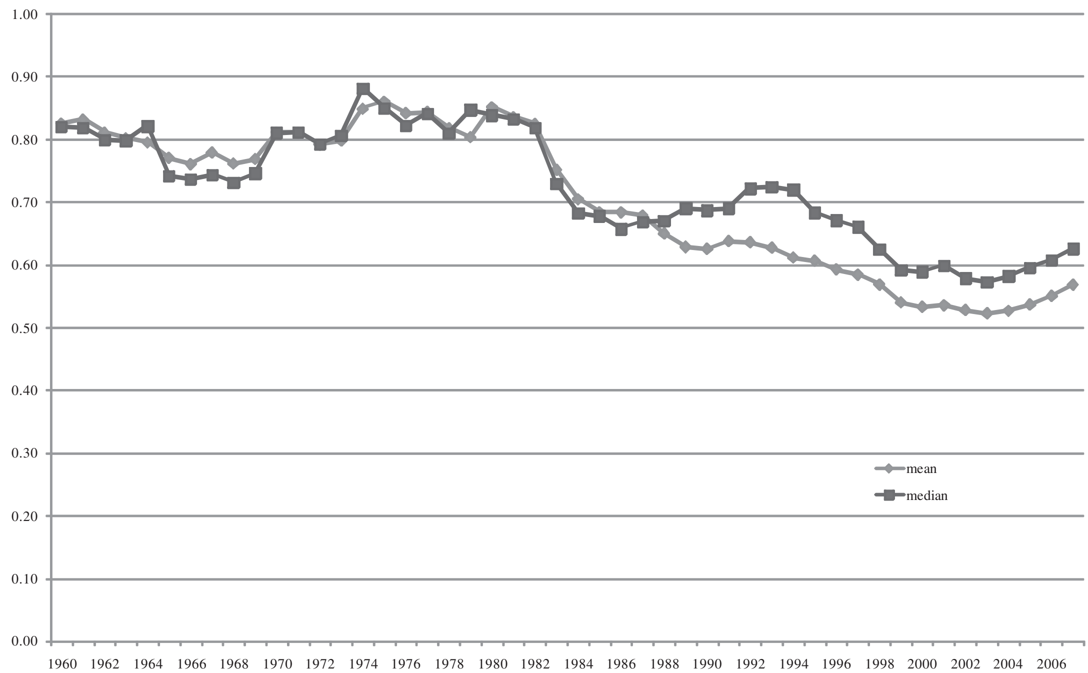


Figure 7 confirms the pattern documented in Figure 1. Mean and median TFP in Latin America corresponded to 81% and 80% of U.S. TFP between 1960 and 1980, respectively. However, since the late 1970s both the mean and the median TFP in Latin America have fallen continuously, declining to 57% and 63% of U.S. TFP in 2007, respectively.

In this paper we follow the procedure in Bils and Klenow (2000) to construct a measure of human capital. Hall and Jones (1999) used a different specification, based on the following formula: $h = e^{\phi(s)}$, where s denotes years of schooling, as before, and $\phi(s) = 0.134.s$ if $s \leq 4$, $\phi(s) = 0.134.4 + 0.101.(s - 4)$ if $4 < s \leq 8$, $\phi(s) = 0.134.4 + 0.101.4 + 0.068.(s - 8)$ if $s > 8$. Figure 8 presents the results for relative TFP in Latin America when we use Hall and Jones (1999)'s human capital methodology. Schooling data is from Barro and Lee (2010), as in our baseline specification.

In the period 1960–1980, the mean and median Latin America TFP amounted to 94% of the U.S. TFP, so they were even higher than the values obtained using Bils and Klenow's (2000) methodology. Mean and median relative TFP declined thereafter and were equal to 54% and 61%, respectively, in 2007.[16]

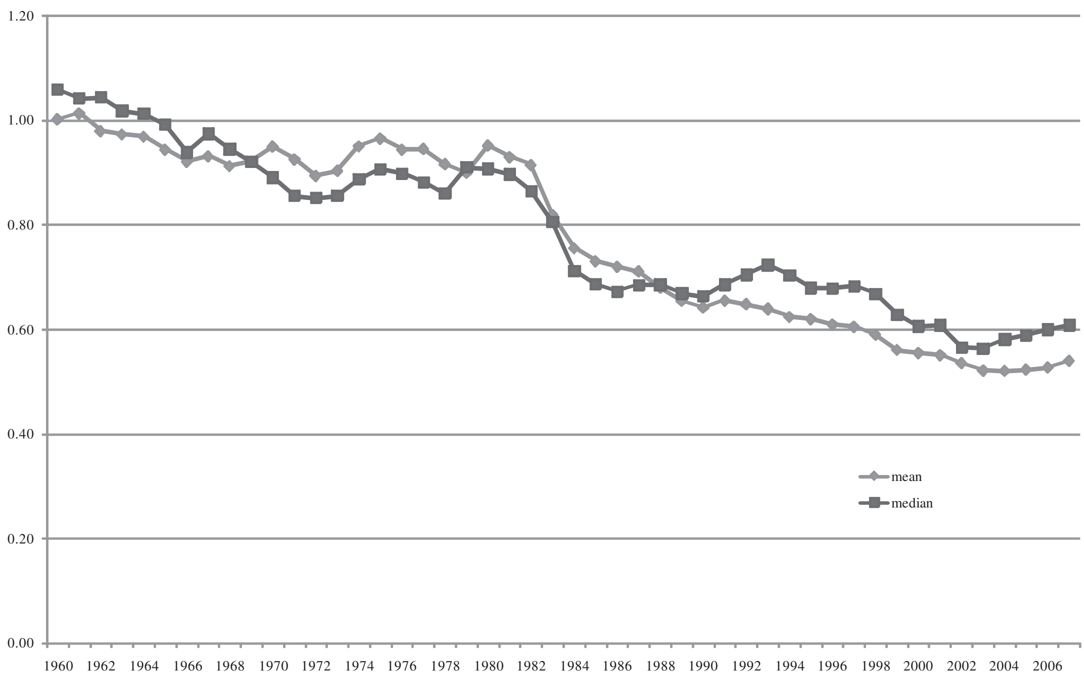
Our baseline human capital specification does not control for differences in the quality of education among countries. Even though there is some recent cross-country evidence on the quality of education based on students' results in standardized tests, there is no time-series data available for our sample of Latin American countries during the period 1960–2007.

In order to provide some evidence on the effect of quality of education on the observed measure of TFP, we use time-series data on the pupil-teacher ratio at the primary level obtained from Lee and Barro (2001). They have data on the pupil-teacher ratio[17] at 5-year intervals for our sample of 18 Latin American countries from

16. Fernandez, Guner, and Knowles (2005) estimated Mincer coefficients for a set of Latin American countries. Their estimates are higher than 13% for most countries. This suggests that Latin America TFP relative to the United States might be even higher before 1980.

17. Lee and Barro (2001) also have data on government expenditure per student, but there are not enough observations to allow us to construct a measure of quality of education for our sample and time period.

FIGURE 8
Latin America Relative TFP, with Hall and Jones (1999) Human Capital Methodology (U.S. = 1)



1960 to 2000.[18] We follow Caselli (2005)'s procedure to adjust the human capital stock for quality of education, where the latter is measured by the teacher–pupil ratio at the primary level. We use the following human capital specification:

$$h = A_h e^{\phi(s)}$$

where A_h denotes the quality of education. The quality of education is assumed to be an increasing function of the teacher–pupil ratio according to:

$$A_h = p^{\phi_p}$$

where p is the teacher–pupil ratio and ϕ_p is the elasticity of the quality of education with respect to the teacher–pupil ratio. As in Caselli (2005), we assume that $\phi_p = 0.5$. For each country, we focus on the teacher–pupil ratio in the year when the average worker attended school. To obtain this year, we estimate the age of the average worker using data from LABORSTA, the data set of the International Labor Organization (ILO).[19] Then we assume that children start primary school at the age of 6. To obtain the measure of the quality of education corresponding to year t, we use the observation for the primary teacher–pupil ratio in year $t - age + 6$.

Figure 9 presents the results for relative TFP in Latin America when we adjust human capital for the quality of education. Since the quality of education in Latin America was lower than in the United States throughout the period, this measure of Latin America relative TFP is higher than in our baseline case in every year.[20]

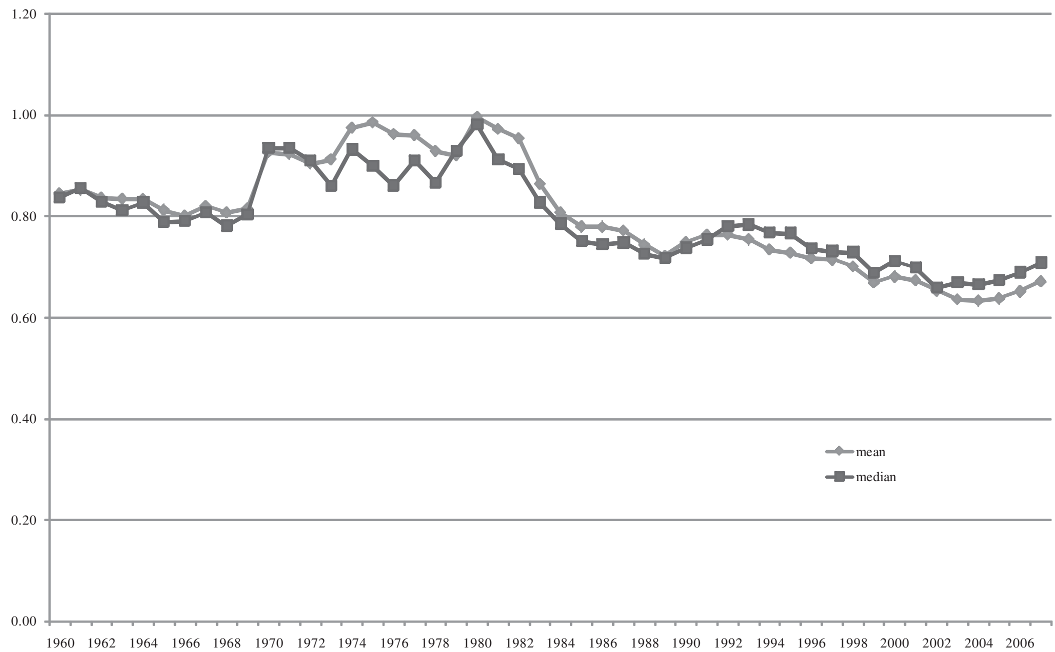
18. Data were interpolated linearly to obtain the values of the intermediate years.

19. There is data for the economically active population at 10-year intervals from 1950 to 2000. The data is broken down in 5-year age intervals. As in Caselli (2005), in order to obtain the average age of a worker we weight the middle year of each interval by the fraction of the labor force in that interval. Data were interpolated linearly to obtain the values of the intermediate years.

20. Since in the baseline case we did not adjust TFP for differences in the quality of education between Latin America and the United States, the lower quality of education in Latin America was captured by a lower relative TFP.

FIGURE 9

Latin America Relative TFP, with Adjustment for the Quality of Education (U.S. = 1)



Specifically, between 1960 and 1980, the relative mean and median Latin America TFP were 89% and 86%, respectively. The teacher–pupil ratio increased over time in both Latin America and the United States, but faster in the latter, which implies that the quality of education in Latin America relative to the United States decreased over time. This in turn results in a smaller decline of Latin America relative TFP in comparison to our benchmark.[21] In 2007, mean and median Latin America TFP were equal to 67% and 71% of the United States, respectively.

IV. CONCLUSION

In this paper we have shown that at least until the late 1970s the average Latin America economy was relatively productive, with a TFP level corresponding to 82% of the United States. Another stylized fact is that relative TFP fell sharply in Latin America after 1980 and reached 54% in 2007. We have shown that these patterns are also observed when we adjust TFP for the presence of natural resources.

However, if human capital is not included in the production function, we obtain a value of 53% for Latin America relative TFP between 1960 and 1980. It then declines and reaches 43% in 2007. Hence the inclusion of human capital in the production function makes a crucial difference in TFP calculations for Latin America. We showed that this result is robust to the use of different sources of schooling data and human capital specifications. We also obtained similar results when we used data on pupil–teacher ratios to adjust human capital for quality of education.

These results allow us to conclude that at least until the late 1970s, TFP was not the main cause for the relative poverty of the region. The main determinants of low output per worker in the region were factors of production, namely physical and human capital.[22] However, after the late 1970s the TFP decline was the main explanation for Latin America stagnation.

21. In our benchmark, the decline over time in the quality of education in Latin America relative to the United States was captured by a reduction of Latin America relative TFP.

22. This is consistent with the evidence provided in Ferreira, Pessôa, and Veloso (2008) that in the early 1970s factors of production (physical and human capital) were the main source of differences in output per worker across countries.

The period between 1960 and 1980 was characterized by widespread government intervention and import-substitution industrialization in Latin America. These interventions were associated with competitive barriers of different forms, including restrictions to international trade and targeted investment subsidies. The puzzle raised by the stylized facts documented in this paper is that, despite these distortionary policies, TFP in the region was high relative to the United States. Moreover, despite the adoption of market-oriented reforms since the 1980s, TFP in Latin America declined relative to the United States between 1980 and 2007. We intend to investigate possible explanations for these facts in future research.

APPENDIX

A. List of Countries

Brazil, Mexico, Colombia, Argentina, Peru, Venezuela, Chile, Ecuador, Guatemala, Dominican Republic, Bolivia, Honduras, El Salvador, Paraguay, Nicaragua, Costa Rica, Uruguay, Panama, Austria, Italy, Finland, Belgium, France, Norway, Iceland, Denmark, Germany, Netherlands, Sweden, Switzerland, Taiwan, Hong Kong, Korea, Singapore, Thailand, Japan, Ireland, United Kingdom, United States, Australia, Canada, New Zealand, Cyprus, Portugal, Spain, Greece, Turkey, Syria, Tunisia, Israel, Iran, Jordan, Malaysia, Indonesia, Pakistan, India, Nepal, Papua New Guinea, Bangladesh, Philippines, Fiji, Barbados, Trinidad & Tobago, Guyana, Jamaica, Botswana, Lesotho, Mauritius, Malawi, Zimbabwe, Uganda, Tanzania, Kenya, Ghana, Cameroon, Togo, Senegal, Mozambique, Zambia, Niger, Central African Republic, South Africa, and Congo.

B. Relative TFP Adjusted for the Mineral Sector

TABLE A1
Relative TFP (U.S. = 1)—Adjusted for the Mineral Sector

	1960	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**
Argentina	1.03	0.94	1.00	1.01	0.98	0.75	0.65	0.71	0.66	0.66
Brazil	0.90	0.92	1.04	1.35	1.42	1.03	0.92	0.78	0.64	0.59
Chile	0.68	0.62	0.72	0.59	0.77	0.56	0.64	0.81	0.76	0.76
Colombia	0.79	0.73	0.82	0.88	0.95	0.73	0.71	0.68	0.54	0.55
Mexico	1.09	1.09	1.13	1.15	1.18	1.01	0.87	0.64	0.69	0.60
Peru	0.51	0.56	0.64	0.74	0.66	0.48	0.37	0.38	0.34	0.34
Venezuela	0.63	0.73	0.88	1.11	0.92	0.73	0.71	0.68	0.56	0.55

C. Relative TFP Adjusted for the Agriculture, Forestry, and Fishing Sectors

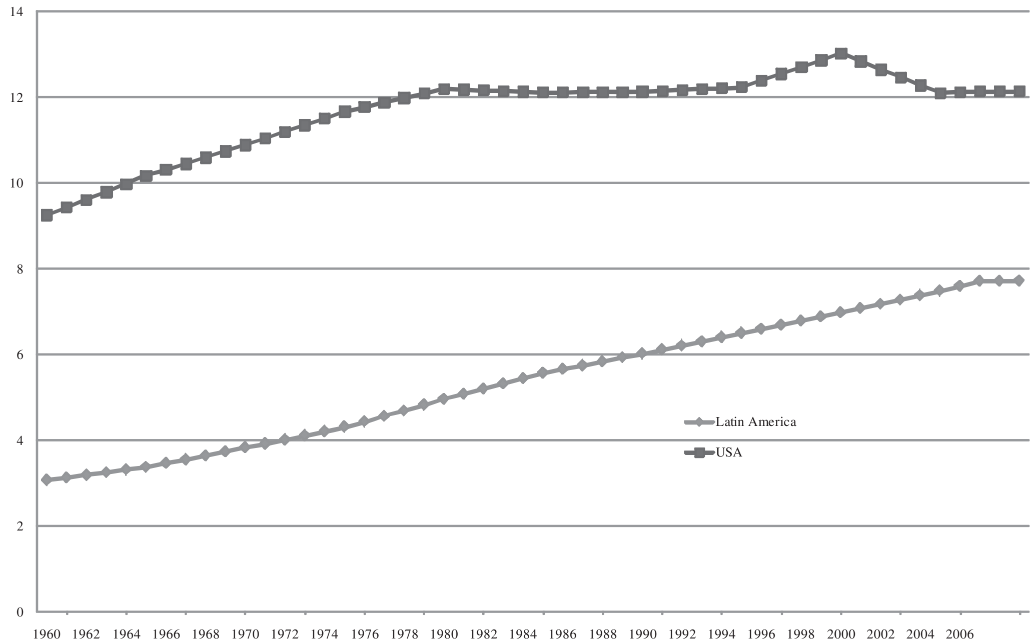
TABLE A2
Relative TFP (U.S. = 1)—Adjusted for the Agriculture, Forestry, and Fishing Sectors

	1960	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**
Argentina	0.95	0.87	0.94	0.96	0.94	0.71	0.61	0.67	0.63	0.62
Brazil	0.79	0.81	0.96	1.27	1.35	0.97	0.87	0.74	0.61	0.56
Chile	0.68	0.62	0.73	0.60	0.79	0.58	0.65	0.81	0.79	0.78
Colombia	0.62	0.59	0.66	0.72	0.77	0.61	0.61	0.59	0.48	0.49
Mexico	0.95	0.96	1.02	1.06	1.11	0.95	0.82	0.61	0.66	0.57
Peru	0.48	0.54	0.61	0.71	0.66	0.48	0.35	0.37	0.32	0.33
Venezuela	1.17	1.30	1.42	1.38	1.08	0.82	0.83	0.84	0.71	0.65

D. Schooling: United States and Latin America (mean)

FIGURE A1

Schooling in the United States and Latin America (1960–2007)



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