Latin America: Total factor productivity and its components

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ABSTRACT

This article applies the stochastic-frontier model to examine total factor productivity (TFP) and its components in Latin America between 1960 and 2010. The likelihood-ratio test shows that, for a selection of Latin American countries over the 50 years analysed, the macroeconomic variables of technical inefficiency included in the model generally have a significant effect; and they allow for a better understanding of technical inefficiency throughout the region. The key variables explaining technical inefficiency in the selected countries are public expenditure and the inflation rate; and there is also an inverse relation between technical inefficiency and the extent to which local prices diverge from purchasing power parity.

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I

Introduction

Using the concept of total factor productivity (TFP), quantified using the Cobb-Douglas production function, Solow (1957) introduced the measurement of the contribution made by technical progress to per capita output growth. This author estimated the production function of the United States economy from 1909 to 1949, and established the existence of a residual, measured as the difference between the growth rates of real output and the weighted growth rates of the individual factors of production, capital and labour. The importance of technical progress, which was discovered when attempting to break down the growth rate of real output using the growth rates of the factors of production, is known as the Solow residual.

The notion of technical progress then came to be used as an abbreviated expression for any shift of the production function. Nonetheless, based on empirical studies founded on growth accounting and inspired in the neoclassical model, some authors started to claim that several causes could be closely related to the measurement of the residual. Drawing on Solow's work, a number of empirical studies were performed —such as those of Griliches (1996), which uses various methodologies and samples— aimed at analysing the components of the aforementioned residual, with a view to quantifying as precisely as possible the real contribution that technical progress makes to output growth.

Orea (2002) studies panel data based on information from Spanish banks and proposes a parametric breakdown of the Malmquist index. The results show that TFP growth can be attributed mainly to technical progress. Färe, Grosskopf and Roos (1998) also study productivity and the Malmquist index. The empirical studies of Färe and others (1994); Johnson and Kuosmanen (2012); Lee and others (2013), and Wang and others (2014), among various authors, also show that it is possible to study the productivity of economic agents using non-parametric or semi-parametric methods. For example, data envelopment analysis (DEA) is a non-parametric methodology that can be used to evaluate the technical efficiency of productive units and estimate the Malmquist index.

The present article reports an application of the TFP decomposition procedure suggested by Bauer (1990) and Kumbhakar (2000) to a sample of Latin American countries for the period 1960-2010, based on the stochastic production-frontier model. The advantage of this approach is that allows TFP to be broken down into components that characterize the general production process. The procedure used makes it possible to identify the components of technical efficiency, which reflect the way an economy moves towards the production frontier, as distinct from the technical progress component, which represents a shifting of the frontier itself.

An advantage of the procedure used by Bauer (1990) and Kumbhakar (2000) is that by permitting a flexible specification of the production frontier, such as translog, TFP can be broken down into the components of technical efficiency, allocative efficiency, scale effect and technical progress. This procedure is superior to decomposition using the TFP Malmquist index (based on a production frontier that is restricted by the imposition of constant returns to scale), which is used in many other studies. In this case, according to Färe and others (1992), TFP is divided into just two elements: the variation in technical efficiency and technological change. This line of research also includes studies by Kumbhakar and Lovell (2003); Sauer, Frohberg and Hockmann (2006), and Henningsen and Henning (2009).

This article uses the stochastic-frontier model to analyse the contribution made by TFP to economic growth in a sample of Latin American countries; for which purpose it examines the components of technical efficiency, allocative efficiency, scale effect, and technical progress in the variation of TFP in those countries. It thus contributes to the empirical literature for a better understanding of the real factors that underlie the economic performance of the sample countries over a 50-year period. A further aim is to understand the influence of the vector of macroeconomic variables on the technical efficiency of the countries in the sample, through the technical inefficiency model, following Battese and Coelli (1995).

The article is divided into six sections including this introduction. Section II briefly explains the stochastic-frontier model and the TFP decomposition procedure; and section III presents the databases, sample of countries and the econometric model used. Section IV demonstrates the calculation of the TFP decomposition, using the Bauer (1990) and Kumbhakar (2000) procedure; and section V presents the results of the estimation and breakdown. The sixth and last section puts forward a number of final thoughts.

II

Stochastic frontier and TFP decomposition

This study uses stochastic production-frontier analysis, which is one of the methods adopted in the technical-inefficiency literature, to identify one of the components of TFP, namely technical efficiency.

The approach uses econometric (parametric) techniques, whose production-frontier models are used to study technical inefficiency, and it is recognized that output can be affected by random disturbances that are outside producer control. Unlike non-parametric approaches, which assume deterministic frontiers, stochastic-frontier analysis allows for deviations from the frontier, for which the error can be broken down into changes in technical efficiency and random disturbances.

In the deterministic-frontier models, deviations from the production frontier are attributed to the producer's technical inefficiency; but those models ignore the fact that production can be affected by random disturbances outside producer control, such as strikes or environmental conditions, among others.

Stochastic-frontier analysis originated in articles by Aigner, Lovell and Schmidt (1977) and Meeusen and Broeck (1977), which were followed by the work of Battese and Corra (1977). Those original studies present the structurally composed error term in the context of the production function. Since then, various authors have collaborated, including Battese and Coelli (1995), who modelled technical inefficiency as time-variant, formalizing the technical inefficiency of the stochastic production function for panel data. The present article adopts the model proposed by Battese and Coelli (1995) and Coelli, Rao and Battese (1998). Accordingly, the stochastic production-frontier model can be described through equation (1), where y_{it} is the vector of quantities produced by the various countries in period t; x_{it} is the vector of factors of production used in period t, and β is the vector of parameters defining the production technology.

$$y_{it} = f\left(t, x_{it}, \beta\right). \, exp\left(v_{it}\right). \, exp\left(-u_{it}\right), u \geq 0 \quad (1)$$
$$i = 1, ..., N, t = 1, ..., T$$

The terms v_{it} and u_{it} are vectors that represent different error components. The first relates to the random part, with a truncated normal distribution, independent and identically distributed, with a constant variance of σ^2, (v ~ iid N (0, σ_v^2)); whereas the second represents technical inefficiency, in other words the part that constitutes a retreat from the production frontier, which can be inferred from the negative sign and the constraint $u \geq 0$. These are non-negative random variables with a zero-truncated normal distribution, independently distributed (not identically) with mean μ_{it} and constant variance σ_u^2; in other words (u ~ NT (μ, σ_u^2)). As the error components are mutually independent and x_{it} is assumed exogenous, the model can be estimated using the maximum-likelihood technique.

Unlike the model used by Pires and Garcia (2004), this one has the advantage of allowing inefficiencies and input elasticities to vary through time, which makes it easier to identify changes in the production structure.

The effects of technical inefficiency (e_{it}) are expressed with the following characteristics:

$$e_{it} = z_{it}\delta + w_{it}$$

where: z_{it} is a vector of explanatory variables of the technical inefficiency of the i-th productive unit (country) measured in time t; δ is a vector of parameters associated with the variables z_{it}; and w_{it} is a normally distributed random variable with zero mean and variance σ_w^2. It is assumed that e_{it} has a zero-truncated normal distribution, so its mean is $w_{it} = z_{it}\delta_t$.

Under this formulation, a functional form is defined, as presented below; and this is used to obtain TFP, which is then broken down into its components.

The decomposition of TFP through the well-known Malmquist index, which separates the total productivity index into technological variation and efficiency variation, has been widely used by a number of authors. For example, Laborda, Sotelsek and Guasch (2011) study productivity growth in 16 Latin American countries between 1996 and 2006, using a stochastic-frontier approach, and they perform a decomposition of the Malmquist index. Nonetheless, in a more wide ranging study, Bauer (1990) and Kumbhakar (2000) propose a type of decomposition which, in addition to the components listed above, captures production-scale effects and changes in the inefficiency of factor allocation. Section III contains a detailed analysis of how to incorporate these components into analyses of TFP variations.

III

Methodology

1. Description of the sample and the data used

The analysis considers the following 19 Latin American countries: Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Paraguay, Peru, the Plurinational State of Bolivia, Trinidad and Tobago, and Uruguay. The data relate to the period 1960-2010, and were obtained from the following sources: Penn World Table 7.1 (PWT 7.1) and the World Development Indicators published by the World Bank. The availability of information from those databases was decisive in choosing 2010 as the upper bound of the sample.

The variables gross domestic product (*PIB*), labour (*L*), government consumption expenditure (*G*) and deviation of local prices from purchasing power parity (*DPPA*) were taken from Penn World Table 7.1. The series for physical capital (*K*) of the individual countries was constructed from estimates based on gross investment, using the perpetual-inventory technique.

The inflation rate data came from the World Development Indicators, although the difficulties in obtaining data for certain countries meant that other sources were also used. In the case of Brazil, the general price index-domestic supply (IGP-DI) published by the Getulio Vargas Foundation was used.

The sample consists of annual data on capital, labour, GDP, government expenditure, purchasing power parity and inflation from the 19 selected countries, totalling 950 observations forming a balanced panel.

2. Econometric model

Total factor productivity was calculated using the stochastic production-frontier model proposed by Aigner, Leobel and Schmidt (1977) and Meeusen and Broeck (1977), which was subsequently improved by Pitt and Lee (1981) and Schmidt and Sickles (1984). This makes it possible to model the panel data with the productive technical-inefficiency component, according to the foundations used by Battese and Coelli (1995), which suggest that technical inefficiency is modelled by a vector of variables.

This being the case, a functional form of the production frontier is modelled, in conjunction with a hypothesis about the distribution of technical inefficiency (Battese and Coelli (1995)).

Firstly, one model was tested using the Cobb-Douglas functional form and another using the translog form. The adequacy test identified the latter functional form as superior in terms of data consistency.

Accordingly, the translog production-frontier function for the 19 selected Latin American countries was specified as follows:

$$LnY_{it} = \alpha_i + \alpha_2 t + \alpha_3 \frac{1}{2}t^2 + \alpha_4 LnK_{it} + \alpha_5 tLnK_{it}$$
$$+\alpha_6 LnL_{it} + \alpha_7 tLnL_{it} + \alpha_8 \frac{1}{2}\left(LnK_{it}\right)^2 + \alpha_9 \frac{1}{2}\left(LnL_{it}\right)^2 \quad (2)$$
$$+\alpha_{10} LnK_{it} LnL_{it} + v_{it} - u_{it}$$

where:
Y_{it} = GDP of country i in period t.
K_{it} = physical capital stock of country i in period t.
L_{it} = labour in country i in period t.
α_i = fixed effects, with the aim of capturing unobserved heterogeneities in the sample of countries.
t = linear trend.
$\frac{1}{2}t^2$ = quadratic trend.
v_{it} = random disturbances of the production function, which are assumed to be normally distributed with zero mean and constant variance.
u_{it} = technical inefficiency of production, modelled as follows:

$$u_{it} = \delta z_{it} + \omega_{it} \quad (3)$$

where:
z_{it} = $(z_{1t}, z_{2t}, z_{3t}, z_{4t})$ represents a vector of variables that explain technical inefficiency, and δ is a parameter of associated with z_{it}.
ω_{it} = assumed normally distributed $N(0, \sigma_\omega^2)$.

Under the foregoing hypothesis, it is also assumed that u_{it} is independently distributed in a truncated normal distribution with mean $w_{it} = \delta z_{it}$, and constant variance of σ_ω^2.

The choice of the variables used to model the technical-inefficiency term is based on a number of empirical studies that use this procedure to estimate parametric frontiers involving aggregate data.

The inefficiency variables considered are as follows:

z_{1t} = trend effect.

z_{2t} = government consumption expenditure relative to the GDP of each country. Some empirical studies have been conducted to quantify the effect of current expenditure outgoings on inefficiency. For example, Bittencourt and Marinho (2007) analyse TFP in Latin American countries and discuss the effects of macroeconomic variables in explaining the technical inefficiency component through the stochastic frontier. They find that current government expenditure contributed to increasing technical inefficiency in the countries of the sample between 1961 and 1990. Thus, an increase in government expenditure would be expected to make production more technically inefficient.

z_{3t} = corresponds to the logarithm of 1 + the inflation rate, π, in other words $\ln (1 + \pi)$. This expression is used because it captures the non-linear effects of inflation on technical inefficiency. According to De Gregorio (1992), some countries experienced periods of deflation and hyperinflation, but the influence of those extreme situations on the inefficiency term is attenuated by using the expression indicated above. Inflation is expected to increase the technical inefficiency of production.

z_{4t} = corresponds to the deviation of the local price level from purchasing power parity, using the United States as the benchmark country. This variable serves above all to control for the technical-inefficiency effects of trade policies that involve devaluation of the real exchange rate.

The parameters of equations (2) and (3) are estimated using the maximum-likelihood method, which makes it possible to calculate the magnitude of technical efficiencies for each country in the sample.

3. Tests conducted

(a) Functional form

Firstly the Cobb-Douglas and then the translog production functions were estimated, for the purpose of using the adequacy test to choose which functional form to use in the study. Although the Cobb-Douglas functional form is commonly used in frontier-estimation models, it is a simple model with few properties, including constant elasticity and returns to scale (Coelli, Rao and Battese, 1998).

Thus, in line with several studies, the functional form test is used to estimate both the Cobb-Douglas and the translog forms; and the null hypothesis that Cobb-Douglas is the appropriate form for presenting the data is tested, given the translog specifications. This can be tested using the likelihood-ratio test. The table published in Kodde and Palm (1986) is used to compare the critical values of the results, given the degrees of freedom. The test proceeds as follows:

After obtaining the two models and their respective maximum-likelihood ratios (LL), the generalized-likelihood statistic (LR) of the estimated production functions is considered. Then the hypothesis test is applied:

H_0: LL Cobb-Douglas.

H_1: LL translog.

and, consequently, the generalized-likelihood ratio,

LR = - 2 [ln LL H_0 – Ln LL H_1]

LR > T KP (Kodde and Palm, 1986 table) H_0 is rejected.

To find an ideal model to represent the data, further functional form tests were conducted in addition to that described above between Cobb-Douglas and translog. These tests only changed some of the inefficiency variables, but owing to a lack of convergence between certain models, it was impossible to make comparisons.

(b) Absence of technical progress

This test considers whether or not the coefficients of the time-related variables in the translog function are equal to zero. In other words, it tests the hypothesis that α_2, α_3, α_5, α_7 in equation (2) are equal to zero. Thus:

H_0: α_2, α_3, α_5, $\alpha_7 = 0$.

H_1: complete translog.

Using the generalized-likelihood ratio,

LR = - 2 [ln LL H_0 – Ln LL H_1]

LR > T KP (Kodde and Palm, 1986 table) H_0 is rejected.

(c) Effect of technical inefficiency on the production function

This case tests for the nonexistence of technical inefficiency; in other words, whether in fact the inefficiency variables depend on the model. For that purpose, the log-likelihood value (LL) is taken of the model estimated without these variables, and the generalized-likelihood test is performed again, comparing it with the critical value of Kodde and Palm (1986). The degrees of freedom correspond to the inefficiency variables.

Thus:

H_0: nonexistence of technical inefficiency.

H_1: alternative hypothesis: the technical inefficiency must be taken into account in the model.

(d) *Absence of fixed effects*

This test is used to evaluate the model without the presence of fixed effects captured by its dummy variables. The model is once again estimated without taking account of the presence of those dummy variables, and the generalized-likelihood test is applied,

with reference to the critical value of Kodde and Palm (1986).

In this particular study, the estimation without fixed effects did not converge after a large number of iterations, so the model could not be estimated and was rejected for comparison purposes.

IV

Decomposition of TFP

1. Composition of the data

In order to break the TPF down into its components, the country data were used to develop the initial econometric model, along with the data calculated from that model.

The 19 countries of the sample were maintained for the econometric model, and the period 1960-2010 was maintained for the analysis, with data on capital (K), labour (L) and GDP (Y) mainly being used. The factor shares S_K and S_L were obtained from calculations based on Penn World Table 7.1 data.

The elasticities ε_k and ε_L were calculated on the basis of the respective derivatives of the translog production function used in relation to the corresponding factors of production.

2. Decomposition procedure

Bauer (1990) and Kumbhakar (2000) proposed a productivity decomposition that goes beyond changes in productivity to capture the effects of technical innovation. This approach also takes account of production-scale effects. That decomposition is performed by firstly estimating the model of equations (2) and (3), after which it is possible to "compose" the rate of change of TPF based on the results.

According to that model, which was used by Pires and Garcia (2004), on the basis of the formulation proposed by Battese and Coelli (1993), it is possible to study the effects of each TPF component. The main advantage of this is that it admits the possibility of variable returns to scale.

In this way, the components of productivity can be identified after some algebraic manipulations on the expression that represents the deterministic part of the production frontier. Pires and Garcia (2004) present an index for the TPF growth rate expressed as:

$$g_{PTF} = \frac{\mathring{y}}{y} - s_K \frac{\mathring{K}}{K} - s_L \frac{\mathring{L}}{L} \tag{4}$$

in the deterministic part, it can be seen that:

$$\frac{\mathring{y}}{y} = \frac{\partial \ln f(t, K, L, \beta)}{\partial t} + \varepsilon_K \frac{\mathring{K}}{K} + \varepsilon_L \frac{\mathring{L}}{L} - \frac{\partial u}{\partial t} \tag{5}$$

where:

S_K = the capital share of income; S_L = the labour share of income; ε_K = the elasticity of capital; and ε_L = the elasticity of labour.

Returns to scale (RTS) are defined as the sum of elasticities, such that:

$$RTS = \varepsilon_K + \varepsilon_L$$

where,

g_K = growth rate of K
g_L = growth rate of L

Setting, $\lambda_K = \dfrac{\varepsilon_K}{RTS}$ and $\lambda_L = \dfrac{\varepsilon_L}{RTS}$, and substituting in the index, a number of algebraic operations are then performed:

$$g_{PTF} = PT - \mathring{u} + (RTS - 1) \cdot \left[\lambda_K \cdot g_K + \lambda_L \cdot g_L \right] \\ + \left[(\lambda_K - s_K) \cdot g_K + (\lambda_L - s_L) \cdot g_L \right] \tag{6}$$

Equation (6) describes the rate of variation of TFP, g_{PTF}, which can be broken down into four elements: technical progress, variation of technical efficiency, variations in the scale of production, and variations in the efficiency of resource allocation.

Technical progress (PT) is represented by the derivative of the production function with respect to time:

$$PT = \frac{\partial \ln f(t, K, L, \beta)}{\partial t}$$

The change in technical efficiency is denoted by the technical inefficiency coefficient with a negative sign $-\mathring{u}$.

It should be noted that the change in production scale is given by the expression that contains the returns to scale and growth rates of capital and labour, in other words the third term of equation (6): $(RTS - 1).[\lambda_K . g_k + \lambda_L . g_L]$.

Changes relating to allocative efficiency are represented by the last term in equation (6), which relates proportionate returns to scale, the shares of capital and labour, and the growth rates, and is thus measured by: $[(\lambda_K - s_k).g_K + (\lambda_L - s_L).g_L]$.

This methodology, with which productivity is broken down into the four components mentioned, makes it possible to evaluate the repercussion of each one separately. For example, if technology does not change (if $PT = 0$ in the item defined above), this will not contribute to productivity gains. Similarly, technical inefficiency, which changes through time, will have repercussions on the rate of variation; otherwise, if $-\mathring{u} = 0 = 0$, it will not affect that rate.

With constant returns to scale ($RTS = 1$), the third component of the formula for the variation in productivity is zero. Nonetheless, if $RTS \ne 1$ productivity can partially explain returns to production scale.

By setting $\lambda_K + \lambda_L = 1$, one can discern a symmetry in the distances of the shares of K and L with respect to λ, where the capital and labour shares are symmetric and, consequently, have opposite signs. According to a reallocation factor, this means that the intensity of one factor will reduce the intensity of the other; in other words, that capital intensity will reduce the amount of labour, and vice versa.

V

Estimation and results

1. Analysis of the estimation of the production frontier

Table 1 shows the model that corresponds to the estimation of the production frontier in the translog functional form, which was the model that best fit the data after the appropriate tests described above. All of the estimated parameters are statistically significant at the 5% level, except for the α_2 of variable t, which did not return a conclusive result.

Nonetheless, the parameters of the stochastic production frontier estimated in terms of the trend components, provide clear evidence that technical progress occurred at an increasing rate (shown by the positive sign of the t^2 variable, which is significant at 1%), which thus means an acceleration in the variation of technical progress.

The value of the technical inefficiency indicator, γ, is 0.51. This means that 51% of the total variance of the composed error of the estimation of the translog production function is explained by the variance in technical inefficiency. This makes it very important to incorporate technical inefficiency into the model.

Table 1 shows that all of the estimated parameters of the variables included to explain the technical inefficiency are statistically significant at the 1% level, and have the expected signs.

For example, the estimated coefficient of the trend variable (z_{1t}) in the technical inefficiency model has a positive sign and is statistically significant at 1%, which could indicate a tendency for inefficiency to increase in the period studied.

The government current expenditure variable (z_{2t}) is significant and has a positive sign, which suggests that the large share of current expenditure in the composition of aggregate spending in Latin American countries, on average, produces inefficiency in the economy. To some extent, these results agree with those obtained by Klein and Luu (2001), who concluded that countries with high levels of current expenditure tend to be less efficient, since a high level of public expenditure crowds out productive investments and thus generates distortions in resource allocation.

The coefficient of the inflation rate (z_{3t}) proved positive and significant, in keeping with the empirical literature that shows the harmful effects that higher rates of inflation have on resource allocation in the economy. Such rates end up inhibiting trade and discouraging capital formation. In this context, it is important to stress that several Latin American countries experienced lengthy

TABLE 1

Results of the model in the translog[a] functional form, 1961-2010

Variables	Estimations	Z-value
$d1$	0.395	8.8
$d2$	-0.683	-13.5
$d3$	1.490	9.9
$d4$	-0.226	-8.2
$d5$	0.416	10.3
$d6$	-0.592	-7.9
$d7$	-0.475	-10.5
$d8$	-0.770	-24.6
$d9$	-0.540	-9.3
$d10$	-0.400	-9.5
$d11$	-0.930	-14.6
$d12$	-0.931	-13.6
$d13$	1.150	14.4
$d14$	-1.020	-13.0
$d15$	-1.073	-18.2
$d16$	-0.155	-5.5
$d17$	-0.844	-7.5
$d18$	-0.934	-16.8
t	-0.014	-1.3
$\frac{1}{2}t^2$	0.001	11.8
LnL	0.973	4.4
LnK	-0.327	-2.2
$tLnL$	0.001	1.8
$tLnK$	-0.002	-3.2
$LnL \cdot LnK$	0.061	5.8
$\frac{1}{2}\left(LnL\right)^2$	-0.069	-4.4
$\frac{1}{2}\left(LnK\right)^2$	0.024	2.9
Constants	11.22	11.2
Z_1-trend effect	0.018	4.3
Z_2-government consumption expenditure	30.729	5.7
Z_3-inflation rate	0.098	2.9
Z_4-degree of openness	-0.806	-3.4
Constants	-0.696	-3.3
lnsigma2	-3.829	-17.7
Ilgtgama	0.042	0.93
sigma2	0.021	-
gamma	0.510	-
sigma_u2	0.011	-
sigma_v2	0.010	-

Source: prepared by the authors, on the basis of the research data.

[a] Number of observations: 950; log-likelihood probability: 729.28 and probability>chi-squared = 0.0000.

Note: the "d" variables represent the fixed effects of the countries. The other variables correspond to those indicated in equation (2). Gamma and sigma correspond to the results of the log-likelihood function expressed in terms of the parameterization specified by $\gamma = \dfrac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$.

inflationary periods, which had negative repercussions on the technical inefficiency and development of their economies.

In the case of the variable that captures the deviation of local prices from purchasing power parity (z_{4t}), the estimated coefficient is significant and has the expected negative sign. This indicates that countries which adopted trade policies based on exchange-rate devaluation succeeded in reducing the level of inefficiency. This type of devaluation can boost exports and consequently support an increase in the installed capacity of the external sector, which leads in turn to an expansion of domestic demand. It is worth highlighting that this effect is greater, the larger is share of the external sector in the local economy.

2. Analysis of the hypothesis tests

Once the models had been estimated, the respective tests were conducted for functional form, the absence of technical progress and technical inefficiency.

Table 2 sets out some of the results. Firstly, the Cobb-Douglas functional form was tested in comparison with the translog model, and then the likelihood-ratio was used to verify the best functional form. This means testing the hypothesis that all of the second-order coefficients and the coefficients of the cross-products of the function defined in (2) are equal to zero. It should be noted that the value of the likelihood ratio was 9.77, which is above the 7.04 critical level of the value statistic of Kodde and Palm (1986) (critical value to the right of the χ^2 distribution at 5% with 3 degrees of freedom). It can therefore be assumed that the most appropriate model for the problem under study is the translog functional form.

TABLE 2

Likelihood-ratio test of the parameters of the stochastic production frontier

Test	Null hypothesis	Value of λ	Critical value	Decision (5% level)
Functional form	$H_0: \alpha_8 = \alpha_9 = \alpha_{10} = 0$	9.55	7.04	Reject H_0
Absence of TP	$H_0: \alpha_2 = \alpha_3 = \alpha_5 = \alpha_7 = 0$	161.23	8.76	Reject H_0
Nonexistence of technical inefficiency	$H_0: z_1 = z_2 = z_3 = z_4 = 0$	118.01	8.76	Reject H_0

Source: prepared by the authors.

λ: Statistical test of the likelihood ratio in which $\lambda = -2$ {log [likelihood (H_0)] – log [likelihood (H_1)]}. This test has a roughly chi-squared distribution with degrees of freedom equal to the number of independent constraints.
TP: technical progress.

Once the functional form had been chosen, the absence of technical progress was tested. In line with the test described above, the model was estimated in the translog functional form, and with the absence of technical progress. The respective values of the log-maximum-likelihood of each estimation were used to obtain LR = - 2 [648.67 – 729.28] = 161.22. The result of the test exceeds the critical value of 8.76 with 4 degrees of freedom and significant at 5% in the table of Kodde and Palm (1986). Consequently, H_0 is rejected, and hypothesis H_1 is accepted, which confirms the presence of technical progress.

Subsequently, the test for the absence of technical inefficiency was applied to the model, with the following results: LR = - 2 [670.28 – 729.28] = 118.01. Nonetheless, the critical value of the Kodde and Palm table is 8.76, with 4 degrees of freedom and a 5% significance interval. Consequently, the value of the maximum-likelihood ratio exceeds the critical value of the Kodde and Palm (1986) table, thus indicating the presence of technical inefficiency in the model.

3. TFP and its components

Based on the results of the model estimation obtained above and the income distribution data (s_K and s_L), total factor productivity is broken down according to the model described in section IV. Table 3 shows the country averages of the decomposition throughout the period analysed (1962-2010).[1] The results shown in tables 3, 4, 5, 6, 7 and 8 are the average values for each country over 10-year time intervals.

The average economic growth rate in Latin America in the 50 years of the study was 4.2%, whereas the rate of change of TFP for the sample as a whole was -0.3% in that period (see table 3). The following tables present those rates separately for each country.

In general, the results agree with those obtained in the studies by de Fajnzylber, Loayza and Calderón (2002) on the growth of the Latin American economies and other countries. Tables 6 and 7 show that the economic growth rates of some countries in the 1990s were less than those recorded in the previous decade. A case in point is Colombia, which grew by 4.67% between 1981 and 1990, and by 4.55% in the following decade. Cárdenas (2007), who obtains similar results, also shows that the long-term economic growth rate in Colombia has fallen since 1980 owing to increasing levels of violence fuelled by an expansion in drug trafficking activities. Among other countries, the Bolivarian Republic of Venezuela recorded growth of 3.7% between 1980 and 1990, but only 3.6% in the following decade.

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[1] The breakdown was performed as from 1962 owing to the availability of data on the variation of technical inefficiency based on the translog model estimated using 1961-2010 data.

TABLE 3

TFP results: averages 1962-2010

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0360	0.0496	0.0161	0.0002	0.0021	-0.0013	0.0102	-0.0109	-0.0299
Bolivia (Plurinational State of)	0.0400	0.0600	0.0240	-0.0093	-0.0019	-0.0014	0.0087	-0.0147	-0.0347
Brazil	0.0550	0.0604	0.0301	0.0096	0.0044	-0.0004	0.0136	-0.0080	-0.0451
Chile	0.0427	0.0553	0.0230	-0.0011	0.0002	-0.0005	0.0116	-0.0124	-0.0346
Colombia	0.0503	0.0583	0.0309	0.0043	0.0027	-0.0014	0.0125	-0.0096	-0.0432
Costa Rica	0.0516	0.0648	0.0348	-0.0049	-0.0022	-0.0038	0.0151	-0.0140	-0.0431
Dominican Republic	0.0541	0.0838	0.0306	-0.0101	0.0010	-0.0010	0.0126	-0.0226	-0.0502
Ecuador	0.0392	0.0419	0.0288	0.0038	0.0044	-0.0028	0.0056	-0.0034	-0.0354
El Salvador	0.0355	0.0583	0.0233	-0.0101	0.0004	-0.0048	0.0095	-0.0152	-0.0360
Guatemala	0.0411	0.0579	0.0263	-0.0051	0.0007	-0.0041	0.0111	-0.0128	-0.0381
Honduras	0.0448	0.0644	0.0327	-0.0079	0.0006	-0.0062	0.0119	-0.0142	-0.0444
Jamaica	0.0229	0.0501	0.0131	-0.0177	-0.0035	-0.0062	0.0084	-0.0165	-0.0226
Mexico	0.0575	0.0607	0.0333	0.0081	0.0017	-0.0011	0.0160	-0.0085	-0.0446
Nicaragua	0.0409	0.0555	0.0344	-0.0077	-0.0005	-0.0098	0.0125	-0.0099	-0.0412
Paraguay	0.0459	0.0681	0.0291	-0.0071	0.0014	-0.0015	0.0103	-0.0174	-0.0442
Peru	0.0450	0.0416	0.0301	0.0086	0.0011	-0.0006	0.0121	-0.0040	-0.0352
Trinidad and Tobago	0.0327	0.0526	0.0162	-0.0137	-0.0066	-0.0005	0.0106	-0.0173	-0.0223
Uruguay	0.0231	0.0509	0.0078	-0.0145	-0.0018	-0.0005	0.0064	-0.0186	-0.0211
Venezuela (Bolivarian Republic of)	0.0522	0.0424	0.0352	0.0113	-0.0010	-0.0004	0.0155	-0.0028	-0.0367

Source: prepared by the authors.

TFP: total factor productivity.

TABLE 4

TFP decomposition: averages 1962-1970

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0802	0.1549	0.0143	-0.0438	-0.0183	-0.0006	0.0205	-0.0454	-0.0452
Bolivia (Plurinational State of)	0.0681	0.1785	0.0182	-0.0717	-0.0174	-0.0012	0.0132	-0.0663	-0.0569
Brazil	0.1014	0.1568	0.0328	-0.0263	-0.0143	-0.0008	0.0215	-0.0328	-0.0619
Chile	0.0641	0.1421	0.0137	-0.0529	-0.0198	-0.0005	0.0161	-0.0487	-0.0388
Colombia	0.0771	0.1477	0.0242	-0.0438	-0.0165	-0.0005	0.0162	-0.0431	-0.0509
Costa Rica	0.0718	0.1599	0.0327	-0.0647	-0.0212	-0.0012	0.0172	-0.0596	-0.0560
Dominican Republic	0.0939	0.2030	0.0417	-0.0695	-0.0169	-0.0007	0.0168	-0.0688	-0.0813
Ecuador	0.0723	0.1450	0.0259	-0.0506	-0.0195	-0.0014	0.0177	-0.0474	-0.0481
El Salvador	0.0812	0.1701	0.0364	-0.0609	-0.0188	-0.0013	0.0174	-0.0581	-0.0644
Guatemala	0.0764	0.1709	0.0256	-0.0619	-0.0182	-0.0012	0.0165	-0.0590	-0.0582
Honduras	0.0759	0.1909	0.0310	-0.0775	-0.0185	-0.0029	0.0155	-0.0717	-0.0685
Jamaica	0.0579	0.1626	0.0114	-0.0745	-0.0227	-0.0008	0.0159	-0.0669	-0.0416
Mexico	0.1066	0.1802	0.0299	-0.0385	-0.0175	-0.0005	0.0263	-0.0468	-0.0650
Nicaragua	0.0826	0.2100	0.0321	-0.0854	-0.0203	-0.0005	0.0183	-0.0830	-0.0741
Paraguay	0.0608	0.1528	0.0260	-0.0640	-0.0163	-0.0007	0.0098	-0.0567	-0.0540
Peru	0.0781	0.1452	0.0235	-0.0440	-0.0195	-0.0005	0.0200	-0.0441	-0.0466
Trinidad and Tobago	0.0427	0.1243	0.0110	-0.0672	-0.0252	-0.0005	0.0125	-0.0540	-0.0254
Uruguay	0.0436	0.1174	0.0083	-0.0561	-0.0205	-0.0007	0.0108	-0.0458	-0.0260
Venezuela (Bolivarian Republic of)	0.0853	0.1485	0.0304	-0.0430	-0.0212	-0.0004	0.0236	-0.0451	-0.0505

Source: prepared by the authors.

TFP: total factor productivity.

TABLE 5

TFP decomposition: averages 1971-1980

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0409	0.0608	0.0145	-0.0133	-0.0096	0.0001	0.0117	-0.0156	-0.0211
Bolivia (Plurinational State of)	0.0375	0.0495	0.0228	-0.0108	-0.0081	0.0001	0.0084	-0.0112	-0.0240
Brazil	0.0810	0.1003	0.0359	-0.0026	-0.0059	0.0000	0.0208	-0.0176	-0.0525
Chile	0.0334	0.0192	0.0260	0.0020	-0.0098	0.0002	0.0089	0.0026	-0.0139
Colombia	0.0521	0.0612	0.0302	-0.0056	-0.0074	0.0001	0.0127	-0.0110	-0.0336
Costa Rica	0.0667	0.0837	0.0410	-0.0144	-0.0124	-0.0007	0.0185	-0.0198	-0.0436
Dominican Republic	0.0681	0.1119	0.0345	-0.0255	-0.0088	-0.0001	0.0161	-0.0327	-0.0528
Ecuador	0.0211	0.0353	0.0273	-0.0111	0.0125	-0.0091	-0.0196	0.0051	-0.0304
El Salvador	0.0462	0.0699	0.0299	-0.0194	-0.0098	-0.0049	0.0126	-0.0174	-0.0341
Guatemala	0.0479	0.0762	0.0227	-0.0192	-0.0097	0.0003	0.0122	-0.0220	-0.0318
Honduras	0.0418	0.0678	0.0230	-0.0201	-0.0098	0.0000	0.0101	-0.0203	-0.0289
Jamaica	0.0367	0.0339	0.0299	-0.0096	-0.0138	-0.0074	0.0133	-0.0017	-0.0175
Mexico	0.0781	0.0671	0.0505	0.0084	-0.0084	0.0001	0.0219	-0.0052	-0.0479
Nicaragua	0.0455	0.0459	0.0368	-0.0086	-0.0114	-0.0066	0.0135	-0.0042	-0.0286
Paraguay	0.0619	0.1194	0.0301	-0.0343	-0.0081	0.0006	0.0131	-0.0399	-0.0533
Peru	0.0402	0.0248	0.0312	0.0036	-0.0096	-0.0002	0.0111	0.0023	-0.0194
Trinidad and Tobago	0.0636	0.1078	0.0299	-0.0334	-0.0165	-0.0001	0.0207	-0.0375	-0.0406
Uruguay	0.0256	0.0734	0.0035	-0.0347	-0.0114	0.0002	0.0070	-0.0305	-0.0165
Venezuela (Bolivarian Republic of)	0.0745	0.0644	0.0469	0.0040	-0.0121	0.0001	0.0228	-0.0067	-0.0409

Source: prepared by the authors.

TFP: total factor productivity.

TABLE 6

TFP decomposition: averages 1981-1990

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0059	0.0046	0.0180	-0.0021	0.0013	-0.0139	0.0058	0.0047	-0.0147
Bolivia (Plurinational State of)	0.0220	-0.0005	0.0246	0.0168	0.0031	-0.0026	0.0056	0.0108	-0.0189
Brazil	0.0325	0.0222	0.0311	0.0117	0.0046	-0.0058	0.0105	0.0025	-0.0325
Chile	0.0333	0.0128	0.0290	0.0164	0.0017	-0.0007	0.0090	0.0064	-0.0251
Colombia	0.0467	0.0319	0.0369	0.0164	0.0033	-0.0010	0.0123	0.0018	-0.0384
Costa Rica	0.0363	0.0214	0.0369	0.0079	-0.0016	-0.0113	0.0136	0.0072	-0.0299
Dominican Republic	0.0401	0.0327	0.0317	0.0092	0.0015	-0.0028	0.0111	-0.0004	-0.0335
Ecuador	0.0355	0.0140	0.0312	0.0155	0.0000	-0.0024	0.0109	0.0070	-0.0252
El Salvador	0.0121	0.0046	0.0166	0.0045	0.0011	-0.0068	0.0048	0.0053	-0.0135
Guatemala	0.0280	0.0074	0.0298	0.0139	0.0011	-0.0055	0.0089	0.0094	-0.0231
Honduras	0.0395	0.0116	0.0386	0.0196	0.0011	-0.0048	0.0110	0.0122	-0.0303
Jamaica	0.0178	0.0152	0.0104	0.0019	-0.0024	0.0017	0.0048	-0.0023	-0.0097
Mexico	0.0217	0.0206	0.0136	0.0055	0.0019	-0.0009	0.0067	-0.0022	-0.0180
Nicaragua	0.0033	0.0204	0.0339	-0.0220	-0.0003	-0.0394	0.0113	0.0063	-0.0289
Paraguay	0.0501	0.0541	0.0348	0.0041	0.0013	-0.0014	0.0129	-0.0086	-0.0428
Peru	0.0239	0.0042	0.0318	0.0119	0.0019	-0.0094	0.0091	0.0103	-0.0241
Trinidad and Tobago	-0.0017	0.0196	0.0093	-0.0244	-0.0067	-0.0186	0.0058	-0.0049	-0.0062
Uruguay	0.0110	0.0121	0.0082	-0.0010	-0.0012	-0.0017	0.0037	-0.0017	-0.0083
Venezuela (Bolivarian Republic of)	0.0379	-0.0056	0.0401	0.0268	-0.0007	-0.0023	0.0124	0.0174	-0.0234

Source: prepared by the authors.

TFP: total factor productivity.

TABLE 7

TFP decomposition: averages 1991-2000

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0327	0.0128	0.0144	0.0322	0.0129	0.0131	0.0057	0.0006	-0.0267
Bolivia (Plurinational State of)	0.0323	0.0124	0.0305	0.0285	0.0149	-0.0018	0.0075	0.0079	-0.0391
Brazil	0.0344	0.0124	0.0292	0.0322	0.0161	0.0028	0.0086	0.0047	-0.0395
Chile	0.0372	0.0532	0.0184	0.0087	0.0125	0.0001	0.0102	-0.0140	-0.0431
Colombia	0.0455	0.0263	0.0406	0.0287	0.0145	-0.0039	0.0130	0.0051	-0.0501
Costa Rica	0.0460	0.0235	0.0335	0.0287	0.0097	0.0015	0.0129	0.0046	-0.0397
Dominican Republic	0.0357	0.0407	0.0218	0.0140	0.0124	0.0004	0.0093	-0.0082	-0.0408
Ecuador	0.0327	-0.0001	0.0338	0.0328	0.0118	-0.0030	0.0100	0.0139	-0.0337
El Salvador	0.0316	0.0255	0.0188	0.0209	0.0125	0.0047	0.0068	-0.0031	-0.0336
Guatemala	0.0247	0.0166	0.0217	0.0190	0.0127	-0.0031	0.0073	0.0021	-0.0326
Honduras	0.0418	0.0336	0.0441	0.0170	0.0125	-0.0145	0.0142	0.0048	-0.0530
Jamaica	0.0065	0.0259	0.0069	-0.0043	0.0085	-0.0084	0.0045	-0.0089	-0.0220
Mexico	0.0562	0.0194	0.0503	0.0398	0.0138	-0.0003	0.0165	0.0098	-0.0533
Nicaragua	0.0515	-0.0018	0.0397	0.0507	0.0119	0.0084	0.0111	0.0194	-0.0371
Paraguay	0.0297	0.0181	0.0267	0.0210	0.0123	-0.0039	0.0086	0.0039	-0.0360
Peru	0.0480	0.0101	0.0376	0.0421	0.0138	0.0071	0.0109	0.0103	-0.0418
Trinidad and Tobago	0.0331	-0.0066	0.0188	0.0360	0.0052	0.0107	0.0075	0.0126	-0.0150
Uruguay	0.0205	0.0300	0.0104	0.0072	0.0099	0.0008	0.0057	-0.0091	-0.0271
Venezuela (Bolivarian Republic of)	0.0369	-0.0047	0.0361	0.0388	0.0116	0.0010	0.0107	0.0156	-0.0334

Source: prepared by the authors.

TFP: total factor productivity.

TABLE 8

TFP decomposition: averages 2001-2010

Country	Economic growth	Capital accumulation	Expansion of labour force	Change in TFP	Technical progress	Technical efficiency	Scale economies	Distributive gains	Random disturbances
Argentina	0.0201	0.0150	0.0192	0.0279	0.0243	-0.0050	0.0072	0.0014	-0.0420
Bolivia (Plurinational State of)	0.0254	0.0063	0.0281	0.0380	0.0265	-0.0047	0.0065	0.0096	-0.0471
Brazil	0.0257	0.0101	0.0217	0.0328	0.0213	0.0017	0.0065	0.0033	-0.0390
Chile	0.0455	0.0492	0.0279	0.0204	0.0166	-0.0015	0.0138	-0.0085	-0.0520
Colombia	0.0300	0.0246	0.0229	0.0257	0.0196	-0.0019	0.0085	-0.0006	-0.0431
Costa Rica	0.0370	0.0354	0.0300	0.0179	0.0145	-0.0073	0.0131	-0.0024	-0.0464
Dominican Republic	0.0326	0.0306	0.0233	0.0213	0.0168	-0.0019	0.0096	-0.0031	-0.0426
Ecuador	0.0342	0.0152	0.0261	0.0326	0.0174	0.0017	0.0091	0.0044	-0.0396
El Salvador	0.0062	0.0212	0.0150	0.0043	0.0171	-0.0157	0.0058	-0.0028	-0.0343
Guatemala	0.0282	0.0184	0.0317	0.0228	0.0177	-0.0108	0.0104	0.0055	-0.0448
Honduras	0.0250	0.0179	0.0268	0.0214	0.0175	-0.0087	0.0088	0.0039	-0.0412
Jamaica	-0.0045	0.0127	0.0070	-0.0019	0.0132	-0.0160	0.0036	-0.0027	-0.0222
Mexico	0.0248	0.0164	0.0220	0.0252	0.0187	-0.0038	0.0085	0.0017	-0.0387
Nicaragua	0.0216	0.0030	0.0293	0.0268	0.0174	-0.0110	0.0082	0.0121	-0.0375
Paraguay	0.0268	-0.0041	0.0281	0.0375	0.0179	-0.0020	0.0073	0.0144	-0.0347
Peru	0.0347	0.0235	0.0262	0.0293	0.0191	-0.0002	0.0094	0.0011	-0.0443
Trinidad and Tobago	0.0258	0.0178	0.0122	0.0202	0.0103	0.0061	0.0066	-0.0028	-0.0244
Uruguay	0.0147	0.0218	0.0085	0.0120	0.0145	-0.0010	0.0046	-0.0061	-0.0277
Venezuela (Bolivarian Republic of)	0.0266	0.0094	0.0226	0.0298	0.0172	-0.0004	0.0079	0.0050	-0.0352

Source: prepared by the authors.

TFP: total factor productivity.

Table 3 also shows that the countries that recorded a larger contribution of technical progress to productivity growth in the 50-year period analysed were Argentina, Brazil, Colombia and Ecuador, with indices of around 0.3%. Brazil displayed an average index of 0.4%, as well as the highest indices in the last three decades (see tables 6, 7 and 8). These results coincide with those reported by Pires and Garcia (2004), which also identified low rates of technical progress in Brazil between 1970 and 2000, because the authors take account of the fact that this country was not a member of the Organisation for Economic Co-operation and Development (OECD), and that the markets of the Bolivarian Republic of Venezuela, Mexico and Peru underwent a process of import substitution related to episodes of economic liberalization, during which the industrialization process slowed down.

As shown in table 3, the 19 countries analysed in this study recorded decreasing technical efficiency, which assumes that the contribution of that efficiency to TFP was negative in all countries. Nonetheless, there was some technical progress in most cases, and output increased in all of them. It is well known that technical efficiency is determined by the distance from the technological frontier and effective use of technologies, so these results suggest that the expansion of the frontier was more intense and faster than the dissemination of new technologies. In other words, some of the countries analysed did not fully keep pace with the technological developments that occurred in the period analysed, possibly owing to problems in the process of diffusion and adoption of more modern technologies.

In a general analysis of the decomposition of TFP, table 8 shows that most of the countries display positive allocative gains, including Brazil. Those results reflect improvements in resource allocation among the factors of production used in those countries.

These results agree with those reported by Pires and Garcia (2004), whose estimations show that Costa Rica and Trinidad and Tobago displayed the largest distributive gains, represented by indices of 4.2% and 13.5%, respectively. Those two countries were also the leaders in the sample in terms of technical progress during the period studied.

Tables 4 and 5 show that Brazil suffered allocative efficiency losses in the first two decades analysed, which are the clear result of a growth strategy that did not take account of the adjustment. It can also be seen that both output and physical capital grew more strongly in the 1970s than in other decades. Those findings agree with those obtained by Pires and Garcia (2004), who argue that in the 1970s there was an intensive process of resource allocation in the economy, which led to a considerable investment in infrastructure in Brazil.

The analysis of the data presented in tables 4 and 5 shows that the indices of economic growth in Brazil were higher in the first two decades before dropping to around 3% between 1980 and 2000. This is explained by a slackening of growth in the country owing to the exhaustion of the industrialization-via-import-substitution model.

In the five decades examined separately, only Trinidad and Tobago posted negative growth in the decade 1981-1990. In general, the pattern of economic growth in the countries is similar, and, as shown in table 6, the average does not exceed 6% in the period studied. The cases of Brazil, Colombia and Paraguay stand out as those with the highest indices of economic growth, averaging 4.3%. The countries with the lowest average growth indices were Argentina and Uruguay, with just 0.59% and 1.10%, respectively.

As can be seen in table 4, all of the Latin American countries analysed displayed negative indices of TFP variation in the first period studied (1962-1970). This situation changed in the subsequent decades, when some countries displayed positive indices. Table 7 and 8 show that all countries except the Jamaica achieved positive indices of TFP growth in the decades of 1990 and 2000. The average growth rate of Brazilian productivity throughout the period analysed were 0.9% per year (see table 3).

Table 8 shows that in the analysis of the decade of 2000, there was positive economic growth (averaging 2.5%) in all countries except Jamaica, where output declined by about 0.04%, with Chile growing by an average of 4.5%. Technical progress and economies of scale were positive in all countries; but, while some recorded positive indices with respect to distributive gains, such as Brazil, the equivalent indices were negative in others, such as Uruguay.

VI

Final thoughts

The analysis of TFP and its components in Latin America in the period 1960-2010, using a stochastic-frontier model which includes macroeconomic variables of technical inefficiency, shows that those variables generally have a significant effect that enables better understanding of technical inefficiency throughout the region.

The significance of the effects is found both through likelihood tests and through the parameter γ, of value 0.51, in the model estimation.

The most important variables for explaining the technical inefficiency of the sample countries, in other words those that display a positive relation to inefficiency, are public expenditure and the inflation rate: the higher these rates are, the more they are associated with technical inefficiency.

In contrast, the variable corresponding to the deviation of local prices from purchasing power parity (used as a proxy variable for the exchange rate) displays an inverse relation with respect to technical inefficiency: the larger deviation of this relative price, the less is technical inefficiency.

Although relatively low throughout the period studied, the average rate of economic growth of the countries studied was positive. Brazil is one of the leading countries in this respect, with a growth rate of 5.5%. The analysis of the 1960s and 1970s shows that the average Brazilian growth rates were around 7%, which possibly coincides with the adoption of the import substitution industrialization model in the countries of the region.

Costa Rica, the Dominican Republic, Ecuador, Guatemala, Mexico and Paraguay recorded similar average GDP growth rates of 5.1%; 4.0%; 4.1%; 5.7%; 4.5%, and 5.4%, respectively. The worst performer in the period was Uruguay, where the average growth rate was just 2.3%.

The results of the decomposition of the change in TFP into technical progress, technical efficiency, economies of scale and distributive gains vary between the countries analysed. Although there is unanimity with respect to technical progress (the average was positive in most of the countries throughout the period analysed), the results in terms of the other components are different.

Lastly, it is worth stressing that the great advantage of this TFP decomposition model compared to that known as the Malmquist index is the possibility of incorporating scale and allocative effects in the analysis of the results.

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