FUNDAÇÃO GETULIO VARGAS

EPGE

Escola de Pós-Graduação em Economia

Ensaios Econômicos

Escola de Pós-Graduação em Economia da Fundação Getulio Vargas

N° 548 ISSN 0104-8910

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Junho de 2004

URL: http://hdl.handle.net/10438/871

A. Veloso, Fernando
The evolution of international output differences (1960-2000): From factors to productivity/ Fernando A. Veloso, Pedro Cavalcanti Gomes Ferreira, Samuel de Abreu Pessoa - Rio de Janeiro : FGV,EPGE, 2010
(Ensaios Econômicos; 548)

Inclui bibliografia.

CDD-330

The Evolution of International Output Differences (1960-2000): from Factors to Productivity*

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June 2004

Abstract

This article presents a group of exercises of level and growth decomposition of output per worker using cross-country data from 1960 to 2000. It is shown that at least until 1975 factors of production (capital and education) were the main source of output dispersion across economies and that productivity variance was considerably smaller than in late years. Only after this date the prominence of productivity started to show up in the data, as the majority of the literature has found. The growth decomposition exercises showed that the reversal of relative importance of productivity vis-a-vis factors is explained by the very good (bad) performance of productivity of fast (slow) growing economies. Although growth in the period, on average, is mostly due to factors accumulation, its variance is explained by productivity.

1 Introduction

It is a well known fact that differences of output per worker across countries are very high. For example, in 2000 the average worker in the U.S. produced 33 times more than a worker in Uganda, 10 times more than one in India, and almost twice as much as one in Portugal.

Understanding the nature of output-per-worker differences across countries should be one of the main objectives of the literature of economic growth, since the level of output

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per worker of a given country can be thought of as the result of its cumulative growth experience. Several authors have decomposed output per worker into the contribution of inputs and productivity, using different methods. In the early nineties, a few studies, e.g., Mankiw, Romer and Weil (1992) and Mankiw (1995) presented evidence that factors of production account for the bulk of income differences across countries.[1] Recent papers by Klenow and Rodriguez-Clare (1997), Prescott (1998), Hall e Jones (1999) and Easterly and Levine (2001), among others, however, have established what now seems to be a consensus that total factor productivity is more relevant than factors of production in explaining output differences.

This paper takes development decomposition seriously. We redo the main exercises of the literature for all years between 1960 and 2000 (and not only for one single year, which is 1985 or some year later in most articles in the literature). We use a neoclassical production function with a Mincerian (e.g., Mincer (1974)) formulation of schooling returns to skills to model human capital.

It turns out that the picture for earlier years is very different from the one that emerged from the literature. From 1960 to as late as 1975 factors are the main source of output per worker dispersion. By the mid-eighties, factors and productivity have roughly the same importance and from 1990 on productivity explains the bulk of international differences in output per worker. By 1960 the correlation of productivity with output per worker (in log terms) is 0.22, whereas the correlation of the latter with factor inputs is 0.71. Forty years later, the correlation of output per worker with productivity jumped to 0.74, while its correlation with factors did not change significantly.[2]

The relevant question, thus, is how one goes from a world where, at least until 1975, differences in output levels are largely due to differences in physical and human capital, to one where productivity plays the leading role. Our results show that one important reason is that there was a strong process of convergence of factors of production, and of the capital-output ratio in particular. Specifically, the variance of factors of production was nearly cut in half between 1960 and 2000.

Another way to tackle this question is via growth decomposition exercises for the sample countries. The results show that the increase in the capital-output ratio and the educational

[1] The view that factors of production, and physical capital in particular, are the main determinants of differences in output per worker across countries has been labelled in the literature either as "capital fundamentalism" (e.g., King and Levine (1994)) or "neoclassical growth revival" (e.g., Klenow and Rodriguez-Clare (1997)).

[2] In 1960, the correlation of output per worker with the capital-output ratio and human capital per worker was equal to 0.57 and 0.72, respectively. By 2000, the correlation of output per worker with the capital-output ratio and human capital was equal to 0.61 e 0.86, respectively, whereas its correlation with factor inputs (capital-output ratio and human capital combined) was 0.79.

level of the labor force explain the *mean* growth of output per worker from 1960 to 2000, while the behavior of productivity explains the *variance* of growth rates in the period. In particular, inputs explain 80% of the growth of output per worker, whereas productivity explains 129% of the variance of the growth rate of output per worker.[3] That is, capital deepening and human capital accumulation are general phenomena experienced by most countries. However, good (bad) growth performance is, in great measure, explained by high (low) productivity growth. In conjunction with the convergence of factors of production, this is the main reason behind the change in the pattern of income level decomposition.

Some particular experiences are helpful in the understanding of this fact. In 1960, productivity in Latin America was very close to that of the leading economies, a fact often neglected in the literature. It was, on average, 182% higher than average productivity of the "Asian Tigers"[4]. Forty years later, after having fallen 9%, productivity in Latin America was way below that of the industrial economies and 33% smaller than the average level of the Asian Tigers. At the same time, as a group, the Latin American economies had the second worst productivity growth record in the world. In contrast, productivity in the East Asian economies grew at an annual rate which is almost 3 percentage points above the world average. Not surprisingly, these countries are among the fastest growing economies in the period. In other words, growth miracles (disasters) are mostly productivity miracles (disasters).

The paper is organized in five sections in addition to this introduction. In the next section we present the methodology of all exercises, the data and calibration procedures. Section 3 presents the results of the level decomposition exercises and Section 4 those of the growth accounting exercises. Section 5 further explores these results and discuss the performance of Latin America and fast growing Asian economies. Section 6 concludes.

2 Model Specification, Data and Calibration

2.1 Model

Let the production function be given by:

$$Y_{it} = K_{it}^{\alpha}(A_{it}L_{it}H_{it})^{1-\alpha}, \tag{1}$$

[3]The variance of productivity growth may exceed the variance of the growth rate of output per worker due to the negative covariance between factors and productivity growth between 1960 and 2000. See Section 4 for details.

[4]Singapore, Korea, Hong Kong, Japan, Thailand and Taiwan.

where Y_{it} is the output of country i at time t, K stands for physical capital, H is human capital (education) per worker, L is raw labor and A is labor-augmenting productivity. Notice that, in this specification, total factor productivity (TFP) is given by $A_{it}^{1-\alpha}$.

We use a Mincerian (e.g., Mincer (1974) and Willis (1986)) formulation of schooling returns to skills to model human capital, H. There is only one type of labor in the economy with skill level determined by its educational attainment. It is assumed that the skill level of a worker with h years of schooling is $H = \exp \phi(h)$ greater than that of a worker with no education, leading to the following homogeneous-of-degree-one production function:

$$Y_{it} = K_{it}^{\alpha}(A_{it}L_{it}e^{\phi(h_{it})})^{1-\alpha}.$$

Our first objective is to understand the relative contribution of inputs and productivity to international differences of output per worker in each year of our sample. The main question here is if the prominent role played by productivity in recent periods is also a feature of previous years. In that sense, 41 variance-decomposition exercises, for the years from 1960 to 2000, are performed. We follow Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), among others, rewriting the per worker production function in terms of the capital-output ratio. This formulation allows decomposing the variation of output per worker into variations of productivity, human capital, and the capital-output ratio. In this sense, the production function is rewritten as:

$$y_{it} = \frac{Y_{it}}{L_{it}} = A_{it}\left(\frac{K_{it}}{Y_{it}}\right)^{\frac{\alpha}{(1-\alpha)}} e^{\phi(h_{it})} = A_{it}\kappa_{it}^{\frac{\alpha}{(1-\alpha)}} e^{\phi(h_{it})}, \quad (2)$$

where κ is the capital-output ratio. Taking logs of (2):

$$\ln y_{it} = \ln A_{it} + \frac{\alpha}{1-\alpha} \ln \kappa_{it} + \phi(h_{it}). \quad (3)$$

Our second objective is to study the relative contribution of factors and productivity to the growth performance of countries. We start from expression (3) above to obtain the following growth decomposition expression between two arbitrary periods:

$$\Delta \ln y = \Delta \ln A + \frac{\alpha}{1-\alpha} \Delta \ln \kappa + \Delta\phi(h), \quad (4)$$

where Δ is the variation in a given variable between two periods. The relative contribution

of, say, productivity to the growth of output per worker is trivially given by:

$$\frac{\Delta \ln A}{\Delta \ln y},$$

The advantage of the decomposition above with respect to the traditional growth accounting procedures is that the accumulation of capital induced by an increase in productivity will be rightly attributed to productivity growth. Moreover, this decomposition also allows us to assess to what extent the trajectory of a given economy reflects transitional dynamics or a balanced growth trajectory. In particular, the neoclassical model predicts that, in balanced growth, the relative importance of capital deepening is null, that is:

$$\frac{\frac{\alpha}{1-\alpha}\Delta \ln \kappa}{\Delta \ln y} = 0,$$

Hence, depending on the value of the expression above we can assess how far or how close any given economy is from a balanced growth path.

2.2 Calibration and data

The specification of the function $\phi(h)$ takes into account international evidence (e.g., Psacharopoulos (1994)) of a positive and diminishing relationship between average schooling and return to education. Hence, instead of the more usual linear return to education we follow Bils and Klenow (2000) and set the ϕ function as:

$$\phi(h) = \frac{\theta}{1-\psi} h^{1-\psi}. \tag{5}$$

According to their calibration, we have $\psi = 0.58$ and $\theta = 0.32$. In addition to these parameters we need to set the values of α and δ, the depreciation rate used to construct the capital series. For α, we use 0.40: estimates in Gollin (2002) of the capital share of output for a variety of countries fluctuate around this value, a number also close to that of the American economy according to the National Income and Product Accounts (NIPA).

We use the same depreciation rate for all economies, which was calculated from US data. We employed the capital stock at market prices,[5] investment at market prices, I, as well as

[5] See Fraumeni (1997) for details on the methodology used in the NIPA for the estimation of the US capital stock. The basic idea is to use past investment data and secondary market prices, at a high disaggregation level, to calculate the value of different types of capital. The total capital stock at market prices is obtained as the result of the aggregation of these series.

the law of motion of capital to estimate the implicit depreciation rate according to:

$$\delta = 1 - \frac{K_{t+1} - I_t}{K_t}.$$

From this calculation, we obtained $\delta = 3.5\%$ per year (average of the 1950-2000 period).

We used data for 83 countries during the period 1960-2000.[6] Data on output per worker and investment rates were obtained from the Penn-World Tables (PWT), version 6.1.[7] We used data on the average educational attainment of the population aged 15 years and over, interpolated (in levels) to fit an annual frequency, taken from Barro and Lee (2000).

The physical capital series is constructed with real investment data from the PWT using the Perpetual Inventory Method. In this case we need an estimate of the initial capital stock. We approximate it by $K_0 = I_0/[(1+g)(1+n) - (1-\delta)]$, where K_0 is the initial capital stock, I_0 is the initial investment expenditure, g is the rate of technological progress and n is the growth rate of the population.[8] In this calculation it is assumed that all economies were in a balanced growth path at time zero, so that $I_{-j} = (1+n)^{-j} (1+g)^{-j} I_0$. To minimize the impact of economic fluctuations we used the average investment of the first five years as a measure of I_0. When data was available we started this procedure taking 1950 as the initial year in order to reduce the effect of K_0 in the capital stock series.[9] We obtained the rate of technological progress by adjusting an exponential trend to the U.S. output per worker series, correcting for the increase in the average schooling of the labor force and obtained g =1.53%. The population growth rate, n, is the average annual growth rate of population in each economy between 1960 and 2000, calculated from population data in the PWT.

In order to compute the value of A_{it}, we use the observed values of y_{it} and the constructed

[6] See the Appendix for a list of the countries included in the sample. For some countries, we do not have data for either 1960 or 2000, but they were still included. In particular, we used 1961 as the initial year for Tunisia. For a few countries, we used a year other than 2000 as the last year, namely Cyprus (1996), Congo (1997), Central African Republic and Taiwan (1998), Guyana, Papua New Guinea, Fiji and Botswana (1999).

[7] For more details on this version of the Penn-World Table, see Heston, Summers and Atten (2002).

[8] This is the discrete time version of the formula used in King and Levine (1994) and Hall and Jones (1999), among others.

[9] For some economies this procedure to calculate the initial capital stock in 1950 yields capital-output ratios far above the observed ratio in the US. At the same time the marginal productivity of capital is very low when we use this measure of the initial capital stock. This results from the fact that Japan and several countries in Continental Europe had very high investment rates in the early fifties, due to the reconstruction effort after the Second World War. In these cases we constructed an alternative measure of K_0 so that the marginal productivity of capital in 1950 was 20% above that of the U.S.. This value of the $PMgK$ seems high enough in order to be consistent with the investment rates observed in the post-war period and prevents the capital-output ratio from declining in some countries. The results are qualitatively similar to the ones reported in the text. Some results based on this measure are reported in the Appendix.

series of κ_{it} and H_{it} so that the productivity of the i-th economy at time t was obtained as:

$$A_{it} = \frac{y_{it}}{\kappa_{it}^{\frac{\alpha}{1-\alpha}} H_{it}}. \tag{6}$$

Using the constructed values of κ_{it}, we can also compute the marginal product of capital as:

$$MgPK_{it} = \frac{\alpha}{\kappa_{it}}. \tag{7}$$

3 Development Accounting

In this section we perform development accounting exercises, based on variance decompositions of output per worker for each year from 1960 to 2000. In most of our calculations we follow Klenow and Rodriguez-Clare (1997) and compare the contribution of X, a composite of the two factors (i.e., $X_{it} = \kappa_{it}^{\frac{\alpha}{1-\alpha}} e^{\frac{\theta}{1-\psi}} h_{it}^{1-\psi}$), with that of productivity. From (3), we have:

$$\ln y_{it} = \ln A_{it} + \ln X_{it}. \tag{8}$$

However, as opposed to these authors, we decompose the variance of $\ln(y)$ according to its mathematical expression, allowing for a covariance term between factors and productivity:

$$var(\ln y_{it}) = var(\ln A_{it}) + var(\ln X_{it}) + 2cov(\ln A_{it}, \ln X_{it}). \tag{9}$$

This is important in the present context because, as we will see shortly, the covariance component has a marked change of behavior in the period, so that leaving it out would imply discarding an important piece of information about the nature of output dispersion.[10] Figure 1 displays, for each year of our sample, the participation of the 3 components of the variance of (the log of) output per worker. Table 1 presents the values of all the components of expression (9) at five-year intervals.

Figure 1 and Table 1 reveal a number of interesting facts. First, output per worker dispersion increases throughout the period, especially in the nineties. In particular, the variance of (the log of) y increased from 0.84 in 1960 to 1.11 in 1990 and 1.32 in 2000. Second, there is a continuous reduction of the absolute importance of factors in accounting for output dispersion. Between 1960 and 2000, the variance of (the log of) X declines nearly

[10] The variance decomposition formula used by Klenow and Rodriguez-Clare (1997) is given by $var(\ln y_{it}) = cov(\ln y_{it}, \ln A_{it}) + cov(\ln y_{it}, \ln X_{it})$. In terms of (9), this amounts to dividing the covariance term $cov(\ln A_{it}, \ln X_{it})$ equally between the variance terms, $var(\ln A_{it})$ and $var(\ln X_{it})$. In the Appendix, we present results for this variance decomposition.

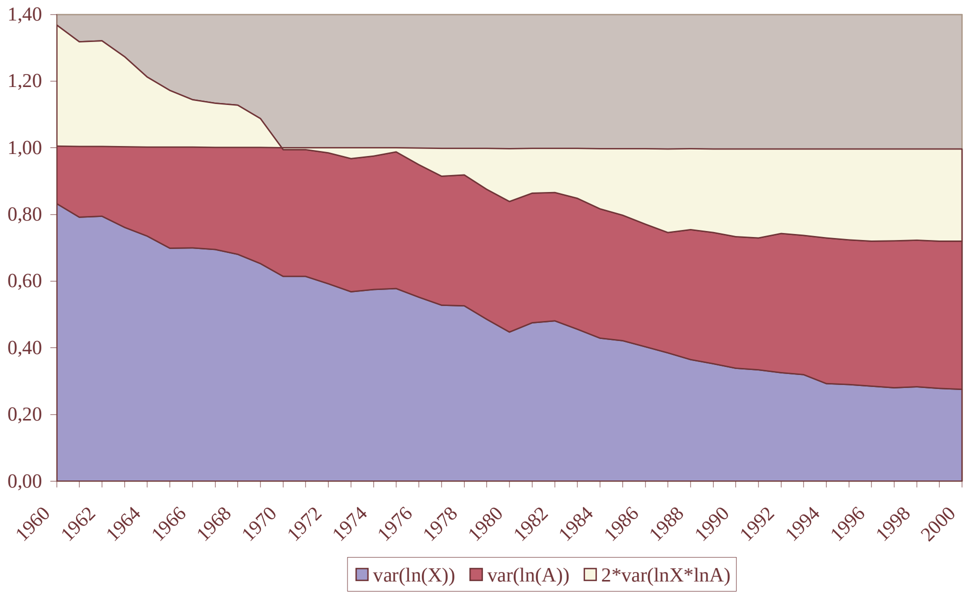

Figure 1: Output per worker variance decomposition - 1960-2000

50%, from 0.70 to 0.36. Hence, while it is observed a strong process of output divergence, factor levels converged.

Table 1: Variance Decomposition 1960-2000

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2covar($\ln X, \ln A$)
1960	0.84	0.70	0.45	-0.31
1965	0.89	0.63	0.42	-0.15
1970	0.92	0.56	0.35	0.01
1975	0.93	0.54	0.38	0.01
1980	0.99	0.44	0.39	0.16
1985	0.99	0.42	0.37	0.20
1990	1.11	0.38	0.44	0.29
1995	1.25	0.36	0.54	0.34
2000	1.32	0.36	0.59	0.36

Third, the variance of $\ln A$ is relatively stable until 1990. By 2000, however, its value was 31% larger than its value in 1960. As a result of the previous two facts, the relative importance of factors in accounting for the variance of output per worker fell considerably during the period. In 1960 the contribution of the variance of factors of production to

the variance of output per worker was 55% higher than that of productivity. By the mid-eighties the variance of factors and productivity had roughly the same importance, whereas in 2000 factors variance was 39% smaller. It should be noted that in 1985 X and A had approximately the same importance as sources of output per worker dispersion.

Finally, the covariance between factors and productivity increases continually. As a matter of fact, it changes signs, going from from -0.15 to 0.18 throughout the period. This means that in 1960 those economies that displayed high productivity were not necessarily those with high factors endowment, but by 2000 productivity, capital intensity and education were positively correlated across countries.

Figures 2 and 3 display productivity levels, relative to the US, plotted against relative output per worker in 1960 and 2000. As the figures show, the relationship between the two variables is much weaker in 1960 than in 2000. Specifically, the coefficient of a simple OLS regression of relative productivity on relative output per worker is only 0.05 ($R^2 = 0.0005$) in 1960, whereas in 2000 the regression coefficient is 0.76 ($R^2 = 0.47$).[11]

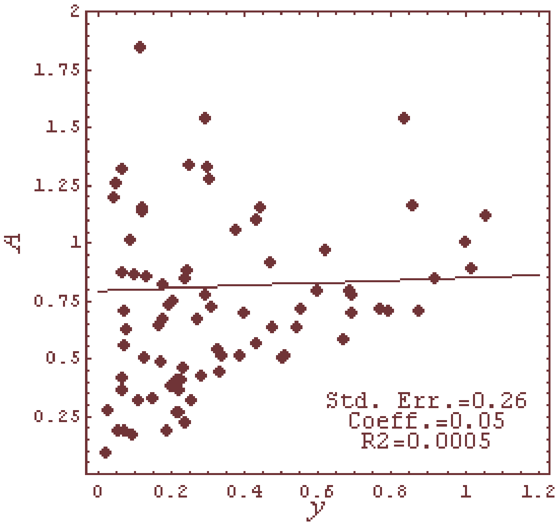

Figure 2: 1960

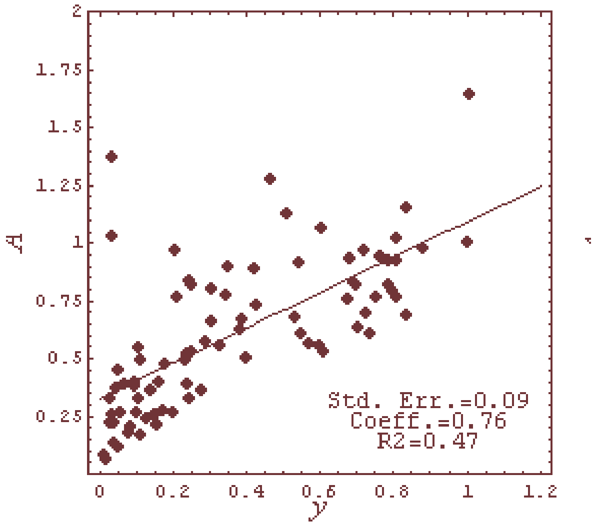

Figure 3: 2000

The picture that emerges from the results above is one where in 1960 the variability of productivity was lower and that of factors was higher. In contrast, throughout the period, there was a strong process of convergence of factors of production. Moreover, especially after the mid-eighties, the variability of productivity increased. This result, in a certain sense, qualifies the literature on international differences in levels of output (Klenow and

[11] In 1975, the cross-country relationship between relative productivity and relative output per worker is weak. In particular, the regression coefficient is 0.34 ($R^2 = 0.05$). This suggests that the result that this relationship became stronger over time is not an artifact of the method we used to construct the initial capital stock.

Rodriguez-Clare (1997), Prescott (1998), Hall and Jones (1999) and Easterly and Levine (2001), among others), whose main finding is that productivity differences account for the bulk of the dispersion of output per worker across countries. We find that this is a recent fact: in 1960 quite the opposite occurred, and factors, not productivity, explained most of the output per worker variation.

Take for instance the BK3 decomposition of Table 2 in Klenow and Rodriguez-Clare (1997). It was calculated using 1985 data and the production function and human capital formulation were similar to the one we use. They found that factors explained 53% of output per worker variance and productivity the remaining 47%. If we use the variance decomposition formula used by theses authors, we obtain very similar results. Specifically, the relative importance of X and A in 1985 were equal to 52% and 48%, respectively (see the Appendix for the calculations).[12] However, the result is very different when we use 1960 data: 64% of the output variance is explained by factors. This result is reversed in 2000, when productivity accounts for 58% of output per worker dispersion.

It should be noticed that there is nothing essentially wrong with previous results. Our point is that one cannot generalize them to early years. The relevant question is how one goes from a world where, at least until 1975, differences in output levels are largely due to differences in physical and human capital, to one where productivity plays the leading role. This is what we investigate in the next section.

4 Growth Accounting

In this section we investigate the contribution of the various components of the production function to the growth experience, from 1960 to 2000, of 83 economies. We use equation (4), so that the variation of the log of output per worker in the period is decomposed into the contribution of productivity,[13] the capital-output ratio and human capital per worker.

In our sample average output per worker went from US\$ 7,127 in 1960 to US\$ 14,683 in 2000, growing 106% in the period.[14] Throughout this paper all results for averages of a given variable among countries were obtained from geometric averages of the given variable across the relevant group of countries. Table 2 presents some descriptive statistics using 1960 and 2000 figures (we set $A = 100$ for the US in 1960):

[12] If we take BK4 in Table 2 of Klenow and Rodriguez-Clare (1997) instead, the contribution of factors and productivity in 1985 are 34% and 66%, respectively, which are closer to our results in 2000.

[13] As mentioned above, it should be noticed that $TFP = A^{1-\alpha}$. However, in the growth decomposition, the contribution of TFP is given by the (log) variation of A, which captures both the direct and indirect (via capital accumulation) effect of TFP on the growth rate of output per worker.

[14] All figures are in 2000 values, corrected for PPP.

Table 2: descriptive statistics (1960-2000)

	y_{60}	y_{00}	A_{60}	A_{00}	κ_{60}	κ_{00}	h_{60}	h_{00}
sample average	US$ 7,127	US$ 14,683	58	67	1.69	2.24	2.9	6.1

In the last forty years mean productivity increased by 15,4%. On average, economies became more capital intensive, with an increase in the capital-output ratio of 33%. It was also observed a vigorous increase in education which jumps, on average, from 2.9 years in 1960 to 6.1 years in 2000.

In order to further understand the role of productivity and factors on the international development process, another set of stylized facts is presented in Table 3. We divide the economies in 5 groups, according to their growth rates of output per worker: in the economic "Miracles" group (15 economies) the growth rate of output per worker ranged from 3.28% to 6.12% per year, in the "Fast Growth" group (14 economies), it ranged from 2.39% to 3.18%; in "Medium Growth" (22 economies), from 1.46% to 2.07%; in "Slow Growth" (19 economies), from 0.61% to 1.45% and in the economic "Disasters" group (14 economies), the average growth rate ranged from -3.25% to 0.44% per year. This procedure is somewhat arbitrary but it serves to our purpose of calling attention to different patterns of development across economies.

Table 3: annual growth rates (1960-2000)

country groups	y	A	H	κ	I/Y
Full Sample	1.84%	0.36%	1.00%	0.71%	15%
Miracles	4.36%	2.72%	1.14%	0.74%	20%
Fast Growth	2.72%	1.14%	1.06%	0.78%	19%
Medium Growth	1.80%	0.43%	0.97%	0.55%	18%
Slow Growth	0.96%	-0.18%	0.83%	0.47%	12%
Disasters	-0.59%	-2.41%	1.04%	1.16%	8%
correlation w/ y	100%	84%	23%	-4%	53%

note: I/Y in levels (cross time cross group geometric average)

The average capital-output ratio grew at 0.71% a year, while average productivity increased 0.36% annually. Table 3 shows that productivity growth increases monotonically with the average growth rate of output per worker. While for the "Miracles", productivity growth averaged 2.72% per year, for the "Disasters" the average growth of A was negative. In fact, the correlation between growth of output per worker and productivity growth was very large in the period (0.84).

The correlation of output per worker growth with the investment rate was relatively smaller, 53%, although average I/Y increases monotonically, across groups, with the growth rate. Moreover, the capital-output ratio raised in all groups, even in the "Disasters" economies (which experienced the highest growth of the capital-output ratio). In fact, the correlation between the growth rates of output per worker and the capital-output ratio is close to zero.[15] Table 3 also shows that average human capital increased 1.00% annually, but its correlation with y growth is small (23%). In fact, the growth rate of H is very similar across groups.[16]

Table 4: Growth Decomposition (1960-2000)

country groups	y	κ	H	A
Full Sample	1.84%	0.47%	1.00%	0.36%
		(26%)	(54%)	(20%)
Miracles	4.36%	0.49%	1.14%	2.72%
		(11%)	(26%)	(62%)
Fast Growth	2.72%	0.52%	1.06%	1.14%
		(19%)	(39%)	(42%)
Medium Growth	1.77%	0.37%	0.97%	0.43%
		(21%)	(55%)	(24%)
Slow Growth	0.96%	0.31%	0.83%	-0.18%
		(32%)	(86%)	(-19%)
Disasters	-0.59%	0.77%	1.04%	-2.41%
		(-130%)	(-176%)	(406%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

Table 4 presents the growth decomposition exercises for each group between 1960 and 2000. The first line of the table shows the important role played by factors to explain growth rates. On average, 80% of the observed growth of output per worker can be accounted by human and physical capital accumulation and only 20% is due to productivity growth.[17]

[15]This result is similar to the obtained by Klenow and Rodriguez-Clare (1997) for the period 1960-1985. They obtained a correlation of 0.04 between the growth rate of output per worker and the capital-output ratio.

[16]This result confirms the findings of Benhabib and Spiegel (1994) and Pritchett (2001).

[17]Independent research by Baier, Dwyer, Jr. and Tamura (2004) found a relative contribution of TFP for output per worker growth of 14%. Their study has several differences from ours. First, they use data for a larger sample of 145 countries, spanning more than a hundred years for 23 of those countries. Second, these authors use the standard growth decomposition formula in which the growth rate of output per worker is related to the growth rates of TFP, human capital per worker and physical capital per worker, instead of the capital-output ratio. Third, in most of their calculations they use weighted average growth rates, in which

Human capital alone accounts for 54% of output per worker growth.[18]

Notice, however, that the sample average hides a lot of information with respect to the behavior of different economies. In the faster growth group, the "Miracles" economies, 62% of output growth is explained by productivity growth. This number falls monotonically with the average growth rate in each group: it is 42% in the "Fast Growth" group, 24% for the "Medium Growers" and -19% for the "Slow Growers". For the "Disasters", the fall in productivity accounts for 406% of the decline in output per worker. In other words, economic miracles were productivity miracles. By the same token, poor performers in general, and disasters in particular, had a very bad record of productivity growth.

Results in Tables 3 and 4 allow us to conclude that the increase in the capital-output ratio and the educational level of the labor force explain the *mean* growth of output per worker,[19] while the behavior of productivity explains the *variation* of growth rates among groups.

Another way to assess the importance of productivity for growth differences between countries is to perform a decomposition of the variance of the growth rate of output per worker in terms of the variance of factors and productivity growth and the covariance between factors growth and A growth. Using (4), we can decompose the variance of output per worker growth as follows:

$$var\,(\Delta \ln y) = var(\Delta \ln A) + var(\Delta \ln X) + 2cov(\Delta \ln A, \Delta \ln X). \tag{10}$$

Table 5 presents the variance decomposition results for the growth rate of output per worker. The table shows that productivity growth accounted for the bulk of the variance of output per worker growth between 1960 and 2000. Specifically, the variance of A growth accounted for 129% of the growth variance, whereas the variance of factors growth accounted for only 35% of the dispersion of output per worker growth.[20]

the weights are the country's labor force in 2000 and the number of years for which data for the country is available. For the unweighted relative contribution of TFP they obtain a startling value of -109%, which to the best of our knowledge is inconsistent with all TFP studies for periods close to the one we consider in this paper.

[18] One should remember that we are accounting as a contribution of human capital to output per worker growth the increase in the capital-labor ratio due to the increase in the educational level of the labor force.

[19] The result is similar if we use the *median* instead of the *mean*. In particular, factors accumulation account for 69% of *median* output per worker growth between 1960 and 2000.

[20] Klenow and Rodriguez-Clare (1997) found that the variance of productivity growth explains between 86% and 91% of the variance of output per worker growth. The variance decomposition formula used by these authors is given by $var(\Delta \ln y) = cov\,(\Delta \ln y, \Delta \ln A) + cov\,(\Delta \ln y, \Delta \ln X)$. In terms of (10), this amounts to dividing the covariance term $cov(\Delta \ln A, \Delta \ln X)$ equally between the variance terms, $var\,(\Delta \ln A)$ and $var\,(\Delta \ln X)$. Using this formula, we obtain that the variance of A growth accounts for 97% of the variance of y growth between 1960 and 2000. In the Appendix, we present results for this variance decomposition.

Table 5: Variance Decomposition of Growth Rates

period	var($\Delta \ln y$)	var($\Delta \ln X$)	var($\Delta \ln A$)	2covar($\Delta \ln X, \Delta \ln A$)
1960-2000	0.51	0.18	0.66	-0.32
1960-1970	0.05	0.02	0.10	-0.07
1970-1980	0.07	0.04	0.12	-0.09
1980-1990	0.06	0.02	0.09	-0.05
1990-2000	0.05	0.02	0.08	-0.05

From Table 5 we can also observe a negative covariance between the growth rates of A and X between 1960 and 2000. In particular, the correlation between the growth rates of A and the capital-output ratio was -0.51 in this period. This negative correlation is observed in each decade and may indicate an overstatement of the contribution of κ to output per worker growth.[21]

Easterly (2001) documents the fact that in the period 1980-1998 median per capita income growth in developing countries was 0.0 percent, as compared to 2.5 percent in 1960-79. This occurred despite the fact that several variables that are supposed to enhance growth improved over the latter period, such as health, education, fertility, infrastructure and macroeconomic variables, including the inflation rate and the degree of real overvaluation of local currency. In order to assesss if this pattern is verified in our sample, we present in Table 6 growth accounting results for two subperiods: 1960-1980 and 1980-2000.[22]

Table 6 shows that there was in fact a significant growth slowdown after 1980. Specifically, average growth in the sample declined from 2.67% in 1960-1980 to 0.99% in 1980-2000. From the table we can also observe that the fall in productivity growth was the main culprit of the growth slowdown. In fact, for the whole sample A growth was positive until 1980 (1.05% per year) and became negative since then (-0.33% per year), whereas the growth rates of the capital-output ratio and human capital per worker declined much less. This pattern is also observed for all groups. In the period 1960-1980 only the disasters experienced negative

Baier, Dwyer, Jr. and Tamura (2004) also obtain the result that the variance of productivity (TFP) is more important than the variance of factors to explain the variation of growth rates.

[21] Klenow and Rodriguez-Clare (1997) obtain a correlation between the growth rates of A and κ of -0.42. See their paper and Pritchett (2000) for an explanation for this result based on an overstatement of the contribution of the capital-output ratio due to the fact that public investment is less efficient than private investment in generating physical capital from a given amount of investment. An alternative explanation based on the neoclassical growth model would be that a decrease in the growth rate of productivity would tend to increase the growth rate of the capital-output ratio in the transition to a new balanced growth path.

[22] Rodrik (1999) also documents that many countries experienced a growth collapse, but he dates the start of the growth slowdown to 1975 instead of 1980 as in Easterly (2001). Based on this, we also performed growth accounting exercises for the subperiods 1960-1975 and 1975-2000. The results are qualitatively similar to the ones reported in the text, and are available from the authors upon request.

A growth, whereas in the subsequent period the "Slow Growth" and "Medium Growth" countries also had an absolute decline in productivity.

Table 6: Growth Decomposition by Subperiods

	1960-1980				1980-2000			
country groups	y	κ	H	A	y	κ	H	A
Full Sample	2.67%	0.53%	1.09%	1.05%	0.99%	0.42%	0.91%	-0.33%
		(20%)	(41%)	(39%)		(42%)	(92%)	(-33%)
Miracles	4.93%	0.28%	1.26%	3.39%	3.78%	0.70%	1.03%	2.05%
		(6%)	(25%)	(69%)		(18%)	(27%)	(54%)
Fast Growth	3.58%	0.59%	1.14%	1.85%	1.86%	0.45%	0.98%	0.43%
		(16%)	(32%)	(52%)		(24%)	(53%)	(23%)
Medium Growth	2.47%	0.41%	1.04%	1.02%	1.08%	0.33%	0.90%	-0.15%
		(17%)	(42%)	(41%)		(30%)	(84%)	(-14%)
Slow Growth	1.96%	0.45%	0.91%	0.60%	-0.04%	0.16%	0.75%	-0.96%
		(23%)	(46%)	(31%)		(-374%)	(-1717%)	(2191%)
Disasters	0.48%	1.02%	1.16%	-1.70%	-1.71%	0.53%	0.93%	-3.17%
		(213%)	(241%)	(-354%)		(-31%)	(-54%)	(185%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

Summing up the results, capital deepening and human capital accumulation are general phenomena experienced by most countries. On the other hand, good (bad) growth performance is, in great measure, explained by high (low) productivity growth. In conjuntion with factors convergence, this is the main reason behind the change in the pattern of output per worker level decomposition documented in the previous section. In 1960, for historical reasons outside the scope of this article, inputs were the decisive difference between rich and poor countries. Between this date and the end of the century fast growers and most of the rich countries experienced a significant increase in productivity, while slow growers and many poor economies lagged behind or even reduced their productivity level, so that productivity variance increased significantly. Factors dispersion, in contrast, declined in the same period. Hence, in 2000 the relative contribution of productivity in explaining international income differences was vastly raised surpassing that of inputs.

5 The Performance of Cultural and Regional Groups

The role of institutions and cultural factors in the economic performance of countries has been the subject of an increasing number of studies in the fields of history and economics (e.g., North (1990), Engerman and Sokoloff (1994) and Acemoglu, Johnson and Robinson (2001), among many). In a way or another societies may choose or inherit sets of laws, institutions and social conventions that are more inductive to investment in business, technology and education and that perform better in protecting property rights and the fruits of these investments. In these countries, the incentives and productivity are higher, and so are investment and growth.

In this section countries are divided in broad groups on a cultural or geographical basis. We have two objectives with this. First, we would like to understand better the evolution of productivity in the period, and the proposed group division may shed some light on this subject. Second, this division reveals growth facts neglected in the literature that will allow us to provide evidence related to some important questions. For instance, we found that as late as 1975 Latin America productivity was high by international standards, that A growth subsequently was strongly negative and that most of the growth in the region between 1960 and 2000 was via factors accumulation. Countries in the region may have experienced transitional growth in that period, which has important implications in terms of their future growth trajectory.

We divided economies in 9 groups, which are presented in detail in the Appendix. They are Western Europe, South Europe, English (speaking), Asian Tigers, Middle East, South Asia, Latin America, Caribe and Sub-Saharan Africa.[23] The first group has 12 countries that comprise most of Western Europe, with exceptions such as Portugal and Spain (that belong, together with Greece, Cyprus and Turkey to "South Europe") and United Kingdom. The latter belongs to the "English" speaking group, which also has USA, New Zealand, Australia, Ireland and, less accurately, Canada. Asian Tigers are Singapore, Korea, Hong Kong, Japan, Thailand and Taiwan. There are 5 and 10 economies, respectively, in the next two groups and 18 in the Latin America, which also includes Caribbean countries that speak mostly Latin languages. The Caribe group contains only 4 countries and the Sub-Sahara contains 17. Table 7 presents averages and growth rates for some variables by cultural and regional groups (we still set $A = 100$ for the US in 1960).

Each cell displays cross-country geometric means of a given statistic in the group. We can observe that the Asian Tigers, on average, experienced an extraordinary growth of

[23] It should be mentioned that our sample of Sub-Saharan countries is very incomplete, as we did not include in our sample those economies for which data is available only after 1960.

productivity of 261% between 1960 and 2000. Whereas in 1960 the level of A for the Asian Tigers was only 33% of the correspondent value for "English Speaking" countries, by 2000 this ratio had increased to 76%. The big losers are Latin American economies and the Sub-Sahara region, with mean reductions of productivity of 16% and 39%, respectively. It should be noticed that this decline in productivity in Latin America occurred after 1975. The level of productivity in Latin America, at least until 1975, was close to the one observed in the advanced countries. In 1960 it corresponded to 79% of the level of A in the US, whereas in 1975 it had increased to 89%. By the end of the century, however, this ratio had shrinked to 45%.[24]

Table 7: Average levels and growth rates (1960-2000)

country groups	Δy_{60-00}	A_{1960}	A_{1975}	A_{2000}	ΔA_{60-00}	κ_{1960}	κ_{2000}	$\Delta\kappa_{60-00}$
English (speaking)	107%	81	103	129	59%	2.50	2.75	10%
Western Europe	140%	71	96	116	63%	3.43	3.93	15%
South Europe	267%	56	90	106	89%	2.34	3.02	29%
Asian Tigers	636%	27	55	98	261%	2.08	3.30	59%
Middle East	149%	86	117	103	19%	1.81	2.01	11%
South Asia	162%	58	58	62	6%	0.97	1.71	76%
Latin America	42%	79	103	66	-16%	1.67	2.11	26%
Caribe	87%	45	63	66	48%	2.70	2.33	-14%
Sub-Saharan Africa	26%	40	39	24	-39%	0.86	1.37	60%

With the exception of the Caribbean countries, in all groups the capital-output ratio increased in the period, with the South Asian countries experiencing the biggest boost in capital intensity. The Asian Tigers and Sub-Saharan countries experienced an increase in κ of 60%. There was an increase in the capital-output ratio even in groups, such as the "English Speaking" and Western Europe, where capital deepening in 1960 was relatively high by international standards. This result confirms that the period between 1960 and 2000 was characterized by widespread factors accumulation, now taking cultural or geographical factors as our standpoint.

As a result of the significant increase in the capital-output ratio, the real return on capital, as measured by the marginal product of capital,[25] declined substantially for all

[24] These results for Latin America are similar if we consider only the most populated countries in 2000 (Brazil, Mexico, Argentina, Colombia, Peru, Venezuela and Chile). Specifically, for this group of Latin American Countries, the values of A were 79 in 1960, 107 in 1975 and 72 in 2000.

[25] Pritchett (2000) argues that public investment is not measured correctly in the National Accounts, which may lead to an overestimation of the standard measures of the capital stock. In this case, our measure of $PMgK$ may not be capturing the marginal impact of capital on output, but instead the degree of efficiency

country groups between 1960 and 2000, converging toward a value between 10% and 22%, with the exception of the Sub-Saharan Countries, which still had a very high real return on capital in 2000 (39%). Figure 4 presents the evolution of $MgPK$ for selected groups throughout the period, using the measure constructed using (7).

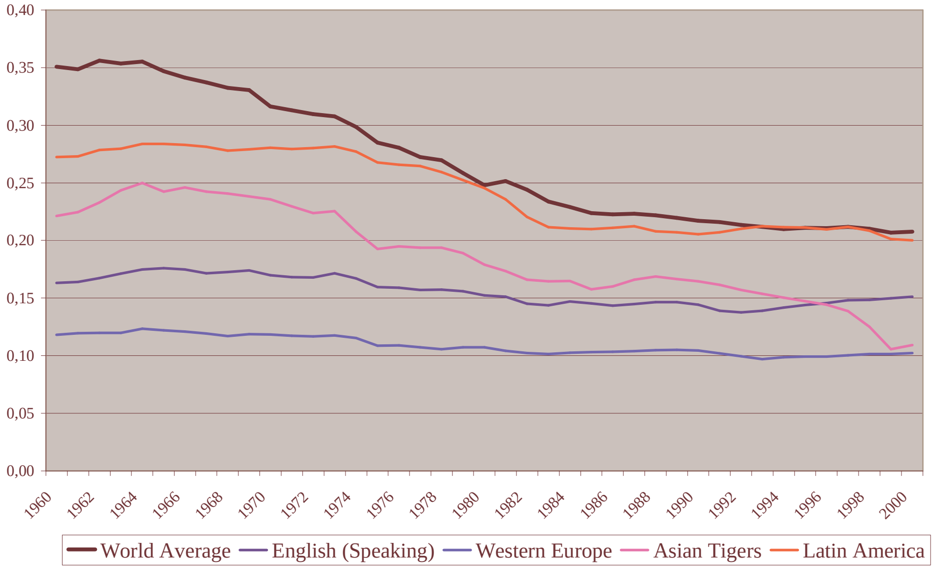

Table 8 summarizes the growth decomposition exercises for each group. The methodology is exactly the same as that of Table 4. In the first four groups, from one half to one third of the growth of output per worker is due to A growth. The contribution of productivity for output per worker growth is particularly high for the East Asian Tigers, both in absolute and relative terms, a point to which we shall return below. At the other extreme, Latin America and Sub-Saharan Africa experienced a fall in productivity throughout the period, which was offset by the contribution of factors to growth.

of the government in transforming investment into units of physical capital. In any case, $PMgK$ would still be a measure of the real return on investment.

Table 8: Growth Decomposition (1960-2000), Cultural and Regional Groups

country groups	y	κ	H	A
English (speaking)	1.82%	0.16%	0.51%	1.16%
		(9%)	(28%)	(64%)
Western Europe	2.17%	0.21%	0.72%	1.23%
		(10%)	(33%)	(57%)
South Europe	3.33%	0.40%	1.25%	1.68%
		(12%)	(37%)	(50%)
Asian Tigers	5.04%	0.78%	1.02%	3.24%
		(15%)	(20%)	(64%)
Middle East	2.29%	0.17%	1.68%	0.45%
		(7%)	(73%)	(19%)
South Asia	2.41%	0.95%	1.32%	0.14%
		(39%)	(55%)	(6%)
Latin America	0.87%	0.38%	0.93%	-0.45%
		(44%)	(107%)	(-51%)
Caribe	1.58%	-0.25%	0.84%	0.99%
		(-16%)	(53%)	(63%)
Sub-Saharan Africa	0.57%	0.80%	1.04%	-1.26%
		(140%)	(180%)	(-222%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

5.1 The Latin America Stagnation

The growth decomposition results for selected Latin American economies presented in Table 9 reveal that most countries in the region experienced a decline in productivity between 1960 and 2000, and consequently growth was mostly due to factors accumulation. One exception is Chile, which had a significant increase in A. On the other hand, the fall in productivity in Venezuela and Paraguay was particularly strong.

Table 9: Growth Decomposition (1960-2000)- Latin America

country groups	y	κ	H	A
Latin America average	0.87%	0.38%	0.93%	-0.45%
		(44%)	(107%)	(-51%)
Argentina	0.79%	0.39%	0.95%	-0.56%
		(50%)	(121%)	(-71%)
Brazil	1.71%	0.45%	0.78%	0.48%
		(26%)	(46%)	(28%)
Chile	1.91%	-0.42%	0.66%	1.66%
		(–22%)	(35%)	(87%)
Colombia	0.83%	0.07%	0.75%	0.02%
		(8%)	(90%)	(2%)
Costa Rica	0.67%	0.90%	0.65%	-0.88%
		(133%)	(97%)	(-130%)
Ecuador	1.45%	0.12%	1.06%	0.27%
		(8%)	(73%)	(19%)
Mexico	1.53%	0.53%	1.47%	-0.48%
		(35%)	(97%)	(-32%)
Paraguay	0.87%	1.41%	0.82%	-1.36%
		(162%)	(94%)	(-156%)
Uruguay	0.95%	-0.42%	0.61%	0.75%
		(-44%)	(65%)	(80%)
Venezuela	-0.88%	0.13%	1.23%	-2.25%
		(-14%)	(-139%)	(254%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

Moreover, the productivity deterioration was observed mainly in the last two decades of the sample, especially in the eighties,[26] when none of the economies of the region had positive A growth. In this decade A fell by 3.35% per year. In the following decade A fell by 0.74% annually in the region.[27] Figure 5 below presents the evolution of A for selected

[26]Among the reasons for the decline in productivity in Latin America in the 1970s and 1980s are the oil shocks in the 1970s, perhaps magnified in countries with significant social conflicts and poor institutions of conflict management, as argued in Rodrik (1999). Other possible reasons include the debt crisis in the 1980s and the growth slowdown of the developed countries, as argued in Easterly (2001).

[27]If we consider only the most populated Latin American countries, A fell by 3.37% annually in the eighties and was nearly stagnant in the nineties (a decrease of 0.17% per year).

countries, the region average and US productivity as a benchmark for comparison. As it is clear from the picture, the fall is dramatic in all but one case (Chile).

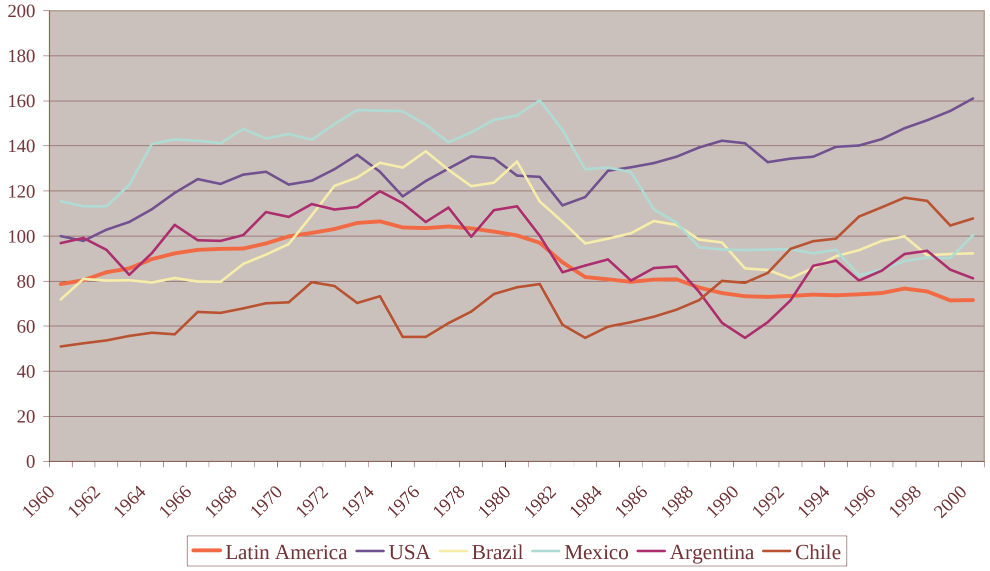

Figure 5: Productivity in Latin America, 1960-2000 (US, 1960=100)

From Table 9, it is clear that Latin America experienced transitory growth in the period (the capital-output ratio and human capital increased significantly even though A decreased). Moreover, the expansion of κ implied, in most countries, a decline in the marginal productivity of capital. In the case of Brazil, for instance, its level in 2000 is close to that of the U.S. (around 15%) when one could expect that, given Brazil's relative capital scarcity,[28] that it would be much higher. This result may help explain the puzzle posed by Lucas (1990) that capital does not flow from rich to poor countries despite the relative capital scarcity in the latter. Even though poor and middle-income countries have less capital per worker, their lower productivity and human capital stocks imply relatively high capital-output ratios and a low real return on capital.

These results may partly explain the disappointing growth performance of countries in the region after the structural reforms they passed through in the 1980s and 1990s:[29] past growth was mainly transitional and, for some reason, the policy reforms did not have a significant effect in productivity, at least until 2000. Hence, there was not enough stimulus to invest, as the return on capital was not much affected. In other words, given low growth

[28]The capital-labor ratio in Brazil in 2000 was one-third of its correspondent in the U.S.

[29]See Easterly, Loayza and Montiel (1997) for econometric evidence that, controlling for the worldwide growth slowdown in the 1990s, the response of economic growth to reforms in Latin America has not been disappointing.

in productivity and returns not much higher than that of the leading economies it is not surprising that investment did not accelerate and output recovery was frustrating. Of course, it may be the case that reforms impact A with a lag so that in the near future faster growth in the region may be observed.

5.2 The Asian Tigers Growth Miracle

In Table 10 we present growth decomposition results for the Asian Tigers. This table reinforces our conclusion that growth miracles were mainly productivity miracles. With the exception of South Korea, all countries in this group experienced a contribution of productivity growth higher than 50%.[30] Productivity growth was particularly strong in Hong Kong and Singapore, contributing for more than 80% of output per worker growth.

Table 10: Growth Decomposition (1960-2000) - Asian Tigers

country groups	y	κ	H	A
Asian Tigers average	5.04%	0.78%	1.02%	3.24%
		(15%)	(20%)	(64%)
Hong Kong	5.52%	-0.64%	1.09%	5.07%
		(-12%)	(20%)	(92%)
Japan	4.04%	1.46%	0.40%	2.18%
		(36%)	(10%)	(54%)
South Korea	5.27%	1.28%	1.70%	2.30%
		(24%)	(32%)	(44%)
Singapore	4.90%	0.09%	0.83%	3.97%
		(2%)	(17%)	(81%)
Taiwan	6.09%	1.23%	1.42%	3.45%
		(20%)	(23%)	(57%)
Thailand	4.41%	1.26%	0.70%	2.45%
		(29%)	(16%)	(56%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

[30] These results confirm the ones obtained by Klenow and Rodriguez-Clare (1997) and may seem at odds with the careful study by Young (1995), which showed that the East Asian Tigers (Hong Kong, Singapore, Taiwan and Korea) grew mostly through factor accumulation. As pointed out by Klenow and Rodriguez-Clare, the differences are mainly due to the fact that Young does not attribute to productivity the growth in physical capital induced by productivity, as we and Klenow and Rodriguez-Clare do. For a more thorough comparison of our results with Young (1995), see Ferreira, Pessôa and Veloso (2004).

Figure 6 below presents the evolution of A for the Asian Tigers and the region average. The figure shows that, as opposed to what occurred in Latin America, productivity continued to grow strongly after 1975.[31]

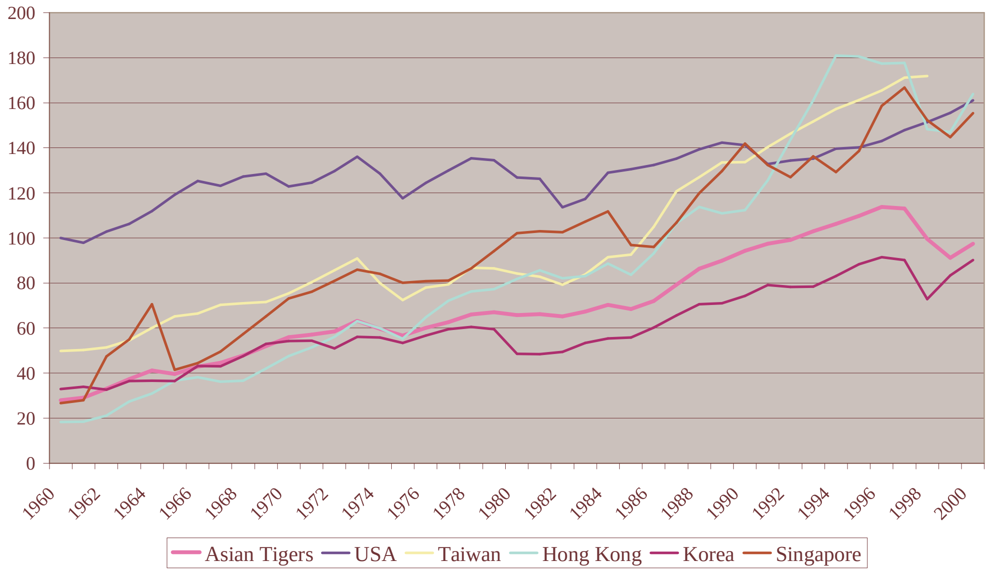

Figure 6: Productivity of the East Asian Tigers, 1960-2000 (US, 1960=100)

6 Conclusions

This article presents a group of exercises on level and growth decomposition for a sample of countries from 1960 to 2000. The development decompositions for earlier years reached conclusions that are quite diverse from those in the literature. Klenow and Rodriguez-Clare (1997), Prescott (1998), Hall and Jones (1999) and Easterly and Levine (2001), for instance, showed that the bulk of international output per worker dispersion is caused by total factor productivity differences. These studies used 1985 or later data. We showed that at least until 1975 factors of production, namely capital and education, were the main source of income dispersion and that productivity variance was considerably smaller than in late years. Only after 1975 the prominence of productivity started to show up in the data. The increase in the relative importance of productivity relative to factors is associated with the reduction across the period in the variance of factors due to convergence in the capital-output ratio and the increase in productivity variance in the nineties.

[31] This fact has also been noticed by Collins and Bosworth (1996) and Rodrik (1999). Note, however, that for all countries in this group, the marginal product of capital declined throughout the period due to the sharp increase in the capital-output ratios. In 2000 the $PMgK$ of the East Asian Tigers was close to that of the US.

The growth decomposition exercises showed that the reversal of the relative importance of productivity vis-a-vis factors is explained by the very good (bad) performance of productivity of fast (slow) growing countries in the period. Although most countries experienced capital deepening and improvements in education, exceptional growth performances were mostly due to productivity growth. Hence, although average growth in the period was mostly due to factors accumulation, its variance is explained by productivity.

The importance of productivity in explaining the dispersion of output per worker reveals the dominance of country or region-specific factors in recent development experiences. The stagnation of Latin America, for instance, is mostly explained by a significant decline in productivity, while the Asian Tigers "Miracle" is mostly a productivity miracle. Although we have now a number of "TFP theories" (e.g., Parente and Prescott (2000), Acemoglu, Johnson and Robinson (2001)) there are not many studies looking at its time series behavior - when and why did "A" in a particular economy changed its path - nor empirical studies linking TFP to exogenous variables. The results in the present study indicate that those may be very fruitful paths of research, given their importance to the understanding of development experiences.

From a theoretical standpoint, despite the importance of productivity in explaining the dispersion of the level and growth rates of output per worker, the implication that the neoclassical growth model is inconsistent with the development facts does not seems to be warranted,[32] for three reasons. First, factors accumulation account for the bulk of mean growth of output per worker between 1960 and 2000. Second, at least until 1975, factors were the main source of income disparity across countries. Third, at least until 1990, the increase in the relative importance of productivity was mainly due to the reduction of factors variance (in particular, of the capital-output ratio), which is consistent with the convergence mechanism predicted by the neoclassical growth model. These results suggest that a version of the neoclassical growth model, suitably modified to take into account differences in productivity, may be a useful framework to interpret development facts.[33]

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[33] One example of this approach is Parente and Prescott (1994). Recent papers pursuing this line of research include Barelli and Pessôa (2002) and Herrendorf and Teixeira (2003).

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7 Appendix

A List of Countries by Cultural and Regional Groups

English (speaking): Ireland, United Kingdom, USA, Australia, Canada, South Africa, New Zealand.

Western Europe: Austria, Italy, Finland, Belgium, France, Norway, Iceland, Denmark, Germany, Netherlands, Sweden, Switzerland.

South Europe: Cyprus, Portugal, Spain, Greece, Turkey.

Asian Tigers: Taiwan, Hong Kong, Korea, Singapore, Thailand, Japan.

Middle East: Syria, Tunisia, Israel, Iran, Jordan.

South Asia: Mauritius, Malaysia, Indonesia, Pakistan, India, Nepal, Papua New Guinea, Bangladesh, Philippines, Fiji.

Latin America: Dominican Republic, Panama, Chile, Brazil, Mexico, Ecuador, Guatemala, Uruguay, Paraguay, Colombia, Argentina, El Salvador, Costa Rica, Honduras, Bolivia, Peru, Venezuela, Nicaragua.

Caribe: Barbados, Trinidad & Tobago, Guyana, Jamaica.

Sub-Saharan Africa: Botswana, Lesotho, Malawi, Zimbabwe, Uganda, Tanzania, Kenya, Ghana, Cameroon, Togo, Senegal, Mozambique, Zambia, Niger, Central African Republic, Congo.

B Development and Growth Accounting with Alternative Calculation for K_0

As we mentioned in the text, for many economies the procedure we use to calculate the initial capital stock, which is standard in the literature, yields capital-output ratios far above the observed ratio in the US. In fact, for some of these economies, we observe a reduction in the capital-output ratio during the fifties, which is inconsistent with the high investment rates observed in the post-war period. At the same time, the marginal productivity of capital is very low when we use this initial capital stock and the measure of A based on it. This results from the fact that Japan and several countries in Continental Europe had very high investment rates in the early fifties, due to the reconstruction effort after the Second World War. In these cases we constructed an alternative measure of K_0 so that the marginal productivity of capital in 1950 for these economies was 20% above that of the US. This value of the $MgPK$ seems high enough in order to be consistent with the investment rates observed in the post-war period and prevents the capital-output ratio from declining in some countries. Table A.1 presents development decomposition results for this measure of the initial capital stock.

Table A.1: Variance Decomposition 1960-2000, other K_0

year	var(ln y)	var(ln X)	var(ln A)	2covar(ln X, ln A)
1960	0.84	0.61	0.41	-0.18
1965	0.89	0.57	0.41	-0.08
1970	0.92	0.54	0.35	0.03
1975	0.93	0.52	0.38	0.03
1980	0.99	0.43	0.39	0.17
1985	0.99	0.41	0.37	0.21
1990	1.11	0.37	0.44	0.30
1995	1.25	0.36	0.54	0.34
2000	1.32	0.36	0.58	0.37

The capital stock in 1950 was calculated such that the marginal productivity of capita for some economies in 1950 was 20% above the one in the US.

The results are similar to the ones reported in the text. In the sixties, the variance of factors of production with the new calculation is smaller than when we use the standard measure of K_0. From 1970 on, the results are nearly identical with the ones presented in Table 1.

Table A.2: Growth Decomposition (1960-2000) - Other K_0

	y	κ	H	A
Full Sample	1.84%	0.66%	1.00%	0.17%
		(36%)	(54%)	(10%)
Miracles	4.36%	0.89%	1.14%	2.33%
		(20%)	(26%)	(53%)
Fast Growth	2.72%	0.81%	1.06%	0.86%
		(30%)	(39%)	(31%)
Medium Growth	1.77%	0.50%	0.97%	0.30%
		(28%)	(55%)	(17%)
Slow Growth	0.96%	0.33%	0.83%	-0.20%
		(34%)	(86%)	(-21%)
Disasters	-0.59%	0.93%	1.04%	-2.57%
		(-157%)	(-176%)	(433%)

Note: The numbers in parenthesis are the relative contributions of each factor to output per worker growth.

Table A.2 presents growth decomposition results for the new measure of the initial capital stock. For the new calculation of K_0, the relative contribution of A to output per worker growth is 10%, instead of 20%, as we obtained for the standard calculation of the initial capital stock. The results are similar to the ones presented in Table 4. In particular, the relative contribution of A increases monotonically with the growth rate of output per worker.

C Development and Growth Accounting Using Klenow and Rodriguez-Clare (1997)'s Formulas

Instead of using (9), Klenow and Rodriguez-Clare (1997) use the following formula for the decomposition of variance of the log output per worker:

$$var(\ln y_{it}) = covar(\ln y_{it}, \ln A_{it}) + covar(\ln y_{it}, \ln X_{it})$$

This formula amounts to splitting the covariance term, giving half to $\ln(X)$ and half to $\ln(A)$. Table A.3 presents the results for the variance decomposition using the formula above:

Table A.3: Variance Decomposition of Levels 1960-2000

year	$\frac{covar(\ln y, \ln X)}{var(\ln y)}$	$\frac{covar(\ln y, \ln A)}{var(\ln y)}$
1960	0.64	0.35
1965	0.61	0.38
1970	0.61	0.38
1975	0.58	0.41
1980	0.52	0.47
1985	0.52	0.47
1990	0.47	0.52
1995	0.42	0.57
2000	0.41	0.58

Table A.3 confirms the results in the text. In particular, there is a reversal over time in the relative importance of factors and productivity as sources of output per worker dispersion. Whereas in 1960 productivity account for only 35% of output variance across countries, its relative contribution increases to 58% in 2000.

Instead of using (10), Klenow and Rodriguez-Clare (1997) use the following formula for

the decomposition of variance of the growth of output per worker:

$$var(\Delta \ln y_{it}) = covar(\Delta \ln y_{it}, \Delta \ln A_{it}) + covar(\Delta \ln y_{it}, \Delta \ln X_{it})$$

This formula amounts to splitting the covariance term, giving half to $\Delta \ln(X)$ and half to $\Delta \ln(A)$. Table A.4 presents the results for the variance decomposition using the formula above:

Table A.4: Variance Decomposition of Growth Rates

period	$\frac{covar(\Delta \ln y, \Delta \ln X)}{var(\Delta \ln y)}$	$\frac{covar(\Delta \ln y, \Delta \ln A)}{var(\Delta \ln y)}$
1960-2000	0.03	0.97
1960-1970	-0.26	1.26
1970-1980	-0.12	1.12
1980-1990	-0.05	1.05
1990-2000	-0.06	1.06

Table A.4 confirms the results in the text. In particular, productivity growth accounts for 97% of output per worker growth between 2000. This patterns is also observed for all decades.