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## On the Role of Productivity and Factor Accumulation in Economic Development in Latin America and the Caribbean

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# **On the Role of Productivity and Factor Accumulation in Economic Development in Latin America and the Caribbean**

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## **Abstract**\*

This paper combines development and growth accounting exercises with economic theory to estimate the relative importance of total factor productivity and the accumulation of factors of production in the economic development performance of Latin America. The region's development performance is assessed by contrast with various alternative benchmarks, both advanced countries and peer countries in other regions. The paper finds that total factor productivity is the predominant factor: low productivity and slow productivity growth, as opposed to impediments to factor accumulation, are the key to understanding Latin America's low income relative to developed economies and its stagnation relative to other developing countries. While policies easing factor accumulation would help somewhat in improving productivity, for the most part, closing the productivity gap requires productivity-specific policies.

**JEL Classification:** O11, O47

**Keywords:** Economic growth, Total factor productivity, Development

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## 1. Introduction

Most countries in Latin America and the Caribbean (LAC) have been growing slowly for a long time and see themselves increasingly poor relative to the rest of the world, both advanced countries and peer countries in other regions. Actual declines in income per capita for substantial periods of time are common. However, as we show in this paper, it would be misleading to blame low investment for this failure. Low productivity and slow productivity growth, as opposed to impediments to factor accumulation, is the key to understanding LAC's low income relative to developed economies and its stagnation relative to other developing countries that are catching up. *A fortiori*, the main development policy challenge in the region involves diagnosing the causes of poor productivity and acting on its roots.

This paper is organized in the following way. In Section 2 we explain how and why we use total factor productivity (TFP, henceforth) as our measure of productivity to understand growth and development in LAC. In the following two sections we establish the basic stylized facts of aggregate productivity using some of the traditional tools of development and growth accounting, and then test their robustness to technical assumptions. Section 5 analyzes the interplay between aggregate productivity and factor accumulation. There we show that traditional tools underestimate the relevance of productivity: once it is recognized that factor accumulation reacts to TFP, it becomes clear that productivity is by far the key to the economic development problematic in the region. We further show that promoting factor accumulation would have only a limited impact on the productivity shortfall. Finally, in Section 6 we conclude by discussing some policy implications of our findings and areas for future research.

## 2. Measuring Aggregate Productivity

The first question to deal with is how to measure aggregate productivity. Standard economic analysis estimates aggregate productivity, or TFP, by looking at the annual output  $Y$  (measured by the gross domestic product, GDP) that is produced on the basis of the accumulated factors of production, or capital, which are available as inputs. For any given stock of capital, the higher the output the more productive the economy. Capital is composed by physical capital,  $K$ , and human capital  $H$ . Physical capital takes the form of means of production, such as machines and buildings. Human capital is the productive capacity of the labor force, which in turn corresponds to the headcount of the labor force or raw labor,  $L$ , multiplied by its average level of skill or

education  $h$ , so that  $H=hL$ . TFP measures the effectiveness with which accumulated factors of production, or capital, are used to produce output.

Therefore output  $Y$  results from the combination of factors of production  $K$  and  $H$  at a certain degree of TFP. Likewise, output growth over time results from accumulation of factors of production and productivity growth. The attribution of output level and growth to factors and productivity is done by using production functions mapping factors into output: what is not accounted for by factors of production as estimated by the production function is attributed to productivity. In particular, we use a standard Cobb-Douglas production function given by:

$$Y = AK^a H^{1-a} = AK^a (hL)^{1-a} \quad (1)$$

where  $a$  is the output elasticity to (physical) capital. The production function parameter  $a$  is set equal to  $1/3$ , a standard value in the literature (see Klenow and Rodríguez-Clare, 2005). Although there is some debate in the literature regarding the validity of this assumption, Gollin (2002) shows that once informal labor and household entrepreneurship are taken into account, there is no systematic difference across countries associated with level of development (GDP per capita), nor any time trend. Hence its uniformity across countries and time appears to be a reasonable assumption.

We construct the relevant series for output, physical capital and human capital ( $Y, K, H$  respectively) based on available statistics and following methods detailed in the Statistical Appendix. It is useful to note that we filter the raw annual data to obtain smooth series reflecting their trends, thus filtering out the business cycle. Using these series, we can compute our measure of TFP by:

$$A = \frac{Y}{K^a (hL)^{1-a}}, \quad (2)$$

which is a comprehensive measure of the efficiency with which the economy is able to transform its accumulated factors of production  $K$  and  $H$  into output  $Y$ . In this way, as noted, we estimate trend TFP series for each country.<sup>1</sup>

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<sup>1</sup> In this formulation, TFP would also reflect the natural resource base (natural capital) of each country. Resource-rich countries would tend to exhibit larger (but possibly less dynamic) measured TFP. Since LAC is a resource-rich region, this observation implies that a symptom of low productivity would signal an even more serious ailment. (On the other hand, it could be argued that natural resources give rise to backward development and ultimately lower productivity (the “natural resource curse hypothesis”); see Lederman and Maloney, 2008, for a critical view.) In any



In terms of the sample of countries utilized, on top of the availability of all these data, we introduce as a further restriction a population size of at least 1 million as of 1960. The resulting sample of 76 countries is shown in Table 1. The data extend from 1960 to 2005.

There are, however, other partial measures of productivity that are commonly used. One is a variant of this TFP measure defined with respect to the size of the labor force  $L$  rather than the total human capital  $H$ , so that education is not considered a factor of production and, therefore, higher average education  $h$  would be reflected in higher productivity, given by:

$$Alt_1 = Ah^{1-a} = \frac{Y}{K^a L^{1-a}} \quad (3)$$

Another partial measure of productivity is the so-called labor productivity, or  $Y/L$ . In this case, as shown in equation (4), physical capital  $K$  is also neglected as a factor of production, and therefore an economy whose labor force counts has more capital at its disposal would tend to exhibit higher productivity.

$$Alt_2 = A \left( \frac{K}{L} \right)^a h^{1-a} = Y / L \quad (4)$$

The trends of these productivity measures differ substantially, so that which productivity measure is selected matters for the conclusions (Figure 1). Arguably, the use of the two alternative productivity measures may produce misleading conclusions. For example, an increase in the labor productivity measure is silent with respect to whether such improvement was produced by more education of the labor force (better quality of the labor input), the accumulation of physical capital (unrelated to the labor input), or something else (unrelated to all factor inputs). In the case of the alternative TFP measure based on raw labor  $L$ , the effect of education becomes unnecessarily confounded with TFP. The discrimination of these different sources is relevant for diagnosis and policy action. Thus, our preferred measure of TFP is a productivity measure which is not contaminated by the evolution of factor inputs.

TFP measures the efficiency with which available factors of production are transformed into final output. This measure of productivity includes a technological component and tends to increase as the technological frontier expands and new technology or ideas become available and

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event, the weight of natural resources based production in GDP is only significant in a few countries and should not distort the overall picture shown in this paper.

are adopted, but it is also affected by the efficiency with which markets work and are served by public services. For example, an economy populated by technologically advanced firms may produce inefficient aggregate results and therefore translate into low aggregate productivity. In particular, market and policy failures may distort the efficiency with which factors are allocated across sectors, and across firms within sectors, thus depressing efficiency at the aggregate level. The upshot is that, while increasing the stock of accumulated factors may require resources that are unavailable in low-income countries and may even be wasteful if productivity is low, boosting productivity directly may “simply” require willingness to reform policies and institutions by taking advantage of successful experiences elsewhere.

It is important to understand what TFP includes and does not include in this paper. Because we are not considering effectively employed labor force and physical capital but the entire stocks available for production, partially utilized factors (e.g., unemployment) would be reflected in low productivity. As noted, in order to avoid the fluctuations this accounting would induce in productivity due to the business cycle, we filtered the annual series of output and factors to retain only their trends, thus obtaining trend productivity. Therefore, in our calculations, only structural underutilization of resources would be reflected in low productivity.<sup>2</sup> At the same time, because we chose to measure labor input as labor force, variations in the share of the population in the labor force (whether because of demographic reasons or the choice of working age population to participate in the labor force) do not affect TFP. In other words, a smaller labor force as a share of the population is not reflected in lower productivity. On the other hand, as discussed above, the quality of education, which may differ significantly across countries, would be reflected in the productivity measure inasmuch as it impinges on the working capacity of the labor force.<sup>3</sup> Similarly, the age profile of the labor force would also entail differences in experience akin to the quality of education.

The above production function framework can be directly applied to account for output per worker  $Y/L$  (or “labor productivity”) in terms of TFP and per-worker factor intensities:  $k=K/L$  (“capital intensity”) and  $h=H/L$  (education of the labor force). It is useful to relate this production function framework to a welfare framework, such as the traditional measure of GDP

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<sup>2</sup> Our choice of measurement implies that an economy with higher structural unemployment is less productive because it wastes available resources.

<sup>3</sup> To the extent that quality differences affect uniformly the education spectrum, the aggregative measure  $h$  would not be distorted and they would only be reflected in TFP differences (see Appendix).

per capita ( $y=Y/N$ ), where  $N$  is the size of the population. This is an income measure commonly used to gauge welfare across countries. In this case, differences in income per capita, or in its growth, can be attributed to TFP and per-worker factor intensities, as before, and an extra term reflecting the share of the population in the labor force ( $L/N$ , denoted by  $f$ ), given by:<sup>4</sup>

$$y = \frac{Y}{N} = A \left( \frac{K}{L} \right)^a h^{1-a} \frac{L}{N} = A k^a h^{1-a} f \quad (5)$$

The enormous diversity of income per capita that exists across countries can be well explained statistically by differences in their aggregate productivity levels as measured by TFP. TFP and income per capita move in tandem (see Figure 2), with a correlation coefficient of 0.91. Thus, in statistical terms, 83 percent of the cross-country income variation in the world today would disappear if TFP were the same across countries in the world. TFP appears central to understanding income per capita diversity across countries and to acting on the root causes of underdevelopment. In the remainder of the paper we will explore the economic determinants of this strong relationship.

In most of the analysis, we consider the productivity of the typical country in LAC, represented by a simple (logarithmic) average of country productivities, irrespective of whether the country is large or small. Thus, the typical LAC country's TFP is measured by:

$$A_{lac} = \left( \prod_{i=1}^n A_i \right)^{\frac{1}{n}}. \quad (6)$$

Similarly, we consider the simple (logarithmic) average of income per capita ( $y$ ), and the corresponding per-worker factor of production intensities ( $k, h, f$ ).<sup>5</sup> To represent the region as a whole, however, where the productivity of larger countries is more influential because it applies to larger stocks of productive factors, we consider a synthetic region country summing up inputs and outputs over countries. For example, Figure 3 shows productivity in LAC (as opposed to the world's TFP shown in Figure 1) for both the typical country and the region as a whole.<sup>6</sup> (More

<sup>4</sup> The parameter  $f$  depends on the share of working age population (a demographic factor) and the rate of its participation in the labor force.

<sup>5</sup> The use of a logarithmic transformation is needed to ensure that the TFP of the typical country so defined coincides with the typical TFP previously defined.

<sup>6</sup> Since technology in principle can only improve over time, we note in passing that a declining TFP over some periods reinforces the notion that TFP is only partially technologically determined.

generally, we represent various country groupings as the typical country and the region following similar methods for the analysis of a number of variables.)

Before embarking in the analysis of regional aggregates, it may be useful to keep in mind that there is substantial diversity in productivity levels across countries in the LAC region. Figure 4 shows our estimation of current productivity levels in each country relative to the typical country in Latin America (as of 2005).<sup>7</sup> For example, TFP in Chile is 2.5 times higher than in Honduras.<sup>8</sup> The diversity within the region, as expected, is highly correlated with income per capita (with a correlation coefficient of 0.86; see Figure 2).

### 3. Stylized Facts of Aggregate Productivity in LAC

In this section we review the patterns of the evolution of aggregate productivity in the economic development of the LAC region, both in growth and levels.<sup>9</sup> This is done using traditional tools of growth and development accounting.

Concerning growth accounting, the growth rate of TFP ( $\hat{A}$ ) is obtained as a residual after accounting for the growth rates of output and factor inputs (measured as their logarithmic increase from equation (5)):<sup>10</sup>

$$\hat{y} = \hat{A} + a\hat{k} + (1-a)\hat{h} + \hat{f}. \quad (7)$$

The above equation can also be used to account for the growth gaps between two countries or group of countries, so that the growth gap in income per capita can be decomposed into the sum of the growth gap in TFP, the (weighed) factors' growth gaps, and the gap in the growth of labor force intensity:

$$Gap(\hat{y}) = Gap(\hat{A}) + aGap(\hat{k}) + (1-a)Gap(\hat{h}) + Gap(\hat{f}) \quad (8)$$

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<sup>7</sup> Country TFP estimations may be subject to measurement errors of the underlying economic variables which would tend to cancel out in regional TFP estimations, for example that of the typical country, which we regard as substantially more reliable.

<sup>8</sup> This particular difference is larger than the TFP gap of the typical country in the region with respect to the United States, as we will show below.

<sup>9</sup> The 18 LAC countries included in the sample are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

<sup>10</sup> We follow the convention to denote the growth rate of a variable  $x$  by  $\hat{x}$ .

Development accounting looks at levels rather than growth rates. It utilizes equation 5 to compare the components behind income per capita between an economy of interest and a benchmark economy taken as a development yardstick, denoted by “\*”, or level gaps:

$$\bar{y} = \frac{y}{y^*} = \frac{A}{A^*} \left( \frac{k}{k^*} \right)^a \left( \frac{h}{h^*} \right)^{1-a} \frac{f}{f^*} = \bar{A} \bar{k}^a \bar{h}^{1-a} \bar{f} \quad (9)$$

A logarithmic transformation of the above equation can then be used to account for the contribution of the TFP gap and that of factor intensities to the overall income per capita gap at a point in time:

$$\log(\bar{y}) = \log(\bar{A}) + a \log(\bar{k}) + (1-a) \log(\bar{h}) + \log(\bar{f}) \quad (10)$$

In order to highlight LAC’s weaknesses and anomalies, these gaps (the growth gaps in equation (8) and the log-level gaps in equation (10) are computed against the rest of the world (ROW) and selected groups of countries, such as the East Asian tigers (EA), currently Developed countries (DEV), and “Twin” countries (TWIN, countries whose income was initially, by 1960, comparable to that of LAC countries).<sup>11,12</sup> Unless noted, comparisons are made between the typical countries of each one of the regions. Following convention, we take the US economy as the technological frontier against which “absolute” gaps in productivity are estimated.

It is worth noting that equation (10) contains all the information needed for this analysis. The time difference over a period of  $p$  years (say from  $t-p$  to  $t$ ) yields a decomposition of how the level gaps opened during the period, to be interpreted as a decomposition of the accumulated growth gap in the period, found in equation (11). In fact, for a period of one year ( $p=1$ , so that the period runs between  $t-1$  and  $t$ ), the time difference yields the annual growth gap in equation (8).

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<sup>11</sup> The latter group of “twin” countries was constructed by selecting all countries in the sample whose 1960 income per capita fell in the inter-quartile range of Latin American countries (incomes within the second and third quartile).

<sup>12</sup> East Asian tigers are Hong-Kong, Korea, Malaysia, Singapore and Thailand; Developed countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom and United States; Twin countries are Algeria, Fiji, Greece, Hong Kong, Hungary, Iran, Japan, Jordan, Portugal and Singapore; countries of Rest of the World include Benin, Cameroon, China, Egypt, Ghana, India, Indonesia, Israel, Kenya, Lesotho, Malawi, Malaysia, Mali, Mozambique, Nepal, Niger, Pakistan, Papua, New Guinea, Philippines, Senegal, Sierra Leone, South Africa, Sri Lanka, Syria, Thailand, Togo, Tunisia, Turkey, Uganda and Zambia.

$$\Delta_p \log \bar{y}_t = \log \left( \frac{\bar{y}_t}{\bar{y}_{t-p}} \right) = \log \left( \frac{\bar{A}_t}{\bar{A}_{t-p}} \right) + \alpha \log \left( \frac{\bar{k}_t}{\bar{k}_{t-p}} \right) + (1 - \alpha) \log \left( \frac{\bar{h}_t}{\bar{h}_{t-p}} \right) + \log \left( \frac{\bar{f}_t}{\bar{f}_{t-p}} \right) \quad (11)$$

In what follows, we highlight three stylized facts of total factor productivity in Latin America and the Caribbean that are central to diagnosing some main weaknesses in the region's economic development.

***Fact 1: Slower growth in LAC is due to slower productivity growth.***

It is well known that Latin America income per capita grows systematically more slowly than in the rest of the world (there is a negative gap in income per capita growth  $\hat{y}$ ). The first stylized fact is that this gap can be largely attributed to a negative gap in TFP growth, rather than to differences in the pace of factor accumulation: the per capita income growth gap is essentially due to a gap in TFP growth. The growth gaps since 1960 in GDP per capita and in TFP relative to the rest of the world appear equally large and systematic (Panel A of Figure 5). Factor accumulation in Latin America was in line with the rest of the world; what sets apart Latin American growth is TFP stagnation.<sup>13</sup> This finding coincides with the analysis in Blyde and Fernández-Arias (2006). While a gap in the rate of factor accumulation with respect to the typical East Asian country was important until about a decade ago (Panel C of Figure 5), this pattern is more a peculiarity of East Asian development than a Latin American weakness.

Systematically slower growth has meant an ever-increasing income per capita gap relative to most countries. Figure 6 depicts the evolution of both income per capita and TFP in the typical LAC country relative to its counterpart among countries in the Rest of the World, and specifically in East Asian countries, the United States, and Twin countries, to show the progressive relative impoverishment of the region and how it can be traced to slower TFP growth. For example, had the typical country in LAC grown at the same pace as its counterpart in the rest of the world since 1960, by now its income per capita would be some 55 per cent higher. The claim is that this accumulated growth gap is mostly due to slower productivity growth. An estimation of the contribution of productivity to this gap compared to the Rest of the World can be obtained from equation (11) and yields about 90 percent. The predominant

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<sup>13</sup> In our sample, similar to the regional statistics, most of the variability in growth gaps in individual Latin American countries can be explained by their TFP growth gaps.

contribution of slower productivity growth to account for slower income growth of the typical LAC country holds true in the comparisons with all our benchmarks (see Table 2, where the relative income deteriorations since 1960 are decomposed using equation (11)).

***Fact 2: LAC productivity is not catching up with the frontier, in contrast to theory and evidence elsewhere.***

Endogenous growth theory suggests that less productive countries should be able to increase their productivity faster because they can adopt technologies from more advanced economies, benefitting from advances at the frontier without incurring the costs of exploration. While it is true that TFP is not just technology—it also reflects inefficiencies in how markets work, as we argued above—but the catching-up argument works just as well for policies and institutions: backward countries have the benefit of being able to improve by learning, rather than inventing.

The rest of the world tends to follow this expected convergent pattern, but not LAC. Figure 7 shows the evolution of productivity in LAC and other regions relative to the frontier, customarily taken as the United States (normalizing the indexes to 1 by 1960). Until the debt crisis of the 1980s, catching up in the typical country was slower than in LAC but faster since then. This divergent pattern in recent decades holds true not only for the typical LAC country but for the region as a whole (*LAC Region* in the figure) as Brazil's earlier dynamism during the 1960s and 1970s slowed down. Other benchmarks further highlight LAC's anomalous productivity trends.

The failure to catch up on productivity is widespread across LAC countries. Figure 8 shows all countries in the sample ranked by overall TFP catch-up (relative to the United States) in the period examined (1960-2005): there is a substantial concentration of Latin American countries in the fourth quartile. Brazil is about the median, and only Chile shows some degree of convergence with the US over the long-run.

***Fact 3: LAC's productivity is about half its potential.***

Current levels of estimated TFP for Latin American countries relative to that of the United States, taken as the frontier, are uniformly subpar (see Figure 9). In particular, in 2005 the aggregate productivity of the typical LAC country (which being an average is subject to less statistical error than that of individual countries) is about half (52 percent).



If factor inputs are kept constant, income per capita would move together with TFP. Therefore if TFP increased to its potential, the income per capita of the typical LAC country would double (to about a third of the US level). In this thought experiment, a better combination of the same inputs emulating what is feasible in other economies, using existing technologies, would render an output substantially larger. More generally, what would have been the evolution of LAC income per capita if its historical production inputs had been applied with US productivity at each point in time? This is an artificial question because, as analyzed in the next section, productivity and factor accumulation are interlinked and changes in productivity are bound to have indirect effects on factor accumulation (and vice versa). Nevertheless, the direct income effect of closing the productivity gap provides a measure of the relevance of such gap. Figure 10 shows the counterfactual scenarios of relative income per capita in which the TFP gap is closed for both the typical LAC country and the region as a whole.

The sizable room for improvement associated with productivity catching-up is in some sense good news for LAC to the extent that rapid progress in income per capita (i.e., high growth) may be unlocked by economic policy reform even in the absence of the burden of increased investment. The potential for improving productivity in the typical LAC country by around 100 percent is not available to the typical East Asian country (40 percent), twin country (40 percent) or developed country (only 15 percent).

Figure 11 shows the evolution over time of the development accounting exercise based on equation (10). Physical capital accounts for almost 40 percent of the income per capita gap, with a stable contribution over time. However, the contribution of human capital has declined from around one fourth of the gap in 1960 to 16 percent in 2005. Similarly, while labor force intensity explained an important share (around one fourth) of the income gap during the early 1980s, today its contribution to the income per capita gap between the typical LAC country and the United States is only 8 percent. By contrast, from 1980 onwards, the contribution of TFP to the income gap has been increasing steadily doubling its importance to reach a level similar to that of physical capital by 2005 of 37 percent.

Figure 12 shows this decomposition country-by-country in 2005. There are clearly differences across countries in the importance of TFP in accounting for the income per capita gap with respect to the U.S. For example, while in Costa Rica and the Dominican Republic TFP



accounts “only” for a fifth or a quarter of the gap, in other countries like Ecuador and Peru it accounts for almost 50 percent of the gap.

#### 4. Robustness of the Stylized Facts

The use of alternative methodologies confirms the robustness of the previous key stylized facts. In particular, we consider first the following three interesting variations of the standard methodology employed:

- a) A production function giving more weight to physical capital and less weight to human capital. In this alternative we use a higher capital share  $\alpha=1/2$ , instead of the standard value of  $1/3$ .
- b) The use of working age population instead of labor force to measure  $L$ , with the effect that TFP becomes sensitive to changes in the participation rate in the labor force (everything else equal, lower participation would translate into lower aggregate productivity, even if lower participation is the result of a stronger preference for leisure).<sup>14</sup>
- c) A different method to estimate the series of physical capital  $K$  that is also commonly used in the technical literature (Caselli, 2005); see Appendix.

In order to test *Fact 1: Slower growth in LAC is due to slower productivity growth*, the annual TFP growth gap between LAC and ROW based on equation (8) shown in the previous section is contrasted with the annual TFP growth gaps produced by the three alternative methodological variations (Figure 13). The contrast demonstrates that the negative TFP growth gap persists under the alternatives and is similar to the baseline case.

The robustness of *Fact 2: LAC productivity is not catching up with the frontier* is tested by looking at the evolution of the typical LAC country’s TFP relative to the frontier under the various alternative methodologies (Figure 14). The remarkable lack of convergence persists under the alternative scenarios.

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<sup>14</sup> Blyde and Fernández-Arias (2006) show that the use of employed labor instead of labor force to measure factor input makes little difference in LAC. We do not attempt to use actual hours worked, which would be a more accurate measure of labor input, because data are not available for a large number of countries over a long period of time, limiting the possibility of a broad and structural comparison across countries. However, it is known that such refinement does not substantially alter measured TFP (see Restuccia, 2008).

Finally, the alternative methodologies broadly confirm *Fact 3: Latin America's productivity is about half its potential*, as shown in Figure 15 where the TFP gap between the typical Latin American country and the frontier is estimated under the various alternatives.<sup>15</sup>

So far the analysis has been based on standard Cobb-Douglas production functions. The use of this family of functions is the conventional approach for a number of good reasons, but has the empirical drawback of collapsing all productivity concerns to a single parameter, the factor-neutral productivity parameter  $A$  or TFP. Rather than experimenting with other families of production functions with more parameters—in particular considering a more general Constant Elasticity of Substitution (CES) production function with lower levels of substitutability between factors—to explore the robustness of the stylized facts in more general settings, we move to the extreme and consider a non-parametric method of estimation that only requires the standard assumptions of free disposal and consider that the production function has constant returns to scale.

This alternative methodology, which is based on the estimation of production possibility frontiers developed by Koopmans (1951) and Farell (1957), has recently been applied to growth accounting exercises by Färe et al. (1994) and Kumar and Russell (2002), and to development accounting by Jermanowski (2007). In this non-parametric approach, the estimation of the degree of aggregate efficiency with which a country produces is only based on the possibilities revealed by the production achievements of the rest of the countries, without the use of an explicit production function. In particular, we estimate a production possibility frontier using a data envelope analysis (DEA) following Jermanowski (2007). Once the production frontier theoretically attainable with the country's factor inputs using “best practices” is estimated, a relative efficiency or total factor productivity index  $E$  can be estimated reflecting actual output relative to the frontier (so  $E$  is an index between 0 and 1). This index tests the robustness of the previous estimation of TFP relative to that of the United States (taken as the frontier), or  $A/A^*$ .

In this methodology, output in a given country can be written as  $Y=EF(K,H)$  where  $F(\cdot)$  has constant returns to scale. However, rather than specifying an explicit functional form whose parameters are estimated to fit the data, it is numerically inferred from picking the feasible “best practices” revealed by the data. Any country  $n$  could replicate the economies of the whole

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<sup>15</sup> Nevertheless, the extreme weight on physical capital in alternative (a) weakens the relevance of the productivity gap somewhat.

universe of countries at arbitrary scales  $\lambda$  and piece them together as long as the required aggregate factor inputs in this combination do not exceed available stocks of factor inputs  $(K_n, H_n)$ . Its frontier is the best of such combinations, i.e., the one yielding the highest output. In particular, we solve the following linear programming problem. Given  $N$  countries and inputs in per worker terms  $(k, h)$ , country  $n$ 's program is given by:

$$\begin{aligned}
& \max_{\theta_n, \lambda_1, \dots, \lambda_N} \theta_n \\
& \text{subject to} \\
& \theta_n y_n \leq \lambda \cdot y, \quad k_n \geq \lambda \cdot k, \\
& h_n \geq \lambda \cdot h, \quad \lambda_{1 \times N} \geq 0
\end{aligned} \tag{12}$$

It turns out that this index of aggregate relative efficiency  $E$  in LAC countries is quite similar to the TFP parameter estimated in the standard Cobb-Douglas model (relative to the United States, taken as the frontier), which buttresses the previous findings.<sup>16</sup> In Figure 16, we plot the resulting estimates for relative efficiency  $E$  with respect to our previous estimates of relative TFP. As shown, the correlation between both measures is extremely high (with a simple correlation coefficient of 0.92!). Furthermore, the efficiency level of the typical Latin American country in 2005 is similar: 62 percent compared with the previously estimated relative TFP of 52 percent.<sup>17</sup> More generally, the time evolution of both measures for the typical LAC country is roughly similar, with an initial period of convergence followed by divergence (Figure 17). Therefore, as an additional robustness test to our results in the previous section, this non-parametric approach also confirms the stylized facts of LAC productivity previously found.

## 5. Productivity and Factor Accumulation

In an accounting sense, a gap in income per capita can be attributed to a gap in productivity ( $A$ ), physical capital intensity ( $k$ ), human capital intensity ( $h$ ), or labor force intensity ( $f$ ) (equation (10)). For example, as shown in Figure 10, a development accounting exercise benchmarking the typical Latin American country with the United States would indicate, as mentioned in Fact 3, that if the productivity gap is closed then relative income would roughly double (TFP in the

<sup>16</sup> It is important to point out that, according to this methodology, the United States turns out to be almost always on the production possibility frontier (i.e., cannot improve by emulating any other country), and it is on the frontier currently (2005).

<sup>17</sup> Since in this non-parametric method the frontier is inferred from observed levels of output of countries which may be less than fully efficient, the estimated efficiency index  $E$  should be interpreted as an upper bound.

typical LAC country would increase by  $A^*/A = 1.93$  times or roughly twice, and so would income). Furthermore, as shown in Figure 11, discussed above, an accounting decomposition of the contributions of each underlying gap to the current income gap with the United States on the basis of equation (10) would indicate that the productivity gap accounts for about 37 percent and accumulated factors for the rest, or 63 percent, as of 2005.

While the income boost produced by closing the productivity gap in this simple accounting calculation is sizable, it would apparently leave most of the observed income gap. This metric would suggest that productivity is an important but not predominant variable behind income gaps, but then why is it that income is so closely associated with productivity across countries (as shown in Figure 2)? An appreciation of the relevance of productivity for the overall economic development process requires the exploration of the interplay between productivity and factor accumulation: the indirect effects of productivity gaps on the incentives to accumulate production factors may account for a substantial portion of the observed development gaps. In fact, the traditional tools previously utilized underestimate the importance that closing the productivity gap would have on welfare. We show in what follows that after a full measure is obtained, it becomes clear that:

***Claim 1: The income per capita gap with respect to the United States would largely disappear if the productivity gap were closed.***

The previous exercises on the contribution of the productivity gaps to development gaps assume that  $k$  and  $h$  are exogenous to TFP levels. Next, we show gap decompositions where these exogeneity assumptions are relaxed. First, we consider the case where human capital continues to be considered exogenous, but physical capital is endogenous. In market economies, private investment in physical capital is such that the marginal return to investing equals the cost of capital as perceived by individual investors, within the financing conditions accessible to them. The private return appropriated by an individual investor may very well be a fraction of the social return to investing, for example if it provides positive externalities to other firms (e.g. non-patentable innovations) or if the firm's returns are taxed away. In particular, let us assume that the representative firm solves the following static maximization problem:

$$\max_k (1-t)Ak^a h^{1-a} - p_k(r + \delta)k, \quad (13)$$

where  $p_k$ ,  $r$  and  $\delta$  are the relative price of capital goods, the real interest rate and the depreciation rate, respectively. We assume the tax rate  $t$  to capture all elements that reduce the private appropriability of output proceeds. The first order condition is given by:

$$(1-t)Aak^{a-1}h^{1-a} = p_k(r + \delta) \quad (14)$$

Dividing the right-hand side of equation (14) by output per worker yields:

$$(1-t)a \frac{Y}{K} = p_k(r + \delta) \quad (15)$$

Thus, we have that the equilibrium capital-output ratio  $\kappa$  is given by:

$$\kappa = \frac{K}{Y} = \frac{(1-t)a}{p_k(r + \delta)} \quad (16)$$

This shows that the capital-output ratio does not depend on the level of productivity but does depend on the interest rate, the degree of private appropriability of returns and the price of capital goods. Therefore distortions to these price-like conditions will be reflected in the capital-output ratio: “price” impediments to physical capital investment leading to a wedge between net marginal returns (net of cost of capital) across countries correspond to lower capital-output ratios. Solving for  $k$ , plugging it into equation 5 and solving for output per capita, we can write the production function in per capita terms in “intensive form” as labeled by Klenow and Rodríguez-Clare (2005):

$$y = A^{\frac{1}{1-a}} \kappa^{\frac{a}{1-a}} h f \quad (17)$$

Dividing equation (17) by the benchmark  $y^*$ , following the notation introduced in equation (9), and taking logs we can decompose the GDP per capita gap as:

$$\log\left(\frac{y}{y^*}\right) = \log(\bar{y}) = \frac{1}{1-a} \log(\bar{A}) + \frac{a}{1-a} \log(\bar{\kappa}) + \log(\bar{h}) + \log(\bar{f}) \quad (18)$$

Irrespective of the size of the impediments to physical capital accumulation, as measured by the gap in the capital-output ratio, an increase in TFP would boost private returns relative to the status quo and lead to a higher stock of accumulated physical capital.<sup>18</sup> In fact, in all cases,

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<sup>18</sup> This process would of course take time; here we are abstracting from transitional issues.

closing the TFP gap would alter incentives boosting physical capital investment relative to the status quo, an indirect effect of closing the productivity gap which ought to be attributed to it. Thus, the overall contribution of the TFP gap to the income gap in equation (18) results from the direct effect estimated with equation (10) plus this additional indirect effect:

$$\frac{1}{1-a} \log(\bar{A}) = \log(\bar{A}) + \frac{a}{1-a} \log(\bar{A}) \quad (19)$$

How large is the overall effect of closing the TFP gap, inclusive of indirect effects on factor accumulation? Under the conservative assumption in equation (18) that human capital is exogenously given, meaning that investment in education does not increase with higher TFP, the overall TFP contribution for the typical LAC country (as of 2005) would amount to 55 percent of the income gap, of which 37 percent is the direct effect mentioned above and 18 percent is the additional indirect effect via induced physical capital accumulation.

In this model of physical capital intensity endogenously reacting to changes in productivity and exogenously given education expressed in equation (18), the remaining 45 percent to make up the entire income gap is divided into the contribution of impediments to physical investment, which as explained are reflected in the capital-output ratio  $\kappa$  (12 percent), human capital intensity or education  $h$  (25 percent), and labor force intensity  $f$  (8 percent); see Figure 18. According to these results, a development agenda exclusively focused on physical capital investment by easing impediments such as undue spreads in the financial system, high taxation and uncertain property rights would be circumscribed to a margin of just 12 percent (unless they also foster productivity, an issue we explore at the end of the section). There is, of course, some variation across countries—for example, in the Dominican Republic investment impediments appear to be as important as TFP shortfalls—but the conclusion holds broadly. The relevance of the productivity gap appears to have been growing over time since 1980 (Figure 19).

If investment in human capital (education), which as shown is dominant among the remaining factor-related gaps, is also recognized as an endogenous variable which would likely react to an increase in productivity, the case for a predominant contribution of the productivity gap becomes stronger. In our context, its consideration will add an additional indirect effect of

closing the productivity gap.<sup>19</sup> This more complete decomposition where both types of capital react to productivity changes crucially depends on how elastic education demand is to increased productivity.<sup>20</sup>

When the level of education of the labor force is also allowed to adjust to changes in returns, equation (17) becomes the “superintensive” form:

$$y = A^{\frac{1}{(1-a)(1-b)}} \kappa^{\frac{a}{(1-a)(1-b)}} \varphi^{\frac{1}{1-b}} f^{\frac{1}{1-b}}, \quad (20)$$

where human capital is assumed to endogenously adjust to income per capita according to  $h = \varphi y^b$ , following standard growth models where endogenous human capital displays this type of log-linear relationship with income. The parameter  $\varphi$  reflects country-specific, non-income factors affecting education, or education propensity, so that a shortfall in this parameter is interpreted as an impediment to human capital investment. Correspondingly, equation (18) becomes

$$\log(\bar{y}) = \frac{1}{(1-a)(1-b)} \log(\bar{A}) + \frac{a}{(1-a)(1-b)} \log(\bar{\kappa}) + \frac{1}{1-b} \log(\bar{\varphi}) + \frac{1}{1-b} \log(\bar{f}) \quad (21)$$

There are no reliable estimations of the income elasticity of education  $b$ . If education is totally inelastic ( $b=0$ ), education is exogenous and equation (21) collapses to equation (20), where  $\varphi=h$ . Erosa, Koreshkova and Restuccia (2007) calibrate a model with this specification obtaining a high elasticity of  $b=0.48$ . This parameter would actually imply that the work force in LAC is, relative to the US, substantially overeducated for its level of income as measured by  $\varphi$ . This calibration would imply that closing the productivity gap would lead to LAC *surpassing* the US income per capita (by some 11 percent) despite the gap in labor force intensity and the impediments to physical capital investment (both working to LAC’s disadvantage). We therefore pick a conservative intermediate elasticity of  $b=0.24$  that cancels any contemporaneous differences in this education propensity between the typical LAC country and the US (e.g.,  $\bar{\varphi}=1$  in 2005).

This elasticity would yield an overall contribution of closing the TFP gap of 73 percent, of which about half are indirect effects through both physical capital and education, each one

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<sup>19</sup> Both indirect effects would actually reinforce each other because of the complementarity between physical and human capital in the production function.

<sup>20</sup> However, economic returns are clearly not the only motivation behind individual education decisions.

contributing roughly the same (Figure 20). This reinforces the conclusion that LAC's income per capita gap would largely disappear if the productivity gap is closed.<sup>21</sup> In this formulation, the relevance of the productivity gap also appears to grow over time since 1980.

The key development policy question is then how to close the productivity gap. As mentioned, the aggregate productivity gap reflects a variety of shortcomings in the workings of the overall economy and should not be narrowly interpreted as a technological gap. However, in answering this question it is important to recognize that factor accumulation, both physical and in terms human capital, may be important to facilitate the objective of reducing the productivity gap. For example, physical capital investment may embody new technologies to help in catching up with the frontier, and human capital investment may facilitate innovation and the adoption of more advanced technologies. This amounts to studying the effects of capital accumulation on productivity, a direction of causation which is opposite to the one we explored to trace the effects of closing the productivity gap. This analysis would answer the question of how far would addressing distortions in capital accumulation go in increasing income via its indirect effects on increased productivity, in addition to the direct effects noted above. (These indirect effects would of course also take into account that increased productivity further boosts capital accumulation and so on.)

In order to explore this issue, we try to quantify the impact of eliminating investment distortions as measured by the capital-output gap and of closing education gaps and arrive at:

***Claim 2: Fixing the shortcomings of factor accumulation in LAC would help productivity but still leave most of the productivity gap open.***

The calibrated model in Cordoba and Ripoll (2008) posits a similar Cobb-Douglas production function in which investment impacts TFP because factors affect the accumulation of knowledge, leading to the adjusted intensive form:

$$y = \tilde{A} \kappa^{\frac{\alpha(1+c)}{1-\alpha}} h^{1+c} f, \quad (22)$$

where  $\tilde{A}$  corresponds to “core TFP,” that is TFP purged from the negative influence of physical and human capital accumulation shortcomings, and the parameter  $c$  captures the amplification

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<sup>21</sup> At the same time, the contribution of impediments to physical capital investment would increase to almost 16 percent (because higher education boosts returns to physical capital investment).



effect of factors on TFP (for details see Córdoba and Ripoll, 2008). In this formulation, education is taken as exogenous (not affected by productivity) and therefore the entire education gap is attributed to accumulation shortcomings. The following equation in decomposition form would account for the exogenous contribution of “core productivity” (first term on the right-hand side), leaving out the productivity benefits of factor accumulation:

$$\log(\bar{y}) = \log(\bar{A}) + \frac{a(1+c)}{1-a} \log(\bar{\kappa}) + (1+c) \log(\bar{h}) + \log(\bar{f}) \quad (23)$$

Thus, the indirect effect of physical capital-related frictions is given by  $c \frac{a}{1-a} \log(\bar{\kappa})$  and that of human capital is given by  $c \log(\bar{h})$ .

Extending the model to allow for education being elastic to income along the lines above would yield a revised decomposition in which shortcomings in investment in education are only those reflected in the gap in education propensity (the parameter  $\bar{\varphi}$ ), not the entire education gap.

$$\begin{aligned} \log(\bar{y}) = & \frac{1}{1-b(1+c)} \log(\bar{A}) + \frac{a(1+c)}{(1-a)(1-b(1+c))} \log(\bar{\kappa}) + \frac{1}{1-b(1+c)} \log(\bar{\varphi}) \\ & + \frac{1}{1-b(1+c)} \log(\bar{f}) \end{aligned} \quad (24)$$

The contributions of “core productivity” according to equation (23) and (24) and considering a value of  $c=0.5$  (following Córdoba and Ripoll, 2008), and imposing again that  $\bar{\varphi}=1$  in 2005, are shown in Figures 21 and 22, respectively. Under the assumption that education is totally inelastic to increased returns, the contribution of the core productivity gap in the first term of equation (23), which would remain after all factor accumulation shortcomings are fixed, is only one third smaller than the previously estimated overall contribution of 55 percent (of which impediments to physical capital accumulation would be responsible for only 6 percentage points of the drop and the education gap would account for the remaining 12 percentage points) (see Figure 21). Thus, two-thirds of the overall contribution of the productivity gap would remain even after these drastic adjustments to factor accumulation gaps.<sup>22</sup> It is important to note

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<sup>22</sup> The contributions of factors are correspondingly boosted by about half; for example, the attribution to impediments to physical capital, including its effect on productivity, increases from 12 percent to 18 percent but is still far less important than core productivity.

that this pure productivity shortfall appeared negligible by 1980 and has been growing since then.

Under the alternative assumption that education is elastic to income, then the productivity gap contribution of 73 percent previously estimated would be marginally reduced to a core productivity gap contribution of 58 percent, so that the bulk of the productivity shortfall would remain (see Figure 22). The drop in this case is lower because education is driven by income and therefore does not play an autonomous role in boosting productivity. These results confirm that policies focused on shortcomings of factor accumulation are relevant but not decisive for addressing the productivity gap: the productivity gap is not the result of insufficient investment, but largely of other, more specific productivity shortcomings.

## **6. Conclusions**

Low productivity and slow productivity growth as measured by total factor productivity, rather than impediments to factor accumulation, are the key to understanding Latin America's low income relative to developed economies and its stagnation relative to other developing countries that are catching up, as summarized by the following stylized facts:

- a) Slower growth in LAC is due to slower productivity growth;
- b) LAC productivity is not catching up with the frontier, in contrast to theory and evidence elsewhere;
- c) LAC's productivity is about half its potential

Higher productivity would entail not only a more efficient use of accumulated capital stocks, both physical and human, but also faster accumulation of these production factors in reaction to the increased returns prompted by the productivity boost. All things considered, closing the productivity gap with the frontier would actually close most of the income gap with developed countries.

Therefore it is clear that the key to the economic development problematic in the region is how to close the productivity gap. The main development policy challenge in the region involves diagnosing the causes of poor productivity and acting on its roots. The analysis shows that policies easing physical and human capital accumulation would be relevant to improving productivity but would leave most of the productivity problem untouched. Consequently, the

core of the aggregate productivity problematic will require specific productivity policies. While impediments to technological improvement at the firm level is part of the problem, aggregate productivity depends on the efficiency with which private markets and public inputs support individual producers. Since firms' productivities may be heterogeneous, aggregate productivity also depends on the extent to which the workings of the economy allocate productive factors to the most productive firms. These considerations open up a rich agenda for productivity development policies.

## Statistical Appendix

Gross output ( $Y$ ) is computed as PPP adjusted real GDP from the *Penn World Tables* version 6.2 (PWT), resulting from multiplying the real GDP per capita (constant prices: chain series)—denoted by *rgdpch* in the database—by the population (*pop*) also provided by the PWT. While data are available only until 2004, we extend the data to 2005 using PPP GDP growth reported by the World Bank’s *World Development Indicators* (WDI).

Labor input is measured by the total labor force from the WDI. It is often argued that hours worked are a more accurate measure. However, these data are not available for a large number of countries over a long period of time, limiting the possibility of a broad and structural comparison across countries in Latin America. Furthermore, short-run fluctuations in labor market participation would not have an influence on the TFP measure because we focus on HP-filtered trends (only permanent differences in unemployment rates, a failure to productively utilize available labor inputs, would affect TFP).

We follow the standard approach by Hall and Jones (1999) by constructing the human capital index  $h$  as a function of the average years of schooling given by:

$$h = e^{\phi(s)}, \quad (\text{A.1})$$

where the function  $\phi(\cdot)$  is such that  $\phi(0) = 0$  and  $\phi'(s)$  is the Mincerian return on education. In particular, we approximate this function by a piece-wise linear function. As shown in equation (A.2), we assume the following rates of return for all the countries: 13.4 percent for the first four years of schooling, 10.1 percent for the next four years and 6.8 percent for education beyond the eighth year (based on Psacharopoulos, 1994).

$$\phi(s) = \begin{cases} 0.134 \times s & \text{if } s \leq 4 \\ 0.536 + 0.101 \times (s - 4) & \text{if } 4 < s \leq 8 \\ 0.94 + 0.068 \times (s - 8) & \text{if } s > 8 \end{cases} \quad (\text{A.2})$$

For each country we then compute the average using the data on years of schooling in the population (older than 15 years) from the Barro-Lee database.<sup>23</sup>

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<sup>23</sup> Linear extrapolations are used to complete the five-year data. Missing values were interpolated using a fixed-effects regression of the average school years on primary, secondary and tertiary enrollment rates. For China and Egypt the Barro-Lee data on average years of schooling are not available before 1975 and in Benin before 1970. We

Clearly, differences in the quality of human capital across countries could affect our measure of human capital. However, if the differences in the quality of education are the same for all levels of education, they would be adequately captured in TFP comparisons. It is straightforward to show this. Suppose that the returns depend on quality adjusted years of education defined as  $\phi(q \times s)$ . Given the (piecewise) linearity and  $\phi(0) = 0$ ,  $\phi(\cdot)$  is homogenous of degree one, such that  $\phi(q \times s) = q\phi(s)$  which implies that  $h$  can be written as  $h = e^{\phi(qs)} = e^q e^{\phi(s)}$ .

We construct series for capital stock using also data from the PWT. Total investment in PPP terms is obtained by multiplying the PPP adjusted investment ratios to GDP ( $ki$ ) by real GDP per capita ( $rgdpl$ ) and the population ( $pop$ ). Following the methodology presented in Easterly and Levine (2001) we use a perpetual inventory method to construct the capital stock. In particular, the capital accumulation equation states that:

$$K_t = K_{t-1}(1 - \delta) + I_t \quad (\text{A.3})$$

where  $K_t$  is the stock of capital in period  $t$ ,  $I$  is investment and  $\delta$  is the depreciation rate which we assume equals 0.07. From the capital accumulation equation (A.3) and assuming steady state conditions, we can compute the initial capital-output ratio as:

$$\frac{K_0}{Y_0} = \frac{i_0}{g + d}, \quad (\text{A.4})$$

where  $i_0$  is the average investment-output ratio for the first ten years of the sample (the 1950s), and  $g$  is a weighted average between a world growth of 4.2 percent (75 percent) and the average growth of the country for the first 10 years of the sample (25 percent). To obtain the initial capital stock  $K_0$  we multiply the capital output-ratio from (A.4) by the average output of the first three years of the sample.

As a robustness check, we also estimated the initial capital stock as in Caselli (2005). In this set-up, instead of using the weighted GDP growth to approximate  $g$  in equation A.4, we use the country's average growth rate of investment in the first 10 years of the sample. Furthermore, we use the initial investment rate instead of the 10-year average investment rate to measure  $i_0$ .

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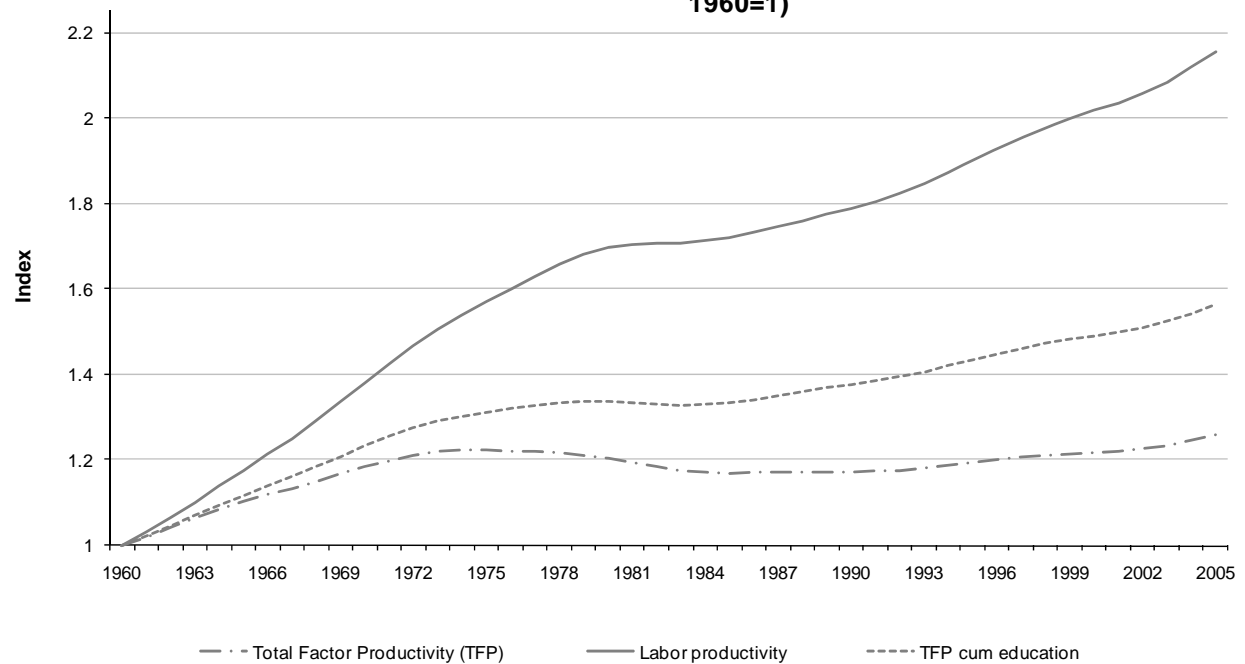
extrapolated the data for these countries using a regression of the average years of schooling (logs) on two period leads.

## References

- Blyde, J., and E. Fernández-Arias. 2006. "Why Does Latin America Grow More Slowly?" Seminar Papers S-856. Washington, DC, United States: Inter-American Development Bank.
- Caselli, F. 2005. "Accounting for Cross-Country Income Differences." In: P. Aghion and S. Durlauf. *Handbook of Economic Growth*. Volume 1. Amsterdam, The Netherlands: North-Holland.
- Córdoba, J.C., and M. Ripoll. 2008. "Endogenous TFP and Cross-Country Income Differences." *Journal of Monetary Economics* 55: 1158-1170.
- Easterly, W., and R. Levine. 2001. "What Have We Learned from a Decade of Empirical Research on Growth? It's Not Factor Accumulation: Stylized Facts and Growth Models." *World Bank Economic Review* 15(2): 177-219.
- Erosa, A., T. Koreshkova and D. Restuccia. 2007. "How Important is Human Capital? A Quantitative Theory Assessment of World Income Inequality." Department of Economics Working Paper 280. Toronto, Canada: University of Toronto.
- Farrell, M.J. 1957. "The Measurement of Production Efficiency." *Journal of the Royal Statistical Society A* 120(3): 253–281.
- Färe, R. et al. 1994. "Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries." *American Economic Review* 84(1): 66–83.
- Gollin, D. 2002. "Getting Income Shares Right." *Journal of Political Economy* 110(2): 458–474.
- Hall, R., and C.I. Jones. 1999. "Why Do Some Countries Produce So Much More Output per Worker than Others?" *Quarterly Journal of Economics* 114(1): 83-116.
- Jermanowski, M. 2007. "Total Factor Productivity Differences: Appropriate Technology versus Efficiency." *European Economic Review* 51: 2080-2110.
- Klenow, P., and A. Rodríguez-Clare. 1997. "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" In: B. Bernanke and J. Rotemberg, editors. *NBER Macroeconomics Annual 1997*. Cambridge, United States: MIT Press.
- . 2005. "Externalities and Growth." In: P Aghion and S. Durlauf, editors. *Handbook of Economic Growth*. Volume 1A. Amsterdam, The Netherlands: North-Holland.
- Koopmans, T.C. 1951. "Efficient Allocation of Resources." *Econometrica* 19(4): 455–465.

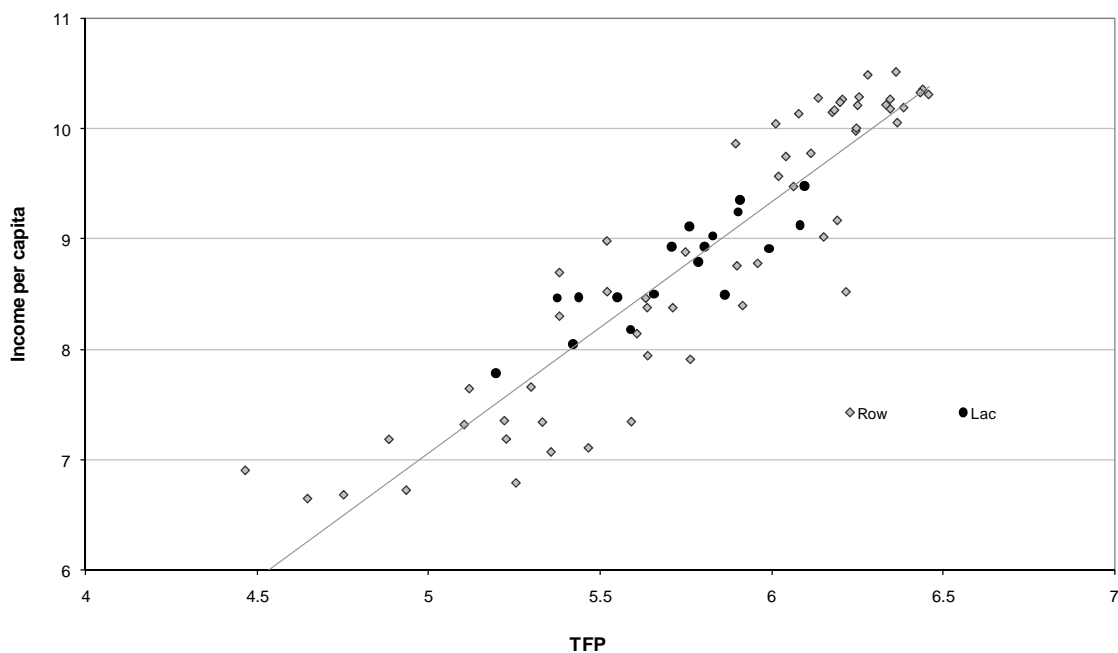
- Kumar, S., and R.R. Russell. 2002. "Technological Change, Technological Catch-Up, and Capital Deepening: Relative Contributions to Growth and Convergence." *American Economic Review* 92(3): 527–548.
- Lederman, D., and W.F. Maloney, 2008. "Natural Resources and Economic Growth." *Economía* 9(1): 1-57.
- Psacharopoulos, G. 1994. "Returns to Investment in Education: A Global Update." *World Development* 22(9): 1325-1343.
- Restuccia, D. 2008. "The Latin American Development Problem." Department of Economics Working Paper 318. Toronto, Canada: University of Toronto.

**Figure 1: Alternative productivity measures (typical world economy country 1960=1)**



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 2: Income per capita and productivity across countries (2005)**

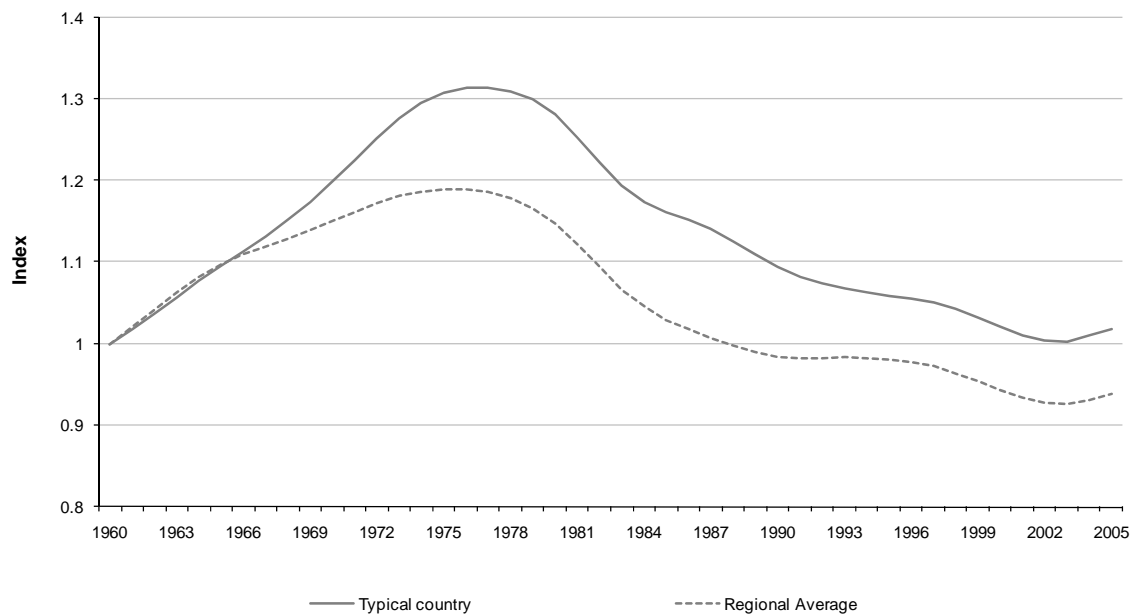


Note: income per capita and TFP measured in logarithmic scale.

Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

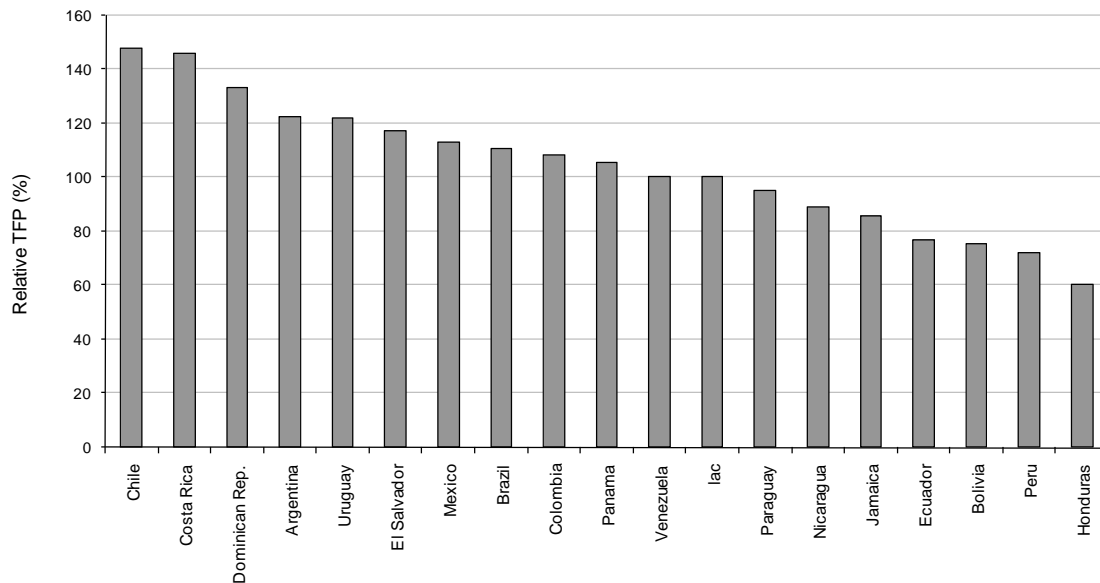


**Figure 3: Productivity indexes (LAC, 1960=1)**



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

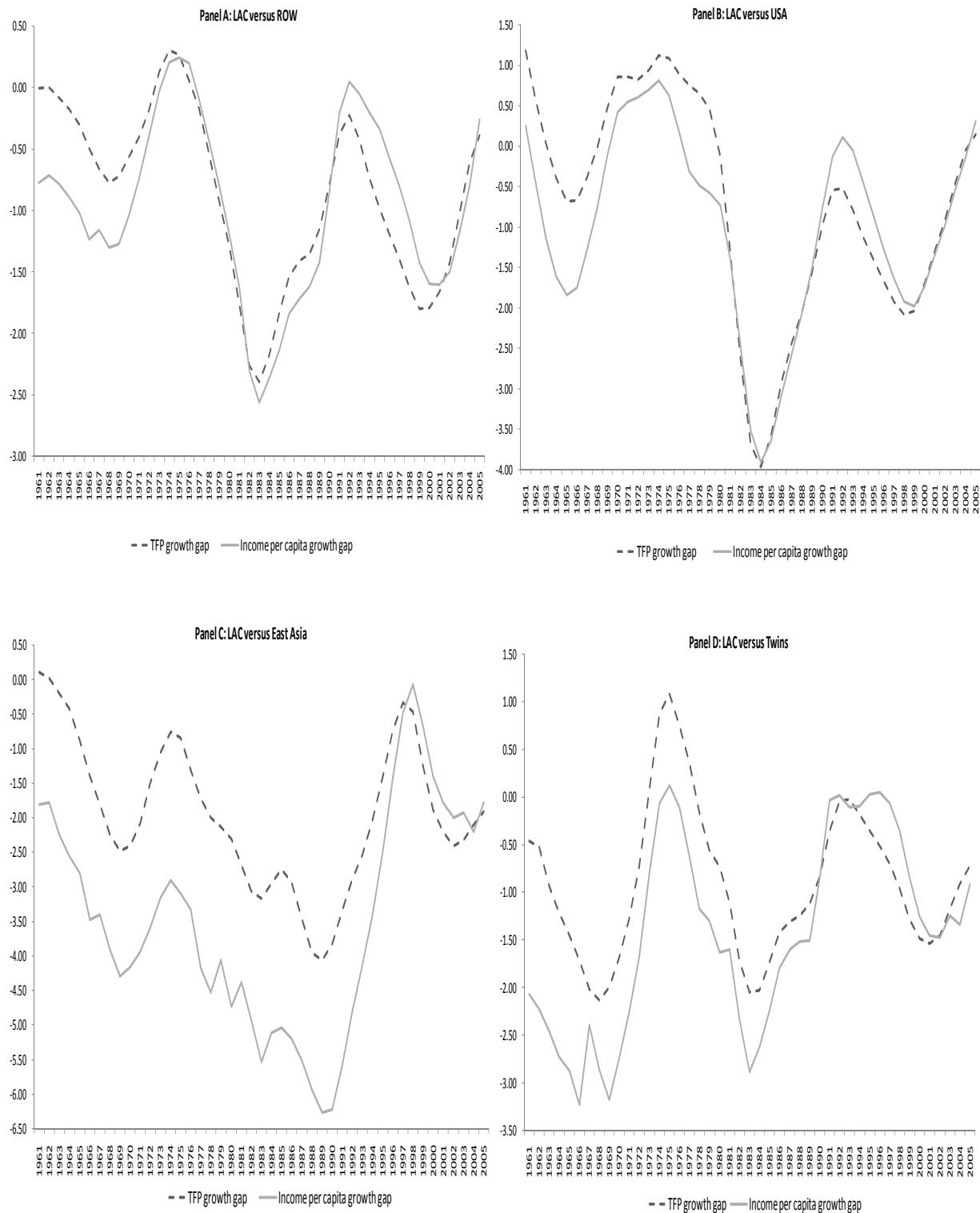
**Figure 4: Productivity diversity within LAC (percentage of the typical LAC country, 2005)**



Note: Country TFP relative to typical LAC country.

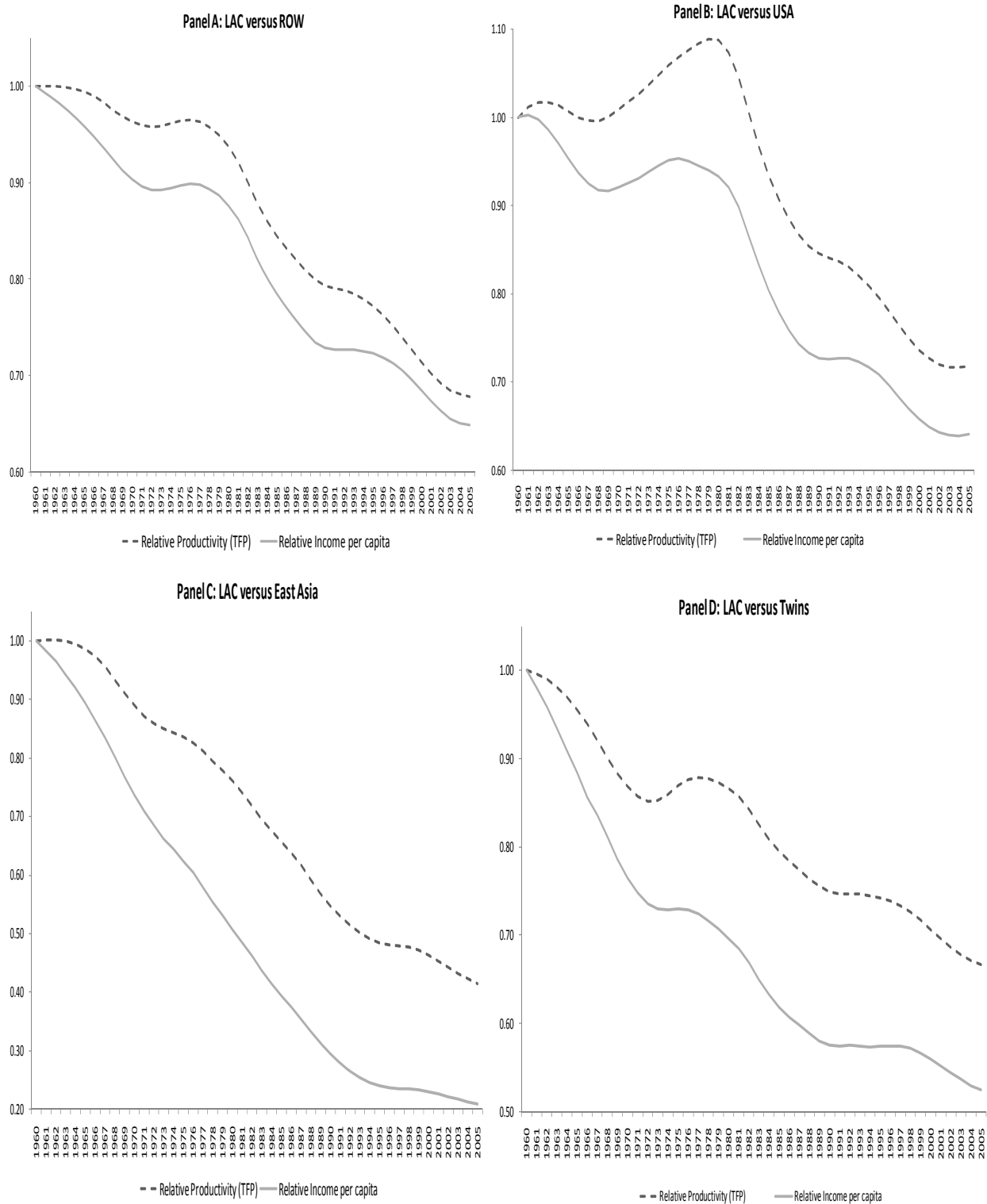
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 5: TFP and Income per capita growth gaps (%)**



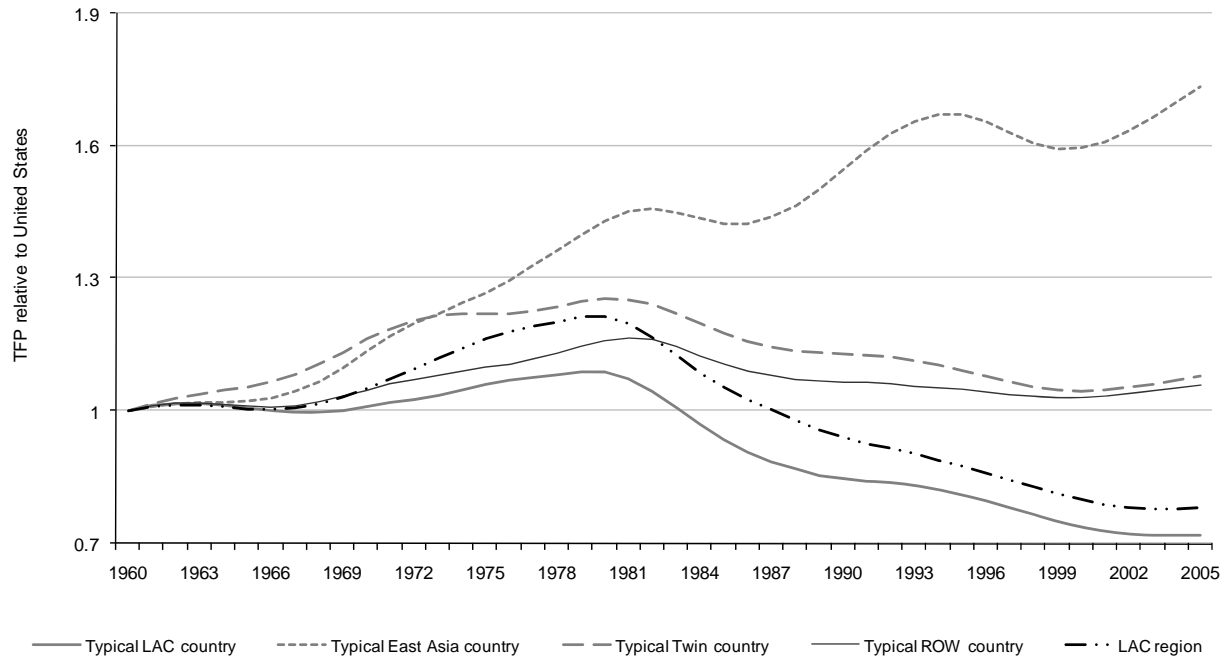
Source: Author's calculations based on Heston, Summers and Aten (2002), World Bank (2002), Barro and Lee (2000).

**Figure 6: TFP and Income per capita levels (1960 = 1)**



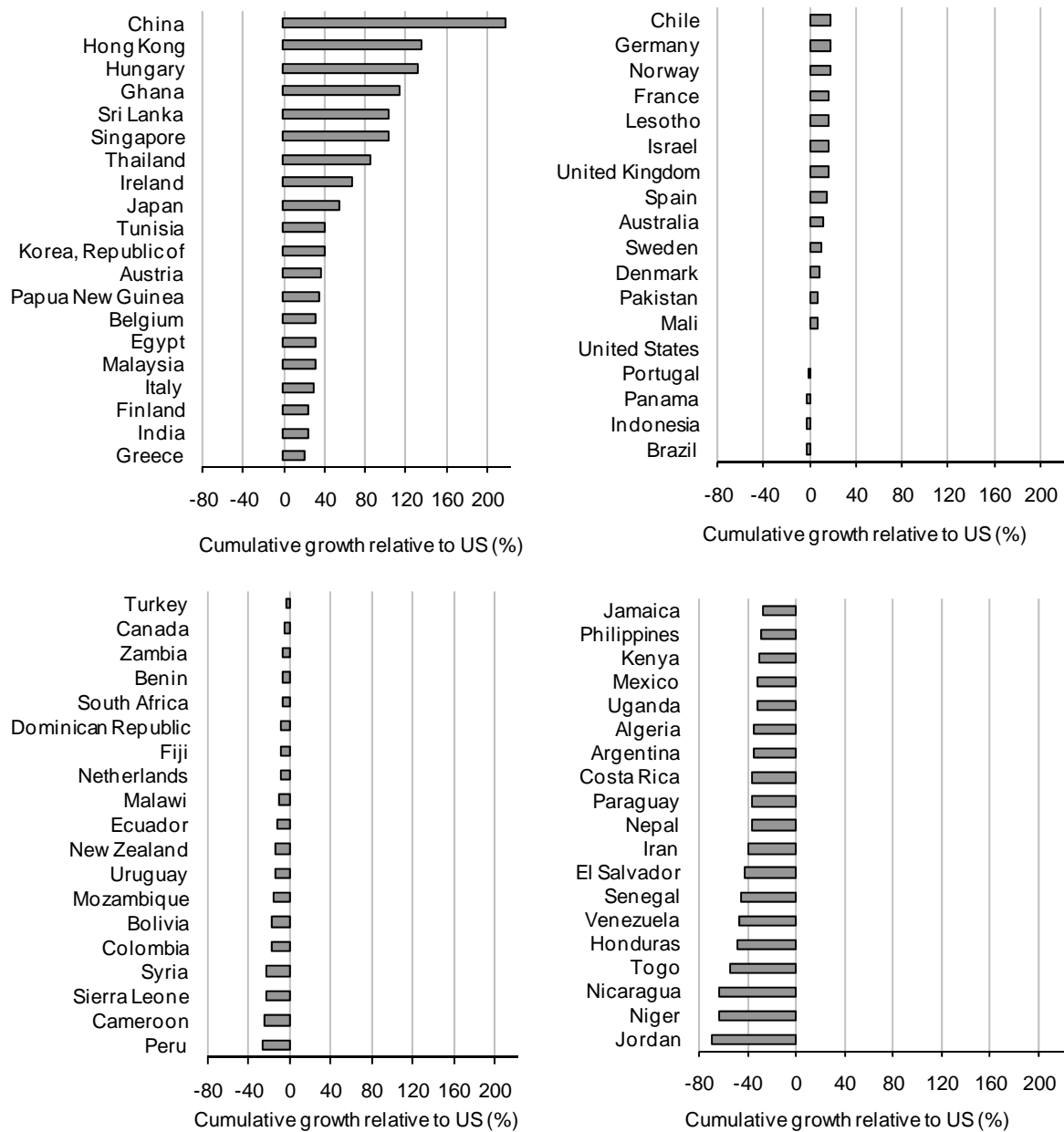
Source: Author's calculations based on Heston, Summers and Aten (2002), World Bank (2002), Barro and Lee (2000).

**Figure 7: Productivity Catch Up (Productivity index relative to US, 1960=1)–  
Contrast with selected regions**



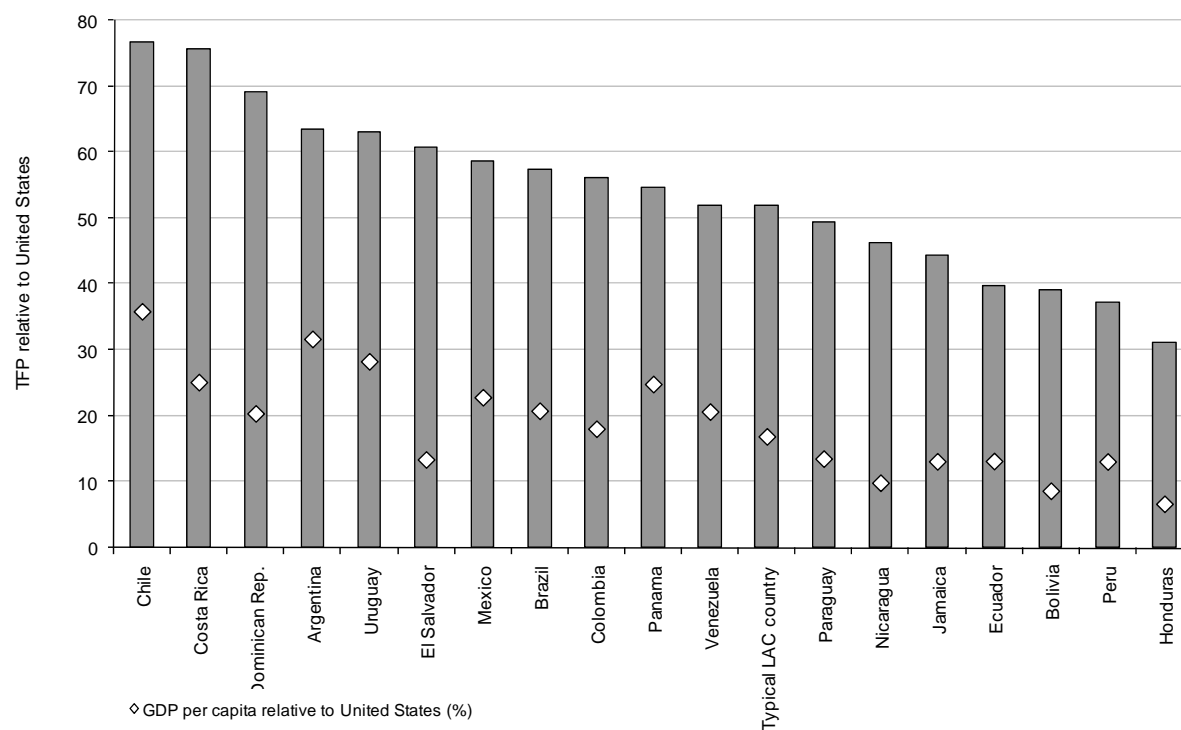
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 8: Cumulative productivity catch up around the world (1960-2005)**

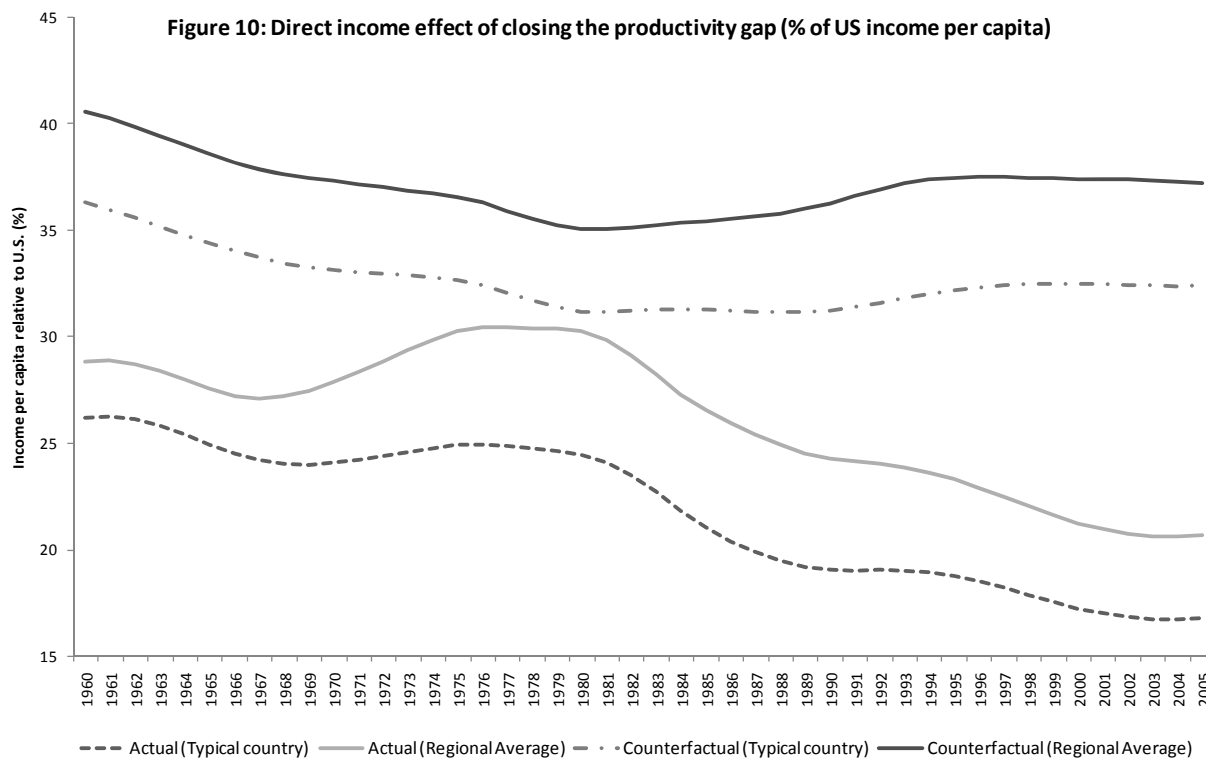


Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 9: Relative productivity in LAC countries (as percentage of US Productivity, 2005)**

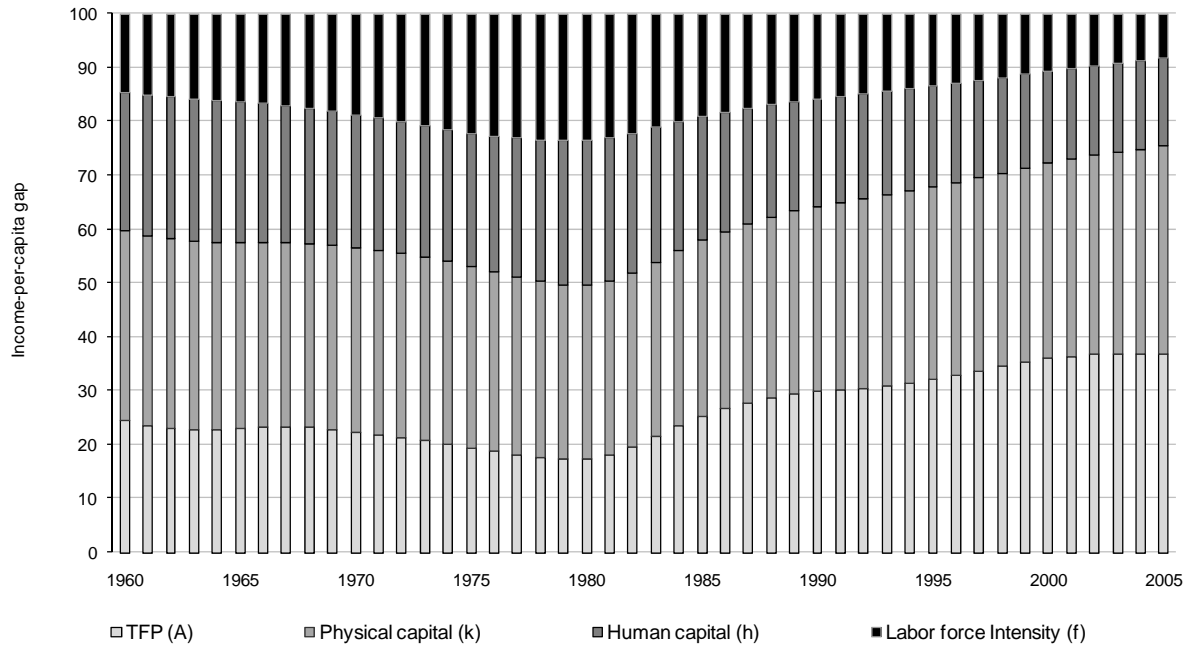


Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).



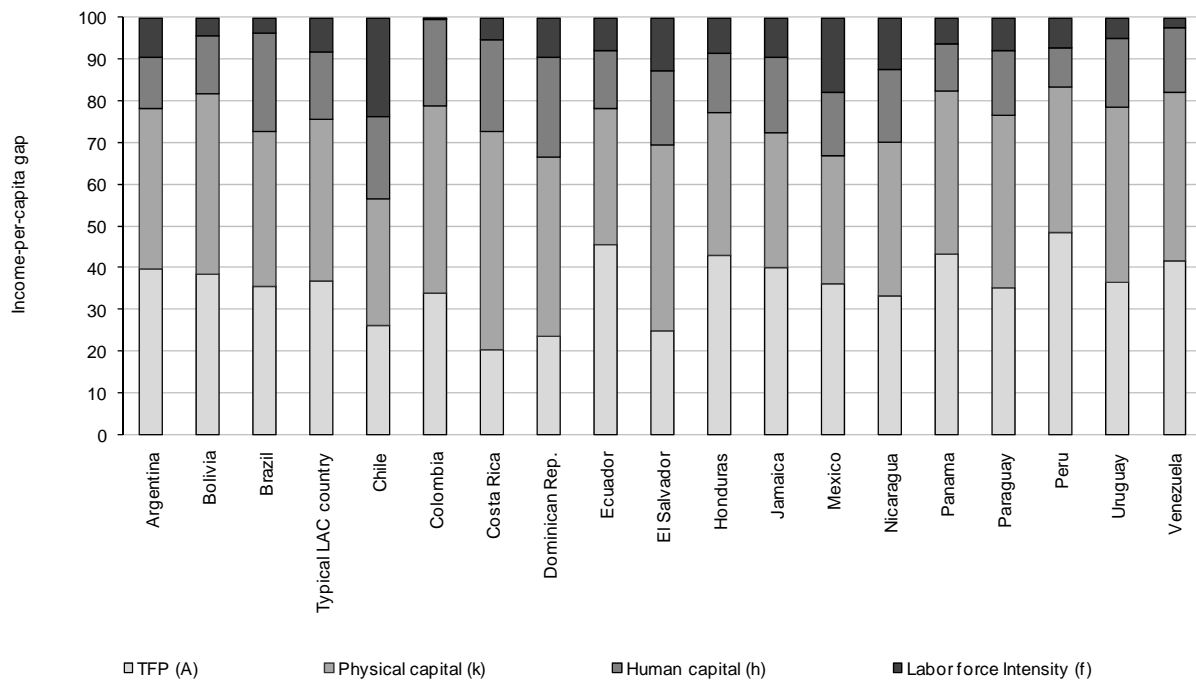
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 11: Contribution to closing the income per capita gap  
(Typical LAC country versus USA)**



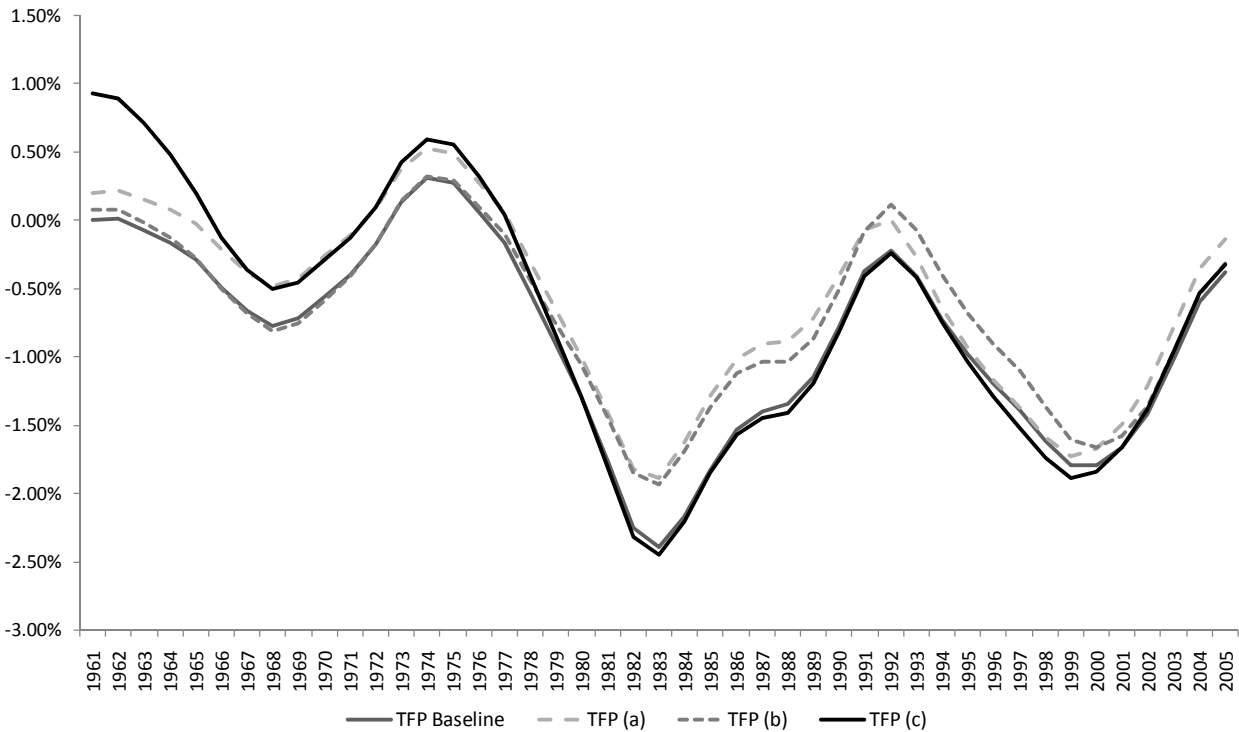
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

**Figure 12: Contributions to closing the income per capita gap versus U.S. in 2005**



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

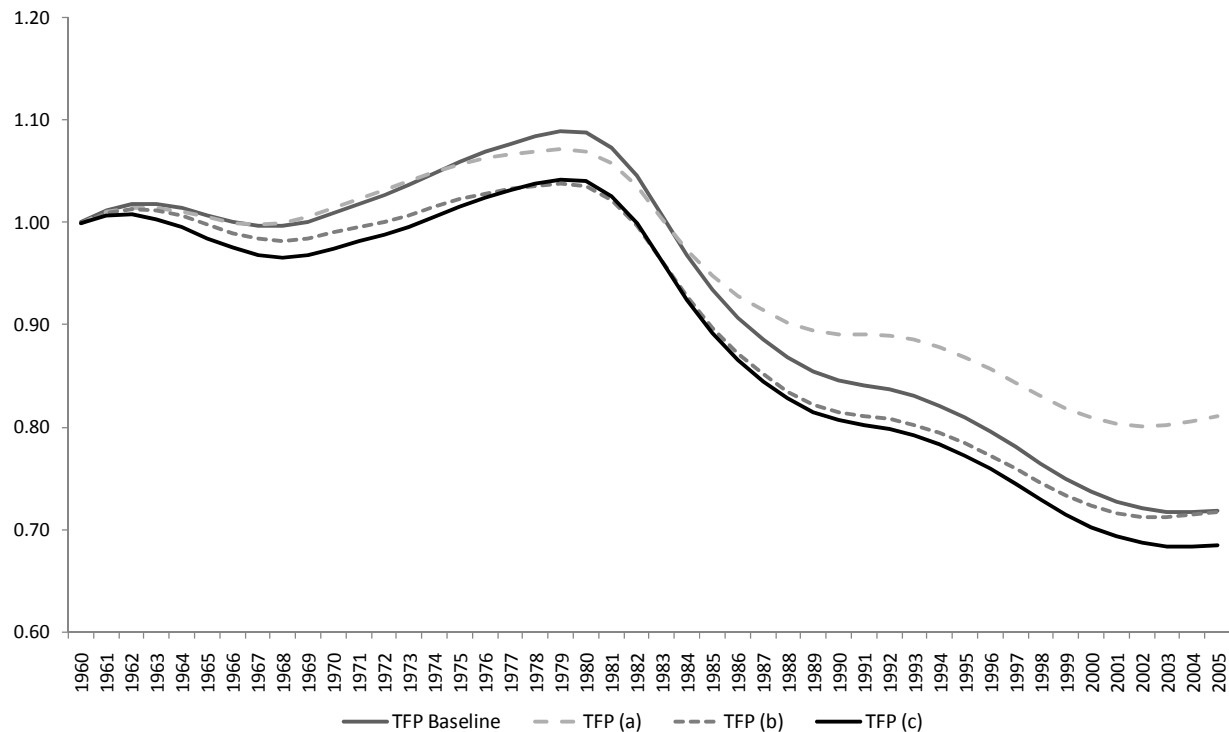
**Figure 13: TFP growth gap under alternative methodologies (LAC versus ROW)**



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

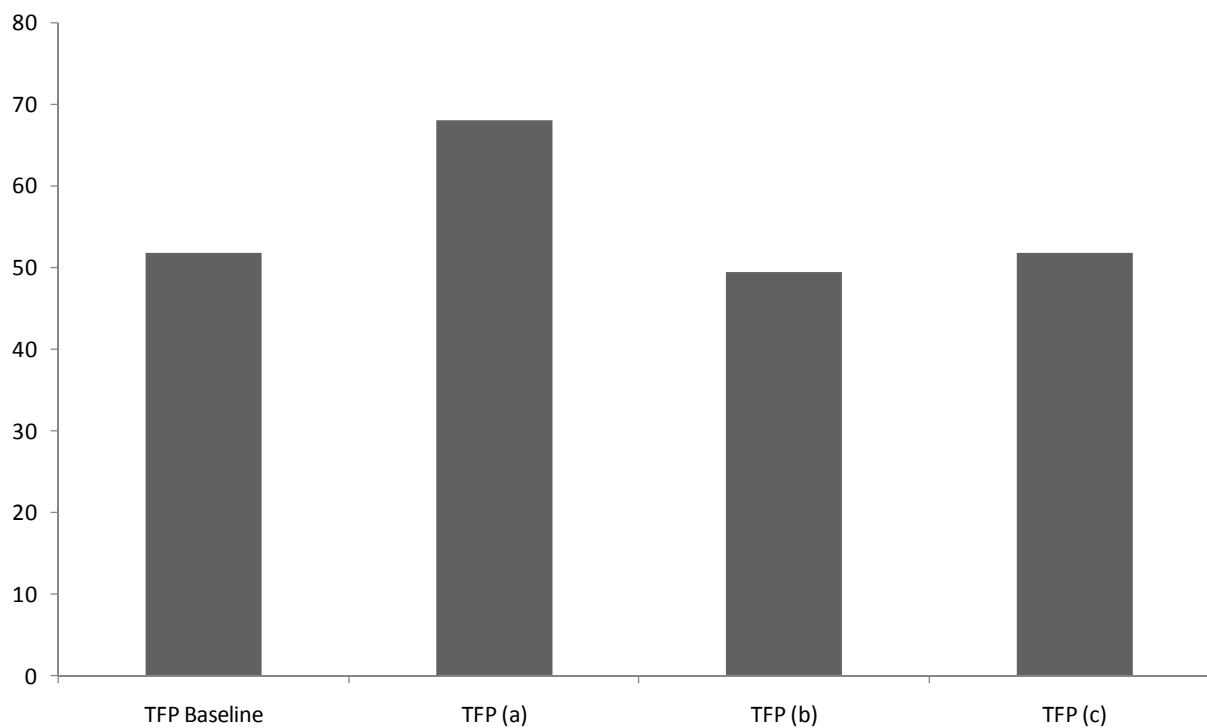


**Figure 14: Lack of productivity catch-up (index relative to U.S. 1960 = 1)**



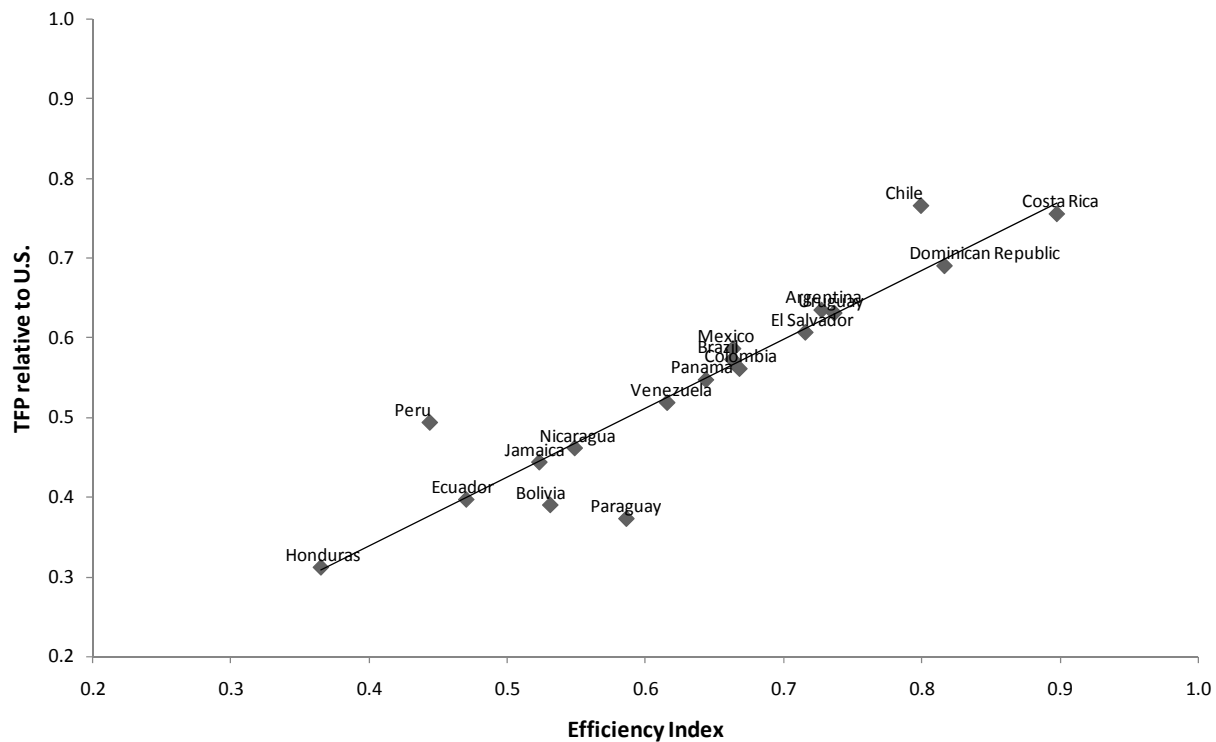
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 15: Relative TFP for LAC typical country (% relative to the U.S. in 2005)**



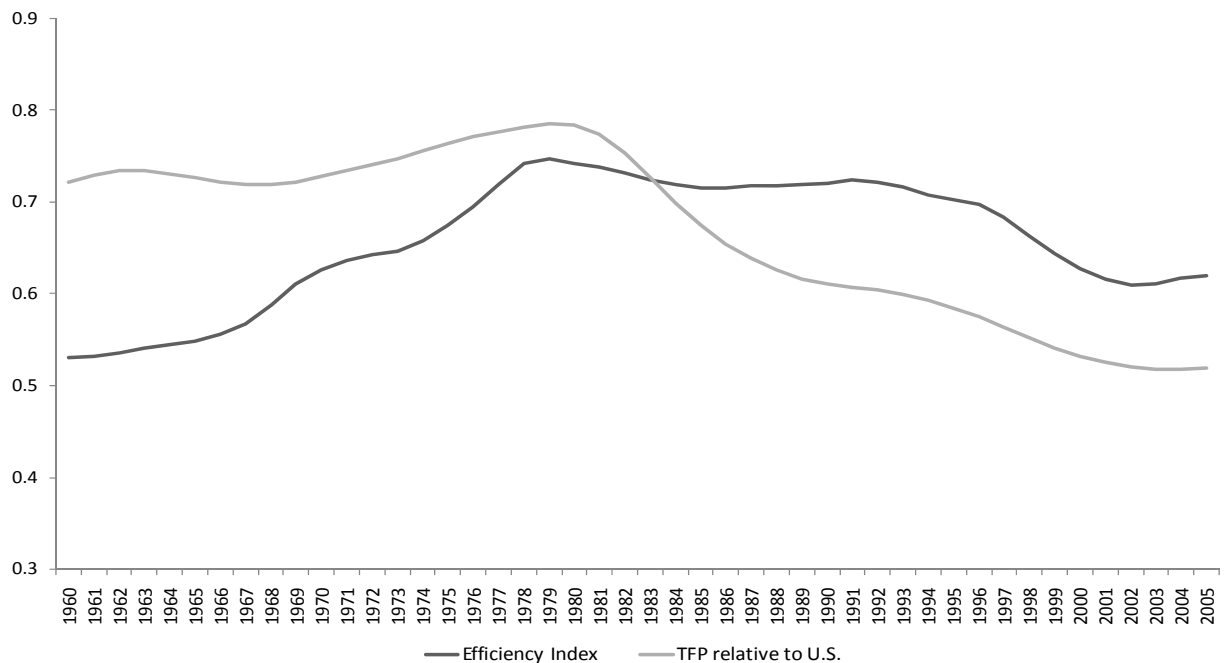
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 16: Relative TFP and Efficiency Index in 2005 in LAC countries**



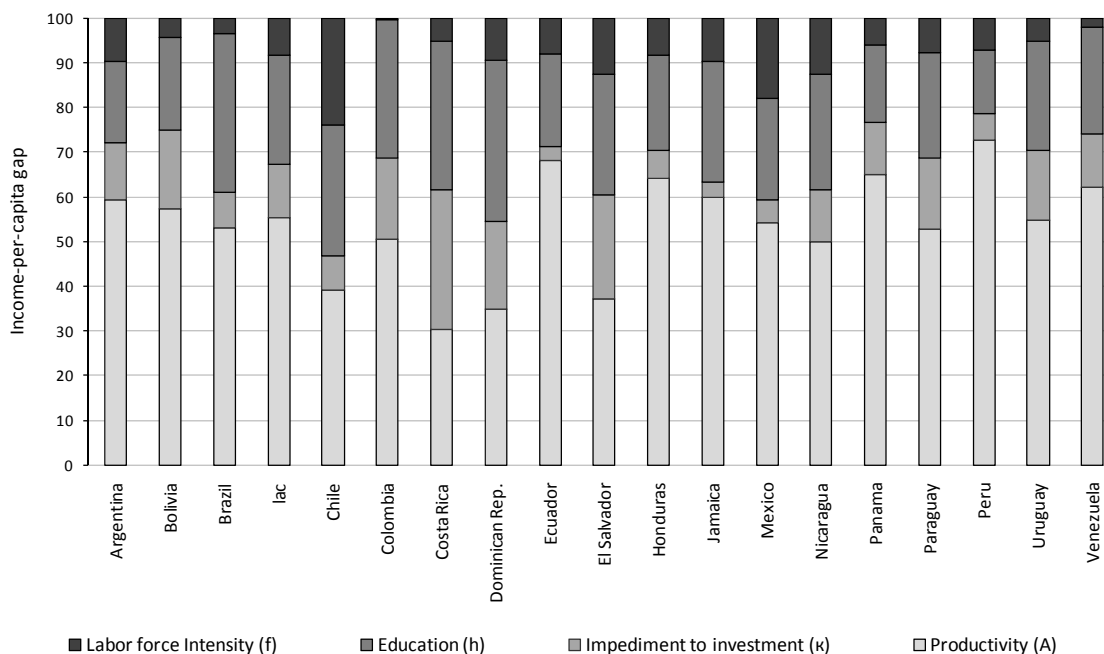
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 17: Relative TFP and Efficiency Index for the typical LAC country**



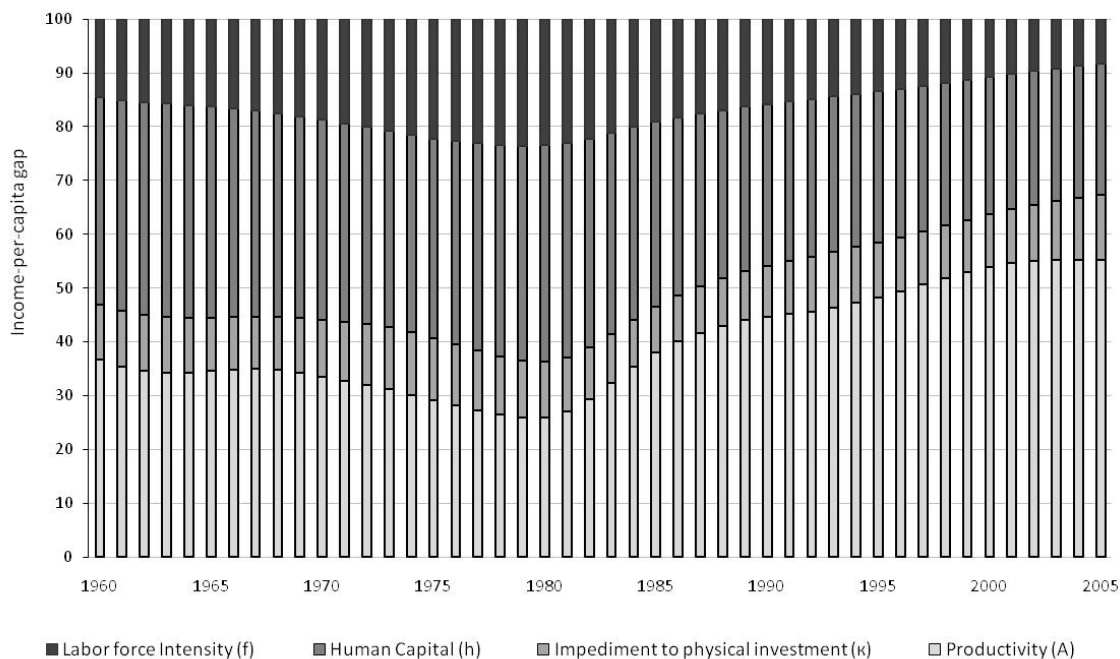
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000).

**Figure 18: Overall contribution of closing the income per capita gap versus the U.S.  
(endogenous K, 2005)**



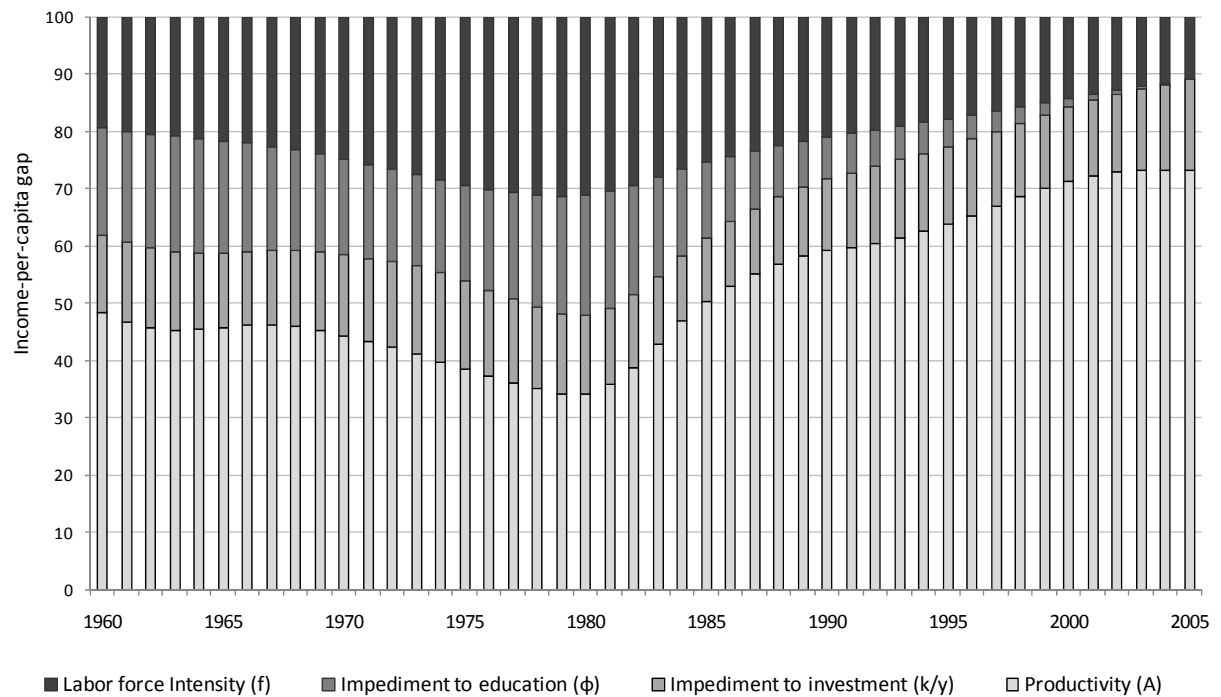
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

**Figure 19: Contributions to income per capita gap LAC typical country versus U.S.  
(endogenous physical capital)**



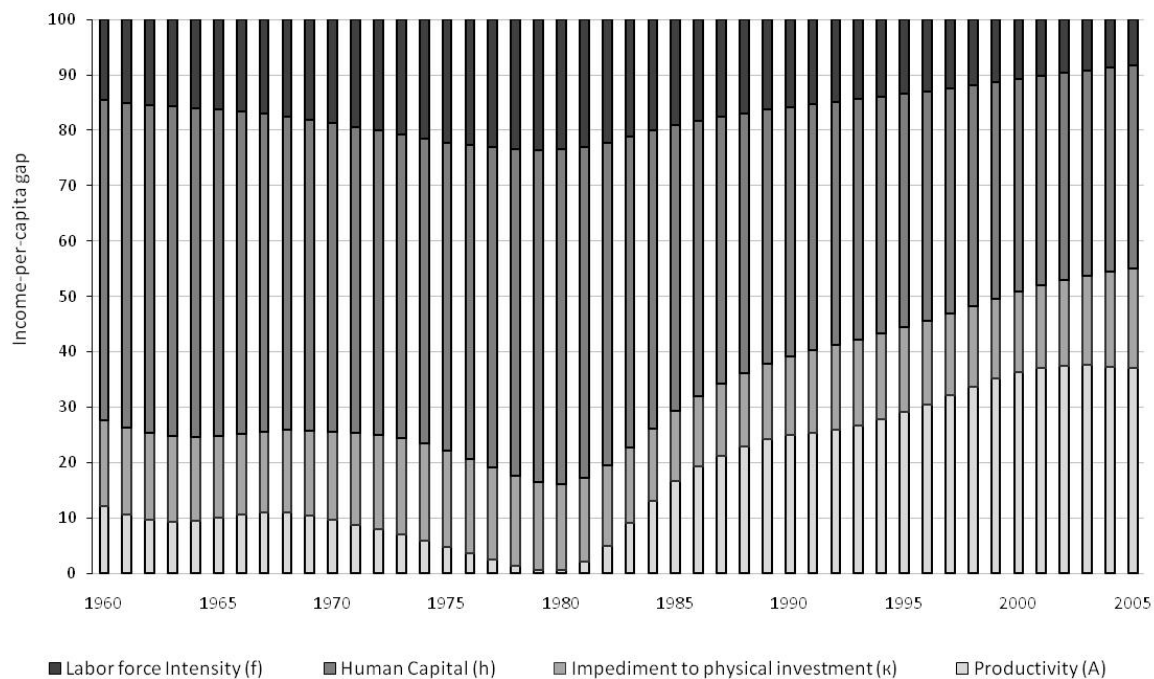
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

**Figure 20: Contributions to income per capita gap LAC typical country versus U.S.  
(endogenous physical and human capital, 2005)**



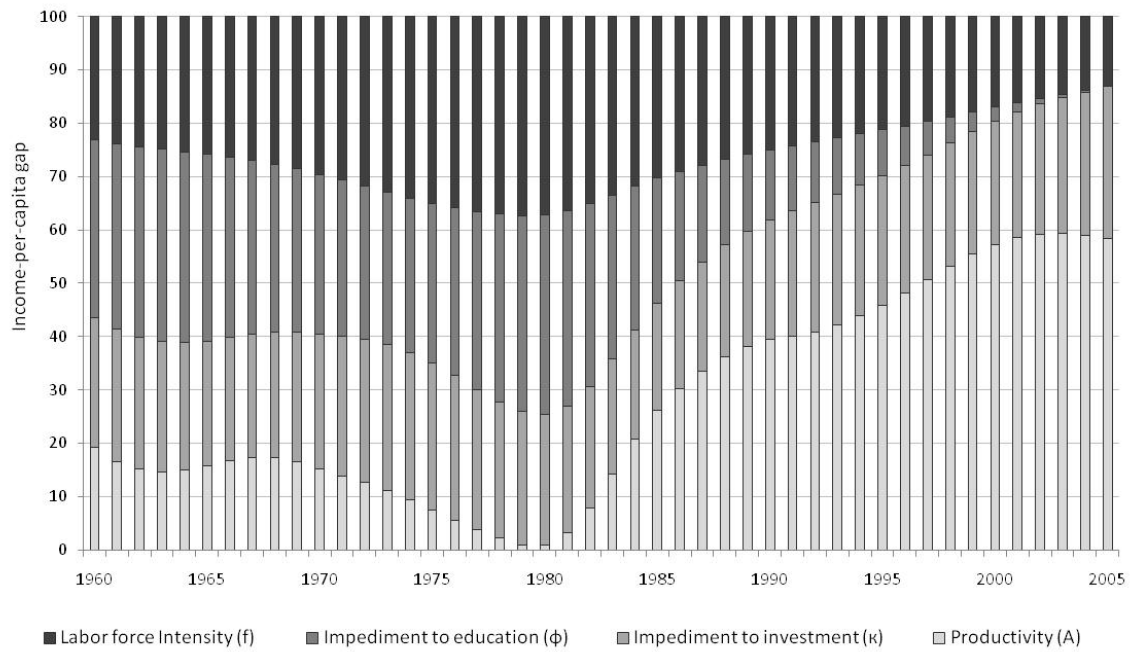
Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

Figure 21: Contributions to income per capita gap LAC typical country versus U.S. (endogenous TFP and physical capital)



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

**Figure 22: Contributions to income per capita gap LAC typical country versus U.S. (endogenous TFP, physical and human capital)**



Source: Author's calculations based on Heston, Summers and Aten (2006), World Bank 2008 and Barro-Lee database 2000.

**Table 1. Sample**

Argentina	Hong Kong	New Zealand
Australia	Honduras	Pakistan
Austria	Hungary	Panama
Belgium	Indonesia	Peru
Benin	India	Philippines
Bolivia	Ireland	Papua New Guinea
Brazil	Iran	Portugal
Canada	Israel	Paraguay
Chile	Italy	Senegal
China	Jamaica	Singapore
Cameroon	Jordan	Sierra Leone
Colombia	Japan	El Salvador
Costa Rica	Kenya	Sweden
Denmark	Korea, Republic of	Syria
Dominican Republic	Sri Lanka	Togo
Algeria	Lesotho	Thailand
Ecuador	Mexico	Tunisia
Egypt	Mali	Turkey
Spain	Mozambique	Uganda
Finland	Malawi	Uruguay
Fiji	Malaysia	United States
France	Niger	Venezuela, RB
United Kingdom	Nicaragua	South Africa
Germany	Netherlands	Zambia
Ghana	Norway	
Greece	Nepal	

**Table 2. Latin American Relative Impoverishment and Productivity Growth**

	Rest of the World	East Asia	Twin Countries	Developed Countries	U.S.
Income per capita gap (cumulative growth %)	35.1	79.0	47.5	47.9	35.9
TFP gap (cumulative growth %)	32.1	58.6	33.3	40.2	28.1
TFP gap (as percentage of income per capita gap)	89.7	56.4	63.0	78.8	74.4

*Source:* Authors' calculations based on Heston, Summers and Aten (2006), World Bank (2008), Barro and Lee (2000)..