The Evolution of TFP in Latin America*

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Abstract

Due to widespread government intervention and import-substitution industrialization, there has been a general presumption that total factor productivity (TFP) in Latin America has been much lower than that of the leading economies in the last decades. In this paper, however, we show that until the mid-seventies Latin America had high TFP levels relative to the US and other regions. It is only after the mid-seventies that we observe a fast decrease of relative TFP in Latin America. As a result of the fall in relative TFP, there was also a significant decline in relative output per worker in Latin America. Results based on a calibrated version of the two-sector neoclassical growth model indicate that policy distortions that reduced TFP in the investment goods sector may explain part of the TFP and output per worker decline in Latin America.

Key Words: Latin America, Total Factor Productivity, Import-Substitution Industrialization.

JEL Classification Code: O11, O47, O54.

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1 Introduction

Due to widespread government intervention and import-substitution industrialization, among other policy distortions, there has been a general presumption that total factor productivity (TFP) in Latin America has been much lower than that of the leading economies in the last decades. Recent papers, such as Hopenhayn and Neumeyer (2004) and Cole et al (2005), seemed to confirm empirically this hypothesis. In particular, Hopenhayn and Neumeyer (2004) found that average TFP growth in Latin America was slightly negative between 1960 and 1985. Moreover, Cole et al (2005) found that average TFP levels in Latin America corresponded to roughly 50% of US productivity between 1950 and 2000.

In this paper, however, we show that until the mid-seventies Latin American countries had high TFP levels relative to the US and other regions. On average, TFP in Latin America corresponded to 88% of the U.S. between 1960 and 1975 and it was higher than that of Western Europe. It is only after the mid-seventies that we observe a fast decrease of relative TFP in Latin America, which fell to 62% of US TFP and 72% of the Western European productivity in 2000. As a result of the fall in relative TFP, there was also a significant decline in relative output per worker in Latin America.

Some studies have documented a negative TFP growth rate in Latin America in the eighties. Bosworth and Collins (2003) and Loayza et al (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.

These papers are consistent with our finding that relative TFP in Latin America was higher before 1980. However, by focusing on relative TFP levels rather than growth rates we are able to provide new evidence that calls into question the results obtained in the recent literature on Latin America productivity, such as Hopenhayn and Neumeyer (2004) and Cole et al (2005). In particular, TFP in Latin America was close to that of the US between 1960 and 1975, when competitive barriers were highest in the region. Moreover, relative TFP in Latin America declined despite the implementation of several market-oriented reforms in the eithties and nineties.

These facts are puzzling from the standpoint of neoclassical growth theory. For instance, Parente and Prescott (2005) develop a model in which barriers to the efficient use of tecnology
reduce relative TFP. According to their model, relative TFP in Latin America should have been low until the seventies and should have increased since then.

This paper documents these stylized facts, using different methodologies and data sources. We then develop and calibrate a version of the two-sector neoclassical growth model in order to explain the relative TFP and output per worker decline in Latin America since the mid-seventies. Our results indicate that policy distortions that reduced TFP in the investment goods sector, such as the policy of import-substitution of capital goods pursued by Brazil in the seventies, may explain part of the TFP and output per worker decline in Latin America.

This paper is organized as follows. In section 2 we present the stylized facts about relative TFP in Latin America and some robustness exercises. Section 3 develops and calibrate a model to Latin America data and presents the results. Section 4 concludes.

2 Recent TFP Trends in Latin America

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

\[ y_{it} = A_{it} k_{it}^\alpha h_{it}^{1-\alpha}, \]

(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 total factor productivity (TFP). Estimates in Gollin (2002) of the capital share of output for a variety of countries fluctuates around 0.40, so we set \( \alpha \) at this value.

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

\[ h = \exp \phi(s) = \exp \left( \frac{\theta}{1-\psi} s^{1-\psi} \right), \]

(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 (2000), 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 6.1 using the perpetual inventory method. 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 $\delta$ is the rate of capital depreciation.

To minimize the impact of economic fluctuations we used the average investment of the first five 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.\footnote{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.} We use the same depreciation rate for all economies, which was calculated from US 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:

$$\delta = 1 - \frac{K_{t+1} - I_t}{K_t}.$$  

From this calculation, we obtained $\delta = 3.5\%$ per year (average of the 1950-2000 period). We obtained 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 2000, calculated from population data in the Penn World Table 6.1.

Data on output per worker in international prices were obtained from the Penn World Table 6.1. In order to compute the value of $A_{it}$, we use the observed values of $y_{it}$ and the constructed series of $k_{it}$ and $h_{it}$ so that the productivity of the i-th economy at time t was obtained as:

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

2.1 Baseline Results

Figure 1 shows the evolution between 1960 and 2000 of the (geometric) mean and the median TFP of 18 Latin American countries\footnote{The Latin American countries are Brazil, Mexico, Colombia, Argentina, Peru, Venezuela, Chile, Ecuador, Guatemala, Dominican Republic, Bolivia, Honduras, El Salvador, Paraguay, Nicaragua, Costa Rica, Uruguay and Panama.} relative to U.S TFP.\footnote{For each country $i$ and year $t$, relative TFP is given by $A_{it}/A_{UST}$, where $A_{UST}$ denotes US TFP. We then computed the unweighted average of this ratio across countries for every year to calculate the Latin} Until the mid-seventies,
total factor productivity in Latin America was very close to that of the leading economy, corresponding to 93% of US TFP in 1975. Moreover, both the mean and the median Latin American TFP increased relative to the US between 1960 and 1975. Specifically, during this period, average TFP in Latin America increased from 87% to 93% of US productivity whereas median Latin American TFP increased from 82% to 95% of US TFP. However, since the mid-seventies both the mean and the median TFP in Latin America fell continuously, especially since 1980, declining to 62% and 65% of US TFP in 2000, respectively.

In absolute values, TFP grew on average 1.1% per year in Latin America between 1960 and 1975, considerably above the US TFP growth rate of 0.6%. Median growth in Latin America was even higher, at 1.6% per year, because it does not take into account outliers such as El Salvador and Nicaragua that experienced revolutions and high political instability in the period. In the following two and a half decades, however, while U.S. productivity growth kept the same pace, at 0.6% per year, Latin America TFP collapsed, declining at an average annual rate of 1.1%. As a result, in the entire 1960-2000 period TFP in Latin America fell in absolute terms 0.3% per year, and in eleven out of 18 countries of our sample it had zero or negative growth.

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4It should be noted, however, that the growth rate of US TFP was not constant between 1975 and 2000. In particular, it was close to zero between 1975 and 1983, corresponding to the well-known productivity slowdown. It increased since then, especially after 1995, averaging 1.4% between 1995 and 2000.
Table 1 presents data on relative TFP for the largest economies in Latin America. In some countries TFP surpassed that of the US before 1980 (e.g., Brazil in 1975, Venezuela between 1960 and 1975 and Mexico from 1960 to 1980), and in eleven out of the 18 economies of our sample TFP was at least 80% of US TFP between 1960 and 1980. This contrasts drastically with the situation in 2000, when relative TFP in Latin America was, on average, 62% of US TFP and in only two economies it was above 0.80.

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<td>Latin America</td>
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Individual examples may be illustrative. TFP in Mexico corresponded to 77% of US TFP in 2000, whereas it was 18% above US TFP in 1975. The fall in Argentina was even more dramatic, and maybe the worst case was that of Venezuela, where relative TFP reached 1.64 in 1970, but in 2000 it was only 61% of US TFP. Only Chile experienced an increase in relative TFP in the period.

We have identified, hence, two general patterns: relative TFP in Latin America was high until the mid-seventies and since then it fell 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 1975 average TFP in Latin America was higher than that of Western Europe and 60% higher than East Asia TFP.\(^5\) Hence, productivity in Latin America was higher than that of richer

\(^5\)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.
or similar regions. However, while in Western Europe and East Asia we observe a convergence to the US productivity level between 1960 and 2000, particularly dramatic in the latter, in Latin America there was increasing divergence relative to US TFP since the mid-seventies. Specifically, in 2000 both regions surpassed Latin America TFP by more than 20%.

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

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. In particular, mean TFP in Latin America was 20% above the average world TFP between 1960 and 1975. However, in 1995 it was only 5% above and five years later it was 3% below average world TFP. Only Sub-Sahara Africa fares worst in terms of TFP reduction in the period.

The countries included in the sample are: 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.


2.2 Robustness

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. 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 4 countries we have investment data since 1951.

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. This new capital stock series was then used to generate a new TFP series according to (3). This exercise is important because a higher depreciation rate reduces the importance of the initial capital stock in the capital stock series. Results did not change much. Between 1960 and 1975, average TFP in Latin America increased from 85% to 94% of US TFP. After this date, it fell continuously and in 2000 it corresponded to only 63% of US TFP.\(^7\)

Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), among others, construct a measure of TFP using a methodology in which the production function is expressed in terms of the capital-output ratio instead of the capital-labor ratio. In this formulation, the effect of productivity on capital accumulation will be attributed to TFP, which is calculated according to the formula:

\[
A_{it} = \frac{y_{it}}{\kappa_{it}^{-1} h_{it}}
\]

where \(\kappa\) is the capital-output ratio. The results confirm the relative TFP pattern documented previously. Between 1960 and 1975, TFP in Latin America increased from 79% to 89% of US TFP. Since 1975, however, it experienced a sharp decline, and in 2000 it corresponded to only 45% of US TFP. The fall in relative TFP is more dramatic when it is calculated based on the capital-output formulation since in this case the reduction in capital accumulation induced by the fall in productivity is attributed to TFP.\(^8\)

Data from Baier, Dwyer and Tamura (2006), comprising historical data that goes as far as 1900 for some Latin America countries, lead to similar results. Between 1930 and 1980, average TFP in Latin America was close to that of Western countries. However, Latin

\(^7\)See Table A1 in the Appendix.

\(^8\)See Table A2 in the Appendix.
America TFP was well below TFP of the Western countries in 2000.

Finally, we repeat our exercises using capital and output data from Nehru and Dhareshwar (1993). This is important as Cole et al (2005) used this data to conclude that Latin America TFP during the post-war period corresponded to only 50% of the US TFP. We use expression (3) to construct TFP measures for Latin America, Western Europe and East Asia.\(^9\) Education data, as before, is taken from Barro and Lee (2000). From 1950 to 1975, average TFP in Latin America fluctuates a little above 80% of US TFP. As shown in Figure 3, mean relative TFP in Latin America fell continuously after the mid-seventies and in 1990 it was only 55% of American TFP. Hence, we can conclude that our previous findings are confirmed using Nehru and Dhareshwar (1993) data set.

![Figure 3: Relative TFP, Latin America and Other Regions (US=1) - Nehru-Dhareswar Data](image)

These stylized facts are puzzling. It has been long believed that policy distortions, such as competitive barriers associated with import-substitution, were among the main determinants of low TFP and output per worker in Latin America relative to the U.S. and other developed countries. Cole et al (2005), for instance, argue that competitive barriers imposed by interest

\(^9\)We use the same sample for Latin America, Western Europe and East Asia that we have been using in the paper.
groups are possibly an important determinant of low TFP in Latin America. Related research by Hopenhayn and Neumeyer (2004) argues that import substitution industrialization and targeted investment subsidies may be key determinants of low productivity in Latin America.

Our results put in question these conjectures, since productivity in Latin America was relatively high in a period (1960-1975) that was characterized by widespread state intervention in the economy and import substitution industrialization. Moreover, relative TFP in Latin America declined despite the implementation of several market-oriented reforms in the eighties and nineties.\textsuperscript{10}

\section{A Two-Sector Neoclassical Growth Model}

As displayed in Figure 4, between 1975 and 2000 there has been a decline not only in Latin America relative TFP, but also in its relative output per worker.\textsuperscript{11} Specifically, until 1975 Latin America output per worker was relatively constant around 45\% of the US. It declined between 1975 and 1990 and it remained roughly constant between 1990 and 2000 at a level around 30\% of US output per worker.

\textsuperscript{10}See Kuczynski and Williamson (2003) for a description of several market-oriented reforms implemented in Latin America in the eighties and nineties.

\textsuperscript{11}This figure refers to a subgroup that includes the seven Latin America countries with the largest populations in 2000: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. When we consider the larger group of eighteen Latin American countries, we observe a modest increase in relative output per worker until 1980 and a sharp decline thereafter.
The decline of relative output per worker in Latin America between 1960 and 2000 stands in sharp contrast to the patterns observed in East Asia and Western Europe, which experienced a catch-up to US output per worker during the same period. Parente and Prescott (2005) argue that the experience of East Asia and Western Europe is consistent with a reduction of barriers to the adoption of better technologies or to the more efficient use of existing technologies. This suggests that the decline in relative Latin America output per worker since the mid-seventies may be associated with an increase in policy-created technology barriers in this region.

Import-substitution industrialization (ISI) is one possible candidate for such a policy. As described in Hirschman (1968), ISI was a development strategy characterized by a sequential nature. It started in the consumption goods sector and proceeded in stages, culminating in the substitution of domestic production for imports in the capital goods and intermediate goods sector. In fact, some Latin American countries implemented import-substitution policies in the investment goods sector in the seventies. In particular, Brazil launched a major ISI program in the capital goods sector called the II Plano Nacional de Desenvolvimento (II PND).\footnote{Another aspect of the II PND that may have contributed to a decline in TFP in the capital goods sector was the significant increase in government production of investment goods. See Schmitz (2001) for}
As shown in Eaton and Kortum (2001), the production of equipments is mainly located in developed countries, especially in countries with the highest R&D expenditures as a fraction of output. This implies that equipment imports are an important source of technological adoption in developing countries. In fact, Lee (1995) and Majumdar (2001) show that equipment imports from developed countries increase the growth rate of developing countries. Hence, the policies of import-substitution of capital goods adopted by some Latin American countries may have contributed for the decline in relative TFP and output per worker in the region since the mid-seventies.

3.1 The Model

The two-sector neoclassical growth model is particularly suitable to study the importance of investment-specific technology in explaining the behavior of TFP and output per worker across countries and over time. In this model, TFP in the capital goods sector relative to TFP in the consumption sector is inversely related to the price of investment relative to consumption. We can thus use data on the relative price of investment to identify the investment-specific TFP level.

Greenwood et al (1997) used a price series for quality-adjusted equipment to investigate the role of investment-specific technological change in explaining postwar US growth. Restuccia and Urrutia (2001) and Hsieh and Klenow (2007) used data on the relative price of investment obtained from the Penn-World Table to analyze the implications of investment-specific TFP for international differences in investment and capital per worker. In the remainder of this section we present a simple version of the two-sector neoclassical growth model and calibrate it to Latin America data.

Consider an economy inhabited by a representative household that solves the following problem:

\[
\max \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \quad \text{s.t.}
\]

a quantitative analysis of the effects of government production of investment goods on aggregate TFP and labour productivity.

\[13\] This corresponds to the second model in Urrutia and Restuccia (2001). In their first model, they interpret the relative price of investment as a measure of policy distortions.
\[
\tilde{c}_t + p_t \tilde{x}_t = \left[ r_t - \tau_k (r_t - \delta p_t) \right] \tilde{k}_t + \tilde{w}_t + \tilde{\chi}_t \tag{5}
\]
\[
(1 + g)(1 + n) \tilde{k}_{t+1} = \tilde{x}_t + (1 - \delta) \tilde{k}_t \tag{6}
\]

where \(\tilde{c}_t\) is consumption per effective labor, \(\tilde{x}_t\) is investment per effective labor, \(p_t\) is the relative price of investment, \(\tilde{k}_t\) is capital per effective labor, \(r_t\) is the rental rate of capital, \(\tilde{w}_t\) is the wage rate per effective labor, \(\tilde{\chi}_t\) is a lump sum transfer per effective labor, \(\tau_k\) is the growth rate of the labor force, \(g\) is the rate of technological progress, \(\delta\) is the rate of capital depreciation, \(\tilde{\beta} \equiv \beta (1 + g)^{1-\sigma} (1 + n)\) is the adjusted discount factor and \(\tau_k\) is a tax rate on capital income.\(^{14}\) Each member of the household supplies inelastically one unit of labor.

The Euler equation is given by
\[
(1 + g)(1 + n) p_t \tilde{c}_t^{1-\sigma} = \tilde{\beta} \tilde{c}_{t+1}^{1-\sigma} \left[(1 - \tau_k) r_{t+1} + (1 - \delta) p_{t+1} + \tau_k \delta p_{t+1}\right] \tag{7}
\]

There are two sectors: the consumption good sector and the investment good sector. The technology for producing the consumption good \(C\) is given by
\[
C = A_c K_c^\alpha \left((1 + g)^t L_c h\right)^{1-\alpha} \tag{8}
\]

where \(A_c\) is TFP in the consumption good sector, \(K_c\) and \(L_c\) are capital and labor devoted to the production of the consumption good and \(h\) is human capital per capita.

The technology for producing the investment good \(X\) is given by
\[
X = A_x K_x^\alpha \left((1 + g)^t L_x h\right)^{1-\alpha} \tag{9}
\]

where \(A_x\) is investment-specific TFP and \(K_x\) and \(L_x\) are capital and labor devoted to the production of the investment good.

The problem of the firm in the consumption sector is given by:
\[
\max \pi_c = C - w L_c - r K_c
\]

\(^{14}\)The tax rate on capital income may be interpreted more generally as a capital wedge. See Chari et al (2007) for such an interpretation.
The first-order conditions for the consumption sector firm are:

\[ \alpha A_c \tilde{k}_c^{\alpha-1} h^{1-\alpha} = r \]  
\[ (1 - \alpha)(1 + g)^t A_c \tilde{k}_c h^{1-\alpha} = w \]  

where \( \tilde{k}_c \) is capital per effective labor in the consumption sector.

The problem of the firm in the investment sector is given by:

\[ \max \pi_x = pX - wL_x - rK_x \]

The first-order conditions for the investment sector firm are:

\[ p\alpha A_x \tilde{k}_x^{\alpha-1} h^{1-\alpha} = r \]
\[ p (1 - \alpha)(1 + g)^t A_x \tilde{k}_x h^{1-\alpha} = w \]

where \( \tilde{k}_x \) is capital per effective labor in the investment sector.

In equilibrium, the marginal products of capital and labor are equated in the two sectors. This implies that capital per effective labor is equated in both sectors. The relative price of investment is given by:

\[ p = \frac{A_c}{A_x} \]

Using \( \tilde{k}_c = \tilde{k}_x = \tilde{k} \) and substituting (12) into (7), we obtain the steady state capital per effective labor:

\[ \tilde{k} = \left[ \frac{\alpha \beta (1 - \tau_k)}{(1 + g)^\sigma - \beta (1 - \delta) - \beta \tau_k \delta} \right]^{\frac{1}{1-\alpha}} A_x^{\frac{1}{1-\alpha}} h \]

Equation (15) shows that \( \tilde{k} \) increases with \( A_x \) and \( h \), and decreases with \( \tau_k \). Substituting (15) into (6), we obtain the investment per effective labor:

\[ \tilde{x} = [(1 + g)(1 + n) - (1 - \delta)] \left[ \frac{\alpha \beta (1 - \tau_k)}{(1 + g)^\sigma - \beta (1 - \delta) - \beta \tau_k \delta} \right]^{\frac{1}{1-\alpha}} A_x^{\frac{1}{1-\alpha}} h \]

Substituting (15) and (16) into (9), we obtain the share of labor in the investment sector,
According to (17), the share of labor in the investment sector decreases with the tax rate on capital income. The capital-output ratio measured in international prices is given by

\[
\kappa = \frac{\eta_x p^I}{[(1 + g) (1 + n) - (1 - \delta)] [(1 - \eta_x) p + \eta_x p^I]}
\] (18)

where \(\eta_x\) is given by (17), \(p\) is given by (14) and \(p^I\) is the relative price of investment in international prices. Equation (18) shows that the capital-output ratio in international prices is decreasing on the relative price of investment. On the other hand, a reduction in the tax rate on capital income increases the capital-output ratio through its positive effect on \(\eta_x\).

The steady state output per effective worker may be written as

\[
\tilde{y} = T F \tilde{P} \tilde{k}^\alpha h^{1-\alpha}
\] (19)

where \(\tilde{k}\) is given by (15) and detrended total factor productivity \(T F \tilde{P} \equiv \frac{TFP}{(1+g)}\) is given by

\[
TF \tilde{P} \equiv A_c (1 - \eta_x) + p^I A_x \eta_x
\] (20)

As shown in (20), detrended total factor productivity can be expressed as a weighted average of \(TFP\) in the investment and consumption sectors, where the weights are the labor shares in each sector.

### 3.2 Calibration

Next we calibrate the model in order to explain the decline in average TFP and output per worker in Latin America relative to the US between 1960-1975 and 1990-2000, which we interpret as steady states of the model. Data on the price of investment relative to consumption is obtained from the PWT 6.1.

To calibrate the model, we assume the following parameter values: \(\beta = 0.96; \sigma = 1; \delta = 0.035; \alpha = 0.4; g = 0.0153\). The value of \(n\) may vary across countries and over time and is obtained from PWT 6.1. We calibrate \(\tau_k\) to match the observed average capital-output ratio in 1960-1975. In the baseline calibration we keep the same value of \(\tau_k\) in 1990-2000. In the
formulas below, the superscript US denote U.S. variables and variables without superscript refer to Latin America. We set \( p^I = 1 \), which is approximately the value of the relative price of investment in Western Europe.

We calibrate \( \frac{A_c}{A_{US}^c} \) using (20), the observed average values of \( TFP \), the computed values of \( \eta_x \) and \( \eta_x^{US} \) from (17) and the average relative prices of investment, \( p \) and \( p^{US} \), in 1960-1975:

\[
\frac{A_c}{A_{US}^c} = \left( \frac{TFP}{TFP^{US}} \right) \left( \frac{1 - \eta_x^{US} + \eta_x^{US}}{1 - \eta_x + \eta_x} \right) \tag{21}
\]

We normalize \( A_{US}^c = 1 \). Given \( \frac{A_c}{A_{US}^c} \), we then compute \( A_c \). Using (14), the observed value of \( p \) and the computed value of \( A_c \), we obtain \( A_x \):

\[
A_x = \frac{A_c}{p} \tag{22}
\]

We assume that \( \frac{A_c}{A_{US}^c} \) is constant between 1960-1975 and 1990-2000 and compute the variation in \( \frac{A_c}{A_{US}^c} \) from the change in \( p \) between these periods. To compute relative \( TFP \) for the period 1990-2000, we use (20) and \( TFP^{\tilde{P}} = \frac{TFP}{1+g} \):

\[
\frac{TFP}{TFP^{US}} = \frac{A_c(1 - \eta_x) + A_x\eta_x}{A_{US}^c(1 - \eta_x^{US}) + A_x^{US}\eta_x^{US}} \tag{23}
\]

We compute the steady state values of \( k, \kappa \) and \( y \) from the model equations. We also perform a second calibration exercise, in which we allow the capital income tax rate \( \tau_k \) to vary over time, and calibrate its value in 1990-2000 to match the average capital-output ratio in the same period.

### 3.3 Results

#### 3.3.1 Brazil

In 1975, Brazil launched a major program of import-substitution in intermediate and capital goods called II Plano Nacional de Desenvolvimento (II PND). Tariffs were increased on imported intermediate and capital goods, ranging from 30% to 100% of the value of imports. For several goods, prior deposits became mandatory in order to receive import licenses, and
several non-tariff barriers were created, including a negative import list known as "Annex C" and a more stringent application of the Law of National Substitute.\footnote{See Pinheiro et al (2006) for a description of the II PND.}

In 1977, Brazil adopted an import ban (zero quota policy) on foreign produced computers. After the policy was adopted, Brazilian computer prices were 70 to 100 percent above international prices. Moreover, domestic content laws required Brazilian computer makers to use domestically produced components. As documented in Luzio and Greenstein (1995), the abandonment of the zero quota policy in 1992 was associated with large price declines and large productivity increases.\footnote{This policy is also analysed in Cole et al (2005).} As a consequence of the import-substitution policy, there was a sharp decline in the quantity of imported capital goods in Brazil since 1974. In 1985, real capital goods imports corresponded to only 19\% of its quantity in 1974.

Figure 5 shows that during the same period there was a sharp increase in the relative price of investment in Brazil. Specifically, between 1960 and 1975 the relative price was low and nearly constant and it more than doubled since the mid-seventies.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Relative Price of Investment in Brazil (1960-2000)}
\end{figure}

This evidence suggests that the increase in the relative price of investment in Brazil may have resulted from the decline in TFP in the investment goods sector associated with the
policy of import-substitution of capital goods. Based on the two-sector neoclassical growth model and the calibration procedure described in the previous subsection, we can compute the investment-specific TFP decline based on the increase in the relative price of investment and its implications for the other model variables, such as capital per worker, the capital-output ratio and output per worker. In the tables below, the notation $\hat{z}$ denotes the value of variable $z$ relative to the U.S. First, Table 2 presents actual values of $TFP$, $\hat{k}$, $\hat{\kappa}$ and $\hat{y}$ for Brazil relative to the US in the periods 1960-1975 and 1990-2000.

<table>
<thead>
<tr>
<th>Year</th>
<th>$TFP$</th>
<th>$\hat{k}$</th>
<th>$\hat{\kappa}$</th>
<th>$\hat{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1975</td>
<td>0.88</td>
<td>0.30</td>
<td>0.88</td>
<td>0.34</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.77</td>
<td>0.30</td>
<td>0.99</td>
<td>0.30</td>
</tr>
</tbody>
</table>

As shown in Table 2, relative Brazilian TFP declined from 0.88 to 0.77 between 1960-1975 and 1990-2000. The relative capital-labor ratio was constant at 0.30, but the capital-output ratio increased from 0.88 to 0.99 of the U.S.. As a result of the TFP decline, output per worker in Brazil fell from 0.34 to 0.30 relative to the US value.

Table 3 presents the results obtained from the calibration of the model.

<table>
<thead>
<tr>
<th>Year</th>
<th>$TFP$</th>
<th>$\hat{k}$</th>
<th>$\hat{\kappa}$</th>
<th>$\hat{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1975</td>
<td>0.88</td>
<td>0.30</td>
<td>0.88</td>
<td>0.34</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.79</td>
<td>0.07</td>
<td>0.39</td>
<td>0.17</td>
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Simulation: increase in $p$

As a comparison between Tables 2 and Table 3 shows, the model can account for the TFP decline in Brazil between 1960-1975 and 1990-2000. However, the model predicts a sharp decline in the capital-output and capital-labor ratio, which was not found in the data.

We then perform a second exercise, in which the tax rate on capital income was calibrated to match the average capital-output ratio in 1990-2000. The results are presented in Table 4.

<table>
<thead>
<tr>
<th>Year</th>
<th>$TFP$</th>
<th>$\hat{k}$</th>
<th>$\hat{\kappa}$</th>
<th>$\hat{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1975</td>
<td>0.88</td>
<td>0.30</td>
<td>0.88</td>
<td>0.34</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.77</td>
<td>0.30</td>
<td>0.99</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Simulation: increase in $p$ and reduction in $\tau_k$
As shown in Table 4, if we allow the tax rate on capital income (capital wedge) to fall in order to match the capital-output ratio in 1990-2000, the model not only accounts for the observed decline of TFP in Brazil, but it also matches the patterns of capital and output per worker.

One possible interpretation is that the market-oriented reforms implemented in Brazil since the early nineties may have contributed for a reduction in the capital wedge, captured in the model by $\tau_k$, which in turn prevented the capital and output per worker from having the sharp decline that would have occurred as a consequence of the fall in TFP.

### 3.3.2 Latin America

In this subsection, the results refer to a subgroup that includes the seven most populated Latin America countries in 2000: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela. We focus on this group due to its greater homogeneity and because it coincides with the sample of Latin American countries studied in the seminal growth accounting analysis of Latin America by Elias (1992).\textsuperscript{17}

A sharp increase in the relative price of investment was not unique to Brazil among Latin American countries. Figure 6 presents the evolution of the relative price of investment in Latin America and other regions between 1960 and 2000.

\textsuperscript{17}Results for the larger group of eighteen Latin American countries are similar and are available upon request.
Figure 6: Relative Price of Investment in Latin America and Other Regions (1960-2000)

One can observe that in the early sixties the relative price of investment in Latin America was close to the corresponding value in Western Europe. Since then it increased continually, especially since the mid-seventies, and in 2000 it was one-third higher than in Western Europe.

Table 5 presents actual values of $T F \hat{P}$, $\hat{k}$, $\hat{\kappa}$ and $\hat{y}$ for Latin America relative to the US in the periods 1960-1975 and 1990-2000.

<table>
<thead>
<tr>
<th>Period</th>
<th>$T F \hat{P}$</th>
<th>$\hat{k}$</th>
<th>$\hat{\kappa}$</th>
<th>$\hat{y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1975</td>
<td>0.91</td>
<td>0.44</td>
<td>1.00</td>
<td>0.44</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.70</td>
<td>0.27</td>
<td>0.89</td>
<td>0.31</td>
</tr>
</tbody>
</table>

As shown in Table 5, relative Latin America TFP declined from 0.91 to 0.70 between 1960-1975 and 1990-2000. The relative capital-labor ratio declined from 0.44 to 0.27 and the capital-output ratio fell from 1 to 0.89. As a result of the TFP and capital decline, output per worker in Latin America fell from 0.44 to 0.31 relative to the US value.

Table 6 presents the model results.
A comparison between Table 5 and Table 6 shows that the model accounts for about 1/3 of the TFP decline in Latin America between 1960-1975 and 1990-2000. However, the model predicts a sharp decline in the capital-output and capital-labor ratio, which is greater than the one found in the data.

We then perform a second exercise, in which the tax rate on capital income was calibrated to match the average capital-output ratio in 1990-2000. The results are presented in Table 7.

<table>
<thead>
<tr>
<th>Year Range</th>
<th>$TF\bar{P}$</th>
<th>$\bar{k}$</th>
<th>$\bar{\kappa}$</th>
<th>$\bar{\dot{y}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1975</td>
<td>0.91</td>
<td>0.44</td>
<td>1.00</td>
<td>0.44</td>
</tr>
<tr>
<td>1990-2000</td>
<td>0.83</td>
<td>0.37</td>
<td>0.89</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Simulation: Increase in $p$ and reduction in $\tau_k$

If we allow the tax rate on capital income (capital wedge) in Latin America to fall in order to match the capital-output ratio in 1990-2000, the model can account for 38% of the decline of TFP, 41% of the reduction of capital per worker and 23% of the decline in output per worker.

As in the case of Brazil, it is possible that the market-oriented reforms implemented in Latin America since the eighties may have contributed for a reduction in $\tau_k$, which in turn contributed for a considerably smaller decline in capital and output per worker than would have occurred otherwise.

4 Conclusion

In this paper it was shown that at least until the mid-seventies the average Latin America economy was relatively productive, with a TFP level close to or above most rich nations. This result is very robust, as it was found using different datasets and alternative methodologies.
to construct capital stocks and total factor productivity. Another stylized fact is that TFP fell sharply in Latin America after 1975, and in 2000 TFP in the region corresponded to 62% of U.S TFP. In only one country, Chile, relative total factor productivity in 2000 was above its corresponding value in 1975.

These results allow us to conclude that at least until the mid-seventies, TFP was not the main cause for the relative poverty of the region. The main determinants of low income per capita in the region were factors of production, namely physical and human capital. However, after the mid-seventies the TFP decline was the main explanation for Latin America stagnation.

The puzzle raised by these results is that policies in Latin America during the entire post-war period were very distortive and in theory were supposed to be associated with low TFP. In particular, the period between 1960 and the mid-seventies was characterized by widespread government intervention and import-substitution industrialization in Latin American economies. To cite a few of the distortions associated with these interventions, there were competitive barriers of different forms, including barriers to international trade, licensing and cartelization, persistent government budget deficits, high inflation and targeted investment subsidies. In spite of this, TFP in the region was relatively high. Moreover, despite the adoption of market-oriented reforms since the eighties, TFP in Latin America declined relative to the U.S. during this period.

A calibrated version of the two-sector neoclassical growth model indicates that policy distortions that reduced TFP in the investment goods sector may explain a significant fraction of the TFP and output per worker decline in Latin America, especially in countries that pursued aggressive policies of import-substitution of capital goods, such as Brazil.

The model results also suggest that the market-oriented reforms implemented in Latin America since the eighties may have contributed for a reduction in the capital wedge, captured in the model by the tax rate on capital income, which in turn prevented the capital and output per worker from having the sharp decline that would have occurred as a consequence of the fall in TFP.

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18 This is consistent with the evidence provided in Ferreira, Pessôa and Veloso (2008) that in the early seventies factors of production (physical and human capital) were the main source of output dispersion across economies.
References


## Appendix

### Table A1: Relative TFP (U.S=1) $\delta = 10\%$

<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td>0.98</td>
<td>0.90</td>
<td>0.92</td>
<td>0.97</td>
<td>0.93</td>
<td>0.77</td>
<td>0.62</td>
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</tr>
<tr>
<td>Brazil</td>
<td>0.72</td>
<td>0.72</td>
<td>0.81</td>
<td>0.98</td>
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<td>0.74</td>
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<td>0.86</td>
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<td>0.78</td>
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<td>0.90</td>
<td>0.95</td>
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<td>0.90</td>
<td>0.76</td>
<td>0.64</td>
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<td>1.03</td>
<td>1.03</td>
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<td>0.79</td>
<td>0.67</td>
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<td>0.84</td>
<td>0.88</td>
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<td>0.88</td>
<td>0.76</td>
<td>0.72</td>
<td>0.71</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### Table A2: Relative TFP (U.S=1) Capital-Output Ratio Methodology

<table>
<thead>
<tr>
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</tr>
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<tbody>
<tr>
<td>Argentina</td>
<td>0.98</td>
<td>0.88</td>
<td>0.89</td>
<td>0.97</td>
<td>0.89</td>
<td>0.62</td>
<td>0.40</td>
<td>0.60</td>
<td>0.53</td>
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<tr>
<td>Brazil</td>
<td>0.73</td>
<td>0.69</td>
<td>0.80</td>
<td>1.11</td>
<td>1.04</td>
<td>0.78</td>
<td>0.62</td>
<td>0.68</td>
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<td>0.49</td>
<td>0.58</td>
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<td>0.84</td>
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