Productivity and Economic Growth in Latin America:

The Stochastic Production Frontier Approach

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ABSTRACT

This paper looks into the total factor productivity performance and economic growth of Latin America. A stochastic production frontier function was estimated as a translog leading to technical inefficiency in a set of 19 Latin American countries over the period 1961–1990. Using the Malmquist productivity index, productivity growth was decomposed into two components: variation in technology and change in technical efficiency. The application of this technique makes it possible to quantify the contribution of productivity to economic growth in Latin America, to identify sources of technical production inefficiency and to understand the factors determining the performance of the Latin American economies. The most important conclusion of the study is that the total factor productivity performance was the chief cause of the low economic growth observed in Latin America for the period in question.

KEY WORDS: Economic growth; stochastic production frontier; total factor productivity.
JEL Classification: C23, 040, 047, 054.

Introduction

Until the 1980s, the neoclassic model of economic growth developed by Solow (1956) held sway as the major analytical instrument of reference for the factors responsible for long-term growth in *per capita* income and, consequently, for the elements determining the great inequalities in income between rich and poor countries. According to this model, long-term growth dynamics would be associated with exogenous technical progress.

If technical progress be admitted in the neoclassic model, the countries' *per capita* income would in the long run grow by a displacement of the steady state towards increasingly higher levels as a result of technical progress. On the other hand, the level of *per capita* income associated with a given steady state would be determined by the growth rate of the population, by propensity to saving and by technical parameters, including the rate of depreciation, all of which are considered exogenous factors. And if the savings rate be endogenized, as in the neoclassic model based on the contributions of Ramsey (1928), Cass (1965) and Koopmans (1965), the *per capita* steady state income level would be a consequence of the parameters determining family preferences, technology – considered an exogenous factor – and production factor availability.

In empirical terms, the contribution of technical progress to the growth of the *per capita* product was quantified by Solow (1957) through the concept of total factor productivity (TFP), which explicitly employs the structure of a Cobb-Douglas production function. In his article, the author describes the occurrence of a significant residue equivalent to the difference between the growth rates of the actual product and the weighted growth rates of the production factors labor and capital, as measured by conventional standards. The notion of technical progress was for Solow an abbreviated expression for any displacement of the production function, the causes of which could be associated with an ample range of phenomena.

The theoretical models based on the tradition of Arrow (1962) and Sheshinski (1967), which appeared subsequent to the publication of the studies by Romer (1986) and Lucas (1988), suggest a greater contribution of capital, including human capital, to economic growth. According to Romer's and Lucas's theoretical interpretations, technical change assumes the central role in the process of capital accumulation and growth.

The central argument is that investment in capital, both physical and human, produces a spillover which raises the productive capacity of the companies responsible for the investments and contributes to increasing the productive capacity of other companies and workers. Thus, the physical capital stock might be taken as an indicator of accumulated know-how and ***learning-by-doing*** experience, the spillover of which would result in growing revenues in terms of aggregated economy.

In spite of differences between the arguments and predictions presented by the main theorists of economic growth, there is a consensus in the empirical literature that the notion of capital accumulation cannot sustain growth over extended periods and that the key to long-term economic progress and prosperity lies in total factor productivity (Senhadji, 1999). Poverty reduction and improvements in living standard are strongly tied up with growth in productivity and of the economy as a whole.

The main objective of the present study is to examine the contribution of TFP variation to economic growth in a sample of 19 Latin American countries over the period 1961–1990, decomposing variation into two components: technical change and change in technical efficiency. Decomposing productivity variation in this manner makes it possible to identify and quantify the factors determining TFP performance over time: the one component is related to catching up with the production frontier, the other with the displacement of this frontier (technical innovation). The methodology employed in calculating TFP variation and its two components is based on the concept of distance functions and on the Malmquist index. The study also looks into the contribution to technical efficiency performance of a set of variables related to the local economic environment of each country.

The selection of the functional form of the production frontier used in the present study is based on sample data and so differs from that described in the traditional literature on TFP estimation, which assumes the Cobb-Douglas model *a priori*. Following the modern literature on productivity (Fried, Lovell and Schmidt, 1993; Battese and Coelli, 1995; Coelli, Rao and Battese, 1998), we modeled the functional form of the production function using sample data. For this purpose we used the LR statistic test to determine the adequacy of the Cobb-Douglas function, which constitutes a quite restrictive form with respect to the economic characteristics of the production process if compared to the more flexible functional form expressed by the transcendental logarithmic function, or translog. The results suggest the adoption of the latter form.

The parametric approach of the stochastic production frontier is used to analyze the economic performance of the countries in the sample. This technique makes it possible to analyze the production units (in this case, the countries) by identifying the production frontier (best productive practice) and by assessing each country's performance in relation to the production frontier. The result is the qualitative ranking of the countries in the sample and the quantification of the efficiency measures.

The present article has five sections. Section I gives a short account of the economic policies adopted by Latin American countries and the results thereof, which motivated the authors to undertake the present study. Section II presents the econometric model to be estimated. Section II defines the data base and the variables employed and analyzes the results of the estimations. Section III deals with the construction of the Malmquist index of TFP variation and its decomposition into technical change and change in technical efficiency. The last section presents the conclusions of the study.

1. Latin America: growth, crisis and reforms

In the 1950s, due to the influence of policies proposed by the Economic Commission for Latin America (ECLA), most countries in the region adopted the import substitution industrialization (ISI) model as a local development strategy featuring as core elements the implantation of industries to meet the domestic demand and the institution of instruments capable of protecting new industries from external competition through taxation and non-taxation-based mechanisms and the concession of subsidies.

However, the local expansion of the activities of the new industry demanded an increasing level of direct state intervention in the economy in order to eliminate strictures in infrastructure and services hindering the expansion of productive activities, especially industrial activities. The industry was identified as the dynamic sector of the economy capable of driving economic growth and – in the concept of ECLA – reversing heavy dependence on external agencies.[1] This dependence took the form of a historical process deteriorating trade relations between the center (rich countries) and the periphery (underdeveloped countries).

Though current economic concepts are for the most part in harmony with the notions expressed by ECLA, especially as regards the need for heavy state intervention in the economy, a minority of economists rejected the ISI model based on arguments in favor of economic freedom, low level of intervention and monetary austerity.[2] According to Latin American monetarists, the inflation process which was racking most of the countries in the region could be easily explained by the excessive government spending required to sustain inefficiencies generated by the ISI model. The high inflation led to reduced interest rates, discouraged private savings and thus caused a negative impact upon capital formation and, of course, economic growth.

On the other hand, overvalued exchange rates ended up introducing further inefficiencies into the use of resources, compromising the international competitiveness of industries whose survival depended on an intensive scheme of taxation and non-taxation-related protective mechanisms and on government subsidies (Reinhardt and Peres, 2000).

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[1] According to Raul Presbich, main author of the intervention policies suggested by the ECLA, the large gap in productivity between central and peripheral countries should be reduced, at least to start with, by importing capital goods which par excellence bring technical progress with them. Though early ECLA studies point to technical progress as a driving force of economic development, the initial emphasis is laid on capital accumulation. Cf. Bernardo Gouthier Macedo (1994). Raúl Prebisch's ideas on peripheral industrialization:1949-1954. Master's thesis, Campinas: IE/Unicamp, mimeographed.

[2] In Brazil, Eugênio Gudin was one of the advocates of this line of thought.

By the end of the 1960s, the ISI model started showing signs of having exhausted its potential for promoting radical changes in the region's economy. Criticism was growing both from within and from without the ECLA regarding the results of the industrialization process initiated in the 1950s. One of reasons for this was technical dependence due to an industrialization model oriented towards the production of lasting commodities for the middle and high income segment of society. The technology required by this type of industry was already available and controlled by developed countries.

The increased inflation rates and the setback in economic growth observed in most of the countries in our sample subsequent to the 1973 oil crisis fueled criticism of the ISI model and led to the proposition of policies calling for deep-reaching changes to the standard adopted in the 1950s. The recommendations were not restricted to aspects related to economic stabilization, but proposed a complete transformation of the productive structure through liberalization, market openness and reduced government intervention in the economy. Most of these measures were part of the prescriptions given by international agencies as a condition for the granting of financial aid[3] (Reinhardt and Peres, 2000).

The three first countries in the region to implement the recommended reforms in the mid-seventies (Foxley, 1983; Ramos, 1988) were Argentina, Uruguai and Chile. The reform program included policies for domestic market liberalization, privatization, market openness, mitigation in restrictions on international money flow and redefinition of the role of the government within specific economic sectors. However, the development of the economies of these countries was compromised by the foreign debt crisis which afflicted the whole region in the early eighties.

The foreign debt crisis was initially a result of the huge imbalance the external sector of oil-importing countries had experienced since supplies dropped in 1973 and 1979. To begin with, the availability of abundant and cheap credit in consequence of the volume of dollars accumulated by oil-producing nations offered remedy for this imbalance through further loans at fluctuating interest rates. However, since 1981 the monetary policy adopted by the United States in order to control domestic inflation became strongly contractionist, resulting in higher international interest rates and, later, in worldwide recession and rapid increases in the debts of nations receiving loans.[4]

In the 1980s and under the auspices of the IMF, many indebted countries were forced to implement programs of economic adjustment. In the mid-eighties, Bolivia, Costa Rica and Mexico joined the group of Latin American countries which had already adopted measures towards economic reforms. Only in the

[3] The structural adjustment programs make up the core of the reforms coordinated through a cooperation between the IMF and World Bank and refer to measures recommended by these international institutions as a precondition for the concession of loans.
[4] The Mexican moratorium in August 1982 triggered the so-called Third World debt crisis by bringing about a retreat of international credit and a huge rise in risk premiums.

eighties did Argentina resume the reforms which had been started in the mid-seventies and then postponed due to the foreign debt crisis. Peru and Venezuela followed suit during this same period. Brazil was the last economically important country in the region to adopt reforms; this took place in the 1990s, although the country had been granted financial aid from the IMF the during the previous decade.

Despite the fact that some of the countries in the region initiated reforms in the mid-seventies rather than in the mid-eighties and nineties, the scheme was basically the same in all cases and included as its core element the need to secure economic efficiency and promote potential long-term growth by encouraging market mechanisms – rather than government intervention – for the allocation of resources (Reinhardt and Peres, 2000).

TABLE 1 – Relative performance of Latin America
Period: 1960–1990 and subperiods: 1970–1980, 1980–1990

Countries/Regions	1970-1980	1980-1990	1960-1990
Argentina	1.40	-3.20	0.20
Bolivia	1.80	-1.80	1.27
Brazil	5.90	-0.60	2.83
Chile	0.80	1.10	1.40
Colombia	3.20	1.10	2.23
Costa Rica	2.50	-0.60	1.73
Dominican Republic	4.30	-0.80	2.00
Equador	6.10	-1.60	2.17
El Salvador	1.10	-1.00	0.83
Guatemala	2.40	-1.90	0.83
Honduras	2.10	-1.00	0.97
Jamaica	-1.10	0.70	1.23
Mexico	4.30	-0.40	2.47
Nicaragua	-2.40	-3.50	-0.67
Paraguai	6.20	-1.70	2.07
Peru	0.50	-2.70	0.30
Trinidad and Tobago	5.20	-3.50	1.20
Uruguai	2.10	-1.00	0.50
Venezuela	-0.50	-2.00	-0.17
Latin America (19)	2.42	-1.29	1.23
Africa – Sub-Sahara (17)	1.10	-0.80	0.80
East Asian countries (8)	6.00	4.60	5.10
OECD (22)	2.50	2.10	2.97
World Economyl (81)	2.60	0.60	2.13

Source: Penn World Table 6.1 and World bank

In spite of changes in the productive sector and efforts to diversify the economic structure, Latin America presented a low *per capita* product growth rate between 1960 and 1990: approximately 1.23% annually for the countries in our sample. This is a far cry from the growth rate observed for East Asian countries (5.1%) and for the world economy as a whole (2.13%). Even developed OECD (Organization for Economic Cooperation and Development) member countries managed to maintain high average growth rates over the period, belying the predictions of the so-called *per capita* income convergence hypothesis.[4] The best performances in the region occurred in the sixties and seventies, while the 1980s were marked by strong economic recession (Table 1). In any case, the data do little to answer the question: how to account for Latin America's modest economic growth over such a long period?

2. Empirical model

2.1 Estimated equation

Using panel data for the sample of 19 Latin American countries, the functional form of the stochastic frontier was determined by testing the adequacy of a Cobb-Douglas frontier in relation to the less restrictive form expressed by the translog function.[5] Hence, we used a translog production frontier function expressed in the following terms:[6]

$$\ln y_{it} = a_i + q_1 t + \frac{1}{2} q_2 t^2 + (b_0 + b_1 t)\ln K_{it} + (l_0 + l_1 t)\ln L_{it} + \frac{1}{2}(h_1 (\ln K_{it})^2 + 2h_2 \ln K_{it} \ln L_{it} +$$

$$+ h_3 (\ln L_{it})^2) + v_{it} - u_{it} \qquad (1)$$

where the technical production inefficiency u_{it} is modeled as:

$$u_{it} = z_{it} d + w_{it}, \qquad (2)$$

with δ representing a vector of parameters and z_{it} a vector of variables accounting for technical inefficiency. We also have that $i = 1,.........,I$ countries, and $t=1,..........,N$ years.

Adopting the hypothesis of constant returns to scale in production function (1) implies the following restrictions for the parameters of this function: $b_0 + l_0 = 1, b_1 + l_1 = 0, h_1 + h_2 = h_2 + h_3$.

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[4] Generally speaking, the so-called convergence hypothesis has it that countries with initially lower per capita income (products) tend to experience higher rates over time than countries in a better position with regard to this variable.
[5] The adopted test for the choice of functional form is shown in Table 3.
[6] The translog function was proposed by Christensen, Jorgenson and Lau (1971) and by Griliches and Ringstad (1971).

The variables *Y, L and K* in the production function represent, respectively, the product, the labor and the physical capital stock in each of the countries in our sample.[7] The parameters a_i, q_i, b_j, l_k and h_l,, as well as those integrating the vector *d*, are estimated together. The a_i's incorporate fixed effects into the model in order to capture heterogeneities not observed in the country sample.

In the equation of technical inefficiency (2), the vector z_{it} is composed of the following variables:

z_{1t} - represents government spending in relation to the GDP of each country;

z_{2t} – is the deviation in local price level in relation to purchasing power parity (PPP) with the United States as country of reference. This country is included here to control for the effects upon technical inefficiency of commercial policies implementing devaluations in real exchange. A growing deviation in local prices compared to PPP is synonymous with devaluation in real exchange (Miller and Upadhyay, 2000);

z_{3t} – is the logarithm of the inflation rate (π) given by ln $(1+\pi)$. The expression considers the non-linear effects of inflation upon technical inefficiency (De Gregorio, 1992);[8]

z_{4t} – is the degree of openness measured by comparing the sum of imports and exports in relation to the GDP of each country. It is generally expected that economies with a higher degree of openness have easier access to imported, modest-priced intermediate inputs, wider markets and more advanced technologies.[9]

The variable v_{it} constitutes the random error in relation to production function and is characterized by an independently and identically distributed Normal distribution with an average of zero and the constant variance s_v^2 . The technical inefficiency (u_{it}) is non-negative with an independently but not identically distributed Normal distribution truncated at zero with the average $z_{it}d$ and the variance s_u^2. Through the maximum likelihood method, the simultaneous and efficient estimation of the parameters of equations (1) and (2) make it possible to calculate the magnitudes of the technical efficiencies for each of the countries in the sample, as well as the TFP variation indices, according to the methodological procedures presented in the following subsections. The parameters were estimated using the software *Frontier 4.1* (Coelli, 1996), for

[7] For a more detailed description of the variables used and their sources of reference, see Table A.1 in the Appendix.

[8] Since some of the countries of the region experienced periods of both deflation and hyperinflation, we have adopted this expression to attenuate the influence of extreme cases in terms of inefficiency.

[9] There are several ways of measuring the variable 'degree of openness', such as through the degree of tariff protection, parallel market exchange rates, indicators of commercial policy regimens, etc. The traditional measure, which expresses the relation between GDP and total exports plus imports, was chosen here in view of the availability in PWT 6.1 of annual data for the countries in our sample.

which the log-odds function is expressed as the parameterization $g = \frac{s_u^2}{s_u^2 + s_v^2}$. The fact that this parameter contains values between zero and one[10] makes the maximization process by iteration easier.

2.2 Total factor productivity

It can be shown that the total productivity index may be decomposed into change in technical efficiency, variation in scale and technical change. If we consider the simplified case of a production function specified by a single product (y) and a single input (x) we shall see that y_t, y_{t+1}, x_t and x_{t+1} correspond to the quantities observed for the product and for the input, respectively, over the periods t and t+1. Thus, the total factor productivity (TFP) index is defined by the equation:

$$TFP_{t,t+1} = \frac{y_{t+1} / x_{t+1}}{y_t / x_t} \qquad (3)$$

If the relations established between the inputs required by the production process and the maximum potential product at t and t+1 be expressed by the functions $f_t(x)$ and $f_{t+1}(x)$ and we admit the possibility of the occurrence of technical inefficiency, it becomes possible to quantify the observed product through a production function in the following terms:

$$y_t = l_t f_t(x_t) \text{ , where } 0 \leq \lambda_t \leq 1. \qquad (4)$$

When λ_t takes on a value below one, there is technical inefficiency in the productive process of the production unit for the observed period. The insertion of equation (4) into equation (3) gives us:

$$TFP_{t,t+1} = \frac{l_{t+1}}{l_t}\left[\frac{f_{t+1}(x_{t+1})/x_{t+1}}{f_t(x_t)/x_t}\right] \qquad (5)$$

Now if it be admitted that different amounts of inputs may be required over two consecutive periods, it is possible to establish a relation between the input volumes of the periods t+1 and t in the following terms:

[10] The closer the estimated value for γ is to zero, the less significant technical inefficiency becomes as a cause of deviation in relation to the production frontier. The closer the value gets to 1, the greater the importance of technical inefficiency as a cause of deviation in relation to the production frontier.

$x_{t+1} = k\, x_t$[7]. Moreover, if the production function is homogeneous in degree γ(t+1) during x_{t+1}, in relation to the period t+1, equation (5) is modified thus:

$$TFP_{t,t+1} = \frac{l_{t+1}}{l_t}[\frac{f_{t+1}(kx_t)/kx_t}{f_t(x_t)/x_t}] = [\frac{l_{t+1}}{l_t}][k^{g(t+1)-1}][\frac{f_{t+1}(x_t)}{f_t(x_t)}] \qquad (6)$$

Equation (6) shows the decomposition of the TFP index as follows: the first component on the right side, $[l_{t+1}/l_t]$, represents change in technical efficiency, the term $[k^{g(t+1)-1}]$ constitutes variation in production scale, and $f_{t+1}(x_t)/f_t(x_t)$ is technical change.[8] Whenever the technology presents constant returns to scale, $[k^{g(t+1)-1}]$ = 1. Therefore, total productivity may be decomposed into variation in efficiency and technical change.

The decomposition of product change over time may be illustrated graphically in terms of variation in scale, change in technical efficiency and change in technical progress (see Figure 1) (Wu, 2000). For particular technologies, points a_1 and a_2 represent the observed product levels y_1 and y_2 over time periods 1 and 2, while points b_1 and b_2 correspond to the potential products y_1^f and y_2^f relative to inputs x_1 and x_2. Differences between potential product levels and observed product levels on the production frontier constitute indicators of technical production efficiency. Thus, with regard to inputs x_1 and x_2, technical efficiencies ET_1 and ET_2 are definable, respectively, by $ET_1 = (y_f^1 - y_1)$ and $ET_2 = (y_f^2 - y_2)$. Product change may therefore be decomposed as:

$$\Delta y = y_2 - y_1 = (y_2^f - ET_2) - (y_1^f - ET_1) = (y_2^f - y_1^f) + (ET_1 - ET_2)$$
$$\Delta y = (y_2^f - y_{12}) + (y_{12} - y_1^f) + (ET_1 - ET_2) \qquad (7)$$

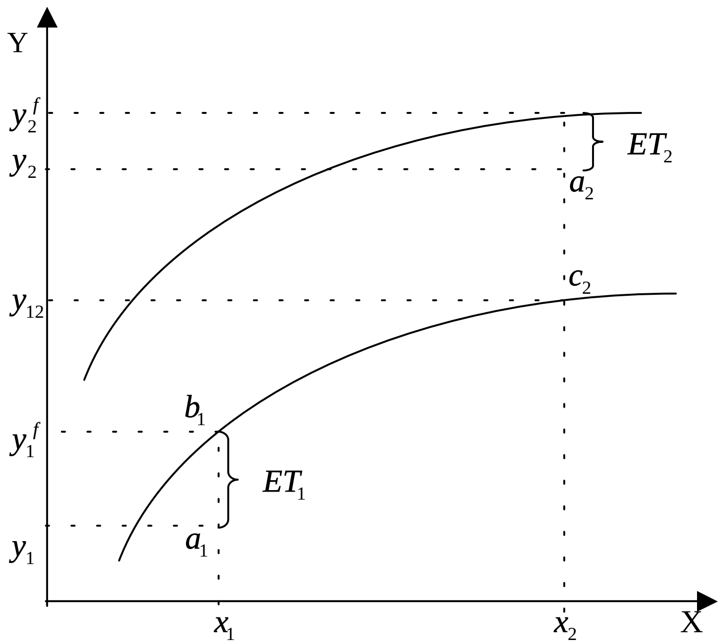
Product variation $(y_2 - y_1)$ is decomposed into technical change, $(y_2^f - y_{12})$, variation in production scale, $(y_{12} - y_1^f)$, and change in technical efficiency, $(ET_1 - ET_2)$, thus presenting an evident correspondence with the terms of equation (6). In the case of constant returns to scale, variation in TFP is defined by the sum

[7] If the amount of an input in t+1 is greater than in t, then k >1.

[8] It should be noted that the effect of variation in scale is a combination of the parameters ‘operation scale’ (k) and ‘return to scale’ (γ).

of the components 'change in efficiency' and 'technical change' alone. Indeed, in this case there is no variation in scale, that is, it makes no difference whether we produce y_{12} using input x_1 or produce y_1^f using input x_2. In these terms, $(y_{12} - y_1^f) = 0$. In Figure 1, the production frontier would be linear and at any point along this curve the average productivity from input x would be constant with no gain of loss of scale.

Figure 1 - Decomposition of product growth



It may be seen that the notion of distance used in calculating the TFP and its components is inherent in these measures. Thus, since the definition of the distance function is required to calculate the Malmquist total productivity index, it will be discussed in the following section.

2.3 The distance function

Production possibility may be represented as a set of all product vectors, $y \in R_+^M$, which can be produced with the input vector, $x \in R_+^N$. In other words, it is equal to the set of all feasible combinations of products and inputs. In formal terms it is defined by

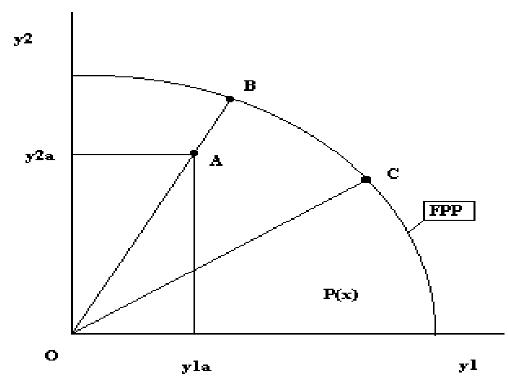
$$P(x) = \{y : x \text{ can produce } y\} \tag{8}$$

Figure 2 shows the concept of a production possibility set. The points along the frontier define an efficient subset of the production possibility set. As depicted, point A is associated with inefficient production but points B and C constitute efficient levels of production. To use a radial measure, the technical inefficiency of point A may be determined by measuring the distance between A and B, that is, by verifying how far the product needs to be expanded proportionally to make it efficient.

According to Farell (1957), the concept of a product-oriented distance function may be used for a particular set of inputs as a measure of technical production efficiency. The measure refers to the distance between the observed product and the maximum potential product and is given as a proportion of the latter. In other words, the distance function is the proportional expansion of the product required to make it efficient. If we express the product-oriented distance function as $D_o^t(x^t, y^t)$ and consider the time period *t*, a more formal definition is reached:[9]

$$D_o^t(x^t, y^t) = Inf(d : (x^t, y^t / d) \in P^t(x)) \qquad (9)$$

Figure 2 – Production possibility set



Based on this definition, in the terms of Figure 2, the distance function referring to the product level observed, represented by point A, is expressed by δ=OA/OB, which is less than 1. Thus, point A is technically inefficient, while with the addition of input x it would be possible to operate at point B which is located on the production possibility frontier. Point B is efficient and has a distance function equal to 1.

[9]Many papers have adopted the concept of a input-oriented distance function: $d_i(x, y) = \sup\{r : (x / r) \in L(y)\}$ where input set L(y) represents all input vectors (x) capable of producing the product vector (y). In other words, L(y) = {x : x can produce y}.

2.4 The Malmquist total productivity index

The product-oriented Malmquist total productivity index, according to Caves, Christensen and Diewert (1982), for a technology of reference over time period *t*, is defined as:

$$M_o^t = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \tag{10}$$

where $D_o^t(x^t, y^t)$ and $D_o^t(x^{t+1}, y^{t+1})$ are defined as in equation (9).

In case of a technology of reference for the period *t+1*, the said index may be defined as:

$$M_o^{t+1} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \tag{11}$$

In order to avoid an arbitrary choice of reference period, the Malmquist index, expressed here as $M_o(x^{t+1}, y^{t+1}, x^t, y^t)$, is constructed as the geometric average of index (10) and (11). Thus:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right)\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right)\right]^{1/2} \tag{12}$$

Through algebric manipulation of (12), Färe and coworkers (1994) have proposed an equivalent way of defining the Malmquist index:

$$M_o(y_{t+1}, y_t, x_{t+1}, x_t) = \left[\frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_o^t(y_t, x_t)}\right]\left[\frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_{t+1}, x_{t+1})} x \frac{D_o^t(y_s, x_s)}{D_o^{t+1}(y_t, x_t)}\right]^{1/2} \tag{13}$$

The first term on the right side of (13) measures how far the observed production is from the maximum potential product between the periods *t* and *t+1*. The term in fact measures the variation in technical production efficiency. The second term quantifies the displacement brought about by technology introduced between *t* and *t+1*, with regard to the use of inputs x_t and x_{t+1}. Hence, the term represents technical change, so that:

$$\text{Change in technical efficiency} = \frac{D_o^{t+1}(y_i^{t+1}, x_i^{t+1})}{D_o^t(y_i^t, x_i^t)}$$

$$\text{Technical change} = \left[\frac{D_o^t(y_i^t, x_i^t)}{D_o^{t+1}(y_i^t, x_i^t)} \frac{D_o^t(y_i^{t+1}, x_i^{t+1})}{D_o^{t+1}(y_i^{t+1}, x_i^{t+1})}\right]^{\frac{1}{2}}$$

According to Coelli, Rao and Battese (1998), the method described is an alternative procedure and is simpler to operationalize than the direct estimation of the distance functions. Since the results are quite similar, we have chosen the simpler procedure here. As in Marinho and Barreto (2000), the distance functions used in calculating the Malmquist index are determined through the simultaneous estimation of the production frontier (1) and the technical inefficiency (2), as defined in Section 1.1. In the case of a single product, the authors demonstrated that technical efficiency is equal to $D_0^t(x_t, y_t) = y_t / f(x_t)$, where y_t is the product observed over period *t* and $f(x_t)$ is the maximum potential product estimated.

3. Sample data, estimation and results

3.1 Sample data

Our data were obtained from three basic sources: Penn World Table 6.1 (PWT 6.1)[10] (Heston, Summers and Aten, 2002), World Development Indicators (WDI), supplied by World Bank, and The International Monetary Fund's Dissemination Standards Bulletin Board (DSBB-IMF). These international data bases are increasingly used as reference in a wide range of empirical studies, especially studies on economic growth in different countries and regions, as available data become systematized through methodologies that allow real comparisons between economies.

Gaps in WDI data on inflation rates in Brazil and Nicaragua had to be filled using alternative sources. As for Brazil, due to the lack of an extensive series expressing the variable ‘inflation’ as based on consumer

[10] Penn World Table 6.1 is a running update of version PWT 5.6.

price indices, the General Price Index-Internal Availability (IGP-DI) was adopted. This index is calculated by the Getúlio Vargas Foundation (FGV) and published in *Conjuntura Econômica*. As for Nicaragua, data on inflation, based on consumer price indices, were obtained from the DSBB-IMF.

In accordance with prevailing views among researchers of economic growth, we have used data from product series and level production factors in the estimation of the stochastic frontier rather than following the conventional procedure which considers these variables as rates of variation. The procedure is justified by the fact that the use of international prices to adjust differences in the purchasing power of different currencies tends to overestimate growth rates of rich countries and underestimate those of poor countries. Thus, no bias is introduced into the data and, consequently, into the estimations (Nuxoll, 1994).

Table 1 – Summary of basic statistics of the sample of Latin American countries

Countries		Population in 1990 in millions	GDP *per capita*[2] 1990	Average annual growth rates 1960-90 (%)			
				GDP[3]	GDP *per capita*	Capital[4]	Labor[5]
Argentina	ARG	32.527	4706	1.46	0.20	3.57	1.15
Bolivia	BOL	6.573	1658	2.40	1.27	2.55	1.92
Brazil	BRA	147.94	4042	5.74	2.83	6.00	2.84
Chile	CHL	13.099	4338	3.43	1.40	3.62	2.18
Colombia	COL	34.97	3300	4.77	2.23	4.24	2.67
Costa Rica	CRI	2.994	3499	4.39	1.73	6.42	3.62
Dominican Rep.	DOM	7.11	2166	4.82	2.00	6.43	2.94
Equador	ECU	10.264	2755	5.03	2.17	5.48	2.59
El Salvador	SLV	5.11	1824	2.52	0.83	4.86	2.15
Guatemala	GTM	8.749	2127	4.15	0.83	4.05	2.36
Honduras	HND	4.879	1377	4.13	0.97	4.40	3.10
Jamaica	JAM	2.4035	2545	2.67	1.23	1.92	1.95
Mexico	MEX	81.745	5827	4.94	2.47	6.11	3.30
Nicaragua	NIC	3.827	1294	2.24	-0.67	4.63	3.05
Paraguai	PRY	4.219	2128	5.28	2.07	8.20	2.84
Peru	PER	21.569	2188	2.98	0.30	3.70	2.61
Trinidad and Tobago	TTO	1.215	7764	3.60	1.20	4.92	1.77
Uruguai	URY	3.106	4602	1.39	0.50	1.85	0.54
Venezuela	VEN	19.502	6055	2.79	-0.17	3.18	3.59

Source:[1]PWT 6.1; [2]Real GDP *per capita* in constant dollars (international prices, year of reference: 1985);
[3]Real GDP (chain) PWT 6.1; [4]World Development Indicators – WDI; [5]calculated from PWT 6.1

The models specified in this study are applied to a sample of annual data regarding Latin American countries and covering the period 1961–1990. The sample contains 570 observations of variables arranged in the form of a balanced panel. The availability of statistical data was the determining factor in the final definition of the countries in the sample, the basic statistics of which are presented in Table 1. On the other hand, the establishment of the year 1990 as upper limit for observations based on this sample was determined by the information on physical capital available.[11]

3.2 Estimation and results

The estimates of the parameters of the production frontier (equation 1) are shown in Table 2. All estimated parameters are statistically significant at the level of 5%. The plus sign before the θ_1 parameter indicates the occurrence of technical progress, no matter how slight. The minus sign before θ_2 shows that variation in technical progress has been reduced. The fact that the indicator of technical inefficiency (γ) displays the value 0.89 – which is also statistically significant – implies that a larger share of the total variance may be attributed to variation in technical inefficiency. In other words, 89% of the total variance is accounted for by variance in the term technical inefficiency. This illustrates the importance of incorporating technical inefficiency into the model.

The estimation of the parameters of the variables of technical inefficiency was performed concurrently with that of the parameters of the production frontier (see Table 2). All estimated parameters were statistically significant (CI 95%) and, as explained in the following paragraph, their signs were consistent with the expected values.

The coefficient of the variable 'current government spending' (z_1) is positive and significant, suggesting that a large participation of this cost component in the composition of the aggregated spending in Latin American countries introduces inefficiency into the economy. Thus, countries with a high level of current spending are less efficient. This may be explained by the fact that pressure resulting from a higher level of government spending leads to a displacement of productive investments, generating distortions in the allocation of resources in the Latin American economies.

The variable 'deviations in local prices in relation to PPP' (z_2) has a negative and significant coefficient. Hence, Latin American countries with commercial policies based on the devaluation of real exchange have managed to reduce their degree of inefficiency through pricing measures.

[11] Data on the capital stock of the countries in the sample are still incomplete and subject to much criticism, although much effort is being invested by international research institutions to make reliable information available. In general, capital series are constructed through estimates based on gross annual investment and obtained through the inventary technique. Proxies are also often used to represent capital. In the present paper we used information gathered by the WDI group (World Bank).

The coefficient of the inflation rate (z_3) was positive and significant, therefore consistent with a considerable corpus of empirical literature showing the harmful effects of high inflation rates upon the economy (Klein and Luu, 2001; De Gregorio and Lee, 1999). Inflationary processes inhibit trade and discourage capital formation as they introduce distortions in relative price formation. In this respect it should be noted that several Latin American countries have experienced long periods of intensive inflationary processes with negative impacts on their economies.

Table 2 – Estimates of production frontier parameters

Parameters/Variables	Estimate	t-value
θ_1(t)	0.1263	12.50
θ_2 (1/2)t^2	–0.0008	–7.18
β_0 (lnK)	–2.8189	–9.13
β_1 (tlnK)	–0.0121	–11.00
λ_0 (lnL)	3.8189	12.39
λ_1 (tlnL)	0.0121	10.96
η_1(1/2)$(\ln K)^2$	0.3783	10.87
η_2 (lnKlnL)	–0.3783	–10.88
η_3 (1/2)$(\ln L)^2$	0.3783	10.87
δ_0 (intercept)	–0.1441	–1.86
δ_1 (z_1– government spending in relation to the GDP)	1.4538	6.96
δ_2 (z_2 – deviation in local price level in relation to purchasing power parity)	–0.1313	–2.40
δ_3 (z_3 – logarithm of the inflation rate)	0.0493	3.93
δ_4 (z_4 – degree of openness)	–0.1887	–2.61
σ_ε^2	0.0190	4.55
γ	0.8921	21.20
Mean efficiency	0.8941	
Log likelihood function	583.84	

*The fixed effects of countries are not shown.

The variable referred to as 'degree of openness' (z_4) has a negative and significant coefficient indicating that countries in the region with more open economies have fared better in terms of technical inefficiency. This result is consistent with the explanation that economies with a higher degree of openness have easier access to new technology, wider markets and intermediary commodities for lower prices.

Table 3 shows statistical tests designed to verify the consistency of specific hypotheses related to the estimated production frontier function.

The first null hypothesis specified in the table mentioned above refers to the adequacy test of the Cobb-Douglas model in relation to the least restrictive functional form expressed by the translog in equation

(1). The hypothesis that all translog coefficients of second order are simultaneously equal to zero is tested in this manner. The value of the LR statistic (146.76) exceeds the critical value of the statistics $c_{(6)}^{2}$ (CI 95%). The Cobb-Douglas function specification is thus rejected in favor of the translog model specified.

The second null hypothesis is adopted to test the absence of effects of technical inefficiency on the production frontier in relation to the sample under consideration. The result indicates that the hypothesis is rejected by the data or, in other words, that the effects of technical inefficiency should be included in the model.

The third null hypothesis refers to the joint significance test of the parameters used in the modeling of the component 'technical inefficiency'. The result rejects the hypothesis that the parameters are simultaneously equal to zero.

Table 3 – LR Statistic Test for Stochastic Production Frontier Parameters

Null Hypothesis - H_0	Statistical Test	Critical Value
$H_0 : \theta_2 = \beta_1 = \lambda_1 = \eta_1 = \eta_2 = \eta_3 = 0$	146.76	12.92
$H_0 : \gamma = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	201.16	11.91*
$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$	119.84	9.49
$H_0 : \tau_1 = \tau_2 = 0$	141.24	5.99

*Critical value obtained in Table 1 of Kodde and Palm (1986) at 6 degrees of freedom and CI 95%. It should be noted that the generalized γ–associated LR statistic will present a mixed χ^2 distribution.

The fourth and last hypothesis tests the stability of the production frontier in relation to the time variable, determining whether there was any technical progress during the analyzed period. The result of the test rejects the null hypothesis that no technical progress has occurred.

4. Technical Efficiency, Technical Progress and Total Factor Productivity

The estimates of the indices of change in technical efficiency, technical progress and total factor productivity are presented in Tables A.2, A.3 and A.4 in the Appendix. These estimates were performed according to the methodology discussed above.

An initial examination of the average[12] behavior of the region (shown in Table 4 and Figure 3) shows the occurrence of a loss of efficiency beginning in the 1980s. In fact, the tendency for continuous growth in the efficiency of the Latin American economies reverted in the year 1981. Technical progress may be said to have experienced three distinct phases: between 1961 and 1969, a positive though moderate variation was observed; the second phase, spanning from 1970 to 1979, was one of technical decline; and the last phase, from 1980 to 1990, was marked by a process of positive variation in technical progress surpassing that of the first phase.

Table 4 – Decomposition of Accumulated Variation of Total Factor Productivity
Latin America – Regional Average – 1961-1990.*

YEAR	Variation in Efficiency	Technical Change	Change in TFP
1961	1.0000	1.0000	1.0000
1962	1.0023	0.9989	1.0011
1963	0.9979	1.0010	0.9990
1964	1.0067	0.9967	1.0033
1965	1.0001	0.9999	1.0001
1966	1.0040	0.9980	1.0020
1967	0.9996	1.0002	0.9998
1968	0.9982	1.0009	0.9991
1969	1.0056	0.9972	1.0028
1970	1.0121	0.9940	1.0061
1971	1.0127	0.9937	1.0063
1972	1.0225	0.9889	1.0112
1973	1.0307	0.9850	1.0153
1974	1.0315	0.9846	1.0156
1975	1.0160	0.9921	1.0080
1976	1.0172	0.9915	1.0086
1977	1.0252	0.9877	1.0125
1978	1.0217	0.9893	1.0108
1979	1.0146	0.9928	1.0073
1980	1.0028	0.9986	1.0014
1981	0.9864	1.0069	0.9932
1982	0.9520	1.0249	0.9757
1983	0.9255	1.0395	0.9620
1984	0.9369	1.0331	0.9679
1985	0.9374	1.0329	0.9682
1986	0.9576	1.0219	0.9786
1987	0.9774	1.0115	0.9886
1988	0.9734	1.0136	0.9866
1989	0.9686	1.0161	0.9842
1990	0.9739	1.0133	0.9869

* Values calculated by the authors using the Malmquist index.

[12] That is, the simple geometric mean. The weighted geometric mean is not used due to the size of the country's economy.

Estimated TFP data, the variation of which is may be calculated by combining the indices 'technical change' and 'change in efficiency', show that by the end of 1961 a decrease of approximately one percent occurred in TFP in accumulated terms. This behavior may be explained by the fact that the observed variation in technical progress was insufficient to compensate for the decrease in technical efficiency. Such adverse behavior may be associated with the debt crisis of the 1980s and accelerating inflationary processes.

If we look into the behavior of the countries in the region, a relatively high level of heterogeneity in TFP performance and related components is observed. An important aspect to consider is that the dispersion of the indices of technical efficiency, technical progress and TFP for most countries in the sample displayed an unmistakable growth from the 1980s on, as shown in Figures 4, 5 and 6.

Figure 3 - Decomposition of Factor Productivity Change
Latin America: 1961-1990 (Accumulated Variation)

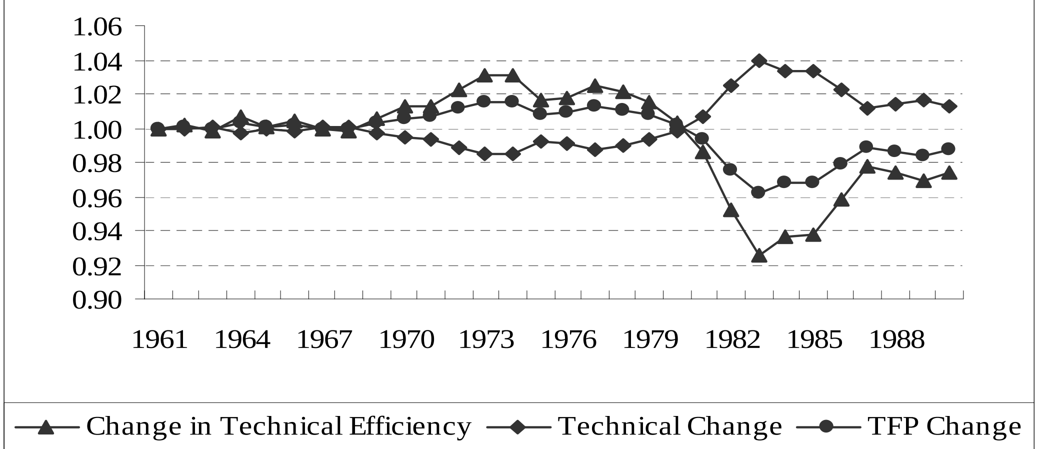
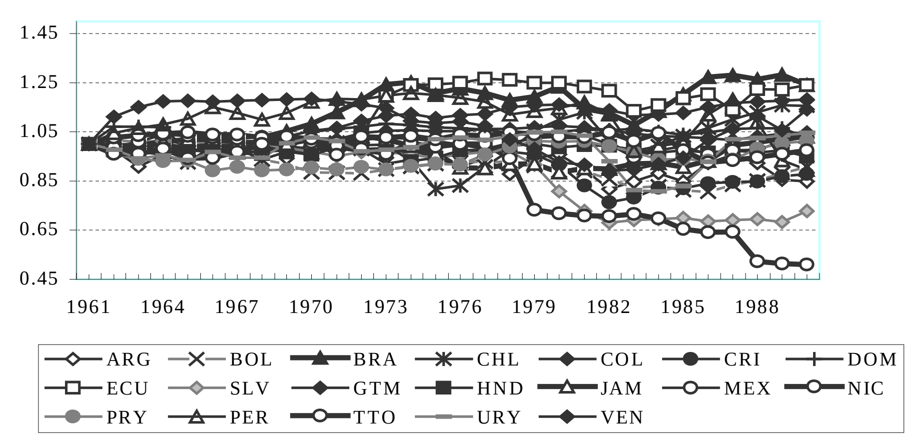


Figure 4 - Change in Technical Efficiency
Accumulated values - 1961 - 1990



As for change in technical efficiency (Figure 4), the estimates obtained indicate that the countries displaying the greatest accumulated variations, in decreasing order of importance, were Brazil (24.2%), Equador (24.1%), Colombia (18%) and Chile (16%). Mexico grew only 3%, while Argentina displayed a loss of efficiency of as much as 15%. Eleven of the nineteen countries in the sample experienced some degree of growth in efficiency while eight countries presented losses, in some cases – such as that of Argentina – even quite significant ones.

As with efficiency, a relative heterogeneity in the accumulated performance of the countries may be observed for the indices of technical progress (Figure 5). Considering the average for the region, the result was 1.0% growth for the period. The three countries with the greatest positive variations in accumulated terms were Nicaragua (40%), El Salvador (17%) and Argentina (9%). The countries with the lowest performance were Brazil (-10.3%), Equador (-10.2) and Colombia (-7%).

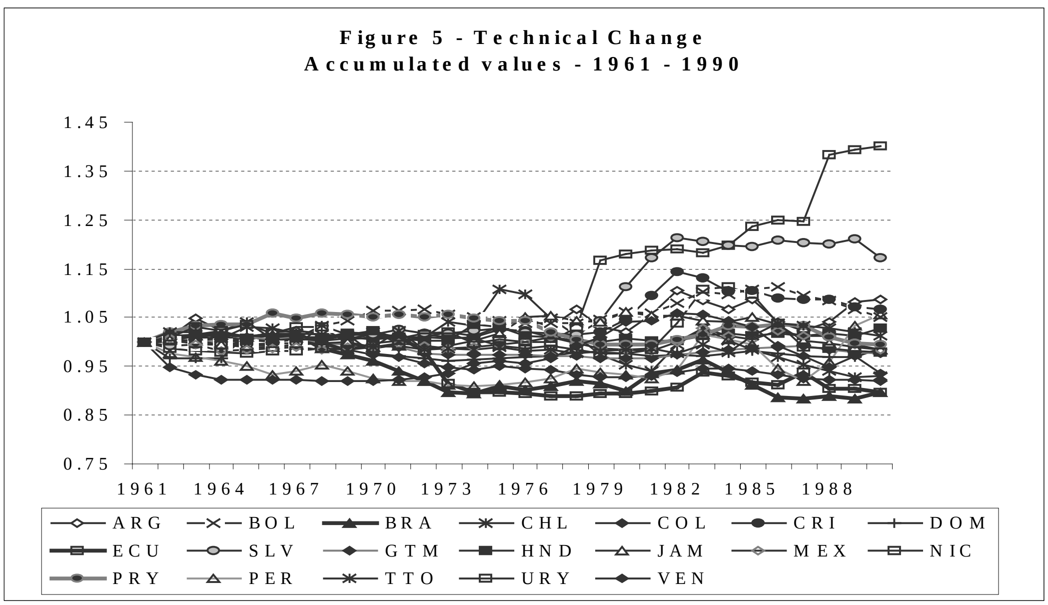
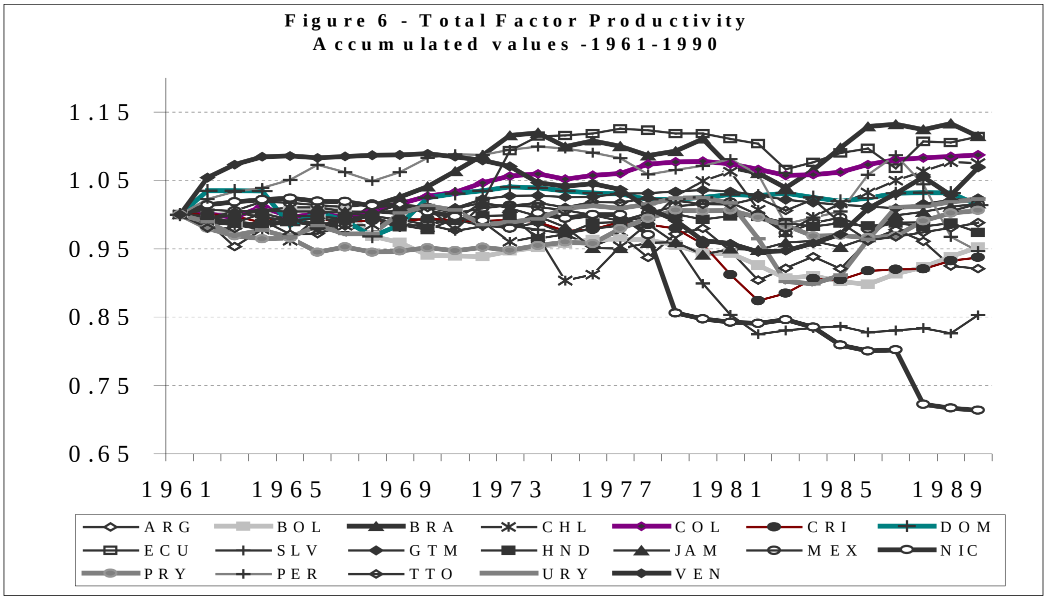


Figure 5 - Technical Change
Accumulated values - 1961 - 1990

The results obtained for TFP are depicted in Figure 6. They tell us that the average accumulated variation for the region was negative, that is, –1% for the period 1961–1990. Nicaragua (-29%), El Salvador (-15%) and Argentina (-8%) presented the worst performance, while the countries with the highest accumulated growth rates were Brazil (11.5%), Equador (11.4%), Colombia (9%) and Chile (8%).

The results found for TFP also indicate consistency for the values obtained from empirical studies using the traditional approach of growth accounting (De Gregorio and Lee, 1999; Senhadji, 1999). These studies show a very slight average growth rate (about 0.1%) in TFP from 1960 to 1990 in a sample of 21 Latin American countries. The worst performances in this group, as expressed by negative annual average growth rates, were those of Nicaragua (-1.5%), Trinidad and Tobago (-1%), Argentina (-0.5%) and

Venezuela (-0.5%). The countries with the highest average growth rates were Equador (1.6%), Colombia (1.3%), Bolivia (1.2%), Chile (0.9%) and Brazil (0.8%).



From these findings it may be concluded that although Latin America has definitely experienced technical progress over the period 1961–1990, it was not sufficiently significant to compensate for the loss of efficiency and to avoid a decrease in TFP for the region.

Conclusion

There is a consensus in the economics literature that physical capital accumulation is unable to sustain a growth process and that in the long run development and economic prosperity can only be achieved by a continuous increase in total factor productivity (TFP). The latter is, according to traditional methodology adopted for the quantification of TFP, unequivocally associated with technical progress. Furthermore, poverty reduction and improvements in the overall living standard present a positive correlation with growth in productivity and in the economy.

The approach chosen for the present study was to decompose TFP into change in technical efficiency and technical change in order to identify the actual contribution of technical progress to TFP growth. It was observed that for the period 1961–1990 the accumulated variation rate for the set of Latin American countries was –1%. This adverse performance is tied up with the fact that the magnitude of technical change (1%) was surpassed by the decrease in the accumulated change in technical efficiency (–3%). The lessened importance of technical progress had already been identified in the estimation of the production frontier and was subsequently confirmed by the construction of Malmquist total productivity indices and their decomposition into change in technical efficiency and technical change.

The worst performances in TFP in terms of accumulated growth rates were displayed by Nicaragua (-29%), El Salvador (-15%), Argentina (-8%), Costa Rica (-6%) and Bolivia (-5%); the countries presenting the highest rates were Brazil (11.5%), Equador (11.4%), Colombia (9%), Chile (8%) and Venezuela (7%). It should be noted that the decomposition of TFP variation into change in technical efficiency and technical change made it possible to identify that not all countries with high productivity growth rates owed their positive performance chiefly to the absorption of technical progress, but to a better combination of the use of production factors leading to significant gains in technical efficiency.

The macroeconomic variable current government spending and the inflation rate were important factors in the explanation of the increase in technical inefficiency of the countries in the sample. The degree of openness and the deviation in local prices in relation to purchasing power parity (the latter used as an approximation to the real exchange rate, proved important indicators of reduction in technical inefficiency

Supported by theoretical reasoning and based on the present findings, it may be affirmed that the modest growth of the actual *per capita* product observed in Latin America over the thirty-year period considered (1961–1990) was due mainly to the frustrating performance of the TFP which displayed a negative accumulated variation close to the end of the period. The loss of technical efficiency in the Latin American economies and the low level of accumulated technical progress both contributed to this outcome. Technical progress proved insufficient to compensate for losses in efficiency in most countries, especially during the 1980s when the impact of the external debt crisis was added to the economic difficulties characteristic of the period.

A plausible explanation for the disappointing TFP performance may be found in the principles underlying the conception and management of the import substitution industrialization (ISI)-based policies adopted by most countries in the 1950s or 1960s under the auspices of ECLA. The basic strategy for dealing with Latin America’s economic dependence on developed nations was based on the assumption that economic growth is driven by physical capital accumulation and was distinguished by the following features: low emphasis on policies related to systematic incorporation of technical innovations, a high degree of protectionism favoring new industries, and the introverted nature of the development process. As the model became obsolete in the region, the initial economic momentum faded out. On the other hand, reforms started in some countries during the 1970s failed to alter this tendency. Although the evidence presented by this study may account for the low TFP performance in Latin America, the cause and effect relationships implied here deserve a more thorough investigation.

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Appendix A.1

Table A.1 – Descripton of Variables and Sources Used

Variable	Original Denomination	Acronym	Source
Product per worker	Real GDP chain per worker	RGDPW	PWT 6.1
Labor	Worker*		PWT 6.1
Capital	Capital Stock	K	WDI
Government spending	Government Share of RGDPL	g	PWT 6.1
Deviations of local PPP prices	Price Level of Gross Domestic Product	P	PWT 6.1
Inflation rate**	Inflation, consumer prices (annual %)		WDI
Degree of openness	Openness in constant prices	openk	PWT 6.1

* Calculated using figures from PWT 6.1. It refers to the concept of work force.

** In the case of Brazil, the inflation rate measured by IGP-DI (Getúlio Vargas Foundation) was used. For Nicarágua the source was The International Monetary Fund's Dissemination Standards Bulletin Board (DSBB).

Appedix A.2

Table A.2

Change in Technical Efficiency – Countries in Latin America – Accumulated values: 1961–1990

YEARS	ARG	BOL	BRA	CHL	COL	CRI	DOM	ECU	SLV	GTM	HND	JAM	MEX	NIC	PRY	PER	TTO	URY	VEN	MEAN
1961	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1962	0.98	1.00	0.99	0.98	1.00	1.00	1.07	0.98	1.01	0.99	1.00	0.99	0.99	1.03	0.96	1.05	0.96	0.98	1.11	1.00
1963	0.91	1.01	0.98	0.97	0.99	1.00	1.07	0.97	1.01	1.01	0.98	1.00	1.01	1.04	0.94	1.07	0.96	0.94	1.15	1.00
1964	0.96	1.00	0.97	0.96	1.02	0.98	1.07	1.00	1.01	0.99	0.97	1.01	1.04	1.04	0.93	1.08	0.98	0.95	1.18	1.01
1965	0.99	1.01	0.98	0.93	0.99	1.00	0.97	0.99	1.01	0.98	1.00	1.02	1.03	1.05	0.93	1.10	0.94	0.93	1.18	1.00
1966	0.96	1.01	0.97	0.99	1.00	0.99	1.01	0.97	1.01	0.99	0.99	1.02	1.03	1.04	0.89	1.15	0.95	0.97	1.17	1.00
1967	0.96	1.02	0.97	0.97	0.99	0.98	0.98	0.99	1.01	0.98	0.99	1.01	1.02	1.04	0.91	1.13	0.97	0.94	1.18	1.00
1968	0.97	0.94	1.03	0.97	1.01	0.98	0.94	0.99	1.00	1.01	0.99	1.01	1.03	1.03	0.89	1.10	1.00	0.94	1.18	1.00
1969	0.99	0.92	1.05	0.98	1.03	0.98	0.97	0.96	0.98	1.01	0.97	1.00	1.02	1.03	0.90	1.13	1.03	1.00	1.18	1.01
1970	0.98	0.88	1.08	0.96	1.05	0.99	1.05	0.97	0.97	1.02	0.96	1.02	1.02	1.01	0.91	1.17	1.02	1.03	1.19	1.01
1971	0.98	0.88	1.13	1.01	1.07	0.98	1.06	0.98	0.95	1.02	0.99	1.02	1.00	0.99	0.90	1.18	0.96	1.01	1.18	1.01
1972	0.97	0.88	1.18	0.98	1.09	0.98	1.07	1.04	0.97	1.05	1.00	1.03	1.02	0.98	0.91	1.18	1.03	0.97	1.16	1.02
1973	0.96	0.90	1.24	0.92	1.12	0.98	1.08	1.20	0.97	1.05	1.00	1.02	1.03	0.96	0.90	1.20	1.03	0.98	1.15	1.03
1974	0.98	0.91	1.25	0.94	1.12	0.98	1.08	1.24	0.96	1.06	0.93	0.99	1.02	1.00	0.91	1.21	1.03	0.99	1.09	1.03
1975	0.94	0.92	1.21	0.82	1.11	0.95	1.07	1.24	0.94	1.05	0.94	0.96	1.01	0.99	0.92	1.20	1.02	1.02	1.08	1.02
1976	0.91	0.93	1.23	0.83	1.12	0.96	1.06	1.25	0.96	1.05	0.98	0.90	1.00	1.00	0.92	1.19	1.04	1.03	1.09	1.02
1977	0.94	0.93	1.21	0.91	1.12	0.98	1.06	1.27	0.97	1.06	0.98	0.90	0.98	1.00	0.96	1.17	1.03	1.02	1.07	1.03
1978	0.88	0.93	1.18	0.97	1.15	0.97	1.04	1.26	0.97	1.06	0.99	0.92	1.00	0.94	0.99	1.12	1.05	1.03	1.02	1.02
1979	0.94	0.91	1.19	1.05	1.16	0.96	1.05	1.25	0.92	1.07	1.00	0.92	1.02	0.73	1.01	1.13	1.04	1.05	0.98	1.01
1980	0.96	0.89	1.23	1.10	1.16	0.92	1.05	1.25	0.81	1.07	0.99	0.89	1.03	0.72	1.01	1.15	1.03	1.05	0.93	1.00
1981	0.90	0.89	1.14	1.13	1.15	0.83	1.06	1.23	0.73	1.07	1.00	0.90	1.04	0.71	1.01	1.17	1.03	1.03	0.92	0.99
1982	0.82	0.86	1.13	1.01	1.14	0.76	1.06	1.22	0.68	1.06	0.99	0.90	1.00	0.71	0.99	1.12	1.05	0.93	0.89	0.95
1983	0.85	0.82	1.08	0.95	1.12	0.78	1.06	1.14	0.69	1.04	0.98	0.92	0.95	0.72	0.97	0.97	1.01	0.81	0.90	0.93
1984	0.88	0.83	1.14	0.99	1.12	0.82	1.05	1.16	0.70	1.03	0.97	0.92	0.97	0.70	0.94	0.99	1.04	0.81	0.92	0.94
1985	0.85	0.81	1.20	1.03	1.13	0.82	1.04	1.19	0.70	1.03	0.98	0.91	0.99	0.65	0.94	1.01	0.98	0.83	0.94	0.94
1986	0.92	0.81	1.27	1.07	1.15	0.84	1.05	1.20	0.69	1.02	0.97	0.93	0.96	0.64	0.93	1.12	0.93	0.93	1.02	0.96
1987	0.96	0.83	1.28	1.10	1.17	0.85	1.06	1.14	0.69	1.02	0.97	1.00	0.98	0.64	0.94	1.18	0.94	1.02	1.06	0.98
1988	0.92	0.85	1.26	1.13	1.17	0.85	1.07	1.23	0.70	1.03	0.97	1.01	0.98	0.52	0.98	1.09	0.95	1.02	1.11	0.97
1989	0.86	0.88	1.28	1.16	1.18	0.87	1.06	1.22	0.68	1.04	0.98	1.02	1.01	0.51	1.00	0.94	0.96	1.04	1.06	0.97
1990	0.85	0.91	1.24	1.16	1.18	0.88	1.03	1.24	0.73	1.05	0.95	1.03	1.03	0.51	1.01	0.90	0.98	1.05	1.14	0.97

Appendix A.3

Table A.3

Technical change - Countries in Latin America – Accumulated values: 1961–1990

YEARS	ARG	BOL	BRA	CHL	COL	CRI	DOM	ECU	SLV	GTM	HND	JAM	MEX	NIC	PRY	PER	TTO	URY	VEN	MEAN
1961	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1962	1.01	1.00	1.01	1.01	1.00	1.00	0.97	1.01	0.99	1.01	1.00	1.00	1.01	0.99	1.02	0.98	1.02	1.01	0.95	1.00
1963	1.05	1.00	1.01	1.02	1.00	1.00	0.97	1.01	1.00	1.00	1.01	1.00	0.99	0.98	1.03	0.97	1.02	1.03	0.93	1.00
1964	1.02	1.00	1.02	1.02	0.99	1.01	0.97	1.00	0.99	1.00	1.01	0.99	0.98	0.98	1.04	0.96	1.01	1.02	0.92	1.00
1965	1.01	0.99	1.01	1.04	1.00	1.00	1.02	1.01	1.00	1.01	1.00	0.99	0.98	0.98	1.04	0.95	1.03	1.03	0.92	1.00
1966	1.02	0.99	1.01	1.00	1.00	1.01	1.00	1.02	1.00	1.01	1.00	0.99	0.99	0.98	1.06	0.93	1.03	1.02	0.92	1.00
1967	1.02	0.99	1.02	1.02	1.00	1.01	1.01	1.00	1.00	1.01	1.01	1.00	0.99	0.98	1.05	0.94	1.02	1.03	0.92	1.00
1968	1.02	1.03	0.99	1.02	0.99	1.01	1.03	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.06	0.95	1.00	1.03	0.92	1.00
1969	1.00	1.04	0.97	1.01	0.98	1.01	1.02	1.02	1.01	0.99	1.02	1.00	0.99	0.99	1.06	0.94	0.99	1.00	0.92	1.00
1970	1.01	1.06	0.96	1.02	0.97	1.01	0.98	1.01	1.01	0.99	1.02	0.99	0.99	1.00	1.05	0.92	0.99	0.99	0.92	0.99
1971	1.01	1.06	0.94	1.00	0.97	1.01	0.97	1.01	1.02	0.99	1.01	0.99	1.00	1.00	1.06	0.92	1.02	0.99	0.92	0.99
1972	1.02	1.07	0.92	1.01	0.96	1.01	0.97	0.98	1.02	0.98	1.00	0.98	0.99	1.01	1.05	0.92	0.98	1.02	0.93	0.99
1973	1.02	1.06	0.90	1.04	0.95	1.01	0.96	0.91	1.02	0.97	1.00	0.99	0.99	1.02	1.06	0.91	0.99	1.01	0.93	0.98
1974	1.01	1.05	0.89	1.03	0.94	1.01	0.96	0.90	1.02	0.97	1.04	1.00	0.99	1.00	1.05	0.91	0.98	1.01	0.96	0.98
1975	1.03	1.04	0.91	1.11	0.95	1.02	0.97	0.90	1.03	0.98	1.03	1.02	0.99	1.01	1.04	0.91	0.99	0.99	0.96	0.99
1976	1.05	1.04	0.90	1.10	0.95	1.02	0.97	0.89	1.02	0.97	1.01	1.05	1.00	1.00	1.04	0.92	0.98	0.99	0.96	0.99
1977	1.03	1.04	0.91	1.05	0.94	1.01	0.97	0.89	1.02	0.97	1.01	1.05	1.01	1.00	1.02	0.92	0.98	0.99	0.97	0.99
1978	1.07	1.04	0.92	1.01	0.93	1.02	0.98	0.89	1.01	0.97	1.00	1.04	1.00	1.03	1.01	0.94	0.98	0.98	0.99	0.99
1979	1.03	1.05	0.92	0.97	0.93	1.02	0.98	0.89	1.04	0.97	1.00	1.04	0.99	1.17	0.99	0.94	0.98	0.98	1.01	0.99
1980	1.02	1.06	0.90	0.95	0.93	1.04	0.98	0.89	1.11	0.97	1.01	1.06	0.98	1.18	0.99	0.93	0.99	0.98	1.04	1.00
1981	1.06	1.06	0.94	0.94	0.93	1.10	0.97	0.90	1.17	0.97	1.00	1.05	0.98	1.19	0.99	0.92	0.99	0.98	1.04	1.01
1982	1.11	1.08	0.94	0.99	0.94	1.14	0.97	0.91	1.21	0.97	1.00	1.05	1.00	1.19	1.00	0.94	0.98	1.04	1.06	1.02
1983	1.09	1.10	0.96	1.03	0.95	1.13	0.97	0.94	1.20	0.98	1.01	1.04	1.03	1.18	1.02	1.01	0.99	1.11	1.06	1.04
1984	1.07	1.10	0.94	1.00	0.94	1.10	0.98	0.93	1.20	0.98	1.02	1.04	1.01	1.20	1.03	1.00	0.98	1.11	1.04	1.03
1985	1.09	1.11	0.91	0.98	0.94	1.11	0.98	0.92	1.20	0.99	1.01	1.05	1.00	1.24	1.03	1.00	1.01	1.10	1.03	1.03
1986	1.04	1.11	0.89	0.97	0.93	1.09	0.98	0.91	1.21	0.99	1.02	1.03	1.02	1.25	1.04	0.94	1.04	1.04	0.99	1.02
1987	1.02	1.10	0.88	0.95	0.93	1.09	0.97	0.94	1.20	0.99	1.01	1.00	1.01	1.25	1.03	0.92	1.03	0.99	0.97	1.01
1988	1.04	1.08	0.89	0.94	0.92	1.09	0.97	0.90	1.20	0.98	1.02	1.00	1.01	1.38	1.01	0.96	1.03	0.99	0.95	1.01
1989	1.08	1.07	0.88	0.93	0.92	1.07	0.97	0.90	1.21	0.98	1.01	0.99	0.99	1.39	1.00	1.03	1.02	0.98	0.97	1.02
1990	1.09	1.05	0.90	0.93	0.92	1.07	0.99	0.90	1.17	0.98	1.03	0.98	0.98	1.40	0.99	1.06	1.01	0.98	0.94	1.01

Appendix A.4

Table A.4
Change in Total Factor Productivity – Countries in Latin America – Accumulated values
1961–1990

YEARS	ARG	BOL	BRA	CHL	COL	CRI	DOM	ECU	SLV	GTM	HND	JAM	MEX	NIC	PRY	PER	TTO	URY	VEN	MEAN
1961	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1962	0.99	1.00	0.99	0.99	1.00	1.00	1.03	0.99	1.01	0.99	1.00	1.00	0.99	1.01	0.98	1.02	0.98	0.99	1.05	1.00
1963	0.95	1.00	0.99	0.98	1.00	1.00	1.04	0.99	1.00	1.00	0.99	1.00	1.01	1.02	0.97	1.03	0.98	0.97	1.07	1.00
1964	0.98	1.00	0.98	0.98	1.01	0.99	1.03	1.00	1.01	1.00	0.99	1.01	1.02	1.02	0.96	1.04	0.99	0.98	1.08	1.00
1965	0.99	1.01	0.99	0.96	1.00	1.00	0.98	0.99	1.00	0.99	1.00	1.01	1.02	1.02	0.97	1.05	0.97	0.97	1.09	1.00
1966	0.98	1.01	0.99	1.00	1.00	0.99	1.00	0.98	1.00	0.99	1.00	1.01	1.01	1.02	0.95	1.07	0.97	0.98	1.08	1.00
1967	0.98	1.01	0.98	0.98	1.00	0.99	0.99	1.00	1.00	0.99	0.99	1.00	1.01	1.02	0.95	1.06	0.98	0.97	1.09	1.00
1968	0.98	0.97	1.01	0.98	1.01	0.99	0.97	1.00	1.00	1.00	1.00	1.00	1.02	1.01	0.94	1.05	1.00	0.97	1.09	1.00
1969	1.00	0.96	1.03	0.99	1.02	0.99	0.98	0.98	0.99	1.01	0.98	1.00	1.01	1.01	0.95	1.06	1.02	1.00	1.09	1.00
1970	0.99	0.94	1.04	0.98	1.03	0.99	1.02	0.99	0.99	1.01	0.98	1.01	1.01	1.00	0.95	1.08	1.01	1.01	1.09	1.01
1971	0.99	0.94	1.06	1.00	1.03	0.99	1.03	0.99	0.98	1.01	0.99	1.01	1.00	1.00	0.95	1.09	0.98	1.01	1.08	1.01
1972	0.98	0.94	1.09	0.99	1.05	0.99	1.04	1.02	0.98	1.02	1.00	1.02	1.01	0.99	0.95	1.09	1.02	0.98	1.08	1.01
1973	0.98	0.95	1.12	0.96	1.06	0.99	1.04	1.09	0.98	1.03	1.00	1.01	1.01	0.98	0.95	1.10	1.01	0.99	1.07	1.02
1974	0.99	0.95	1.12	0.97	1.06	0.99	1.04	1.11	0.98	1.03	0.96	1.00	1.01	1.00	0.95	1.10	1.02	0.99	1.05	1.02
1975	0.97	0.96	1.10	0.90	1.05	0.98	1.03	1.12	0.97	1.03	0.97	0.98	1.01	0.99	0.96	1.10	1.01	1.01	1.04	1.01
1976	0.95	0.96	1.11	0.91	1.06	0.98	1.03	1.12	0.98	1.03	0.99	0.95	1.00	1.00	0.96	1.09	1.02	1.01	1.05	1.01
1977	0.97	0.96	1.10	0.95	1.06	0.99	1.03	1.13	0.98	1.03	0.99	0.95	0.99	1.00	0.98	1.08	1.02	1.01	1.04	1.01
1978	0.94	0.96	1.09	0.99	1.07	0.99	1.02	1.12	0.99	1.03	1.00	0.96	1.00	0.97	0.99	1.06	1.02	1.02	1.01	1.01
1979	0.97	0.96	1.09	1.03	1.08	0.98	1.02	1.12	0.96	1.03	1.00	0.96	1.01	0.86	1.01	1.07	1.02	1.02	0.99	1.01
1980	0.98	0.94	1.11	1.05	1.08	0.96	1.02	1.12	0.90	1.04	0.99	0.94	1.02	0.85	1.01	1.07	1.02	1.02	0.96	1.00
1981	0.95	0.94	1.07	1.06	1.07	0.91	1.03	1.11	0.85	1.03	1.00	0.95	1.02	0.84	1.01	1.08	1.01	1.02	0.96	0.99
1982	0.90	0.93	1.06	1.01	1.07	0.87	1.03	1.10	0.82	1.03	1.00	0.95	1.00	0.84	1.00	1.06	1.02	0.96	0.95	0.98
1983	0.92	0.91	1.04	0.97	1.06	0.88	1.03	1.07	0.83	1.02	0.99	0.96	0.97	0.85	0.98	0.99	1.01	0.90	0.95	0.96
1984	0.94	0.91	1.07	1.00	1.06	0.91	1.02	1.08	0.83	1.02	0.98	0.96	0.99	0.84	0.97	1.00	1.02	0.90	0.96	0.97
1985	0.92	0.90	1.10	1.02	1.06	0.90	1.02	1.09	0.84	1.01	0.99	0.95	1.00	0.81	0.97	1.00	0.99	0.91	0.97	0.97
1986	0.96	0.90	1.13	1.03	1.07	0.92	1.02	1.10	0.83	1.01	0.98	0.97	0.98	0.80	0.97	1.06	0.96	0.96	1.01	0.98
1987	0.98	0.91	1.13	1.05	1.08	0.92	1.03	1.07	0.83	1.01	0.99	1.00	0.99	0.80	0.97	1.09	0.97	1.01	1.03	0.99
1988	0.96	0.92	1.12	1.06	1.08	0.92	1.03	1.11	0.83	1.02	0.98	1.00	0.99	0.72	0.99	1.04	0.97	1.01	1.06	0.99
1989	0.92	0.94	1.13	1.08	1.08	0.93	1.03	1.11	0.83	1.02	0.99	1.01	1.01	0.72	1.00	0.97	0.98	1.02	1.03	0.98
1990	0.92	0.95	1.11	1.08	1.09	0.94	1.01	1.11	0.85	1.02	0.97	1.02	1.02	0.71	1.01	0.95	0.99	1.02	1.07	0.99