Growth in Latin America: Models and Findings *

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Abstract

1 Introduction

The performance of the Latin American economies in the 20th century has been disappointing. Using per capita GDP as a measure, Latin America has roughly maintained its income (relative to the world) over the last 100 years. If, instead the post-1950 performance is considered, the results are more discouraging. Using data from Maddison (2003), it follows that the Latin American economies had a level of income per capita that was 18% higher than the world average in 1950. After 30 years, Latin America's per capita income exceeded the world average by almost 20%. However, in the early 1990s per capita income in the region was equal to the world average. Moreover, in the last fifteen years it has not improved. Even though Latin America is not the only region that has underperformed relative to the world (e.g. Africa's performance is even worse), it stands out because its endowment of natural and human resources, its institutions, and the (relative to the world) low level of social conflicts would have made it a natural candidate for a 'high growth' region at the turn of the 20th Century. It is this divergence between reasonable expectations and outcomes that makes the study of the determinants of growth in Latin America such a fascinating topic.

The objective of this paper is twofold. First, using the results produced by individual country studies as well as region-wide analysis, I discuss the proximate reasons for the poor economic performance of Latin America. I summarize the major findings of both growth and development accounting exercises that allocate differences in output per capita (or its growth rate) to differences in factor inputs and total factor productivity (TFP). Even though it is not easy to generalize from the sample of

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Latin American countries included in the study, it is clear that input accumulation, both physical and human capital, has proceeded at a steady pace over the last 50 years. On the other hand, measured TFP has shown more instability. Of particular interest is the observation that during the 'lost decade' of the 1980s, TFP decreased. This suggest that it is difficult to view TFP as just a measure of technology and, consequently, individual country studies and the region-wide analyses investigate the role of real and policy shocks in affecting TFP. Even though the details vary across countries and periods, most studies find that polices, and in particular bad policies, can negatively influence measured productivity.

The second objective of the paper is to develop some ideas that can provide intuition as to the channels through which real and policy shocks affect TFP. It is argued that 'standard' distortions (e.g. the type of wedges created by distortionary taxes) cannot account for changes in TFP. Distortions affect factor accumulation but not measured productivity. It is necessary to consider more elaborate distortions that, effectively, imply that the economy is in the interior of the production possibilities set. Alternatively, it is possible that there are no inefficiencies and that movements in TFP just reflect measurement problems. The relevance of each class of factors cannot be decided theoretically. It is necessary to develop fully specified models, and to take them to the data. This section is only a sketch of what seems promising avenues of future research.

The paper is organized as follows. Section 2 discusses the major findings. Section 3 presents a series of theoretical model that are helpful in understanding the connection between shocks, TFP and factor accumulation. Section 4 summarizes the results of the country studies. Finally, section 5 offers some concluding comments.

2 Findings

Even though individual country studies, as well as the background papers and the aggregate analysis by Blyde and Fernandez-Arias (this volume) used slightly different methodologies to study the major determinants of growth in Latin America, a reading of the findings uncovers some regularities. It seems convenient to distinguish between the role played (in an accounting sense) by factor accumulation and productivity, from the impact of real and policy shocks on the same variables.

From a purely accounting framework, differences and changes in aggregate output can be decomposed in a simple way in changes in the quantities of inputs used, and a residual element that captures, as a first approximation, movements in the efficiency in the use of resources, or TFP.[1]

To formalize this decomposition, assume that there is an aggregate production of

[1]Since TFP is a residual it is not easy to interpret. Given the way that it is measured it includes measures of technology, as well as any distortions that result in an economy operating in the interior of the production possibilities frontier.

the form

$$Y_t = A_t K_t^{\alpha} (e^{h_t} L_t)^{1-\alpha},$$

where K_t is the capital stock, L_t is number of hours employed (or number of individuals employed if hours variation is not important), and h_t is a measure of human capital, it follows that

$$\ln(Y_t/P_t) = \frac{1}{1-\alpha}\ln(A_t) + \frac{\alpha}{1-\alpha}\ln(K_t/Y_t) + \ln(L_t/P_t) + h_t, \tag{1}$$

where P_t is population at time t. According to this specification, changes in output per capita are due to changes in the capital intensity of production (as measured by K/Y), changes in the labor force participation rate (as measured by L/P), changes in the average level of human capital, h, and changes in the residual (or TFP), A.

More precisely, if γ_x denotes the growth rate of variable x, and under the assumption of constant growth rates, it is possible to rewrite the previous expression as

$$\gamma_{Y/P} = \frac{1}{1-\alpha}\gamma_A + \frac{\alpha}{1-\alpha}\gamma_{K/Y} + \gamma_{L/P} + \gamma_h. \tag{2}$$

This expression shows that it is possible to decompose the growth rate of per capital output in terms of its sources: changes in inputs, $\gamma_{K/Y}, \gamma_{L/P}$ and γ_h, and changes in TFP, γ_A. To make either one of these formulas operational, it is necessary to have good measures of inputs and α. If factors are paid their marginal products, α corresponds to the share of capital payments in GDP.

Both the estimation of the appropriate measures of inputs (quality adjusted levels of capital and labor), and the choice of the best value of α received a significant amount of attention by the authors of the individual country studies.[2] The findings imply that possible values of α range from 0.3 to 0.7. The high values tend to reflect measured (in the National Income and Product Accounts) capital income. However, as argued by Gollin (2002), there are severe measurement problems that require a downward adjustment in the estimate of the capital share. Since most of the country studies decomposed total growth using a value of α equal (or close to) 1/3, I will base my comments on that particular decomposition.

2.1 The Evolution of TFP

In this section I discuss, at a very general level, some of the findings about the factors that influence TFP. For a specific analysis of the role of these effects in specific countries, see section 4.

1. **The Contribution of TFP**. For the majority of the countries in the sample, the contribution of TFP, defined as $(\frac{1}{1-\alpha}\gamma_A)/\gamma_{Y/P}$ is significant. Even in countries in which this effect is not large on average (e.g. Chile), it seems that in

[2]For an early and comprehensive analysis as applied to some Latin American countries see Elias (1992).

periods of high growth in output per capita, the importance of TFP is magnified. These results can be extended to the typical Latin American country as shown by Blyde and Fernandez-Arias (this volume) and De Gregorio and Lee (this volume). Moreover, the variance of measured TFP accounts for most of the variance in growth rates.

2. **Movements in TFP**. In most Latin American countries, the growth rate of TFP until the mid to late 70's is positive and relatively small. From that time until the early 90's —and, in particular, during the 'lost decade' of the 80's— there is a sharp drop in the level of TFP. In the 90's the picture that emerges is mixed: in some countries (e.g. Argentina and Chile), measured TFP increased at exceptionally high rates, while in others (e.g. Brazil, Peru) the increase was modest. In some cases (e.g. Uruguay and Paraguay), TFP decreases in the 1990s. Relative to the rest of the world, Latin American countries have been losing productivity in all decades since 1960. However, when considering TFP differences with the rest of the world, the 1960s and 1970s look very similar to the 1990s. The 1980s still appear as a poorly performing decade (see Blyde and Fernandez-Arias (this volume)).

3. **Policies and TFP**. The interpretation of changes in A_t as being exogenous changes in productivity is not supported by the data. First, under this interpretation, a decrease in the level of TFP is equivalent to assuming that firms 'forget' from one period to the next how to use efficiently a technology. Second, and more to the point, different country studies have found that policy changes are correlated with changes in TFP. In some cases, documenting this correlation is easy. For example, TFP appears to be correlated with the relative price of capital goods, with measures of the real exchange rate, the domestic inflation rate, as well as other measures of the size of the government (e.g. the ratio of government consumption to output). These findings are consistent with the view that changes in the trade regime —as proxied by the first two variables— and changes in the level of domestic distortions —as proxied by the other two variables— can affect measured TFP. These examples, however, do not completely exhaust the findings about the connection between policies and TFP. It appears that during periods of liberalization of economic policies (e.g. Chile in the late 1970s, and post 1985; Argentina and Peru in the 1990s), TFP tends to increase significantly above trend. This observation does not apply uniformly to all the countries included in the study (e.g. Uruguay and, to some extent, Brazil in the 1990s). The difficulty in assessing the impact of the major reforms is that they typically include some structural shifts (e.g. privatizations and deregulation) whose short-run and permanent effects are not easy to evaluate in the absence of models, and with a small amount of data. In their study of all Latin American countries, Blyde and Fernandez Arias (this volume) find that the three variables that affect the growth rate of TFP are a measure of openness,

the quality of institutions (both positively), and the inflation rate (negatively). Thus, it seems safe to conclude that the studies in this volume support the view that TFP is not exogenous. Rather it appears related to changes in government policies, technology or price shocks, as well as to the quality of institutions.

4. **Real Shocks and TFP**. Several country studies (e.g. Chile, Peru, and Uruguay) find that periods of deterioration of the terms of trade, and shocks to the real exchange rate, influence measured TFP. In other cases, economic shocks to neighboring countries —a shock that in some sense is similar to a movement in the terms of trade— also seems to feed back into measured TFP (e.g. Uruguay and Paraguay). As in the case of policies, it is difficult to generalize, as not all the individual studies used a common methodology. However, it appears that any successful attempt at explaining growth in Latin America will have to develop an analytical framework that allows for the impact of technology and terms of trade shocks on measured TFP.

5. **TFP and Inputs**. Most country studies find that TFP and the level of capital and labor are highly correlated. The movements are, in general, not proportional. Thus, in periods of fast increases in TFP, capital does not grow as fast, and in periods of productivity decline, capital fails to decrease at the same rate. The correlation between TFP and human capital —at least as proxied by education— is weaker. This variable displays an upward trend, even in the low TFP decade of the 1980's.

2.2 The Role of Factor Accumulation

A natural first approach is to view policies (and shocks) as major determinants of economic performance. Policies (shocks) can affect both the amount of factors used in production, as well as their productivity. In the previous section, I described some of the findings on the relationship between policies (shocks) and movements in TFP. In this section, I present the results on the impact of policies on factor accumulation are presented.

Over the period covered by the studies in this volume, it is possible to observe substantial variability both in the time series dimension (i.e. changes over time for a given country), as well as in the cross-section dimension (differences across countries) in the policies pursued by the countries in the sample.

Analyzing the effects of policies and shocks for a sample of Latin American countries, Blyde and Fernandez-Arias (this volume) find that the growth rate of factor accumulation depends negatively on the level of output per capita, a standard convergence effect. They also find that deviations of TFP from its trend value —which is also a measure of cyclical variation— have a positive impact on factor accumulation. Thus, there is evidence for the Latin American economies that convergence effects are present. Periods of low factor accumulation can be expected to be followed by periods of relatively high use on account of this catch-up effects.

In addition to the transition effects, Blyde and Fernandez-Arias find that improvements in human capital (measured as increases in life expectancy), lower levels of government consumption (relative to output), and a reduction in the black market premium (a variable that is probably correlated with poor overall economic policies) are positively associated with growth in the factor component of output. Their results are consistent with the view that domestic policies have a causal effect on resource accumulation. For example, consider the effects of a policy that results in an increase in life expectancy. This can be viewed as equivalent to an increase in an individual's planning horizon. In this case, most models that treat human capital as an investment imply that economic agents will react by increasing their schooling and training. On the other hand, a large ratio of government consumption to output is most likely associated with a higher level of distortions which, in turn, reduce both physical and human capital accumulation. Finally, the black market premium is also an indicator of policy instability, in the sense that it signals that the market views the price of foreign exchange set by the government as unsustainable. As it will be argued in the next section, policy instability can result in lower investment since it induces some firms to postpone implementing investment projects. Another interesting result in their study is that they find no effects associated with standard policy variables such as openness and inflation, and even institutional quality is not significant to explain the rate at which factors are accumulated.

In the last 50 years most Latin American countries have made substantial progress toward the goal of increasing the educational attainment of the population, and the quality (and access) of health care. Even though it is not immediate how to translate improvements in education and health into measures of improvements in the stock of human capital, it is the case that the outcome must have been an increase in the efficiency of the labors force.[3]These policies have resulted in a significant increase in the stock of human capital per worker, even though it is not immediate how to translate schooling gains into human capital gains. In general, the time series evidence shows a rising stock of human capital even during the 1980s, a period in which the region had negative growth rates on a per capita basis. In the 1990s the rate of increase in the stock of human capital has decelerated, and in some cases, has turned negative. It is not easy to find a simple relationship between economic policies and schooling and health care decisions. The Latin American experience indicates that poor economic policies have not discouraged human capital accumulation. More of a puzzle is to understand the 1990s. This decade witnessed a number of major policy reforms that have aligned private incentives with marginal costs. However, these regime changes have not increased the rate of human capital formation.

The behavior of capital is difficult to summarize. In the period 1950-1980, the

[3]For a discussion on the connection between schooling and the quality of human capital in the context of dynamic models of development see Manuelli and Seshadri (2004).

capital-output ratio increased moderately in most Latin American countries. This result is consistent with a long term decrease in the relative price of capital goods (see Gordon (1990)). It is the last two decades that provide somewhat puzzling observations. The capital-output ratio kept increasing in most countries during the 1980s, although at more moderate rates, in a context of stable or decreasing output. In the 1990's many countries exhibit substantial decreases in the capital-output ratio, even when the economy was expanding.

Can this behavior be explained by changes in prices or policies? During the 1980s most countries faced much higher interest rates on their international borrowing. This, in turn, resulted in fairly high domestic interest rates. In addition, several countries adopted trade policies that, effectively, increased the price of capital. The combination of these two effects work in the direction of predicting a *lower* capital-output ratio in the 1980s. There are at least two arguments that might explain the observations. First, in a world in which TFP is viewed as stochastic, a negative (positive) shock to TFP results in a higher (lower) level of capital per unit of output (see section 3). Since the 1980s were a decade of unusually low TFP, and the 1990s a decade of high TFP, this could help resolve the puzzle. A second relevant consideration has to do with the level of public investment. If in response to the weak economic conditions in the 1980s, governments increased the levels of public investment, and compensated for that in the 1990s (when many countries adopted 'small government' policies), then it is possible that the capital output ratio moved in agreement with the observations (for a more formal argument see section 3).

A final theme that emerges from the country studies, is that uncertainty about the economic environment has contributed to lowering the level of output. In some cases (e.g. Peru) economic policy fluctuated between fairly extreme values, with the average duration of a regime being less than 6 years. The uncertainty associated with future economic conditions —even if it does not affect the price of capital goods— results in lower investment in physical capital.

3 Simple Models

In this section I present a series of simple models that shed light on the mechanisms that can explain the effects of policy changes and exogenous shocks on TFP and factor accumulation. The presentation is not rigorous. The objective is to provide a somewhat formal intuition about the channels through which policies affect measured TFP, and the equilibrium levels of capital and labor.

3.1 Policies, Shocks, TFP and Resource Accumulation

As indicated above, a simple model of growth can be summarized in the growth accounting relationship

$$\ln(Y_t/P_t) = \frac{1}{1-\alpha}\ln(A_t) + \frac{\alpha}{1-\alpha}\ln(K_t/Y_t) + \ln(L_t/P_t) + h_t.$$

In a standard growth setting, TFP is interpreted as a measure of (exogenous) productivity. However, as mentioned above, this interpretation is difficult to reconcile with the evidence that indicates that, over a period of a decade or so, the level of TFP can decrease by about 10-20%. A broader interpretation of TFP is needed.

A natural first approach is to view policies as influencing TFP. This is consistent with the evidence, and also appealing from a theoretical point of view. Unfortunately, standard models of distortions are *inconsistent* with the view that policies affect TFP. To illustrate this, it is useful to consider a steady state in which population (and employment) is stationary, and A (the 'true' measure of productivity) is constant. Given an interest rate r, and a tax rate on the returns to capital equal to τ[4], standard profit maximization implies that

$$(1-\tau)\alpha A K^{\alpha-1}(e^h L)^{1-\alpha} = p_k(r+\delta),$$

where p_k is the price of capital goods and the term

$$\frac{p_k(r+\delta)}{(1-\tau)}$$

is a measure of the user cost of capital.

The previous expression shows that increases in the tax rate decrease the stock of capital per worker, and the level of per capita output. If the above expression is rearranged, the capital-output ratio is given by

$$\kappa \equiv \frac{p_k K}{Y} = \frac{\alpha(1-\tau)}{(r+\delta)}.$$

From this formula it follows that not all increases in the user cost of capital translate into lower capital-output ratios; in particular, changes in the price of capital goods have no impact on κ.[5] This extreme result is due to the assumption that the price of capital is constant and that it is the same price used in computing the capital stock. Even though those assumptions are reasonable in some long-run applications, they are not appropriate when trying to use the model to understand short term changes in κ.

[4] The results are similar when more realistic tax codes are taken into account.

[5] In this discussion the capital-output ratio is measured in domestic prices. If instead, measures of κ at international proces are used, then changes in the wedge between domestic and international prices of capital (e.g. due to tariffs) influence the measured capital-output ratio.

To study the effect of shocks and uncertainty, I assume that, in period t, individuals have to form expectations of future productivity shocks and prices of capital goods.[6] The appropriate version of the optimality condition is

$$p_k(1+r) - (1-\delta)E[p_k^{'}] = (1-\tau)\alpha E[A']K^{\alpha-1}(e^h L)^{1-\alpha},$$

where a $'$ indicates a future value, and the symbol E denotes the conditional expectation. Note that, given the current price of capital goods, p_k, an increase in the expected future price, $E[p_k^{'}]$ reduces the user cost of capital, and this induces higher levels of investment. The reason for this is simple: The expected price increase creates the possibility of a windfall gain for the owner of capital, and this acts as an incentive to purchase capital goods.

A simple manipulation of the above expression shows that the observed capital-output ratio is given by

$$\kappa \equiv \frac{p_k^B K'}{Y'} = \frac{E[A']}{A'} \frac{p_k^B(1-\tau)}{p_k(1+r) - (1-\delta)E[p_k^{'}]}, \tag{3}$$

where p_k^B is the (constant) price used to compute (in the National Income and Product Accounts) the real level of investment. This simple formula reveals some interesting effects. First, if the realized value of TFP, A', is lower than the expected value, $E[A']$, κ increases. This is what might be called a 'recession' effect: If investment plans were made at a time in which expectations about future output exceeded actual output, decision makers find themselves with 'unwanted' excess capital. Of course, this effect can explain some short run changes in κ, but it is less likely to explain decade long variations unless there are long gestation lags.

It is possible that, even in a period of increasing prices of capital goods, the capital-output ratio increases as well. This will be the case if increases in p_k are associated with (sufficiently large) increases in $E[p_k^{'}]$, so that the denominator of (3) decreases. This is consistent with a situation in which, in anticipation of a government policy that will result in an increase in the price of capital goods, the private sector responds to a moderate increase in prices by increasing investment.

Even though shocks to the price of capital goods, actual TFP, and the interest rate are likely to have a substantial impact on measures like the capital-output ratio and the equilibrium levels of labor, they do not affect measured TFP. If these were the only shocks hitting the Latin American economies, and if the simple model captured all the relevant features of the economic environment, TFP should be identical to technology. This implication is at odds with the finding that TFP is not only important explaining growth, but that it is not exogenous, since it is influenced by policy and technology shocks. Thus, to borrow Ed Prescott's words we need a 'theory' of Total Factor Productivity (see Prescott (1998)). In what follows I present a

[6] I concentrate on the uncertainty about those two variables to simplify the presentation. A more complete model should also take into account the covariation between those shocks and interest rates.

series of ideas, in the form of incomplete models, that are suggestive of the mechanisms through which shocks and policies can affect measured TFP. The analysis is not meant to be complete. Rather, it tries to emphasize some frictions that seem relevant in the case of Latin America.

Changes in Utilization Rates One view of the factors that drive changes in measured TFP over the business cycle relies on measurement error. According to this explanation, the *effective* amount of inputs differs from the *measured* level due to changes in the rate of utilization. This, in turn, can result in changes in measured productivity. To see how the argument works, consider a firm that uses capital and labor to produce output. Suppose that the technology can be described by a Cobb-Douglas production function of the form

$$Y = A(\nu_K K)^{\alpha}(\nu_L L)^{1-\alpha},$$

where K is the stock of capital, L the stock of labor, and the coefficients ν_j capture the rate of utilization of each factor. Installed capital is difficult to reallocate. Thus, shocks that require decreases in output may be accommodated by decreasing the utilization rate of capital. A similar argument applies to labor: in a downturn a firm may find it optimal not to lay off specialized workers, either because it expects that it will want to rehire them in the future, or because there are costs associated with layoffs. In these cases, ν_K and ν_L are less than one. Measured TFP is simply

$$TFP = A(\nu_K)^{\alpha}(\nu_L)^{1-\alpha}.$$

It follows that variations in the rate of utilization of inputs will be indistinguishable from changes in the productivity parameter A. Even though this argument is plausible when analyzing business cycle (see Burnside and Eichenbaum (1996)), it is unlikely that changes in utilization rates can explain decreases in measured TFP that persist for a decade or longer. However, it is possible that in economies with adjustment costs, these changes in utilization rates can be made both widespread and persistent. Constructing quantitatively realistic models that deliver these results is one of the challenges for future research.

Changes in Relative Prices A second shock that could give rise to movements in measured TFP is a change in relative prices. To illustrate this channel, consider a two sector economy where output of good i satisfies

$$Y_i = AK_i^{\alpha}(e^{h_i}L_i)^{1-\alpha},$$

where L_i is employment in sector i, and h_i is a measure of sector specific human capital.

Consider an initial situation in which the prices of the two goods are equal, and normalize $h_2 = 0$. Since human capital is sector specific, wages (per unit of h) need not equal across sectors. However, since capital is mobile, we impose that the rate of return on capital must be the same in the two sectors. A simple calculation shows that total output of this economy is given by

$$Y \equiv pAK_1^{\alpha}(e^{h_i}L_1)^{1-\alpha} + pAK_2^{\alpha}(L_2)^{1-\alpha} = pAK^{\alpha}(e^{h_i}L_1 + L_2)^{1-\alpha}.$$

To capture the possibility that shocks might 'destroy' human capital, I will assume that if a sector 1 worker reallocates to sector 2, then his specific human capital is lost. Thus, the difference between $e^{h_i} - 1$ is a measure of industry specific human capital lost due to reallocations.

I use this simple economy to study the impact upon measured TFP of a shock to the relative price of good 1 received by producers. Let the post-shock price of good 1, p', satisfy $p' = p/(1+\phi)$. In the short run, the allocation of capital across sectors is fixed, and the total supply of hours is also constant at $L = L_1 + L_2$. Labor, unlike capital, can be reallocated across sectors. Simple but tedious calculations show that aggregate output (at constant pre-shock prices) is given by

$$Y' = Y[\zeta \left(\frac{L_1^{'}}{L_1}\right)^{1-\alpha} \frac{1}{1+\phi} + (1-\zeta)\left(\frac{L_2^{'}}{L_2}\right)^{1-\alpha}],$$

where ζ is the share of GDP corresponding to sector 1,

$$\zeta = \frac{e^{h_i}L_1}{L_2 + e^{h_i}L_1}.$$

From an aggregate point of view —the one taken in the computation of TFP— the stock of capital, K, and the stock of labor, L, have not changed. Thus, any change in output is interpreted as a change in TFP. In this case *changes* in measured TFP are given by

$$\Delta TFP = \zeta \left(\frac{L_1^{'}}{L_1}\right)^{1-\alpha} \frac{1}{1+\phi} + (1-\zeta)\left(\frac{L_2^{'}}{L_2}\right)^{1-\alpha}.$$

It follows that if $\phi = 0$, then $L_1^{'} = L_1$ and $L_2^{'} = L_2$, and there is no change in measured TFP. Thus, for this mechanism to affect productivity, it is necessary that relative producer prices respond to a shock.

Can these relative price effects be quantitatively important? As a rough indication, consider the case in which sector 1 employs 30% of the work force (i.e. $L_1/(L_1 + L_2) = 0.3$), and the sector-specific human capital generates a wage premium of 10% (i.e. $e^{h_i} = 1.1$). For this economy a 20% decrease in the relative price of good one (i.e. $\phi = 0.2$) results in a *decrease* in measured TFP of almost 30%. In this case, the post-shock share of employment in sector 1 decreases by over 16% (from .30 to .25). Since some workers lose their jobs in sector 1 and find employment in sector 2, their 'effective' human capital is lost. However, since aggregate employment (and the identity of those employed) is unchanged, aggregate measures of labor (both raw and quality adjusted) are unchanged.

One issue that this example raises is whether the measured change in TFP is larger when the sector-specific human capital is more important. To study this possibility, consider a similar economy in which the initial industry specific human capital is larger (e.g. $e^{h_i} = 1.15$). In this case, the decrease in measured TFP is substantially smaller, and less than 20%. Thus, contrary to intuition, immobility induced by sector specific skills makes measured decreases in TFP *less severe*. The reason for this is that to induce workers to give up the extra income that they receive in their original industry, a larger change in wages is required. Thus, for a given price shock, fewer workers reallocate and hence the smaller the change in TFP. In the extreme case in which neither capital nor labor are mobile there is *no change* in measured TFP. The reason is simple: if inputs are not mobile then physical output does not change. Since the prices used to compute GDP are fixed, there is no change in measured output.

To ascertain the quantitative importance of this effect it is necessary to have access to the relevant price data. What these prices are, precisely, depends on institutional details. If there are *no differences* between consumer and producer prices, a decrease in TFP should be accompanied by changes in measured relative prices. In this case, the existence of a link is relatively easy to quantify. However, if there are policies that create a *wedge* between cost per unit and market price, the implications are less obvious. To illustrate this, suppose that the producers of good 1 receive a subsidy at rate τ. In this case, the price that determines resource allocation is not p but $(1+\tau)p$. Consider the case when the 'shock' consists of the elimination of the subsidy. Let the after shock market price (also the amount received by the firm per unit of output) be p'. The key comparison is now between $(1+\tau)p$ and p'. Without further assumptions, little can be said. However, if the good in question is traded internationally, and hence its market price is independent of demand, it follows that $p' = p$, and the relative price shock is equal to the change in the tax rate. In this case, recorded relative prices do not change, and economy-wide price data *are not* useful to detect the presence of this type of shock. Measured TFP decreases as a result of the elimination of subsidies. Of course, the mechanism is symmetric: Increases in subsidies (starting from a neutral situation) also induce drops in measured TFP.

Even though this mechanism appears to be a reasonable approximation of the policies pursued by certain government in certain periods (e.g. industrial policy-driven subsidies), determining whether it is a significant source of changes in TFP will require more precise documentation of specific distortions.

Changes in Exchange Rates and the Terms of Trade In some cases, changes in the relative price of imported inputs can induce changes in measured TFP. To see this, consider a one sector model in which aggregate output is produced using capital, labor —we ignore human capital for now—, and imported intermediate inputs. The aggregate production function is

$$Q = AK^{\alpha}L^{\beta}M^{1-\alpha-\beta},$$

where M is a measure of intermediate inputs.

The representative firm maximizes total output minus the cost of producing it. Thus, if p_M is the price of imported inputs and e the exchange rate, it follows that value added (GDP) is

$$Y = (\alpha+\beta)AK^{\alpha}L^{\beta}M^{1-\alpha-\beta}.$$

Substituting in the equilibrium demand for imports in the previous expression, it follows that domestic output is

$$Y = (\alpha+\beta)A\left(\frac{A(1-\alpha-\beta)}{ep_M}\right)^{\frac{1-(\alpha+\beta)}{\alpha+\beta}} K^{\frac{\alpha}{\alpha+\beta}}L^{\frac{\beta}{\alpha+\beta}}. \tag{4}$$

In this case, measured TFP is

$$TFP = \frac{Y}{K^{\frac{\alpha}{\alpha+\beta}}L^{\frac{\beta}{\alpha+\beta}}} = (\alpha+\beta)A\left(\frac{A(1-\alpha-\beta)}{ep_M}\right)^{\frac{1-(\alpha+\beta)}{\alpha+\beta}}.$$

The previous equation shows that increases in the relative price of imports — either due to changes in the exchange rate or the terms of trade— can result in lower measured TFP.

Can this channel explain the observed changes in TFP in the context of Latin America? Clearly, Latin American economies have experienced large shocks to their real exchange rates, as well as their terms of trade. Some of the country studies (see section 4) provide concrete evidence for this mechanism, as they find that the real exchange rate and the terms of trade affect measured TFP. However, the existence of a correlation, even with the right timing, is insufficient to accept this mechanism as the culprit behind movements in TFP. It is necessary to determine if the theory is consistent with the *magnitude* of the changes.

To this end, note that the elasticity of TFP with respect to the price of imports is $[1-(\alpha+\beta)]/(\alpha+\beta)$, which is also the share of intermediate goods imports in domestic value added. If we consider a country in which those imports are 10% of GDP, then extremely large increases in the price of imports (or real exchange rate shocks) are necessary to account for drops in measured TFP in the range of 10%-20%.

Is it possible that the quantitative effect of a change in p_M is much larger than the estimate provided by the previous model due to a mispecified production function? To analyze this possibility, I consider a different specification of the technology. In particular, I assume that, once installed, capital and imported inputs are perfect complements. I also assume that there is a per-period cost of operating capital equal to c_K. To be specific, assume that the (short-run) technology is

$$Q = AL^{1-\alpha}[\min(K, \eta M)]^{\alpha}.$$

It can be shown that, in this case, domestic value added is

$$Y = A\left(\frac{\eta c_K + (1-\alpha)ep_M}{\eta c_K + ep_M}\right)K^{\alpha}L^{1-\alpha},$$

and measured TFP is

$$TFP = A\left(\frac{\eta c_K + (1-\alpha)ep_M}{\eta c_K + ep_M}\right).$$

Increases in the exchange rate and the price of imported inputs tend to reduce — as in the Cobb-Douglas case— measured TFP. How large is this effect? It is possible to show that

$$TFP = A\frac{1}{1+\zeta},$$

where, as before, ζ is the ratio of the value of imports of intermediate inputs relative to GDP. Thus, the model predicts a *negative* correlation between imports and GDP. The reason is simple: an increase in the cost of imports reduces the volume of imports and the rate of utilization of capital, at the same time that it reduces domestic value added since imports must be subtracted from total output. Even for this more rigid specification, it seems that the magnitude of the observed changes in import shares is insufficient to account for the large changes in TFP. Of course, it is possible that a richer model —in terms of the specification of the technology— can generate quantitatively reasonable estimates.

It is often argued that one of the effects of changes in the exchange rate is that it affects the price of capital goods, and this, in turn, affects investment and output. Even though this argument is correct, it does not seem important to understand changes in TFP even though, as argued before, it may be relevant to understand changes in the amounts of factors used in production. To illustrate this, consider a steady state version of the model with a Cobb-Douglas production function. In the long run, the marginal product of capital must be equal to the rental price of capital. Let the domestic price of capital be ep_K, the interest rate, r, and the depreciation rate, δ. The equilibrium capital-labor ratio satisfies

$$(r+\delta)ep_K = \alpha A\left(\frac{A(1-\alpha-\beta)}{ep_M}\right)^{\frac{1-(\alpha+\beta)}{\alpha+\beta}}\left(\frac{K}{L}\right)^{-\frac{\beta}{\alpha+\beta}}.$$

Increases in the exchange rate (e), the price of capital goods (p_K), and the price of intermediate imported inputs (p_M) reduce the equilibrium capital-labor ratio. However, equation (4) still holds, and those shocks do not affect measured GDP.

As these examples suggest, shocks to exchange rates or terms can have an impact on measured TFP. However, there are two reasons why these shocks, by themselves, are not a promising candidate to explain changes in TFP. The first one, as discussed above, is that using standard parameter values, extremely large shocks would be required to account for the substantial changes in measured productivity. Thus, it is possible that exchange rate and terms of trade shocks contribute to changes in measured productivity, but their contribution cannot be large. The second argument is that if this is the 'true' source of movements in TFP, then the best response is to ignore TFP movements altogether. The reason is simple: these shocks just capture measurement error, and they do not affect welfare in a way that standard policies can (or should) control. If national accounts were computed using current (instead of base year) prices, then the model would predict no effects on TFP.

Changes in Public Investment Policies In the last 50 years, almost all Latin American countries have, at some point, pursued vigorous public investment policies. It is very difficult to ascertain the efficiency of the government investment criteria, as it varies over time for a particular country, and across countries.

Within the sample of countries whose experience is summarized in this volume, Peru appears as an example of significant and, apparently, inefficient government investment during the 1968-1990 period (see Carranza, Fernández-Baca and Morón (this volume)).[7] At the other end, the Chilean government in the post 1985 period seems to have used standard efficiency criteria to determine public investment.

In this section I show that inefficient public investment policies can account for both increases in the capital-output ratio, and decreases in measured TFP. This is consistent with the evidence for Peru.

Let the technology be given by

$$Y_t = AK_t^{\alpha}(e^{h_t}L_t)^{1-\alpha}.$$

Assume that the relevant aggregate capital stock, K_t, is a combination of private and government capital. Specifically, let

$$K_t = K_{Pt}^{\eta}K_{Gt}^{1-\eta}.$$

The Cobb-Douglas specification for the composite capital stock assumes that the elasticity of substitution between private and public capital is constant and equal to one. This formulation is adopted because it simplifies the presentation. The main qualitative results can be obtained using more general aggregators, provided that they display constant returns to scale.

Given an interest rate, r, and a unit price of capital, p_k the amounts of private and government capital solve

$$\begin{aligned} p_k(r+\delta) &= (1-\tau^k)\alpha\eta\frac{Y_t}{K_{Pt}}, \\ p_k(r+\delta) &= (1+s)\alpha(1-\eta)\frac{Y_t}{K_{Gt}}, \end{aligned}$$

[7] Paraguay during the construction of the Itaipú hidroelectric project is another candidate.

where δ is the depreciation factor. In this expression, τ^k is a measure of the distortions that affect private investment. It is expressed as a 'tax rate equivalent' level of distortions. Intuitively, it gives the value of a tax rate on capital income that would be required to rationalize a given investment level. We assume that $0 < \tau^k < 1$, and that increases in τ^k correspond to more distorted economies. The factor $1+s$ is a measure of the inefficiency of government spending. In the context of this simple economy, it can be shown that an efficient level of public capital is obtained when $s = 0$.

Using the two previous expression it is possible to show that measured TFP is given by

$$TFP \equiv \frac{Y_t}{\bar{K}_t^{\alpha}(e^{h_t}L_t)^{1-\alpha}} = A\left(\frac{(\eta(1-\tau^k))^{\eta}((1-\eta)(1+s))^{1-\eta}}{\eta(1-\tau^k)+(1-\eta)(1+s)}\right)^{\alpha}, \tag{5}$$

where $\bar{K}_t = K_{Pt} + K_{Gt}$. Equation (5) completely summarizes the impact of both the barriers to the accumulation of private capital and the subsidies to public capital on measured TFP. It is easy to see that this expression is maximal when $\tau^k = s = 0$.

Can this type of distortion be quantitatively important? In order to tackle this question it is necessary to obtain estimates of the vector (η, τ^k, s) in each period. As an illustration, I consider what might be relevant values for Peru in 1968-1990. I assume that before 1968, and after 1990, the relative components of total capital are undistorted. Since the share of private capital is approximately 75% in those periods, I assume $\eta = 0.75$. I assume that, before 1968, $\tau^k = s = 0$. I assume that, during the 1968-1990 period, the restrictions on private capital are such that its private marginal product is about 80% of its true marginal product. This implies that $\tau^k = 0.2$. Finally, I choose the value of s corresponding to the 1968-1990 period to match the change in capital-output ratio. According to Carranza, Fernández-Baca and Morón (this volume) the increase in the aggregate K/Y ratio is 90%. This implies that $s = 4.2$.[8] With these values, the simple model predicts a decrease in TFP of approximately 12%. Even though this is a substantial drop, it falls short of the cumulative 1.5% decrease estimated by Carranza, Fernández-Baca and Morón (this volume).

In summary, a simple model that relies on misallocation of public investment can explain both large increases in the capital-output ratio and significant decreases in measured TFP. In this case, the main channel through which policy affects TFP is the induced misallocation of the two forms of capital, private and public.

Changes in Sector Specific Subsidies In many Latin American economies, prices of specific inputs vary by sector or geographic area. These differences are driven

[8] This estimate implies that the actual marginal product of public capital was about 20% of its efficient level. This is a large degree of inefficiency, but it does not seem inconsistent with the analysis of Carranza, Fernández-Baca and Morón (this volume).

by a variety of policies and institutional features. For example, the firm-specific cost of a unit of labor can be affected by the existence of sectoral (or regional) promotional regimes, the prevalence of temporary contracts[9], and differences in the enforcement of labor laws. Variations in the cost of capital can result from policies that direct credit to specific sectors or regions, as well as from imperfections of capital markets.

Is it possible that differences across sectors/regions in factor input prices account for changes in TFP? The simple intuition is that when different productive units face different prices, the resulting allocation is inside the production possibilities frontier. In this sense, changes in the distortions that affect resource allocation can also influence how 'far' the economy is from the efficient frontier and, hence, the size of measured TFP. To illustrate this, consider an economy that produces a large number of (perfectly substitutable) goods indexed by i.[10] The production technology for sector i is,

$$y_{it} = Ak_{it}^{\alpha}n_{it}^{\theta}a_i^{1-\alpha-\theta} \qquad 0 < (\alpha, \theta) < 1, \qquad \alpha + \theta < 1, \tag{6}$$

where k_{it} and n_{it} are, respectively, the amount of capital and labor allocated sector i. The factor a_i, which is assumed fixed, is interpreted as managerial ability, although it is a stand-in for all sector-specific factors. It is also a measure of size of each sector. It turns out that allowing the $a_i^{\prime}s$ to be jointly distributed with the distortions has no impact on the predictions of the model for the measurement of TFP. Thus, without loss of generality, set $a_i = 1$ for all i.[11]

To model distortionary government policy we assume that, through the use of sector specific regulations and/or subsidies, the government affects the effective factor prices faced by the firms in each sector. More precisely, if the price of a factor is p in the "open market" a producer in sector i faces a price equal to $p/(1-\tau_i^j)$, where τ_i^j is the tax/subsidy rate faced by producers in sector i when purchasing input j. If τ_i^j is positive, it corresponds to a tax, while if it is negative it is a subsidy. Note that although producers face an "effective" price given by $p/(1-\tau_i^j)$, factor owners receive only p. The difference is a tax (or subsidy) that accrues to the residual claimants. I assume that both inputs are mobile. However, the same results apply if capital is not mobile ex-post; that is, if capital is assigned to a specific sector before the sectoral realization of tax/subsidy rates is known.

[9] For example, regimes that confer tax exempt status to some firms. This effect is particularly relevant when the incidence of social security taxes varies across firms. This can be driven by explicit differences in legal regimes, or they can be the result of the interaction between regulations and technology. For example, if temporary workers are exempt from social security contributions, firms that hire easily replaceable workers will, effectively, face a lower price of labor.

[10] Alternatively, it is possible to interpret i as an index of the location where the homogeneous good is produced. Both interpretations —different sectors or different regions— yield exactly the same results.

[11] This is due to the assumption that the function is homogeneous of degree one in all factors. This implies that changes in a_i correspond to changes in the size of each sector.

In order to more precisely characterize the role of the cross-sectional variability in incentives it is convenient to assume that the joint distribution of the logarithms of $(1-\tau_{it}^{n}, 1-\tau_{it}^{k})$ is normal, with mean $(1-\mu_n, 1-\mu_k)$, and variance-covariance matrix with diagonal elements σ_n^2 and σ_k^2, and off-diagonal elements given by $\rho\sigma_n\sigma_k$. Thus, ρ is a measure of how strongly the two sectoral distortions are correlated. A positive ρ indicates that sectors with high capital taxes (or subsidies) are also sectors with high labor taxes (or subsidies).

It is possible to show (see Manuelli (2003)) that aggregate output is given by

$$y_t = \Delta(\sigma_n, \sigma_k, \rho) A k_t^{\alpha} n_t^{\theta} \tag{7}$$

where the function $\Delta(\sigma_n, \sigma_k, \rho)$ satisfies

$$\Delta(\sigma_n, \sigma_k, \rho) = \exp\{-\frac{1}{(1-\alpha-\theta)}[\frac{\theta(1-\alpha)\sigma_n^2}{2} + \frac{\alpha(1-\theta)\sigma_k^2}{2} + \rho\alpha\theta\sigma_n\sigma_k]\} \tag{8}$$

In the absence of distortions, TFP in this economy is just A. Thus, $\Delta(\sigma_n, \sigma_k, \rho)$ is a measure of the TFP "gap." If either σ_n or σ_k are positive, $\Delta(\sigma_n, \sigma_k, \rho) < 1$, and *actual* TFP falls short *potential* TFP. In this setting distortionary government policies decrease TFP. What drives the results?

1. **The Mean Level of Distortion Does Not Affect TFP**. Since the μ_j do not enter in the expression for the TFP gap, $\Delta(\sigma_n, \sigma_k, \rho)$, changes in mean taxes (or subsidies) do not affect TFP. This is the analog of the result that was discussed at the beginning of this section: high average distortions have an impact on factor use, but not on measured TFP.

2. **The Cross-Sectional Variation of Distortions Affects TFP**. Increases in the variances of the two taxes (or the correlation between the two tax instruments) results in a *decrease* in measured TFP. This approach suggests that periods in which there is more dispersion of sectoral (or regional) incentives are also periods of low measured TFP.

3. **More Distorted Economies Have More Than Proportionally Lower TFP**. The TFP gap is proportionally larger the higher the level of variability. This follows since the function $\Delta(\sigma_n, \sigma_k, \rho)$ is strictly convex in $(\sigma_n, \sigma_k, \rho)$. Thus, the costs of additional variability is higher the more distortionary is the initial situation.

Are these effects quantitatively important? A complete answer to this question requires knowledge of empirically reasonable values of the relevant measures of dispersion. Unfortunately, there is no available data to estimate these second moments. As a first pass, I study the quantitative effects of different levels of distortion. The finding is that for substantial, but not extreme, variability, the model predicts large drops in TFP.

Consider an economy in which the 'true' shares of capital and labor equal to 0.4 ($\alpha = \theta = 0.4$). This implies that if a_i is interpreted as returns to managerial ability, total returns to labor and managerial ability are 60% of output.[12] Since I have no a priori information on whether capital or labor distortions are more severe I assume $\sigma_n = \sigma_k = \sigma$. For the lognormal distribution the coefficient of variation of a variable is approximately equal to the standard deviation of its logarithm. Thus, the values of (σ_n, σ_k) should be interpreted as measures of the cross-sectional variability of incentives relative to the mean level of distortion. Thus, a value of 0.5 corresponds to the case in which the coefficient of variation is 50%. I consider values of σ in the interval [0.1,0.7] with increment size equal to 0.1, and several values of the correlation coefficient ρ. The resulting measured TFP for each combination is presented in Table 1

Table 1: TFP Gap

σ	ρ					
	-0.8	-0,4	0.0	0.4	0.8	1.0
0.1	.99	.99	.98	.98	.98	.98
0.2	.98	.97	.95	.94	.93	.92
0.3	.95	.92	.90	.87	.85	.83
0.4	.91	.87	.83	.78	.74	.73
0.5	.87	.80	.75	.68	.63	.61
0.6	.82	.73	.65	.58	.52	.49
0.7	.76	.65	.56	.47	.41	.38

There are a couple of significant patterns. First, for high, but not extreme, levels of variability the model generates a substantial drop in TFP. For example, a country in which distortions are uncorrelated ($\rho = 0$) and the standard deviation of incentives is 50% ($\sigma = 0.5$) is predicted to have a level of TFP that is 25% lower than a country with no distorions. Second, and more interesting, when distortions are correlated within a sector (i.e. for high values of ρ), even moderate cross-sectional coefficients of variation can result in large drops in productivity. Taking the example used above if the assumption of zero correlation is replaced with perfect correlation ($\rho = 1$), then the drop in TFP is lamost 40%. From this numerical exercise, it is clear that the correlation of distortions across sectors is at least as important as their variability when it comes to estimating the output costs of policy distortions. It is also clear that high distortion countries (or periods) —as measured by σ_k and σ_n— are also low TFP countries (periods).

[12] The National Income and Product Accounts use arbitrary rules to allocate the return to some factors. In some instances, special skills —e.g. owner's organizational skills— are likely to be counted as profits and, therefore, as part of the return to capital. This would argue for smaller values of α and higher values of θ. In other cases, the same skills are priced by the market and are counted as labor compensation.

From a practical point of view it is very difficult to directly measure the 'gaps,' $(\tau_{it}^n, \tau_{it}^k)$, since they capture a number of different distortions. However, it is possible to determine the impact of the relevant coefficients —the second moments of the distribution of distortions— upon some observables. It turns out that the model has predictions about the effect of $(\sigma_n, \sigma_k, \rho)$ on the capital-labor ratio, and on the the return to managerial ability.

Let κ_{it} be the capital-labor ratio in sector i at time t. It can be shown (see Manuelli (2003)) that the variance of the cross sectional distribution of the (log of the) capital-labor ratio is given by

$$\sigma^2(\ln \kappa_{it}) = \sigma_k^2 + \sigma_n^2 - 2\rho\sigma_k\sigma_n.$$

Thus, if the is no cross-sectional variability in tax/subsidies, $\sigma^2(\ln \kappa_{it})$ should be zero. Evidence of variability, and especially changes over time, is indirect evidence for the presence of distortions.

Another variable that depends on $(\sigma_n, \sigma_k, \rho)$ is the unit price of the sector-specific resource, a_i. In applications, this is a measure of ex-post profits in excess of the normal rate of return to capital and/or excess payments to managers. The unit price of a_i, denoted p_i, is given by $p_i = (1 - \alpha - \theta)\frac{y_i}{a_i}$. It follows that the variance of $\ln p_{it}$ is given by,

$$\sigma^2(\ln p_{it}) = \left(\frac{\alpha}{1-\alpha-\theta}\right)^2 \sigma_k^2 + \left(\frac{\theta}{1-\alpha-\theta}\right)^2 \sigma_n^2 - \frac{2\alpha\theta}{(1-\alpha-\theta)^2}\rho\sigma_k\sigma_n.$$

As in the case of the capital-labor ratio, variability across sectors in pure profits is indirect evidence of the presence of the type of distortions emphasized in this note.

As a final comment on the relevance of this model, consider the effect of a real shock that affects, asymmetrically, all sectors. If the economic authorities respond by providing positive incentives to the most affected sectors, this may result in an increase in the cross-sectional variance of effective incentives. In the context of this model, this would further reduce TFP. Even though suggestive, the quantitative importance of this channel remains to be studied. The challenge will be to identify changes in (σ_n, σ_k) and, given those, to quantitatively determine what they imply for both factor accumulation and measured productivity.

Labor Market Distortions I: Formal and Informal Sectors Latin American countries have labor market institutions that are highly protective of formal employment by international standards. At the same time the rate of compliance with labor codes is relatively low (see Interamerican Development Bank (IDB) (2003)). Even though it is difficult to measure non-compliance, both direct anecdotal evidence and indirect evidence suggests that firms that do not comply with regulations have, on average, lower productivity.[13] In this section I explore how changes in labor market regulations affect measured productivity. Since I ignore the impact of policies on individual productivity, the approach emphasizes the consequences of different shocks on the allocation of labor between the high productivity (or 'formal' sector), and the low productivity ('informal') sector. To this end, it is necessary to develop a theory that is rich enough to accommodate the observation that, in equilibrium, some workers voluntarily choose to be employed in the low productivity sector, even though formal sector wages are higher. I use a version of the matching model developed by Mortensen and Pissarides (1994), suitably modified to capture the differences between formal and informal sectors.

The key friction that allows for the coexistence of both sectors in equilibrium is the assumption that jobs in the formal sector are difficult to find, and that workers choose to be employed in the informal sector until they find a job in the formal sector. Thus, I view employment in the low productivity (informal) sector and search for high wage jobs as complements.[14]

Assume that labor productivity in the formal sector, y, exceeds its counterpart in the informal sector, z. To simplify the presentation, I ignore capital, even though it is possible to view the productivity level in the formal sector as a function of capital per worker. Let u be the number of workers in the informal sector who are looking for formal sector jobs, and let v be the number of vacancies available in the formal sector. Then, following the matching literature (see Mortensen and Pissarides (1994), Diamond (1992)) the number of successful matches is an increasing function of both u and v, and given by $AM(u, v)$. Given the findings of Blanchard and Diamond (1990) I assume that there are constant returns to scale in matching and, hence, that M is homogeneous of degree one. This implies that only the ratio of vacancies to employment in the informal sector, denoted θ, matters to determine the allocation of workers to the two sectors.

Let $\theta q(\theta)$ be the 'job finding rate.' Then

$$\theta q(\theta) \equiv \frac{AM(u, v)}{u} = AM(1, \theta).$$

The function $\theta q(\theta)$ is increasing in θ. This is intuitive. It just says that if there is an increase in the number of vacancies per worker looking for a formal job, then the job finding rate is higher. Note that a change in A corresponds to a change in the efficiency of the matching process.

I assume that jobs in the formal sector are exogenously destroyed at the rate s. Informal sector jobs can be obtained instantaneously, so the rate at which they are

[13] For example, using the fraction of employment that is not covered by social security regulations as an indicator of informality, it follows that workers with little or no education, young workers and workers employed in small firms are more likely to be in the informal sector (see IDB (2003)).

[14] This is, undoubtedly, an extreme simplification. A more realistic model should allow for unemployment and variable search efforts. However, the simple version described in the text is sufficient to describe the main qualitative results.

destroyed is irrelevant. Firms in the formal sector have to pay corporate income tax rates and the employer share of social security taxes. Moreover, these firms face costs of creating vacancies, c, and also costs associated with terminating employment, F.[15] Workers in the formal sector pay both income and social security taxes on their income from the formal sector. Both firms and workers in the informal sector evade taxation. To simplify the presentation, I assume that employment in the informal sector does not require any matching.[16] Firms maximize profits and workers maximize expected discounted value of income (we ignore risk aversion).

Given an equilibrium job finding rate, $\theta q(\theta)$, the number of workers in the informal sector at time $t+1$ satisfies

$$u_{t+1} = (1-u_t)s + (1-\theta_t q(\theta_t))u_t. \tag{9}$$

The first term on the right hand side is the fraction of workers in the formal sector $(1-u_t)$ that lose their job at time t. The second term is the fraction of workers in the informal sector that do not find formal sector jobs at time t. For any initial condition, u_0, and given a guess as to the evolution of θ_t, (9) can be used to determine employment in the informal sector.

Aggregate labor productivity —which corresponds to TFP in this economy with fixed capital— is given by

$$a_t = y(1-u_t) + zu_t.$$

In this simple model any factors that increase the share of workers in the informal sector, result in lower measured (and actual) TFP. To highlight the role played by distortions and shocks, I concentrate on the steady state. In the steady state, average labor productivity is

$$a = \frac{y\theta q(\theta) + zs}{\theta q(\theta) + s}, \tag{10}$$

and wages in the formal sector are given by (see Manuelli (2004))

$$w = \frac{z + \phi[(1-\tau^\pi)y - z + \theta c + F(1-\beta+\beta s\theta q(\theta))]}{(1-\tau)(1-\phi) + \phi(1-\tau^\pi)(1+\tau^s)},$$

where τ^π is the corporate tax rate, τ^s is the employer's share of the social security tax, and τ is the tax rate faced by workers in the formal sector, which combines income and social security taxes.

[15] These costs correspond to resources lost, and they do not include transfers from firms to workers corresponding to government mandated (or union negotiated) severance payment programs. It does include that administrative costs (e.g. lawyer fees, costs of negotiating with labor unions) that firms must incur in order to fire a worker.

[16] This is equivalent to an infinite job finding rate in this sector.

In equilibrium, θ is a function of all the parameters of this economy. It can be shown (see Manuelli (2004)), that it is the solution to

$$\begin{aligned} & \frac{z+\phi[(1-\tau^{\pi})y - z + \theta c + F(1-\beta+\beta s\theta q(\theta))]}{(1-\tau)(1-\phi)+\phi(1-\tau^{\pi})(1+\tau^{s})} \\ = \; & y - \frac{1}{(1-\tau^{\pi})(1+\tau^{s})}[\frac{(r+s)c}{q(\theta)} + \beta s F. \end{aligned} \tag{11}$$

Equation (11) summarizes the implications of the model for the ratio of vacancies in the formal sector to employment in the informal sector, θ. Given this quantity, (10) can be used to evaluate the impact on TFP. Before proceeding it is useful to characterize the exogenous variables of the model in terms of the type of shocks and distortions that they capture.

Movements in the vector $(\tau^{\pi}, \tau^{s}, \tau)$ capture not only variation in tax rates, but also changes in all 'wedges' between prices and marginal products. Shocks to the productivity parameters, (y, z), can be interpreted in several ways. First, they obviously capture actual real shocks. Second, they also represent variations in labor regulations and enforcement of labor laws. An example of this is a mandated increase in holiday time. Given that y is a (flow) measure of productivity per period, the increase in holiday time results in fewer effective hours worked and a decrease in y. Similarly, a relaxation in the enforcement of labor regulations (and tax collection) can result in more efficient technologies being used in the informal sector, which could be captured as an increase in z. Shifts in labor regulations that affect the efficiency of the matching between workers and firms appear as shifts in the function $q(\theta)$. On the other hand, policy changes that increase the degree of protection of formal jobs are captured by movements in F. Macroeconomic shocks that affect job instability correspond to movements in the rate of job destruction, s, and regulations that make it more difficult to create firms in the formal sector are captured in increases in c, the cost of opening a vacancy. Thus, this simple setting is sufficiently rich to derive implications for both measured TFP and wages in the formal sector

The main *qualitative* results are:

1. **Productivity Shocks**. An increase in y, unambiguously increases measured TFP. The impact of an increase in z is ambiguous. The direct effect is to increase TFP, but since this induces more workers to accept jobs in the informal sector, this second effect tends to decrease productivity. An increase in job instability, s, decreases the share of workers in the formal sector and, consequently, will result in lower productivity.

2. **Tax Policy Shocks**. Even though I formally model policy shocks as tax rate shocks, they actually capture all form of 'wedges' between marginal products and market prices. Increases in τ^{π} and τ^{s} induce more workers to find jobs in the informal sector. Measured productivity (and wages in the formal sector)

decrease. An increase in τ also results in lower measured TFP. However, in this case, wages in the formal sector increase.

3. **Distortions**. In the context of this simple model, a downward shift in the matching function captures increased rigidities in the labor market. A decrease in $q(\theta)$ results in lower measured TFP (as a larger fraction of individuals work in the informal sector) and lower wages in the formal sector. An increase in the cost of creating a vacancy, c, also induces a reallocation of employment from the formal to the informal sector and the consequent decrease in measured TFP. The impact on wages is ambiguous. On the one hand, firms are willing to pay less given the higher costs of creating a job. On the other hand, the 'size' of the surplus from a match increases, and this makes workers who have a job in the formal sector more demanding.

4. **Labor Market Regulations**. As discussed above, changes in required benefits can be modeled as a decrease in y, and, at the same time, they appear as a decrease in labor input (if it was properly measured). If these were the only effects, then measured TFP does not change. However, in this model, the decrease in y results in a decrease in the wage rate in the formal sector, w, and this, in turn, induces a reallocation of workers toward lower productivity jobs in the informal sector. This results in lower TFP. An increase in the cost of firing, F, decreases the share of employment in the formal sector, and has an ambiguous impact on wages.

Are the predictions consistent with the evidence? It is not possible to directly test the implications of the model given the lack of data on employment in each of the two sectors. However, indirect evidence suggests that the forces that we identified have some predictive power to explain movements in TFP. If formal sector jobs correspond to jobs that offer social security benefits, and informal sector with jobs that do not, the flow of workers between sectors is significant in some Latin American countries. In Argentina, approximately 10% of workers who are in formal sector jobs transition to informal sector jobs in a six-month period. At the other end, approximately 12% of informal sector workers find formal sector jobs in the same period. This corresponds to estimates of s of 0.10, and $\theta q(\theta)$ of 0.12. Ignoring unemployment, this implies that the share of informal sector jobs is around 45%. The actual value for Argentina is somewhere between 40% (if only salaried workers are considered) and 55% (if all those employed are included). Since the class of employed individuals must surely include some part-time family members, the model's estimate of 45% seems reasonably close the actual value.

Using a measure of Conditions of Employment that includes laws and regulations in each country on the maximum number of hours in a workweek, overtime work, night shifts, holidays, hours of work, maternity and other types of leaves and vacation days, a study by the Interamerican Development Bank finds that increases in an index of those legislated benefits correspond to increases in fraction of workers who are self-employed (and likely to be low productivity in the model) for Latin American countries (see IDB (2003), Appendix Table 7.1). However, the same variable does not seem to affect the growth rate of TFP. Social security contributions have negative effects both on the employment rate and the rate of employment growth.

The evidence on the impact of job security is mixed. Heckman and Pages (2003) review the evidence for Latin America and note that, in some countries (Argentina and Peru), greater job security lowers employment rates in manufacturing (probably a sector with a larger share of formal firms). Studies of labor reforms in Chile and Brazil find no evidence of significant effects.

Even though it is difficult to have accurate measures of c, the indicators of Start-up Costs compiled by the World Economic Forum (2003), show that the median Latin American country has a higher cost of creating a firm than any other region in the world. Using the index as a cardinal measure, the cost of creating a firm in the median Latin American country is more than double the cost in the median developed country. On this account, TFP in Latin American should be, on average, lower than in developed countries. Unfortunately, there is no evidence of the time series behavior of these barriers to firm creation.

Overall, these ideas seem promising. They suggest that changes in TFP are associated with changes in the sectoral allocation of labor. If one assumes that the degree of informality is higher in the service sector (excluding government services), the implications of the model are consistent with the evidence presented by Hopenhayn and Neumeyer (this volume), that points out that decreases in changes in TFP and employment in the service sector comove.

Labor Market Distortions II: Search Costs It is widely believed that Latin American labor markets are less transparent than labor markets in developed countries. In particular, the ability of workers to move from job to job is probably low relative to other regions. Is it possible that changes in the cost of searching for a job will appear as changes in TFP? To study this, I consider a model in which wages in the formal sector are drawn from a given distribution, G. As before, the informal sector offers a wage equal to z, normalized to 0. Unlike the previous model, workers employed in the formal sector are allowed to search while employed. The cost of searching is κ. Assume, as before, that the exogenous rate of job destruction is s. In this setting it can be shown that workers with wages greater than a given cutoff wage, w^* do not search, where w^* is given by

$$\kappa(1-\beta s) = \frac{\beta(1-s)}{1-\beta(1-s)} \int_{w^*}^{\infty} (w-w^*)G(dw). \tag{12}$$

It follows that increases in both the cost of search and rate of job destruction, decrease the cutoff wage, $\bar{w}$, and increase the amount of job turnover. Differences in the amount of job turnover result in differences in average productivity. The reason for this is that when many workers are searching, a smaller fraction is, at any point, employed in low wage jobs. Thus, the average wage —which in this model equals productivity— increases with mobility. To formalize this intuition, let $N_t(w)$ be the fraction of all employed workers who are in jobs that pay at most w. Then a simple argument shows that this cumulative distribution function satisfies the following difference equation.

$$N_{t+1}(w) = \begin{cases} N_t(w)(1-s)G(w) + sG(w) & w \leq w^* \\ (N_t(w) - N_t(w^*))(1-s) + (1-s)N_t(w^*)G(w) + sG(w) & w \geq w^*. \end{cases} \tag{13}$$

The steady state wage distribution is

$$N(w) = \begin{cases} \frac{sG(w)}{1-(1-s)G(w)} & w \leq w^* \\ \frac{G(w)-(1-s)G(w^*)}{1-(1-s)G(w^*)} & w \geq w^*. \end{cases} \tag{14}$$

Standard arguments show that steady state average wages (and average productivity) are

$$\bar{w} = \int wN(dw) = \int (1 - N(w))dw. \tag{15}$$

It follows that increases in the cost of search decrease average wages (or average productivity). The formal expression is given

$$\frac{\partial \bar{w}}{\partial \kappa} = \int_{w^*}^{\infty} \frac{1 - G(w)}{(1-(1-s)G(w^*))^2}(1-s)g(w^*)\frac{\partial w^*}{\partial \kappa}dw < 0.$$

Thus, two countries that have the same distribution of entry level jobs (and the same distribution of accepted wages) can differ in terms of their average productivity because of differences in search costs. Since in these economies there are no differences in either employment or capital, the effects of search costs are captured in measured TFP.

3.2 Uncertainty and Investment

Latin American economic policies are characterized by a high degree of instability. For example, major policy changes that are reversed in a few years are far from exceptions (e.g. Peru, Argentina, Brazil). In this section I present a series of examples that suggest that increases in the variability of the demand faced by a firm, and of interest rates (for example, driven by policy variability) result in lower investment and output. I also show that expectations of delays in implementing required regime changes also have a detrimental impact on investment.

Following McDonald and Siegel (1986) I consider the optimal timing to make an irreversible investment (e.g. build a plant) by a firm that faces a stochastically fluctuating demand. Let profits, π_t, satisfy

$$d\pi_t = \mu\pi_t + \sigma\pi_t dW_t \tag{16}$$

where W_t is a standard Brownian motion. This specification implies that the mean growth rate of profits is μ, and the instantaneous standard deviation is $\sigma\pi_t$. Let the cost of the investment be I, and the interest rate, which is assumed constant for now, be r. The firm's problem is to find a time (a stopping time) to maximize

$$V(\pi; \sigma, r, \mu) = \sup_{\tau} E\left[e^{-rt}(X_\tau - I) \mid \pi_0 = \pi\right].$$

It can be shown that the optimal investment rule is: Build the plant the first time that profits reach the level π^*, where π^* is given by

$$\pi^* = \frac{\theta}{\theta - 1}(r - \mu)I, \tag{17}$$

and $\theta > 1$ is a function of both the mean growth rate, μ, and its standard deviation, σ. Increases in μ and σ decrease θ, while increases in r —the interest rate— has the opposite effect. Thus, increases in demand uncertainty make this firm more cautious: it waits until potential profits are higher —relative to an identical firm in a more stable environment— before it makes the investment decision. From the point of view of the impact on output what is relevant is not the 'investment threshold' but the impact on the average time until the investment is made. A simple calculation shows that given that potential profits today are at the level π, the expected delay is

$$\bar{\tau}(\pi; \sigma, r, \mu) = \frac{1}{\mu - \sigma^2/2} \ln\left(\frac{\pi^*}{\pi}\right). \tag{18}$$

It follows that:

- Increases in demand uncertainty result in a postponement of investment.
- Increases in the interest rate delay investment.

In many Latin American countries, government policies have an impact on the variability of factor prices. This is particularly important in the case of interest rates. During periods of major reforms, or when countries are faced with large external shocks, interest rates are highly variable. There are many ways of modeling the effects of variable interest rates. In what follows two possibilities are considered. First, I study the effects of shocks to the 'speed of adjustment' to the long-run interest rate. This exercise is meant to capture the effects of transitory versus permanent shocks. Then, the model is extended to allow for permanently fluctuating interest rates.

Consider the case in which profits grow at a deterministic rate. More precisely, potential profits evolve according to (16), with $\sigma = 0$. Thus, at time t profits are $\pi_t = \pi e^{\mu t}$, where π is the initial level of profits. Assume that at the time the project is implemented the interest rate is 'locked in.' Thus, the net present discounted value of the investment project that is implemented at time t is $\pi_t/(r_t - \mu) - I$. To capture changes in the interest rate, it is assumed that the interest rate evolves according to

$$dr_t = \phi r_t(1 - \frac{r_t}{\bar{r}})dt. \tag{19}$$

Thus, the long run interest rate is $\bar{r}$. This setting will be used to study how differences in ϕ affect investment. Higher values of ϕ are interpreted as capturing faster adjustment process, or more credible reforms. If greater uncertainty about the impact of a policy (or an external shock) manifests itself in the form of slower speeds of adjustment —this also captures increases in the permanence of government policies that prevent adjustment— then the model will capture this through increases in ϕ. It is possible to show that the length of time that it takes to implement a project, T, given an initial interest rate, r, an initial level of potential profits, π, and a 'speed of adjustment' parameter, ϕ, is the solution to

$$\pi e^{\mu T} = \bar{r}I + (r - \bar{r})\{\frac{I}{e^{\phi T}r + (r - \bar{r})} + \frac{\phi}{e^{\phi T}[r(\bar{r} - \mu) + \mu(r - \bar{r})e^{-\phi T}]^2}\}. \tag{20}$$

To understand the effects of policy shocks on decisions to delay investment, consider the following simple scenario: Suppose that a country's (current) budget policy is not feasible in the long run, and it is known that, at some point in the future, an adjustment which will result in a decrease in the interest rate will be implemented. Assume that the best policy is one that makes the adjustment instantaneously, and that the current interest rate exceeds the long-run rate, $r > \bar{r}$. If the instantaneous adjustment scenario also results in an instantaneous convergence of the interest rate to its long run value (formally, I take the limit when $\phi \to \infty$ in (20)), the previous expression shows that the equilibrium level of delay is given by

$$\pi e^{\mu T_0} = \bar{r}I.$$

This result is intuitive. It says that the investment should be made at the point where the flow of profits equals the capital cost —using the long run interest rate— of investment. Consider now the effect of a 'policy shock' that announces that a *delay* in the policy adjustment. Even if this delay does not affect neither the short nor the long-run interest rate (an unlikely event), it will result in a lower value of ϕ. Then, equation (20) shows that the optimal timing of investment is $T_1 > T_0$, and the required threshold of profitability to build a plant increases. In the aggregate, investment decreases. Thus, as expected, policies that result in slower convergence of interest rates —e.g. policies that either delay necessary adjustments, or policies that are viewed as infeasible— result in lower levels of investment.

In the previous example, interest rate variability is only a temporary phenomenon, as all paths converge to the deterministic value of the long-run interest rate, $\bar{r}$. However, permanent uncertainty about the cost of capital can also result in investment delays. To capture this, assume that the interest rate evolves according to

$$dr_t = \phi r_t(1 - \frac{r_t}{\bar{r}})dt + \gamma r_t dW_t, \tag{21}$$

where W_t is a standard Brownian motion, and γ is a measure of interest rate volatility. Under standard conditions, the long-run interest rate is given by (see Alvarez and Shepp (1998))

$$\lim_{t\to\infty} E[r_t] = \bar{r}\left(1 - \frac{\gamma^2}{2\phi}\right) \tag{22}$$

which falls below the 'non-stochastic' long run interest rate, $\bar{r}$. On the demand side, I simplify the model, and assume that the present value (once implemented) of the investment project is independent of the interest rate, and evolves according to $v_t = ve^{\mu t}$.[17] The firm's problem is to choose the optimal timing of investment, τ, to maximize the expected present discounted value of profits, given by

$$V(v, r; \gamma) = \sup_{\tau} E\left[e^{-\int_0^\tau r_s ds}(v_t - I)dt \mid v_0 = v,\ r_0 = r\right].$$

Under standard regularity conditions, it can be shown that increases in the variability of interest rates, γ, result in the firm choosing higher cutoff rates for the minimum acceptable v_t and, consequently, in lower investment.

To summarize, policy shocks that increase the level of uncertainty about either demand or the cost of capital, result in firms requiring higher levels of profitability before they invest in new plant or equipment. In the aggregate, these policy shocks tend to reduce investment. Policy changes that delay (necessary) adjustment have similar effect.

Even though these shocks cannot directly explain decreases in measured TFP, they are consistent with anecdotal evidence that shows that movements in productivity and the age of the capital stock are negatively correlated. Thus, uncertainty that delays investment, results in the average age of the capital stock to increase and this, in turn, appears as a slowdown in the growth rate of TFP, as newer capital goods are more productive.

4 Country Studies

This section summarizes the main results from the individual country studies.

4.1 Argentina

In their analysis of Argentine economic growth, Hopenhayn and Neumeyer (this volume) argue that Argentina's growth experience can be reasonably described by subdividing the last fifty years into three periods. The first period (1950-1974) is characterized by relatively stable (and low) growth in per capita income. The period 1975-1990 is one of substantial decreases in income per capita. During this period,

[17] This, of course, is an extreme assumption. Allowing the interest rate to influence the present value of the project complicates the analysis.

per capita output decreased at a cumulative rate of over 1% per year. Finally, the 1990s where a period of sustained growth, with per capita income growing at a rate of over 4% (for the subperiod 1991-1997).

Hopenhayn and Neumeyer argue that policy shocks are at least partially responsible for the disappointing performance of the Argentine economy in the 15 years after 1975. Their emphasis is on understanding how policy changes, and the uncertainty associated with future policy reversals, can account not only for the poor aggregate performance of the Argentine economy, but also for some puzzling observations.

According to Hopenhayn and Neumeyer (this volume), the main features of the Argentine economy are:

- Behavior of quantities

  1. During the period 1950-1974, the economy appears to be on a balanced growth path. Output per worker grew at a rate just below 1.8% per year. Growth was partially fueled by an increase in the capital-output ratio, which increased at an annual rate of 1.49%. In terms of the composition of employment, there is a very limited amount of sectoral labor reallocation.
  2. The period 1975-1990 is characterized by negative growth of income per capita (-1% per year), the stock of capital per worker (-0.70%), and measured TFP (-1.67%). However, the process of capital deepening did not stop: The capital-output ratio increased at the rate of 0.49% per year. During this period the stock of human capital per worker grew at a rate of almost 1.5% per year. The structure of production and employment shifted significantly. The share of employment in services in total employment displays a substantial increase, at the expense of agricultural and manufacturing employment.
  3. The decade of the 1990s witnessed an increase in per capita income, and high and positive rates of growth of both capital per worker and measured productivity. The growth process was mostly driven by increases in TFP. The capital-output ratio *decreased* at a rate exceeding 2.2% per year, and the stock of human capital per worker grew at a much slower rate.

- Behavior of prices

  1. The real exchange rate appreciates temporarily during the late 1970s. During the 1980's its level is comparable to that on the pre-1975 period. There is a significant real appreciation of the peso in the 1990s. Periods of temporary changes in policy or high inflation are also characterized by substantial volatility in the real exchange rate.
  2. Even though trade policy in Argentina was subject to substantial changes during the period under study, Hopenhayn and Neumeyer conclude that

the level of protection in the 1990s is very similar to other decades. The internal terms of trade (domestic price of imports relative to exports) relative to the external terms of trade (international price of imports relative to exports) shows significant increases in 1975 and during the 1980s. Moreover, this relative price is characterized by substantial variability. The relative price of capital goods shows a long run decreasing tendency, with peaks in 1975 and 1983.

3. Up until 1977, domestic interest rates were well below the market clearing price, and credit was rationed. During the 1980s, interest rates exceed 20% in real terms. The rates decrease to 10% in the 1990s.

Hopenhayn and Neumeyer analyze different models that can, in principle, shed light on the types of policies and shocks that influenced the economic performance of Argentina.

First, they consider a model in which capital is fixed and the degree of substitutability of capital and labor is much lower in manufacturing than in services. In this setting, increases in the labor force result in lower relative prices of services and higher employment in that sector, which is consistent with the Argentine experience. At constant prices this reallocation is consistent with the drop in measured TFP. A key element of the argument is that the stock of capital is held (approximately) constant. Why is this? Hopenhayn and Neumeyer point out that the increase in real interest rates and in the price of investment goods in the 1980s reduces the demand for capital. Thus, they attribute the poor performance of the economy to bad policies.

Even though the previous model is consistent with some of the observations for Argentina, it cannot explain the large drop in output in the 15 years after 1975. To this end, Hopenhayn and Neumeyer study the effects of policy uncertainty on the desired capital stock. They consider the impact of pursuing an infeasible trade policy. Because the policy is believed to be infeasible, economic agents expect a change in the future. However, they are uncertain about the *timing* of the reform. This uncertainty, effectively increases the cost of investing, since firms have to take into account the option value of waiting and avoiding a capital loss associated with investing in the 'wrong' sector. Hopenhayn and Neumeyer show that policy uncertainty can lower output and induce a substantial employment reallocation.

The model is fairly successful at explaining the Argentine depression of the 1980s. However, more work remains to be done, as this set up is unable to rationalize the decrease in measured TFP in the pre-reform period, and the subsequent increase in the 1990s.

4.2 Brazil

The chapter by Castelar Pinheiro, Gill, Servén and Thomas (CGSP hereafter) studies the determinants of growth in both factors and TFP in Brazil over the course of the

20th century. In addition to an aggregate analysis, the chapter also investigates the determinants of TFP and income growth at the micro level.

Brazil experienced a sustained increase in output per worker in the period 1900-1980, which exceeded 3% in almost every subperiod. As other Latin American countries, the 1980s were a negative growth decade: output per worker decreased at 0.5% per year in the 1980-1993 period. After 1994, Brazil resumed its long run growth rate, and output per worker increased at a rate of 3.4% in the 1994-2000 period.

What are the sources of growth in Brazil?

1. **Capital**. In the pre-1993 period, the capital-output ratio displayed substantial increases, with the 1951-1963 subperiod showing the highest growth rate, 1.8% per year. As in Argentina, the negative growth period (on a per capita basis) of 1981-1993 did not result in capital shallowing. To the contrary, the capital output ratio grew at a rate close to 1% per year. However, this aggregate value hides divergent behavior of different components. It is particularly noteworthy that the stock of machinery and equipment decreased at rate of over 2.5% per year. Thus, the increase in aggregate capital is mostly driven by the construction sector. The recovery of output after 1993 was not driven by investment. More specifically, the capital-output ratio decreased at a rate of 0.65% per annum. However, as a mirror image of the previous period, investment in machinery and equipment increased at an annual rate that exceeded 7% per year.

2. **Labor**. The stock of human capital per worker (measured in terms of years of schooling) shows substantial growth in the pre-1980 period, with an average rate of increase exceeding 2%. In the post-1980, the growth rate of human capital per worker is substantially slower, and close to 0.5%. This, as in the case of capital, the substantial recovery that starts in 1994 is not driven by an improvement in the quality of the workforce.

3. **Total Factor Productivity**. With the exception of the 1981-1993 period, TFP in Brazil grew at an annual rate of over 2%. During the 1981-1993 period, the growth rate was negative but much smaller than in other Latin American countries: 0.66% per year.

The relatively stable —with the exception of the 1980-1993 period— aggregate performance of the Brazilian economy, hides significant changes in the composition of output. The agricultural sector, which in 1900 accounted for 45% of GDP, contributes less than 13% in 2000, while the industrial sector's share increases from 13.2% in 1900, to 38.4% in 2000.

During this period, Brazil experienced significant changes in economic policy. Given the findings of CGSP, it appears the policy changes had a substantial impact on the composition of output, and much smaller aggregate effects. In order to discover which were the factors that can best explain Brazil's growth relative to other Latin American countries, CGSP estimated a growth regression using a sample of Latin American countries. The explanatory variables can be grouped in three categories:

1. **Shocks**. CGSP include a measure of World Growth to account for aggregate shocks, as well as to partially control for external demand shocks. In addition, they included a measure of the country's terms of trade.

2. **Policies**. Under this category CGSP include the rate on inflation and the black market premium. Even though these variables can have direct effects on growth, it is more likely that they capture infeasible budget and exchange regime policies (and these two are not independent). They also consider a measure of Openness, given by the ratio of the sum of imports and exports relative to GDP.

3. **Factors**. To control for changes in factors, CGSP include the investment rate, the number of years of secondary schooling and life expectancy among the explanatory variables. In order to allow for convergence effects, they also include initial income per capita.

CGSP estimate the regression using data for 20 Latin American countries, covering the period 1960-1999. The results are mostly in line with the findings of De Gregorio and Lee (this volume), with the exception of the openness variable, which CGSP do not find significant. Unlike De Gregorio and Lee (this volume) and Blyde and Fernandez-Arias (this volume) CGSP do not include any institutional variables. The authors use the regression results to predict Brazil's growth rate for each of the sub-periods of the 20th century *relative* to 1964-1980, and compute the contribution of each variable to the prediction. There are several noteworthy results:

1. The growth regression performs reasonable well in the sense that the prediction errors are small, except for the 1994-2000 period where it severely overpredicts growth.

2. For the 1931-1950 period, the most important factors that accounts for the lower growth rate in per capita GDP relative to the observed growth rate in 1964-1980 (-2.65%) are the low growth rate of world GDP, relatively low life expectancy, and insufficient investment.

3. The 1951-1963 period presents a small deficit relative to the reference period. The most important determinants are life expectancy and schooling, with the rest of the variables having a small aggregate impact.

4. The slow growth period of 1981-1993 is partially explained by the high inflation rate, and slow growth of world output.

5. Finally, the 1994-2000 period appears very different from the others. While the regression result predicts a positive growth differential of 1.45%, the data show that the differential was negative and large (-4.74%). What are the factors that explain this optimistic (but incorrect) forecast. The most important contributors are improvements in the measures of human capital: life expectancy and schooling. On the negative side, world growth and low investment are predicted to decrease the differential growth rate.

It seems that in the Brazilian case, policies that affect human capital formation have a large impact on growth. However, the results show that the level of those variables is not enough to accurately predict growth. They suggest that the sectoral allocation of resources is another possible channel through which human capital and growth are linked in Brazil. Among the policy variables, the high inflation of the 1980s stands out for its negative impact. In addition, policies that discourage investment have reduced growth.

As indicated above, TFP growth seems an important determinant of the recent growth performance in Brazil. In order to better understand the determinants of productivity growth, CGSP studied the factors that affect TFP at the firm level in a subset of industries, covering the period 1987-1998. There are several interesting findings. First, productivity at the firm level does not move as much as it does at the aggregate level. Their result lends support to the view that measured changes in TFP are only partially influenced by variations in the technology level, since they type of measurement errors discussed in section 3 are less likely to be important with firm level data. Second, CGSP find that measures that capture exposure to international competition are associated with higher TFP. In particular, lower tariffs, a more depreciated real exchange rate, and a larger share of imports are associated with higher levels of TFP. Third, policies that affect the age distribution of firms (e.g. barriers to firm creation, aid packages for older firms) matter for TFP, as older firms display both low levels of productivity and low growth rates. Finally, several measures that capture either the quality of the capital stock or the skill level of the labor force do not appear to be significant. Overall, the results and the low explanatory power of the regression suggest that the large movements in measured productivity are driven by policies that create misallocation of resources at the macro level. It does not seem that those policies influence TFP at the firm level.

In order to gain a different perspective on how macro policies affect welfare, CGSP studied income growth at the household and state level, over the 1980-2000 period. The major finding is that improvements in schooling have both increased growth, and reduced inequality. Other factors that influence income growth —especially among the poor— are low inflation, and access to better quality infrastructure.

CGSP conclude that the policies that will promote higher growth in Brazil include continued investment in the formation of human capital, low barriers to international trade and a fiscal policy that is consistent with low inflation.

4.3 Chile

The chapter by Chumacero and Fuentes (this volume) studies Chilean economic growth in the period 1960-2000. The authors identify two main subperiods. The first, 1960-1974, is associated with a growth rate of GDP per worker slightly over 2%. During this period, Chilean economic policy mostly followed the recommendations of the ECLAC and emphasized protection of domestically produced goods. This period culminates with the increased level of intervention in the economy corresponding to the Allende administration during the early 1970's. The second subperiod, 1974-2000, is characterized by higher average growth, and more variability in the growth rate of GDP per worker. Chilean economic policy during this second subperiod is characterized by liberalization of the trade regime, decreased regulation of domestic activities, and the privatization of many economic activities controlled by the government.

In Chile, unlike other Latin American economies, the contribution of TFP to growth over the entire period is not large. This, however, hides fairly different behavior during periods of fast and slow growth. Over the entire 1960-2000 period, the growth rate of GDP per worker was 2.15%. Of this, approximately 11% can be accounted for by increases in TFP, with the remaining 89% corresponding to variation in inputs. However, during three subperiods of relatively fast growth, 1960-1971, 1975-1981 and 1985-1998, the contribution of TFP is significantly higher. For the first subperiod, 1960-1971, is 18%, for the second, 1975-1981, is 88%, while in the third period, 1985-1998, is 48%.

These observations suggest that during periods of unchanged economic policy (1960-1971), TFP does not move much. However, during the reform periods, 1975-1981 and 1985-1998, changes in TFP account for a large share of growth.

Chumacero and Fuentes analyze the factors that affect TFP. Their findings suggest that TFP increases whenever

- The relative price of capital goods decrease.
- The terms of trade improve.
- The share of government spending in output decreases.

Chumacero and Fuentes estimate a reduced form equation in which GDP (in logs) depends on lagged GDP, a time trend, and the three shocks identified above. In addition, they estimate univariate representations for the price of capital goods, the terms of trade and their measure of internal distortions —the ratio of government spending to GDP. They interpret these variables as exogenous driving shocks (in addition to an exogenous productivity shock) in a standard representative agent stochastic growth model. In order to introduce a role for the terms of trade, the authors study a two sector model. One sector produces an exportable that is not consumed locally, while the other produces an internationally tradable good that is also domestically consumed. They assume that trade is balanced in every period, and, hence, that the domestic interest rate is independent of external conditions. Chumacero and Fuentes calibrate the model to coincide with long run observations for Chile.

The model is evaluated in terms of its ability to replicate the impulse response functions observed in the data. From this perspective, the exercise is extremely successful. The impulse response functions for all four shocks predicted by the model are indistinguishable from those estimated in the data.

Since Chumacero and Fuentes use a neoclassical growth model which has domestic taxes as its sole distortions, the model is unable, by design, to capture the impact of the non-technology shocks (price of capital, terms of trade, and their measure of government intervention) upon measured TFP. Nevertheless, their analysis proves that the factors that they consider are sufficiently successful in accounting for the change in input use, so as to explain aggregate growth in Chile.

The results of Chumacero and Fuentes suggest some important areas for future research. In particular, the main challenge that is derived from both the empirical work and the model analyzed by the authors is to identify other shocks and domestic distortions that can account for the observed correlations between the price of capital, the terms of trade, and the size of the government in TFP. As the authors point out, changes in the price of capital could be driven by changes in the trade regime. As such, these changes —which are very difficult to quantify— could, in a model with distortions affect measured TFP. Another revealing finding of this chapter is that periods of high output are also periods of high TFP growth, as well as periods in which there were major changes in domestic economic policy. In particular, periods of fast growth coincide with periods of liberalization of the state control over the economy. Whether those structural policy changes, can account for the observed shifts in measured productivity, and the identification of the mechanisms and channels that mediate this effect are major challenges for future research.

4.4 Paraguay

Economic growth in Paraguay over the period 1960-2000 is characterized by a high degree of instability. Even though the average (over the whole period) growth rate exceeds that of Latin America as a whole (and even Paraguay's neighbors) this is the result of very dissimilar behavior over this 40 year period. More precisely, Paraguay underperformed (relative to the average Latin American country) in all decades except the 1970s. This ten year period coincides with an exogenous demand shock financed (mostly) by influx of foreign capital: the construction of the Itaipú hydroelectric complex.

In their chapter, Fernández Valdovinos and Monge Naranjo (this volume) describe the salient features of the time series corresponding to inputs and TFP. The main results are:

1. During the 40 year period covered by the study there is an increase in the stock of capital. Moreover, the composition of capital has changed significantly.

While the overall stock of capital has increased by a factor of 13 over the 1962-2000 period, output increased less than 6 times. Thus, the capital-output ratio increased by a factor of approximately 2.5. As the authors point out, the composition of total capital has changed significantly. The construction capital-output ratio has increased by a factor of 3, while the equipment capital-output ratio displays a more modest (but still large) 50% increase. The differences between the two ratios widened in the late 1970s (probably associated with investment in Itaipú), and the late 1980s and 1990s. Fernández Valdovinos and Monge Naranjo suggest that this latter episode is associated with increased construction corresponding to a boom in the real estate sector.

2. The labor output ratio has increased as well. Over the 40 year period, the increase is approximately 50%. According to Fernández Valdovinos and Monge Naranjo, the increase in the quality of the labor force (human capital) has been small.

3. In Paraguay the stock of productive land increased in the late 1970s.

4. Remarkably, TFP —estimated in a variety of ways— shows a downward trend over the whole period. Depending on the methodology used there are small differences in subperiods. However, all estimates point to a steady decrease during the 1970s until the mid-1980s. Using a more standard approach (i.e. assuming a Cobb-Douglas production function and a share of capital equal to 1/3) the decline in TFP continues into the 1990s. However, the authors also estimate a more flexible specification in which the elasticity of substitution between capital and labor is not forced to be one (they find it to be approximately 1.25), and they allow for non-neutral (capital augmenting) technological change. With this alternative specification, they find that TFP grew in the second half of the 1980s and it drops in the 1990s.

According to Fernández Valdovinos and Monge Naranjo the picture that emerges is that Paraguay's development failure is mostly driven by negative growth in TFP. Surprisingly, in the face of declining productivity, factor accumulation remained strong. To illustrate this it is possible to compute the (counterfactual) growth rate that Paraguay would have enjoyed had TFP remained unchanged (and factor accumulation stayed at their historical values). In this case the per capita growth rate would have increased from 1.8% per year to 2.4% per year.[18] This is a significant increase, and it would have put Paraguay ahead of the world average.

The Paraguayan experience points to two puzzles. First, why did TFP decrease over such a long period of time? Second, what explains the accumulation of factors

[18] Since the authors present multiple estimates of TFP, the results depend on the particualr measure adopted. The calculation presented in the text uses the Cobb-Douglas specification wiht total capital. However, since all five specifications produce decreases in TFP in the range of -50% to -65%, the results will not vary much if some other estimate is used.

in the face of declining productivity? In their analysis, Fernández Valdovinos and Monge Naranjo do not study directly the determinants of TFP. However, they present a detailed description of the real and policy shocks that hit the Paraguayan economy over this period. Since the discussion requires choosing one measure of TFP, I will use the estimate that they present from their CES production function. The stylized behavior of this measure of TFP is that it grows 30% from the beginning of the period until 1973. From then one it decreases to only 65% of the 1962 value in 1984. It increases to slightly above 80% of its 1962 value in 1990, and then decreases to a value close to 50% of the initial level (1962) in the 1990s. Thus, there are two periods of growth —1962-1973 and 1984-1990— and the rest of the period is characterized by declines. There are no stable years.

Even though it is difficult to single out one factor in each of these subperiods, it seems that the relatively good performance in the 1960s is associated with an expansion in the agricultural frontier that allowed Paraguay to dramatically change the composition of exports. The second growth period includes some of the reforms of the late 1980s as well as positive shock in the agricultural sector. What are the main features associated with the declines? First, the most significant decrease is contemporaneous with the construction of the large hydroelectric complex at Itaipú.[19] The speculation is that this government regulated project lead to inefficiencies in the allocation of resources. This, of course, would also be consistent with the increase in factor accumulation as distorted incentives can compensate for declining productivity.

The significant drop in TFP in the 1990s is more difficult to explain since this is a period during which Paraguay liberalized its economy. However, there are two factors that stand out as possible reasons. First, uncertainty over the future 'rules of the game' following the ousting of long term dictator Stroessner could have resulted in economic agents choosing to allocate their investment to ex-post inefficient, but ex-ante safe, projects. The second factor is associated with the banking crises from the mid 1990s. This crises, according to Fernández Valdovinos and Monge Naranjo, was due to mistakes in the process of liberalization of the banking sector (basically, there was a shortage of bankers that understood lending in a market environment) and deficiencies in macro policies that promoted lending for speculative activities.

Fernández Valdovinos and Monge Naranjo explore to what extent economic integration influenced growth performance in Paraguay. Their results suggest that at both high and low frequencies, Paraguayan output is not highly correlated with that of its neighbors. Thus, it seems that shocks to neighbors cannot be viewed as the culprit underlying the poor performance of Paraguay.

In summary, Paraguay is an interesting case study as it experienced a sustained and large drop in measured TFP. Even though the evidence suggests that policy (and real) shocks might have influenced the behavior of productivity, much more work is needed to better estimate TFP, and to analyze the factors that have affect it.

[19] Total investment in this project was approximately four times Paraguay's GDP according to the authors.

4.5 Peru

In their chapter on the performance of the Peruvian economy, Carranza, Fernández-Baca and Morón (this volume) (CFM, hereafter) have a dual objective. First, they want to document the pattern of growth in Peru. Second, they try to uncover the factors that account for Peru's less that stellar performance over the last 25 years.

The last century of Peruvian economic growth can be divided, according to CFM, into four periods. The first, which lasts until the end of WWII, is characterized by moderate growth. From 1945 to 1965, the Peruvian economy grows at a higher rate. After 1965, Peruvian economic policy became more uncertain with major shifts occurring every few years. Even though the growth rate is positive in the 1965-1976 period, the following 15 years witnessed a decline in Peruvian GDP. Its level in 1990 (in real terms) is close to the level attained in the mid 1960s. Finally, in the decade of the 1990s Peru resumed a positive growth path. Due to data limitations, CFM can only explore the sources of economic growth since 1950.

To analyze the sources of growth, CFM present data for each of the last five decades of the 20th century. The major findings are:

1. During the period 1950-1970, output per worker grew at a high rate of over 3% on an annual basis. Since the capital-output ratio stays approximately constant, the candidate sources of growth are changes in human capital per worker and TFP. There is no available data on human capital for the first decade of this period. However, for the 1961-1970 period, human capital per worker —measured as average years of schooling— grows at an annual rate of over 2%. TFP growth was positive, and close to 2% per year.

2. During the 1970-1990 period output per worker decreases. In the first, decade, the growth rate was slightly positive (around 0.5% per year). In the second decade, total output declined at an annual rate of 0.68%. This results in a negative growth rate of GDP per worker of 3.75%. In both decades, the capital-output ratio rises significantly. The growth rates are 1.8% and 3.07%, respectively. Thus, the recession in Peru was accompanied by capital deepening. Increases in the stock of human capital also contribute to growth. It follows that TFP must have decreased. CFM present different estimates of the change in TFP, but representative values are growth rates of -0.7% in 1971-1980, and -3.8% in the 1981-1990 period.

3. In the 1990s the growth rate of output per worker is 1.27%. During this period the capital-output ratio decreases at an annual rate of 0.75%, driven mostly by a reduction in the stock of machinery and equipment. The change in human capital per worker is positive, but smaller than in previous decades. Finally TFP grows at a rate of 2.5% per year.

What are the factors that influenced movements of TFP in Peru? To study this question, CFM estimate a regression that has the level of TFP as its dependent variable and that includes a number of variables to capture the relationship between productivity and macroeconomic factors, external conditions, and changes in institutional factors. The major findings are:

- Among the macroeconomic factors, high inflation, high levels of the real exchange rate, and high public debt are associated with low TFP. The results corresponding to an openness variable are not consistent across specifications. However, when significant, this variable has the expected sign: increases in openness are associated with increases in measured TFP.

- Good external shocks in the form of more favorable terms of trade, and lower world interest rates are related to higher levels of TFP. CFM did not find any impact from aggregate shocks like measures of world or Latin American growth.

- Measures of structural reform —which were available only for a subset of the period under study— did not appear significantly.

To account for the importance of these factors in the movements of TFP, CFM decompose the total estimated effect into its components for the 1970-2000 period. The two major negative forces are changes in the real exchange rate and in the level of public external debt. These two measures, which can be viewed as indicators of policy induced distortions, have particularly large and negative effects in the 1980s. The world real interest rates also appears as a negative factor in the 1980s and 1990s (but not before), while inflation increases its negative, albeit small, contribution until 1990, with an improvement after that. At the opposite end, Peru faced favorable terms of trade that are associated with higher levels of TFP. Thus, if one adopts a causal interpretation of these results, it appears that bad internal policies, even in the face of relatively benign external conditions are responsible for the decline in measured TFP.

How did policies affect factor accumulation? As in other Latin American countries, Peru experienced a steady increase in the stock of human capital per worker. This increase did not slow down during the low (or negative) growth decades of the 1970s and 1980s. Paradoxically, it is during the 1990s, when Peruvian economic policy appears more consistent with long term growth, that the stock of human capital per worker declines. At the aggregate level, it is not possible to determine the effect of policies on this measure of human capital. The reason is simple: Since the index is a measure of the quality of the stock of human capital embodied in the population, decisions to acquire less schooling in the 1980s (i.e. low investment in human capital) will result in lower human capital in the 1990s. Thus, without enrollment data, it is not possible to establish a simple connections between contemporaneous policies and human capital.

The behavior of the capital-output ratio is interesting. The 1970s and 1980s were not only periods in which the governments seriously interfered with market signals, they were also decades of high instability in government policies, with major changes taking place every four to five years. To some extent this is reflected in the variability of per capita GDP which, according to CFM, increased significantly in the 1980s. As argued in section 3, increased instability should decrease investment. However, the increase in the capital-output ratio in Peru during this period seems to contradict this prediction. This apparent paradox can be resolved by inspecting the behavior of private and public investment: Starting in 1966, private investment as a fraction of GDP decreased significantly (with the exception of four year period associated with a brief liberalization in the early 1980s) until 1990. At that point there is substantial increase. Public investment was fairly high during the 1970s and 1980s. If public investment is not determined according to market rules, as the analysis of CFM suggests, then it is possible to show (see section ****) that the result is an increase in the capital-output ratio, and a decrease in measured TFP.

In summary, CFM make a persuasive case that policy actions are an important determinant of the growth experience of Peru over the last 50 years. In particular, they find that poor macro policies —including public investment, as well as fiscal and monetary policies— are largely responsible for the poor economic performance on the last 30 years.

4.6 Uruguay

Uruguay's growth experience over the last 50 years can be divided into three periods. A slow growth period from 1955 to 1973, a recovery during 1974-1990, and an era of relatively faster growth in the 1990s. The main features of each of these periods are as follows:

1. 1957-1973. Output grows at an average rate of 0.7% per year. Factor accumulation (capital and labor, and to a lesser extent human capital) are the engines of growth. Measured TFP growth is negative (-1.07% per year).

2. 1974-1990. GDP increases at an annual rate of 2.1%. Accumulation of capital and increases in employment (quality adjusted) make equal contributions to aggregate growth. During this period, measured TFP grows at the modest rate of 0.3%.

3. 1991-1999. This is a period of fast growth. Total output increases at an annual rate that exceeds 3%, and the most important factor is the significant growth in the stock of human capital per worker. During this period, measured TFP decreases at an annual rate of 1.86%.

How did policies affect the performance of the Uruguayan economy? de Brun (this volume) identifies two major policy changes. In 1973, the Uruguayan government initiated a process of trade liberalization that lowered the price of imported goods. Since a substantial fraction of capital goods is imported, this policy change can be expected to increase the demand for capital, and the capital-output ratio (at constant prices). The second major policy change occurs in the 1990s when Uruguay joins Mercosur —the Southern Cone free trade association— and, concurrently, institutes a series of market oriented reforms. This policy change could potentially account for the increase in the domestic price of skilled labor, since Uruguay has a relative (to the other Mercosur countries) abundance of high skill labor. This, in turn, contributed to the increase in the supply of human capital observed in the 1990s.

To understand the impact of trade reforms, de Brun studies a complex dynamic equilibrium model. He assumes that the economy produces three goods: exportables, importables and non-trade goods. Individuals have to make decisions about the amount of human capital that they want to acquire. Physical capital is produced using traded goods, while the production of human capital uses both traded and non-traded goods. To capture Uruguay's comparative advantage, it is assumed that exportables are produced with capital and skilled labor, while imports are produced with capital and unskilled labor. Non-traded goods are produced with skilled labor.

de Brun uses this model to evaluate the effects of an improvement in the domestic terms of trade, which can be driven international price changes, or by changes in the trade regime. There are several relevant findings. As in the standard Stolper-Samuelson result, the relative price of skilled labor increases. This induces a process of human capital accumulation which results in an increase in the long-run level of income. Under some reasonable conditions, de Brun shows that the rate of increase of skilled workers in the sector producing exportables is higher than the increase in the non-traded sector. Nevertheless, output of non-tradables and exportables goes up, while domestic production of import competing goods decreases. Depending on parameters, it can be shown that total output increases and the 'engine of growth' is the accumulation of human capital.

The findings from the theoretical model seem to agree with the Uruguayan experience: the post trade liberalization period —which started in 1973, with an extra shock in the early 1990s— is associated with higher growth and, more importantly, is a period of rapid accumulation of human capital.

To test the ability of the model to quantitatively explain the performance of Uruguay, de Brun estimates a set of equations consistent with the theoretical construct. One of the equations corresponds to the production function, while the other two represent the equilibrium laws of motion of physical and human capital. The empirical results conform with the theory. In particular, an index of commercial policy has a positive impact on human capital formation. In summary, the major changes in the growth experience of Uruguay seem reasonably well explained by the dynamic model that de Brun analyzes.

The results also pose some challenges. For example, it is somewhat puzzling that given the high level of integration between the economies of Uruguay and its neighbors, Argentina and Brazil, the behavior of some important variables differs significantly across these countries. In particular, de Brun shows that the evolution of TFP during the recovery of the 1990s was quite different in Uruguay, compared to Argentina and Brazil. The latter experienced a 'TFP-led' growth during the 1990s which resulted in significant increases in capital per worker. Human capital played a minor role. Uruguay's experience is almost the opposite: during the 1990s increases in human capital fueled growth, while TFP decreased, and capital accumulation was not significant. Even though more research is needed, it seems that the different policies adopted by the Uruguayan authorities can account for the differences in the performance of the Southern Cone countries in recent years.

5 Concluding Comments

There is no question that the economic performance of Latin American countries has been, with few exceptions, very disappointing. The set of countries represented in this volume is no exception. What are the causes of Latin America relative backwardness? The research papers reviewed in this chapter do not offer definitive answers to this question, but they do suggest several promising avenues of inquiry. First, it is clear that, notwithstanding the effort on the part of the authors of individual country studies, the quality of the data is poor. This is particularly true of the labor input. In most cases, it has been very difficult to accurately measure the stock of human capital over a long period of time. This is, in any case, a difficult task but efforts directed to improving the measurement of aggregate quantities for the Latin American economies will generate a large payoff.

Second, the empirical findings suggest that large changes in measured TFP can account for a substantial fraction of the changes in growth rates, and that TFP movements are statistically associated with real and policy shocks. In this chapter, I presented several simple models that can 'rationalize' the observed relationship. However, much more work is needed. The full implications of the models —with particular emphasis on their 'cross-equations' restrictions— have to be fleshed out. The next step is to take the models to data by picking the deep parameters and confronting the predictions of the theoretical models with the evidence. This will be a difficult but rewarding task. The research reported in this book is an excellent first step.

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