Differences in Long Run Growth Path Between Latin American and Developed Countries: Empirical Evidences

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Abstract

Comparing the long run growth paths between regions of Latin American countries and developed countries is the main focus of this paper. Exogenous and endogenous growth models provide the theoretical background. Simulations of growth rates for developing and selected developed countries are made based upon explanatory variables, using the US as the benchmark. Data for the period 1950-1992 were applied to suitable econometric models – polynomial distributed lag, simultaneous equations – where estimates showed with confidence and accuracy that: 1) In all economies, simulations have proved that human capital and, consequently, technological improvement in the economy as an engine of growth are the responsible factors for generating increasing returns to scale to accelerate the rate of growth; 2) Brazilian growth is the most sensitive to technological change, compared to other regions of Latin American Countries; 3) There is no unique growth policy for the developing economies, but improvement of productivity is common to all of them although at different rates; 4) Political and institutional factors seem to play an important role to explain the growth gap between developed and developing countries.

Key words: Economic Growth, Latin American and Developed Countries, Forecasting.
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1. Introduction

Economic growth has been one of the main concerns among economists. There are two major conceptual approaches to explain the process of sustainable growth. The first is the exogenous growth approach, based on Ramsey (1928) – refined by Cass (1965) and Koopmans (1965) - and Solow (1956), and the second is the endogenous growth approach, based primarily on Romer (1986) and, in another dimension, Lucas (1988).

Early studies built models accounting for growth where product, capital and consumption levels achieve a stationary state at exogenous rates of population growth and technical progress. The endogenous approach suggests that the contribution of capital to growth is undervalued in the traditional model of Solow, since there exist external factors in the use of capital. The basic idea is that capital investments, either in machines or labor, creates positive externalities, so that, investment increases not only the productive capacity of the investing firm and its workers, but also the productive capacity of other firms and workers. This is the starting point for the foundation of the endogenous growth theory on increasing returns. Unlike the traditional theory, human capital, technology, and government spending help explain long run economic growth.

The endogenous growth models are currently a theoretical reference for the formulation of macroeconomic policies, and they have been used worldwide by policy makers in the social, economic and political realms to promote growth. As much research points out, government expenditures bring positive externalities in the private investments. Endogenous growth models view government expenditures not as generating growth through a Keynesian demand shift, rather, they are used to stimulate supply.

In effect, a study that compares the endogenous versus exogenous growth models, demonstrating their viabilities and possible limitations, may be considered of extreme relevance for the formation of strategies of sustainable economic growth, while providing to policy makers theoretical and empirical underpinnings to the comprehension of new policies that aid to guide a optimal choice of the public resources.

This paper focuses on investigating the formulations of endogenous and exogenous growth models, starting with an empirical test in order to compare them. The factors that cause growth in Latin American countries will be compared to those of the most developed countries. Based upon this theoretical framework, empirical tests to forecast and simulate the per capita product growth process in the analyzed economies will be carried out.

2. THEORETICAL BACKGROUND

The neoclassical growth paradigm was accepted widely in economic thought until the mid-eighties. Since then the field has become a research area with extreme activity both in theoretical and empirical grounds, where several conceptual methodological alternatives have been implemented by new models of economic growth. In order to appreciate the recent theoretical developments and to understand the associated controversies, it is necessary to say a few words on the foundations of this evolution. This section brings a brief review of the hypotheses and basic conclusions of the traditional neoclassical models. These are then compared to the innovations in the endogenous growth models, and the rationale for scale effects in growth is established.

2.1. Endogenous versus Exogenous Growth Models

Traditional neoclassical theoretical models emphasize capital accumulation as the engine of economic growth. Based upon the works of Solow (1956) and Swan (1956), their theories use a production function that aims to satisfy the condition of flexible proportions in the use of the inputs to ensure that the private saving is equalized to the ex-post investment, thus eliminating Keynesian unemployment. Consequently, a stable equilibrium is attained in these models. The specification of the production function of the exogenous models in the simplest case is given by,

$$Y = F\left(K, L\right) \tag{1}$$

where Y is product, K is stock of physical capital, and L is labor. The fundamental assumptions of the model are constant returns to scale and decreasing returns to all inputs.

Since investment equals saving ex-post, and saving is a constant fraction of product, the stock of physical capital will be,

$$\dot{K} = I - \delta K = s \cdot F\left(K, L\right) - \delta K \tag{2}$$

where δ is the depreciation rate of the stock of physical capital.

If all variables are measured in per capita values, then, after a slight rearrangement, equation (2) becomes:

(3) $$\dot{k} = s \cdot f(k) - (n+\delta) \cdot k$$

where k is the stock of per capita capital, $f(k)$ is the intensive form of (1) and n is the population growth rate.

The model summarizes that at the steady state $\dot{k} = 0$, therefore, per capita product, y, will be constant as a consequence of $y = f(k)$. Besides, the per capita variables, k and y, are constants because K and Y increase at the same rate as population growth. Since technical progress is given as exogenous, the key variables of the model, K and Y, increase at a rate $x+n$, where x is the growth of technical progress.

Thus, as a practical result, the traditional neoclassical model concludes that the marginal propensity to save only determines the capital-labor ratio and the speed of adjustment of the economy toward the steady state, which is determined exogenously by the rates of technological progress and population growth.

By considering the traditional formulations of Solow's model not sufficiently robust, Romer (1986), and in a different approach Lucas (1988), used an idea originally developed by Arrow (1962) and Sheshinski (1967), to build models of economic growth, and to introduce an endogeneity proposition to achieve the long run steady state. The principal argument used by them is that the stock of physical capital must be interpreted as an index of accumulated knowledge and an experience of the type learning by doing, so as to generate externalities which promote increasing returns or spillovers.

Romer's starting point is the formulation of a homogeneous concave production function given by,

(4) $$Y_i = F(c_i, C, x_i)$$

where Y_i and c_i are product and level of knowledge respectively of firm i, C is the aggregated stock of knowledge of the economy, and x_i is a vector of all other inputs, such as physical capital and labor. It is implicit in this function that an increase in the stock of knowledge of the firm generates a positive effect on aggregate knowledge, which, in its turn, raises the product of other firms, and therefore the product of the economy grows. Thus, the essence of the model hypothesis relies on the existence of increasing returns to scale in the production function and increasing marginal returns of knowledge.

Romer (1986) demonstrates mathematically the occurrence of a fixed point that supports a situation of competitive equilibrium under those hypotheses. He develops a simple relationship of dependence of the product level on the existent relationship between knowledge and price of the knowledge, where the competitive equilibrium differs from the optimum situation, which indicates the need of government intervention so that aggregated knowledge matches with the optimal social level. A consequence of extreme relevance that stems from this is the possibility of occurrence of different levels of growth among different economies in the long run.

2.2. Scale Effects versus Technological Adoption Models

Different theoretical interpretations of models of endogenous growth have divergent policy implications. The debate on which of these interpretations provides the best alternative is crucial to the determination of the state of the art of economic growth theory. This section provides a brief discussion of the main points of two basic theoretical interpretations: models with scale effects and models with technology adoption.

Models with scale effects started with Arrow (1962), where the engine of growth appears in the form of the process of learning by doing in the production of capital goods. In this process, learning is purely external to the productive sphere and productivity depends on the aggregate level of capital goods, where invention costs or costs of technological adoption are not considered. In that context, an investment promotes external effects besides its initial purpose. The externality is not appropriated by any individual agent; rather it elevates substantially the productive capacity of the economy and contributes to economies of scale.

Since then, several authors, like Romer (1990), Jones (1995a), Aghion and Howitt (1992, 1995) and Grossman and Helpman (1991), have formulated such models by inserting the research sector (R&D), in such a way to consider invention cost. So, a component to accelerate the economic growth became represented by the number of researchers and new research, instead of the population it self. At the same time, cost of technological adoption remains null.

In the formulations of models that adopt R&D, the essential idea on the scale effects can be established in the following equations that describe a production function and the knowledge generation (accumulation of ideas), that is,

(5) $$Y = A\left(P L_Y\right)^{\alpha} K^{1-\alpha}$$

(6) $$\dot{P} = \overline{\delta}\, L_P$$

where, Y is product; K is capital; P is knowledge; L_Y is manpower used in production; L_P is manpower used in the development of research; $\overline{\delta}$ is an average rate of knowledge production.

The equation (6) characterizes R&D in models of endogenous growth. There are several hypotheses on the average rate of arising new ideas ($\overline{\delta}$) related to the scale effects of knowledge, whose generic specification is given by $\overline{\delta} = \delta P^{\phi}$, where positive, negative or null values denote that the rate of innovation of ideas presents increasing, decreasing or null external returns, respectively, with the knowledge stock. Furthermore, due to the duplication and redundancy in research generation, manpower in research should be realistically expressed by L_P^{λ}, $0 < \lambda \leq 1$, instead of simply L_P. Thus, incorporating those changes in the equation (6), the fundamental equation of R&D is derived:

(7) $$\dot{P} = \delta\, L_P^{\lambda}\, P^{\phi}$$

This equation differs from the models originally formulated due to the arbitrarily in taking $\phi = 1$. Romer (1990), for example, argues that the existence of increasing ($\phi > 1$) or decreasing returns ($\phi < 1$) in R&D is to some extent a philosophical matter. In view of that, it is chosen to follow the plausible idea of Jones (1995b), who imposed the restriction $\phi < 1$, to allow for a balanced growth path. Along this trajectory the growth rate of knowledge is, by definition, constant, since the acceptable hypothesis that L_P^{λ} and $P^{1-\phi}$ grow at the same rate, as can be seen from equation (7), or from equation (8) below, which is derived straightforwardly.

(8) $$\frac{\dot{P}}{P} = \delta \frac{L_P^{\lambda}}{P^{1-\phi}}$$

By differentiating both sides of equation (8), and using the hypothesis above mentioned, it is deduced that the growth rate of the balanced trajectory of the knowledge is given by,

(9) $$g_P = \frac{\lambda\ n}{1-\phi}$$

where n is the growth rate of the labor force. It is worth noting, that the balanced growth rate is very consistent, since it grows with the labor force and with the increase of the scale returns in R&D. That result clearly addresses scale effects in agreement with the dynamics of the research activity.

However, it remains a pertinent question on how large would be the scale effect in the model based on research. Taking this question into consideration several studies like the one of Radner and Van Zandt (1992), minimize the scale effects by assuming the relative effects of the costs of adopting new technologies. In this reasoning it is found the models of technology adoption due mainly to Stokey (1991), Lucas (1993), Parente (1994), and Young (1993), to explain the difference in the rates of productivity growth among areas based on the level of worker's knowledge.

In the microeconomic model of Parente (1994), expanded from Lucas (1993), let $b(t)$ be the index of average technological grade and $h(t)$ be the level of technological capacity in the interval (0,1). Then it is implied that the knowledge level is $s(t) = s[b(t), h(t)]$. The product of the firm is measured by $b(t)h(t)$. If $a(t)$ is the size of the technological innovation of the firm, then,

(10) $$b(t+dt) = a(t)\,b(t)$$

If $a(t)=1$, there are no innovation, even so the worker maintains training and a certain level of human capital, whereas, if $a(t)>1$ there is a loss of training from the technological upgrade of the firm. The variations in technological capacity can be summarized by,

(11) $$h(t+dt) = \begin{cases} h(t) + \{\lambda\,[1-h]\}\,dt & \text{if } a(t)=1 \\ h(t) - [\kappa + \delta\, a(t)] & \text{if } a(t)>1 \end{cases}$$

where $\lambda > 0$ represents the speed of learning a given technological grade b, $\kappa > 0$ and δ are the fixed cost of incorporing technological progress and the variable cost in the dimension of technological progress, respectively. So the relationship between the next innovation and the human capital required for such innovation is clear. The basic conclusion of such a model is that the choice for technological adoption can produce significant growth rates.

The inclusion of technology adoption cost is important to explain different growth levels reached by nations. While the models with scale effects imply a given productivity convergence while assuming that technology adoption cost is equal to zero, the models of technological adoption insert a crucial point by considering that the costs of technological adoption are different among economies at different periods of time. Therefore, there is no unique recipe for economic growth, insofar as different countries, or even a given country at different periods of time, have distinct technology adoption costs and different needs for the decrease of such costs. It is worthwhile to point out that most evidence favors the models with technology adoption. Jovanovic (1995), for example, states that the expenses in technology adoption in the United States are on the order of 20 to 30 times higher than the expenses in invention, while, in the developing countries that proportion tends to assume much higher values. Therefore, it seems clear that differences in institutional organization, education, infrastructure and financial markets, for instance, alter the costs of technological adoption directly, and so play an essential role for the formation of differences in productivity levels among nations, and consequently, economic growth.

Lucas (1993) identifies the accumulation of human capital as the main engine for economic growth, since it tends to decrease the training cost considerably for a new technology. He reaches a parallel result to his own original model (1988), although in a different framework, by relating human capital and growth in a two way direction relationship between human and physical capital, what is denominated the imbalance effect by Barro and Sala-i-Martin (1995). Benhabib and Spiegel (1994) and Lau et al. (1993), for instance, demonstrate empirically the positive relationship between human capital and growth for countries and regions, respectively.

Endogenous growth calls for different approaches to modeling. Barro (1990) notes the influence that different fiscal policies can promote in the long run growth, where government size can affect growth in a positive or negative way, depending basically on the magnitude of the tax burden and the efficiency of the public expenditures. Aschauer (1989) analyses several types of public expenses to find those that promote positive effects on income, finding that an increase in expenditure on infrastructure decreases production costs causing positive externalities on the productivity and, consequently on the output level. Such a relationship is considerably strengthened by the empirical evidence given by Munnel (1992), Easterly and Rebelo (1993) and Hall and Jones (1998), among others.

Regarding the importance of the degree of economic openness on the level of economic growth, Rivera-Batiz and Romer (1991), Sachs and Warner (1995), Grossman and Helpman (1990) and Edwards (1993) affirm the relevance of such a connection, arguing that mobility of ideas, the specialization through comparative advantage in production, and technological catch-up are the crucial factors. A concluding remark points to the elevation of the technological level in those economies with larger degree of economic openness and, consequently, higher rates of economic growth.

Another important source of influence in the endogeneity of growth is provided by Alesina and Rodrik (1994), Deininger and Squire (1995), Benabou (1996), and Barro (1999) where they relate the path of economic growth due to alterations in the level of distribution of income. A roughly equal distribution of income, together with a democratic system where a "natural political competition" prevails, would tend to favor the majority by taxing capital, resulting in a deceleration of economic growth. In agreement with the Kuznets' curve, that effect would tend to not happen in wealthier economies even if the income is not very evenly distributed. The importance of a developed financial sector is also treated by Greenwood and Jovanovic (1990), King and Levine (1993) and Levine (1997) as a stimulating factor for economic growth, following a traditional Schumpeterian analysis, as a developed financial market broadens the existent technological base.

Four basic differences between the endogenous and exogenous growth models, based upon micro foundations, can be summarized:

i. Traditional models emphasize physical capital as the engine of economic growth, while the endogenous models emphasize technological change and the stock of human capital as the main factors for growth, both being taken as measurement of aggregate knowledge;
ii. Exogenous growth models, unlike the endogenous models, do not take into consideration the possibility of any alteration in the cost of the process of knowledge diffusion as the technological parameters of the economy are changed;

iii. Endogenous growth models allow a better understanding of the dynamics of the effects of economic planning on different growth rates, as long as international trade, fiscal policy, educational formation, income distribution, stock of infrastructure, institutional quality, and incentives to technological progress, constitute externalities generated to the productive process, that is, spillovers;

iv. Endogenous growth models allow the possibility of theoretical divergence in the levels of income for different economies, insofar as models such as Lucas' (1988) conclude that the normal tendency is the perpetuation of differences of growth rates among nations, resulting in a continued gap between developed and developing economies.

Based on this theoretical discussion, three questions will be approached by the empirical analysis:

- To what extent do scale effects and costs of technological adoption explain the difference in income among countries or regions?
- Does the economic growth of developing economies present the same dependence on the factors considered for the developed economies?
- What policies should be adopted to aim an increase in the economic growth rate of developing countries – Latin American countries for example?

3. METHODOLOGY

The academic world has recently exhibited a return of interest to models of economic growth. This renewed interest has accompanied the spread of endogenous growth models, which are distinguished from traditional models, such as those of Ramsey and Solow, fundamentally by the fact that technical progress is determined endogenously, rather than being an exogenous factor. While in traditional models the existing conditions and stability of growth trajectories are only certain for given individual preferences and technology, the endogenous growth models theory relies on the fact that economic externalities promote the dynamics of the process of economic growth. In other words, models of endogenous growth formulate that variations in education, fiscal policy and market openness, distribution of income, and development of the financial sector provoke permanent effects on the per capita product.

Since models of endogenous growth predict that the behavior of externalities in the economy leads to continuous effects on per capita product, while models of exogenous growth predict that such variables are not capable of permanently influencing per capita product, a test of these two classes of models can be performed by examining the permanent effects of externalities on growth.

The hypothesis test will be then for the existence of feedback from temporary changes in the identified variables and level of long-term growth. To do so, the use of lagged variables is required to measure the dynamic effect on the per capita product. If it is assumed that the effect of a change is perpetual, although decreasing in the future, a infinite lag model is called for to test such a trend. The model, in a simple form, is given by,

(12) $$Y_t = \sum_{i=0}^{\infty} \beta_i X_{t-i} + \varepsilon_t$$

where Y is per capita product; X is an explanatory variable.

There are several assumptions that can be used to reduce the infinite parameters in equation (12) to a finite number, where the most common are the models of adaptive expectation or partial adjustment, such that the effect of the variable decreases geometrically with the following basic hypothesis, $\beta_i = \alpha \lambda^i$, $0 < \lambda < 1$. By substituting this hypothesis into (12), and using the geometric infinite summation, it comes to[1],

(13) $$Y_t = \alpha + \beta X_t + \gamma t + \lambda Y_{t-1} + \varepsilon_t^* \qquad \varepsilon_t^* = \varepsilon_t - \lambda \varepsilon_{t-1}$$

On the other hand, there are other polynomial lag models when the effect of variation of one variable on the dependent variable occurs only temporally in a finite horizon of time. In this case, econometric theory approaches several specifications and hypotheses, from where it is chosen a polynomial distributed lag model specified by,

(14) $$Y_t = \delta + \sum_{i=1}^{n} \phi\, w_i\, X_{t-i} + \varepsilon_t$$

and considering Almon´s polynomial equation,

(15) $$w_i = \sum_{j=0}^{k} c_j\, i^j$$

Where Y is the per capita product, X is the explanatory variable, n is the maximum lag k is the polynomial degree. Substituting (15) into (14) yields,

(16) $$Y_t = \delta + \sum_{i=1}^{n} (\phi \sum_{j=0}^{k} c_j\, i^j) X_{t-i} + \varepsilon_t$$

[1] The introduction of variable t in model (13) is justified to capture any exogenous movements on the per capita product growth.

Model (16) is then estimated by OLS for each one of the explanatory variable in each considered region, and the estimates of the parameters in model (14) are obtained. If $\sum_{i=1}^{n} \phi w_i$ of model (14) is statistically significant, then it can be concluded that the corresponding explanatory variable produces a cumulative effect on per capita product, supporting thereby the endogenous growth model. It is worth noting that there must be a distinct dynamic effect of each variable on per capita product in each region due to particular characteristic of several factors and the growth rate among the variables. The explanatory variables chosen to meet the theoretical foundation are: technological progress (A), per capita physical capital (K), size of government (G), economic openness (OPEN), financial market (F), transportation infrastructure (TRANSP), electricity/communication infrastructure (ELETEL), income inequality (GINI).

The second model aims to evaluate the impacts of the explanatory variables on the economic growth of each country/region in panel data, so that, given the endogenous characteristics of the variables per capita product growth rate, physical capital, human capital (H) and technology, the structural simultaneous equations model is built as,

$$\begin{aligned} \text{GDPC} &= f_p(\text{A}, \text{K}, \text{H}, \text{G}) \\ \text{A} &= f_a(\text{K}, \text{G}, \text{OPEN}, \text{F}) \\ \text{K} &= f_k(\text{TRANSP}, \text{ELETEL}, \text{GINI}, \text{H}) \\ \text{H} &= f_h(\text{K}, \text{TRANSP}, \text{GINI}) \end{aligned} \tag{17}$$

The key-endogenous variable of that model, GDPC, follows the theoretical arguments of Barro (1990). The technological component, assuming endogenous behavior in the model, is determined by the levels of economic openness, the development of the financial sector, as well as the stock of physical capital and the government's size, since it is expected that more capital intensive economies have larger technological levels, and a great deal of technological research is dependent on government influence. The stock of physical capital varies with the infrastructure stock, distribution of income and human capital, whose relationship is referred to the imbalance effect, which also contains an important element in the fourth equation, where human capital is dependent on the stock of physical capital, the distribution of income and transportation infrastructure, while the latter is inserted here as a proxy for the conglomeration conditions given by Lucas (1999) and Henderson (2000).

The methodology of panel data was used because of the heterogeneity of the rates of economic growth among countries. Several works have converged to a methodological consent about the use of this procedure, among which stand out Benhabib and Spiegel (1997), Canova and Marcet (1995), Caselli et. al. (1996), Evans (1998), Islam (1995), Lee et. al. (1997) and Nerlove (1996). Durlauf and Quah (1998, p.47) point out that the estimates in panel data reduce the "individual effects" that represent obstacles to a clearer statistical interpretation. It can also be argued that any bias contained in the regression tends to be reduced as the time series increases. Nevertheless, regressions in panel data call for an inevitable question regarding a distinction between fixed and random effects models. Although Mundlak (1978) argues that cross-sectional effects should always be treated as random, a Hausman test is to be performed to guide the estimation procedure to avoid inconsistency or inefficiency due to omitted variables from the fixed effects.

The sample data covered the following countries: 1) Developed countries (United States, Canada, Japan, France, Germany, Italy and United Kingdom). 2) Central America (Barbados, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, Panama, Puerto Rico, Trinidad Tobago). 3) Group A, includes countries that possess largest GDP in Latin America, except Brazil (Argentina, Mexico, Chile, Colombia, Venezuela). 4) Group B (Bolivia, Ecuador, Guyana, Paraguay, Peru, Uruguay). 5) Brazil. Annual data for the period 1950-1992, where per capita GDP, the government's size (total expenditure/GDP) and economic openness ((Exports+Imports)/GDP) are from Penn World Table 5.6a., human capital (average of years of education of the population over 25 years of age) are from Barro and Lee (1993), per capita physical capital is from King and Levine (1994), financial market (total of supplied credit) is from IMF, infrastructure data are from Canning (1998), and distribution of income (Gini coefficient) is from Deininger and Squire (1996). After testing several hypotheses it was verified that the ratio product/human capital is the better proxy found to represent the technological basis of the economies. The missing values of human capital and distribution of income were estimated by polynomial interpolation.

4. Empirical Analysis

The parameters of models (13) and (16) were estimated. For the latter the best fit is obtained through the polynomial of third three, checking with the simulations done by Amemiya and Morimune (1974, p.383). For the finite lag models each variable was lagged up to twenty years, at five year intervals. The results, expressed in elasticities, are in Tables 1-5.

The results should be interpreted as the systematic time effects corresponding to the extension of the lag of each variable on per capita GDP. For instance, annual increments of 1% in the physical capital in the short term of five years would increase per capita GDP of the developed countries by 2,96%, Brazil by 0,94%, Central America by 0,76%, countries of group A by 0,66%

TABLE 1.
DYNAMIC EFFECTS ON THE PER CAPITA PRODUCT OF DEVELOPED COUNTRIES# FROM CONSTANT VARIATION IN EACH VARIABLE

Variable	Lag (Years)				
	infinite	5	10	15	20
H	1.0223*	2.2779*	2.0661*	2.4294*	2.0180*
A	0.6604*	1.0622*	1.0480*	1.0421*	1.1169*
K	-0.1481	2.9613*	2.5533*	2.4476*	1.8308*
G	-0.1839*	-4.2594*	-4.1976*	-3.1987*	-1.9190*
OPEN	-0.0479	1.5999*	1.5167*	1.5127*	1.2553*
F	-0.0314	0.2501*	0.2259*	0.1855*	0.1482*
GINI	0.3769	-13.4851*	-11.9110*	-11.4565*	-9.6472*
TRANSP	-0.1970	3.1369*	3.0551*	2.7773*	2.0132*
ELETEL	0.0933	-1.7751*	-1.6502*	-1.7178*	-0.9914*

* significance up to 5%
\# United States, Canada, Germany, Italy, Japan, France and United Kingdom

TABLE 2.
DYNAMIC EFFECTS ON THE PER CAPITA PRODUCT OF BRAZIL FROM CONSTANT VARIATION IN EACH VARIABLE

Variable	Lag (Years)				
	infinite	5	10	15	20
H	2.2568*	-4.3420	-13.8993*	-34.5970*	-36.4903*
A	0.7716*	0.7185*	0.7378*	0.7324*	0.6493*
K	-0.0964	0.9439*	0.9142*	0.7450*	0.2198*
G	-0.1320*	-2.6818*	-2.3075*	-1.3774*	-0.6211
OPEN	0.0145	2.0976*	2.0606*	1.6706*	0.3514
F	-0.0013	0.2259*	0.2077*	0.1624*	0.0691*
GINI	.....	.....	.....	.....	.....
TRANSP	0.3376*	0.7916*	0.7496*	0.7555*	0.6337*
ELETEL	0.0815*	-0.1203	0.3321*	1.5308*	2.0946*

* significance up to 5%

TABLE 3.
DYNAMIC EFFECTS ON THE PER CAPITA PRODUCT OF GROUP A# FROM CONSTANT VARIATION IN EACH VARIABLE

Variable	Lag (Years)				
	infinite	5	10	15	20
H	0.4256	-1.1746*	-2.6871*	-3.5351*	-2.9890*
A	0.5317*	0.6576*	0.6439*	0.6020*	0.5941*
K	-0.1073	0.6631*	0.5890*	0.5402*	0.5411*
G	-0.1828*	2.1176*	1.7245*	1.2258*	1.7484*
OPEN	-0.0058	1.3476*	1.0477*	0.4195*	0.5519*
F	-0.0040	0.0910*	0.0807*	0.0598*	0.0450*
GINI	.....	.....	.....	.....	.....
TRANSP	-0.0370	0.4811*	0.4550*	0.2808*	-0.0833
ELETEL	0.0693*	0.4850*	0.4145*	0.4459*	0.2532*

* significant up to 5%
\# Mexico, Argentina, Chile, Venezuela and Colombia

and countries of group B by 0,76%. However, when analyzing the longer run lags 10, 15, 20 years, it is observed that there is a tendency of the physical capital effect being reduced gradually, reaching negligible effects in the long run, for all countries. It is possible that there is a transitory influence of physical capital on product, although, not so short as estimated by Jones (1995b) for some developed countries when the continuous effect of investment on the product is null after the seventh year. His conclusion is to reject the hypothesis of endogenous growth model AK for developed countries.

TABLE 4.
DYNAMIC EFFECTS ON THE PER CAPITA PRODUCT OF GROUP B# FROM CONSTANT VARIATION IN EACH VARIABLE

Variable	Lag (Years)				
	infinite	5	10	15	20
H	0.3714	-1.0455*	-3.6338*	-6.4319*	-8.7456*
A	0.1557*	0.7320*	0.6799*	0.7853*	1.4474*
K	-0.1822	0.7654*	0.6709*	0.5049*	2.1576*
G	0.0803	1.1037*	1.4188*	1.4343*	1.1329*
OPEN	0.1193*	1.2143*	1.4092*	1.1940*	0.6668*
F	-0.0091	0.1166*	0.1115*	0.0978*	0.0816*
GINI	2.8208	.....	.....	.....	.....
TRANSP	0.1255	0.5785*	0.6018*	0.4798*	0.3254
ELETEL	-0.0051	0.2229*	1.3545*	3.5669*	3.9927*

* significant up to 5% level
# Peru, Paraguay, Uruguay, Guyana, Ecuador and Bolivia

TABLE 5.
DYNAMIC EFFECTS ON THE PER CAPITA PRODUCT OF CENTRAL AMERICA FROM CONSTANT VARIATION IN EACH VARIABLE

Variable	Lag (Years)				
	infinite	5	10	15	20
H	0.4846*	-1.3688*	-2.6689*	-3.6482*	-3.3770*
A	0.4915*	0.9874*	1.0150*	1.1043*	0.9968*
K	-0.1539*	0.7609*	0.6660*	0.5795*	0.5063*
G	-0.1968*	1.1452*	1.3087*	1.6249*	3.7871*
OPEN	0.0646	3.3501*	3.0561*	2.5058*	1.4525*
F	-0.0485*	0.1868*	0.1660*	0.1660*	0.1311*
GINI	.....	.....	.....	.....	.....
TRANSP	-0.0507	1.0926*	0.8428*	0.7144*	0.5242*
ELETEL	-0.0054	1.0553*	1.2818*	1.5307*	0.9385*

* significant up to 5% level

From a theoretical standpoint, the most interesting finding is the significantly negative coefficients of human capital in the polynomial distributed lag specifications for developing countries. Among the polynomial distributed lag specifications for developing countries, only the Brazilian 5 year equation does not have a significantly negative coefficient. This is the opposite result from developed countries, where all polynomial distributed lags are positive and significant. This result, together with the result for technological progress, are consistent with the endogeneity of economic growth in the long run. The negative sign of the human capital coefficient for short lags points to diminishing returns. Both short and long run effects may be explained through low investments and vulnerability to all sorts of institutional crises and transitory economic problems, corroborating the finding of Senhadji (1999), among others. On the other hand, technological progress (A) produces significant positive effects on sustainable long-run growth in all countries, with the largest effect for the Brazilian economy. This result seems plausible as the effects of the considered variables on growth in developing countries tend to increase with product.

Results for the effect of infrastructure on growth are according to expectations, since in developed countries, the effect on product should be stronger in the short run than in the long run, and for developing countries, due to the limitation of stock, the effect on product should be roughly equal throughout the period.

The empirical results demonstrate a strong relationship between the explanatory variables and the per capita growth rate path in the long-run. We therefore fail to reject the endogenous growth hypothesis for all countries/regions. Therefore, simultaneous equations models in panel data will estimate the effects of the explanatory variables, as specified by equation (13), for each group of countries and Brazil. The estimates are presented in table 6.

TABLE 6.
SIMULTANEOUS EQUATIONS ESTIMATES FROM PANEL DATA

Equations		Developed Countries	Central America	Group A	Group B	Brazil
GDPC	C	-7.2171*	-10.6085*	-0.1208	3.5123*	2.2089*
	H	0.8527*	-1.6344*	0.2646	0.6261*	1.8985*
	K	2.2346*	2.0597*	1.0215*	0.1943*	-0.0967
	A	0.4320*	0.0512	0.0189	0.1372*	0.1310*
	G	1.9258*	1.2862*	-0.4425*	-0.1124*	0.0407
	R^2	0.70	0.81	0.76	0.80	0.78
A	C	2.0323	30.6765*	10.0661*	21.1838*	33.4354*
	OPEN	-1.7121*	-0.4789	-1.3298*	-0.4774*	-0.3970*
	F	0.4929*	0.5247*	0.0121	0.3620*	0.2699*
	G	6.1797*	-1.6089*	-0.1521	-1.1276*	-1.7825*
	K	4.1859*	-1.2364*	1.3385*	-0.1737	1.9987*
	R^2	0.88	0.88	0.74	0.59	0.74
K	C	-4.5100*	6.7876*	5.5997*	8.0169*	-11.1968*
	TRANSP	-0.3378*	0.0098	0.0521*	0.1577*	-0.2567*
	ELETEL	-0.2837*	-0.2560*	0.5679*	-0.1600*	0.4919*
	GINI	1.7169*	-0.4093*	1.3004*	-0.8191*	-4.8171*
	H	1.0633*	0.9158*	0.4140*	1.0695*	-1.6304
	R^2	0.46	0.80	0.48	0.43	0.60
H	C	3.0295*	-8.4198*	2.6850*	2.6046*	2.5864*
	GINI	-1.3566*	0.5344*	-1.5627*	-0.7731*	-1.3489*
	TRANSP	0.2488*	0.0683*	0.1518*	-0.0731*	-0.0572*
	K	0.5531*	0.8977*	0.3638*	0.2887*	0.2019*
	R^2	0.63	0.73	0.42	0.45	0.32

Notes: group A: Mexico, Argentina, Chile, Venezuela and Colombia.
group B: Peru, Paraguay, Uruguay, Guyana, Ecuador and Bolivia.
(*) significance at the 10% level.

The results of the simultaneous equations identify different relationships between the explanatory variables and per capita GDP for the analyzed economies. The effects of the factors can be grouped by three types of behavior identified by the estimates. First, for developed economies, there is a significant effect of physical capital, technology and the government's size on per capita GDP, and strong evidence toward the imbalance effect, given by the impacts of the human capital on the physical capital, as demonstrated in the third equation. Such results point notably to an elevated scale effect of the technological factor, as well as to an efficient use of public resources. The results of equations for physical capital and human capital demonstrate a relatively weak effect of the distribution of income, as predicted by the Kuznets' curve, and the relevant effect of the variable TRANSP on the stock of human capital, which, following a logic traced by Lucas (1999), indicates that the tendency for agglomeration of economic activities can motivate the accumulation of human capital and, on the other hand, the controversial result of such a variable in the equation of physical capital demonstrates that agglomeration economies, at the extreme act as a negative externality to the accumulation of physical capital.

The second pattern of results is for Brazil, "group A" that includes the largest economies of Latin America, excluding Brazil, (Mexico, Argentina, Chile, Colombia and Venezuela), and "group B" that includes the other countries of South America (Uruguay, Peru, Guyana, Paraguay, Ecuador and Bolivia). This pattern is characterized by a reduced scale effect of the factor technology, and by the inefficiency of the government, indicated by the negative relationship or small elasticity between government size and per capita GDP in the first equation. That result can be attributed to an inappropriate system of taxation in such economies, as well as of the inefficient allocation of resources, which is illustrated by the negative relationship between government and technology in the second equation, contrary to what is observed in the developed countries where the government plays an important role on the technological research. The agglomeration effects seem to act incisively, although in different ways on those economies, the same happening with the imbalance effect between human capital and physical capital, corroborating with the findings of Arraes and Teles (1999), that foresees heterogeneity among industrial sectors in different economies. Also, improvements in the distribution of income show a clear effect on growth.

The third pattern refers to the countries in Central America, which are characterized by their low development stage and seem to present the same growth diagnosis. The results converge in the sense of the importance of the stock of physical capital and the government's size in the process of growth of this region. The structure of such economies is characterized by the formation of industries of low technological level and by little need for qualified human capital. The negative and significant effect of the government's size on technology demonstrates that the relationship between the government intervention and the economy is preponderantly one of dependence, not acting as an incentive to economic efficiency, promoting in last analysis, a perverse effect on long run growth. The imbalance effect and the relationship between income distribution and growth demonstrate similar results to the second pattern of results presented previously. Furthermore, the positive relationship between agglomeration and growth indicate that such economies are not aware of the importance of economic integration. Low levels of economic openness (variable OPEN) have hindered the technological formation of this region, consequently, reflecting insignificant effect of technology on growth, as opposed to the significant and expected positive effect for all other groups of countries.

While the effects of financial market on the growth point for a positive and significant relationship for all investigated economies, the results reached for the infrastructure variables are inconsistent, so that the individual effects of each infrastructure type tend to vary differently for each economy.

In order to verify the productive deficiency lacks of each analyzed country, the model specified by equation (13) accomplishes comparative simulations between the country leader and each region of countries as shown by the results in table 7.

TABLE 7.
SIMULATIONS FOR PER CAPITA PRODUCT

Countries	GDPC	A	H	K	G	OPEN	F	GINI	TRANSP	ELETEL
					United States leader in GDPC					
USA	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Canada	99.06	130.58	96.79	104.77	96.93	99.86	108.81	102.26	78.52	98.50
Japan	98.24	106.10	94.17	98.32	91.11	98.55	98.05	96.02	88.16	98.63
Germany	97.97	109.63	97.92	79.92	99.18	97.63	97.03	101.72	99.66	97.78
France	97.41	106.83	102.08	98.23	99.18	96.15	98.30	95.42	39.57	97.30
UK	96.49	109.71	100.12	95.95	98.06	95.65	97.51	96.95	74.58	96.50
Italy	96.49	101.56	109.77	89.68	95.41	97.25	97.93	92.54	84.45	96.45
					Group A leader in GDPC					
Group A	100.00	104.75	104.28	104.29	100.00	106.59	103.26	100.00	123.99	100.00
Brazil	97.88	100.00	119.46	100.00	140.29	75.36	100.00	128.30	100.00	116.60
Central Am.	97.65	112.05	100.00	110.53	95.64	97.65	84.56	95.44	140.13	103.34
Group B	91.81	102.45	95.67	99.05	94.42	100.00	94.55	94.79	99.89	94.27

Notes: group A: Mexico, Argentina, Chile, Venezuela and Colombia
group B: Peru, Paraguay, Uruguay, Guyana, Ecuador and Bolivia

The second column of table 7 shows the ratio of the logarithm per capita products of each country and region and The US, while the remaining columns present the simulation of that relation if the country or region had the stock of the corresponding factor of production (A, H, K, etc.) by the same amount of the leader country. As an example, consider the Brazilian case whose per capita product in 1992 represented X% of the american one, if Brazil possessed the american technological level its per capita product would increase Y%. That is, the technological gap accounts for a crucial determinant of the backwardness of the Brazilian productive system in relation to the American one. By repeating this exercise for each country, the results point to human capital and technological progress as the main factors to induce comparative advantage among the sampled countries.

Two basic conclusions arise from this analysis. Firstly, scale effects seem to be broader for the developed countries, whereas the costs of technological catch up are higher for underdeveloped countries. This finding has severe implications on the convergence process among heterogeneous economies, leading to conclude that the velocity of convergence is faster among the developed economies. Secondly, there are distinct pattern of the explanatory factors in the formation of per capita product, therefore, recipes for growth are not constant across countries. The reason for that is very probably due to institutional background of each country.

5. Conclusions

The purpose of this paper was to compare empirically endogenous versus exogenous growth models and to make comparisons of the processes of growth of developed countries with Brazil and Latin America. To reach this goal, several polynomial distributed finite lag models and an infinite lag model were used to verify the impacts of eight variables: human capital, infrastructure – rail, electricity, road and communications – openness, government expenditure, distribution of income and development of the financial sector – on the process of economic growth of long term by testing the hypothesis of the influence of such variables on the growth rates, as predicts the endogenous growth model. Statistical tests resulted in the failure to reject the endogenous model hypothesis in all countries.

In the second part of the work, a model of simultaneous equations was applied to developed countries, to Brazil and Latin American countries. Results are consistent with an endogenous model hypothesis with respect to the significant dependence of product growth on technological levels in the economy, which improve economies of scale, rather than the level of physical capital, as predicted by the traditional models. The results also indicated that human capital elevates strongly, not just the level of the product, but fundamentally, the level of technological progress of the productive sector, where effects work simultaneously for the raising income either in developed or developing countries.

Simulations for the analyzed economies by means of simultaneous equations estimation were performed, and the conclusions indicated that the stocks of human capital and physical capital are the main decisive variables of comparative advantages for developing countries, where the former plays a stronger role in those countries with higher GDP per capita. Moreover, the technological gap turned out to be the determinant of inter-regional differences of per capita income. Nevertheless, some puzzling results found here, contrary to growth theory, might indicate that the institutional background of developing countries is definitely a factor to be taken into account for a better understanding of their growth path. Insertion of political variables, such as corruption, civil rights, colonial inheritance, may be a good start to solve those shuffling effects.

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