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

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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 later years. Only after this date did the prominence of productivity start 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, is on average, is mostly due to factor accumulation, its variance is explained by productivity.

Key Words: Cross-Country Income Inequality, Development, Total Factor Productivity, Aggregate Production Function, Growth Decomposition.

JEL Classification Code: O11, O47.

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1 Introduction

Differences of output per worker across countries are known to be 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. 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. Recent papers by Klenow and Rodriguez-Clare (1997), Prescott (1998), Hall and 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. In 1960 the correlation of productivity with output per worker (in log terms) was 0.22, whereas the correlation of the latter with factor inputs was 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.

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 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 the contribuition of the variance of productivity to the variance of the growth rate of output per worker is more than three times larger than that of factors. 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 understanding 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 the average productivity of the "Asian Tigers".[1] 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 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 discusses 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:

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

where Y_{it} is the output of country i at time t, K stands for physical capital, H is human capital 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)) formulation of schooling returns to skills to model human capital, H. There is only one type of labor in the economy with skill level

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

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 whether 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:

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

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

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

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:

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

where Δ is the variation of a given variable between two periods.

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 the distance 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, investment at market prices, I, as well as 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.[2] Data on output per worker and investment rates were obtained from the Penn-World Table (PWT), version 6.1. 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, following Hall and Jones (1999), among many, by $K_0 =$

[2]See the Appendix for a list of the countries included in the sample.

$I_0/[(1+g)(1+n)-(1-\delta)]$, 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. In this calculation we follow the standard assumption that all economies were in a balanced growth path at time zero, so that $I_{-j} = (1+n)^{-j}(1+g)^{-j} I_0$.[3] 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. 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 series of κ_{it} and H_{it} so that the productivity of the i-th economy at time t was obtained as:

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

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:

$$\ln y_{it} = \ln A_{it} + \ln X_{it}. \tag{7}$$

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:

$$var(\ln y_{it}) = var(\ln A_{it}) + var(\ln X_{it}) + 2cov(\ln A_{it}, \ln X_{it}). \tag{8}$$

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

[3] While rich countries may satisfy the balanced-growth assumption in the initial year, for poor countries the investment rates were probably lower before than after the initial year for which there is available data. Hence, the balanced-growth assumption possibly overestimates the initial capital stocks of the latter. (see Caselli (2004)). We will discuss in detail the sensitivity of our results to the initial capital stock.

discarding an important piece of information about the nature of output dispersion.[4] Figure 1 displays, for each year of our sample, the relative contribution of the 3 components of the variance of (the log of) output per worker. Table 1 presents the absolute values of all the components of expression (8) at five-year intervals.

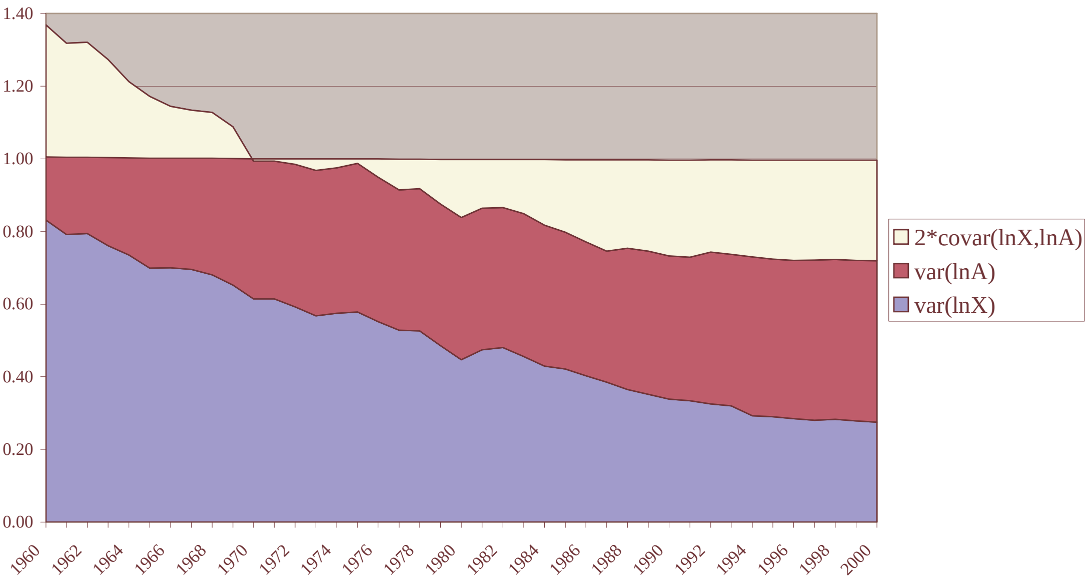

Figure 1: Output-per-worker variance decomposition (1960-2000)

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 $\ln y$ 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 $\ln X$ declines nearly 50%, from 0.70 to 0.36. Hence, while a strong process of output divergence is observed, factor levels converge.

[4]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 (8), this amounts to dividing the covariance term $2cov(\ln A_{it}, \ln X_{it})$ equally between $\ln A_{it}$ and $\ln X_{it}$. In the Appendix, we present results for this variance decomposition.

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 factor variance was 39% smaller.

Finally, the covariance between factors and productivity increases continually. As a matter of fact, it changes signs, going 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 factor 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 ($R^2 = 0.47$).[5]

[5] 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 showing that this relationship became stronger over time is not an artifact of the method we used to construct the initial capital stock.

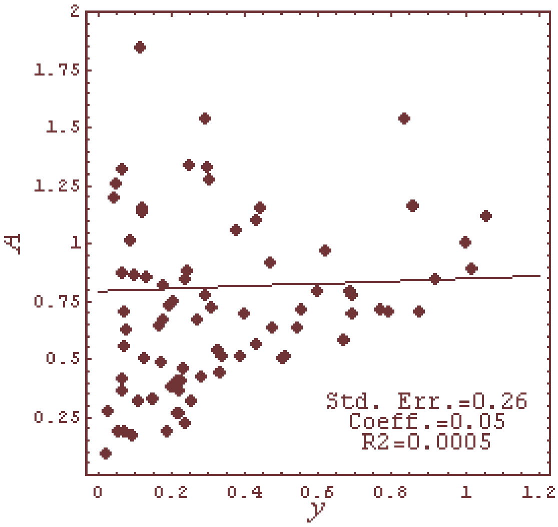

Figure 2: 1960

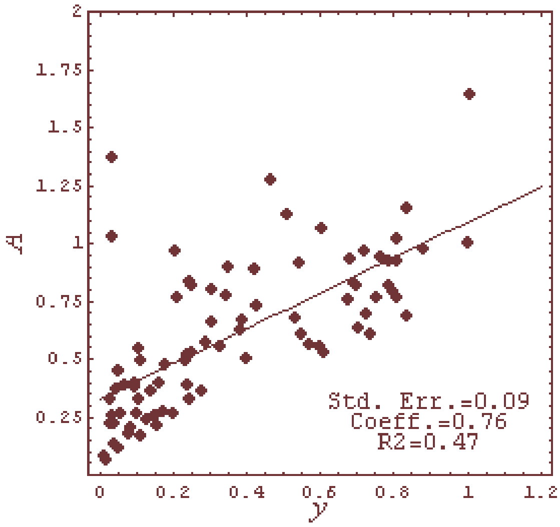

Figure 3: 2000

The picture that emerges from the results above shows that in 1960 the variability of productivity was lower while 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. In a certain sense, this result qualifies the literature on international differences in levels of output per worker (Klenow and 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, with productivity accounting for the remaining 47%. Using the same methodology used by these authors, we find that the relative importance of X and A in 1985 was 52% and 48%, respectively, very close to their figures (see the Appendix for the calculations). However, values are considerably different when we use 1960 data, as in this case 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.

One could argue that our claim that the importance of TFP is increasing over time is driven by measurement error. It could be the case that since for most countries reliable data starts in 1960, the initial capital-stock figures are only very rough approximations, so that our estimates of the capital stock grow more accurate over time as we use better data.

Hence, the finding that factor differences accounted for more income differences in 1960 may simply reflect the fact that we are measuring K_{1960} with a large error. We believe this is not the case and that results are robust to the capital-stock series used.

In order to verify the sensitivity of the results to the capital-stock series, we performed several robustness exercises (see the Appendix for more details). First, we reconstructed K using depreciation rates of 7% and 10.5%, which imply a faster decline of the importance of the initial capital stock. Results did not change much, and as far as 1975 the variance of $\ln X$ dominates that of $\ln A$ (0.52 and 0.39, respectively, using a depreciation rate of 10.5%). In both cases the importance of A increases over time. Second, in order to reduce the role of the initial-capital stock, we also perform calculations focusing on the sample of 54 countries for which there is complete investment data starting in 1950. The results are qualitatively similar to those obtained with our full sample. The contribution of the variance of factors of production to the variance of output per worker was 81% higher than that of productivity in 1960. As late as 1975, the relative contributions of factors and productivity were very similar to their 1960 figures, whereas in 2000 the variance of factors was 35% smaller than that of productivity. We also observe the same patterns of convergence of factors and divergence of productivity over time.

In a third exercise, still using the smaller 54-country sample, we constructed a counterfactual capital-stock series in which the initial capital-output ratio is equal to 2 in 1950 for all countries. Of course, this is an extreme assumption that biases the results against our findings. Even in this case we found that, at least since 1975, both the absolute and relative importance of the variance of factors as a source of output dispersion declined, whereas the variance of productivity increased. Moreover, the covariance between factors and productivity increases since 1975. Fourth, note that in the early fifties, Japan and several countries in Continental Europe had very high investment rates, due to the reconstruction effort after the Second World War. For these economies the balanced-growth assumption used to calculate the initial capital stock in 1950 yields capital-output ratios far above the observed ratio in the US, while the marginal productivity of capital is at the same time very low. 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 MPK seems high enough to be consistent with the investment rates observed in the post-war period and prevents the capital-output ratio from declining in some countries. Once again, results are qualitatively similar to the ones reported in the text.

The main findings are also robust to methodology changes. Note that in this paper capital is measured using the capital-output ratio. However, Bosworth and Collins (2003) argue that this formulation overstates the importance of TFP since, for instance, both TFP and capital may vary together due to a third factor. In their opinion, the truth may lie between this representation and one with capital-labor ratio, although in their exercises they use the latter. Our results, presented in the Appendix, are qualitatively similar if we do the same. Specifically, the relative importance of productivity increases over time as a source of output-per-worker dispersion, as does the covariance between factors and productivity. Factors accounted for 77% of output-per-worker dispersion in 1960 but only 45% in 2000.

We provide an additional piece of evidence of the robustness of the pattern of the correlation across countries between A and X by examining the correlation between productivity and the relative price of investment (data once again was obtained from the Penn-World Table, version 6.1). As can be observed in Figure 4 below, there is a striking negative association over time between the correlation of factors and productivity, on the one hand, and the correlation between productivity and the relative price of investment, p, on the other hand. In 1960, the correlation between A and X (in logs) was -0.27, whereas the correlation between A and p (in logs) was 0.15. Hence, in 1960 the more productive countries had smaller capital-output ratios (and factors in general). This is consistent with the observed positive correlation between A and p, which indicates that high-productivity countries had a higher relative price of investment in 1960. In 2000, on the other hand, the correlation between A and X was 0.40, whereas the correlation between A and p was -0.22. In other words, in 2000 the high-productivity countries had higher capital-output ratios (and factors in general). This is consistent with the negative correlation between A and p, which indicates that in 2000 the relative price of investment was smaller in the high-productivity countries.

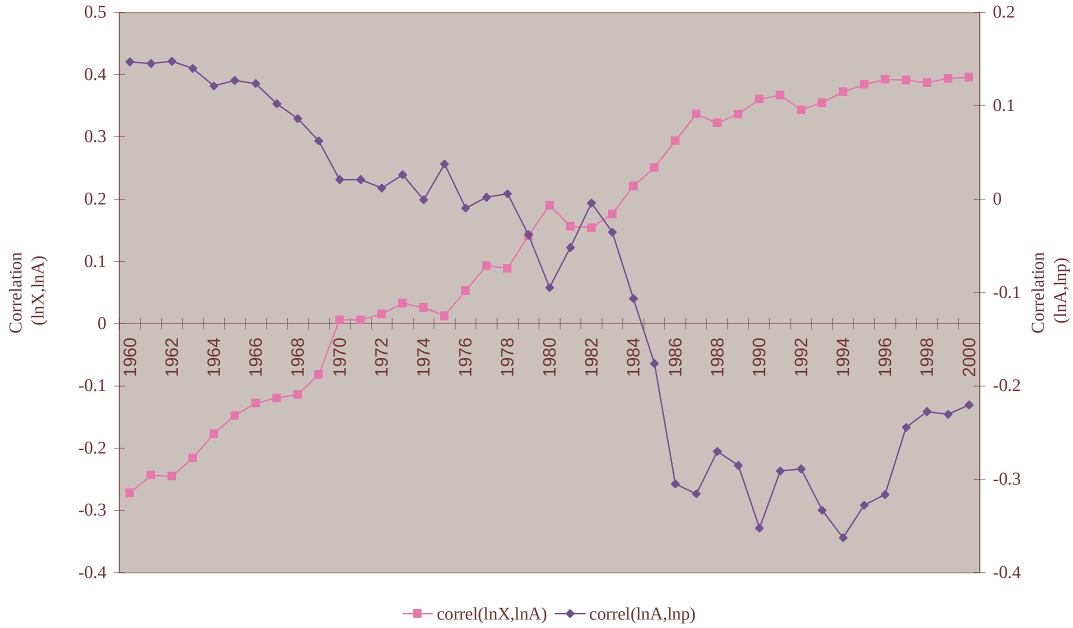

Figure 4: Correlations between productivity, factors and the relative price of investment (1960-2000)

Hence, we conclude that our main findings are robust to different assumptions about the capital-input measure, depreciation rates, country sample and initial capital stocks. Moreover, data on the relative price of investment gives further support to our findings on the evolution over time of the covariance between factors and productivity[6]. It should be noticed that there is nothing essentially wrong with previous results on the relative importance of factors and productivity as sources of output-per-worker dispersion. 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 examine 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),

[6]Note also that, as pointed out by Caselli (2004), the balanced-growth assumption possibly overestimates the initial capital stocks of poor countries in the initial year and, as a result, may bias downward the relative contribution of the variance of factors to the variance of y. This implies that the prominence of factors as a source of output dispersion in the early sixties was probably even higher than the one we obtained.

so that the variation of the log of output per worker in the period is decomposed into the contribution of productivity,[7] 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.[8] 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):

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%. A vigorous increase in education was also observed, jumping on average from 2.9 years in 1960 to 6.1 years in 2000.

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 our purpose of calling attention to different patterns of development across economies.

[7] 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.

[8] All figures are in 1996 values, corrected for PPP.

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	1.77%	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 the growth rate of output per worker 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, something already noted by Klenow and Rodriguez-Clare (1997) for the period 1960-1985. 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.

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 for by human- and physical-capital accumulation, while only 20% is due to productivity growth.[9] Human capital alone accounts for 54% of output-per-worker growth.

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-per-worker 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

[9] Baier et al (2004) found a relative contribution of TFP for output per worker growth of 14%, using data for a sample of 145 countries, spanning more than a hundred years for 23 of those countries. In most of their calculations they use weighted average growth rates, in which 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 obtained a startling value of -109%.

worker, while the behavior of productivity explains the *variation* of growth rates among groups. This result is similar if we use the *median* instead of the *mean*.

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 factor growth and A growth. Using (4), we can decompose the variance of output per worker growth as follows:

$$var\,(\Delta \ln y) = var(\Delta \ln A) + var(\Delta \ln X) + 2cov(\Delta \ln A, \Delta \ln X). \tag{9}$$

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 factor growth accounted for only 35% of the dispersion of output-per-worker growth.[10]

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

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 assess whether this pattern is verified in our sample, we present in Table 6 growth-accounting results for two sub-periods: 1960-1980 and 1980-2000.

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

[10] 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 formula used by these authors ignores the covariance between factors and productivity growth. Using the same 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.

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

Table 6: Growth Decomposition by Sub-periods

	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 conjunction 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 experienced a significant increase in productivity, while slow growers 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 rose substantially and surpassed 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 one way or another, societies may choose or inherit sets of laws, institutions and social conventions that are more inducive 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 into broad groups on a cultural or geographical basis. Here our objectives are two-fold. 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 American 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 factor 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, Caribbean and Sub-Saharan Africa.[11] The first group has 12 countries that comprise most of Western Europe, with exceptions such as Portugal and Spain (which belong, together with Greece, Cyprus and Turkey, to "South Europe") and the 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 9 economies, respectively, in the next two groups and 18 in Latin America, which also includes Caribbean countries that speak mostly Latin languages. The Caribbean group contains only 4 countries and the Sub-Sahara

[11] 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. Our Middle East group actually includes one country from North Africa (Tunisia).

contains 18. 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 productivity of 261% between 1960 and 2000. Whereas in 1960 the level of A for the Asian Tigers was only 35% of the correspondent value for English-speaking countries, by 2000 this ratio had increased to 75%. The big losers are Latin American economies and the Sub-Sahara region, with mean reductions of productivity of 16% and 29%, 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 that 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%.[12] We will discuss these results for Latin America in more detail in the next section.

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)	118%	78	98	130	65%	2.64	2.96	12%
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	146%	60	57	54	-9%	0.89	1.75	97%
Latin America	42%	79	103	66	-16%	1.67	2.11	26%
Caribbean	87%	45	63	66	48%	2.70	2.33	-14%
Sub-Saharan Africa	37%	42	43	30	-29%	0.94	1.39	48%

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 59% and 48%, respectively. 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 factor accumulation, now taking cultural or geographical factors as our standpoint.

[12] 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.

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,between one half and two thirds of the growth of output per worker is due to A growth. The contribution of productivity to 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.

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

country groups	y	κ	H	A
English (-speaking)	1.94%	0.19%	0.49%	1.26%
		(10%)	(25%)	(65%)
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	2.26%	1.13%	1.36%	-0.23%
		(50%)	(60%)	(-10%)
Latin America	0.87%	0.38%	0.93%	-0.45%
		(44%)	(107%)	(-51%)
Caribbean	1.58%	-0.25%	0.84%	0.99%
		(-16%)	(53%)	(63%)
Sub-Saharan Africa	0.78%	0.66%	1.01%	-0.90%
		(86%)	(130%)	(-115%)

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

5.1 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 factor accumulation. One exception is Chile, which had a significant increase in A. On the other hand, the fall in productivity was particularly stong in Venezuela and Paraguay.

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

country groups	y	κ	H	A
World average	1.84%	0.47%	1.00%	0.36%
		(26%)	(54%)	(20%)
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, productivity deterioration was observed mainly in the last two decades of the sample, especially in the eighties,[13] when none of the economies of the region had positive

[13] Among the possible reasons for the productivity decline 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 conflict-management institutions, 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).

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. 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). Figure 6 below presents the evolution of A for selected countries, the regional average and US productivity as a benchmark for comparison. As is clear from the figure, the fall is dramatic in all but one case (Chile[14]).

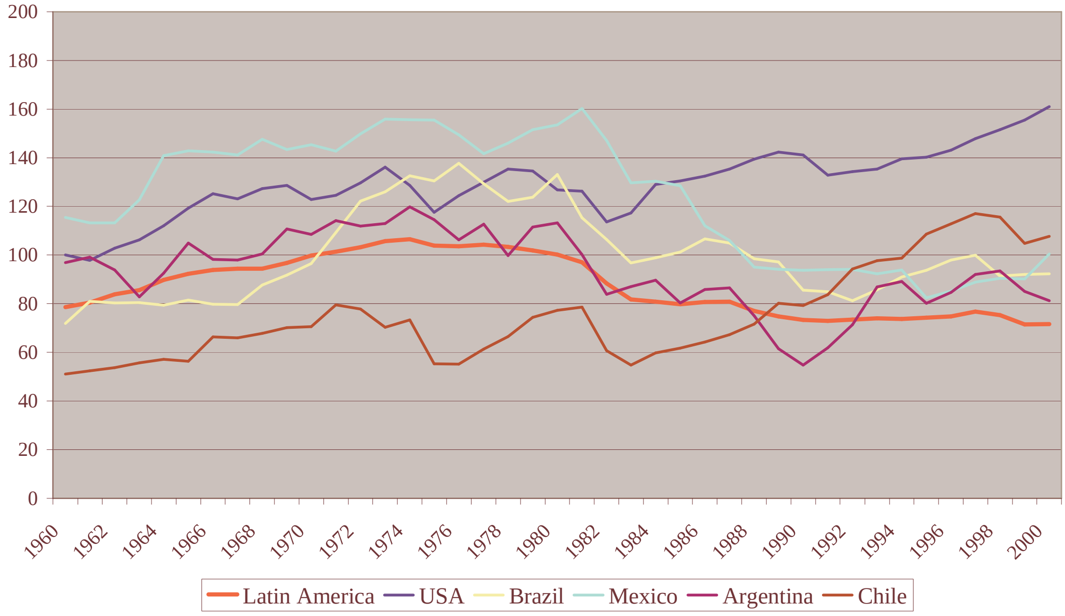

Figure 5: Productivity in Latin America, 1960-2000 (US, 1960=100)

Cole et al (2005) conclude that most of the gap in income per capita between Latin America and the US is due to low TFP in Latin America. They also argue that competitive barriers are possibly an important determinant of low TFP in Latin America. Related research by Hopenhayn and Neumeyer (2004) argues that import-substitution industrialization and targeted investment subsidies may be key determinants of low productivity in Latin America. Our results put these conjectures in question, since productivity in Latin America was relatively high in a period (1960-1980) that was characterized by widespread state intervention in the economy and import-substitution industrialization. The evidence in Figure 6 (and Table 7) show that at least until the mid-seventies, productivity in Latin America was close to the level observed in the US, and that in the mid-seventies some Latin American

[14]Bergoeing, Kehoe, Kehoe, and R. Soto (2001) had already made the point that Chile's TFP growth was exceptionally good (for Latin America).

countries had a level of A which was nearly equal to or even higher than US productivity (in the case of Brazil and Mexico, respectively).

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%. Productivity growth was particularly strong in Hong Kong and Singapore, where more than 80% of output-per-worker growth is due to A growth. These results confirm those 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.

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

country groups	y	κ	H	A
World average	1.84%	0.47%	1.00%	0.36%
		(26%)	(54%)	(20%)
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.

As shown in Table 10, almost all of the difference in growth rates between the East Asian Tigers and the world average is due to differences in productivity growth. Even though the Asian Tigers experienced high rates of physical- and human-capital accumulation, they were not extraordinary relative to the world figures. In particular, their annual growth rates of the capital-output ratio and human capital per worker were only 0.31% and 0.02% above the world average, respectively. On the other hand, their productivity grew on average 2.9% faster than world productivity. Hence, higher productivity accounted for 90% of the 3.2% annual difference in growth rates of output per worker between the East Asian Tigers and the world average. These results place the Tigers growth experience in a very different perspective than that presented in Young (1995). Whereas Young (1995) argues that factor accumulation was the key determinant of growth in East Asia, Table 10 shows that, relative to the rest of the world, the distinguishing characteristic of the East Asian miracles was their productivity growth.[15]

Figure 7 below presents the evolution of A for the Asian Tigers and the regional average. The figure shows that, unlike what occurred in Latin America, productivity continued to grow strongly after 1975.

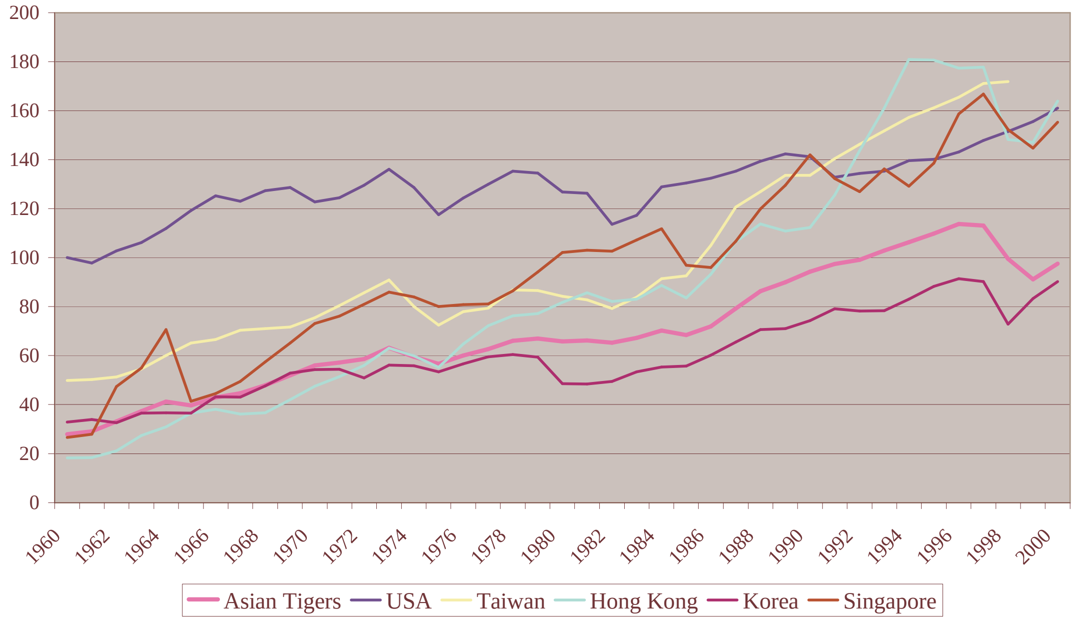

Figure 6: Productivity of the East Asian Tigers, 1960-2000 (US, 1960=100)

[15] For a more thorough comparison of our results with Young (1995), see Ferreira, Pessôa and Veloso (2004).

6 Conclusions

This article presents a group of exercises on level and growth decomposition for a representative sample of countries from 1960 to 2000. The development decompositions for earlier years reached conclusions that are quite different 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 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 human capital per worker, and with the increase in productivity variance in the nineties.

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 factor 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. The results also present a puzzle about Latin America productivity: we found that productivity was high in Latin America between 1960 and 1980, when competitive barriers in general, and import substitution in particular, were highest in the region.

Although we now have a number of "TFP theories" (e.g., Parente and Prescott (2000), Acemoglu, Johnson and Robinson (2001)), few studies look at its time-series behavior - when and why "A" in a particular economy changed its path - and few empirical studies link TFP to exogenous variables. The results in the present study indicate that these could 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 seem to be warranted, for three reasons. First, factor accumulation accounts 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 factor 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.[16]

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7 Appendix

A List of Countries by Cultural and Regional Groups

English (-speaking): Ireland, United Kingdom, USA, Australia, Canada, 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: 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.

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

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

Note that some countries, although we do not have data on them for either 1960 or 2000, 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).

B List of Countries by Growth Groups

Miracles: Botswana, Taiwan, Hong Kong, Korea, Singapore, Thailand, Cyprus, Japan, Ireland, Mauritius, Malaysia, Portugal, Barbados, Indonesia, Spain.

Fast Growth: Pakistan, Greece, Austria, Italy, India, Syria, Finland, Turkey, Tunisia, Israel, Belgium, Dominican Republic, France, Lesotho, Norway.

Medium Growth: Panama, Malawi, Nepal, Bangladesh, Iceland, Iran, Chile, United Kingdom, USA, Denmark, Trinidad & Tobago, Netherlands, Germany, Brazil, Sweden, Australia, Canada, Mexico, Zimbabwe, Jordan, Ecuador.

Slow Growth: Guatemala, Uganda, Philippines, Papua New Guinea, Fiji, South Africa, Switzerland, Tanzania, Uruguay, Guyana, Paraguay, Kenya, Ghana, Colombia, Argentina, El Salvador, Costa Rica, New Zealand.

Disasters: Honduras, Cameroon, Togo, Jamaica, Bolivia, Peru, Senegal, Mozambique, Zambia, Venezuela, Niger, Nicaragua, Central African Republic, Congo.

C Development-Accounting Results Using the Capital-Labor Ratio as the Capital Measure

Table A.1 presents a development-accounting exercise using the capital-labor ratio as the capital measure. See discussion in the text.

Table A.1: Variance Decomposition 1960-2000 (capital-labor ratio)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2covar($\ln X, \ln A$)
1960	0.84	0.65	0.16	0.03
1965	0.89	0.63	0.15	0.11
1970	0.92	0.62	0.13	0.17
1975	0.93	0.60	0.14	0.19
1980	0.99	0.57	0.14	0.28
1985	0.99	0.56	0.13	0.29
1990	1.11	0.56	0.16	0.38
1995	1.25	0.59	0.19	0.46
2000	1.32	0.60	0.21	0.50

D Development-Accounting Results Using a 7% Depreciation Rate

Table A.2 presents a development-accounting exercise using a depreciation rate of 7% to construct the capital-stock series. As mentioned in the text, the results are very similar to the ones obtained in our main specification, which uses a depreciation rate of 3.5%.

Table A.2: Variance Decomposition 1960-2000 (7% depreciation rate)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2covar($\ln X, \ln A$)
1960	0.84	0.68	0.45	-0.28
1965	0.89	0.60	0.42	-0.13
1970	0.92	0.54	0.35	0.02
1975	0.93	0.52	0.38	0.02
1980	0.99	0.43	0.39	0.18
1985	0.99	0.40	0.36	0.22
1990	1.11	0.37	0.42	0.32
1995	1.25	0.36	0.51	0.37
2000	1.32	0.36	0.55	0.39

E Development Accounting for Subsample of Countries with Investment Data Starting in 1950

Table A.3 presents a development-accounting exercise for the subsample of 54 countries for which there is investment data since 1950. See discussion in the text.

Table A.3: Variance Decomposition 1960-2000 (Subsample)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2covar($\ln X, \ln A$)
1960	0.66	0.43	0.25	-0.02
1965	0.69	0.40	0.28	0.01
1970	0.68	0.40	0.24	0.05
1975	0.68	0.41	0.25	0.02
1980	0.73	0.35	0.24	0.14
1985	0.70	0.34	0.23	0.13
1990	0.80	0.30	0.29	0.20
1995	0.88	0.29	0.36	0.22
2000	0.96	0.28	0.43	0.25

F Development 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 MPK seems high enough to be consistent with the investment rates observed in the post-war period and prevents the capital-output ratio from declining in some countries. These calculations were performed for the following countries: Austria, Italy, Finland, Belgium, France, Norway, Iceland, Denmark, Sweden, Cyprus, Portugal, Spain, Greece, Taiwan, Hong Kong, Korea, Singapore, Japan, Iran, Peru, Venezuela, Barbados, Jamaica, Philippines, Malawi, Zimbabwe, Kenya, Zambia.

Table A.4 presents development-decomposition results based on this measure of the initial capital stock.

Table A.4: 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 capital for some economies in 1950 was 20% above the one in the US.

The results are similar to those 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 to those presented in Table 1.

G Development-Accounting Results for $\frac{K_0}{Y_0} = 2$ in 1950.

Table A.5 presents a development-accounting exercise for the counterfactual capital series in which all countries in the subsample of 54 countries for which there is investment data since 1950 start with a initial capital-output ratio equal to 2 in 1950. See discussion in the text.

Table A.5: Variance Decomposition 1960-2000 ($\frac{K_0}{Y_0} = 2$)

year	var(ln y)	var(ln X)	var(ln A)	2covar(ln X, ln A)
1960	0.66	0.23	0.31	0.11
1965	0.69	0.26	0.32	0.11
1970	0.68	0.30	0.26	0.12
1975	0.68	0.33	0.27	0.08
1980	0.73	0.29	0.26	0.17
1985	0.70	0.30	0.24	0.17
1990	0.80	0.28	0.30	0.21
1995	0.88	0.28	0.37	0.23
2000	0.96	0.26	0.44	0.25

Figure A.1 shows the evolution between 1960 and 2000 of the relative importance of each component of the variance of the log output per worker.

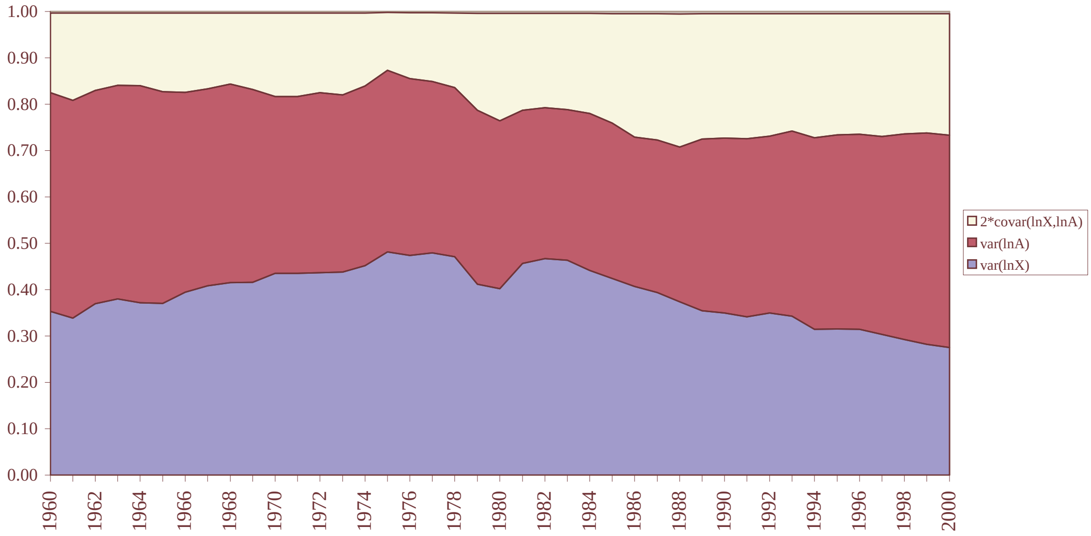

Figure A.1: Output-per-worker variance decomposition (1960-2000) - Initial K/Y=2

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

Instead of using (8), 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.6 presents the results for the variance decomposition using the formula above:

Table A.6: 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.6 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 accounts for only 35% of output variance across countries, its relative contribution increases to 58% in 2000.

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

$$var(\Delta \ln y) = covar(\Delta \ln y, \Delta \ln A) + covar(\Delta \ln y, \Delta \ln X)$$

This formula amounts to splitting the covariance term, giving half to $\Delta \ln(X)$ and half to $\Delta \ln(A)$. Table A.7 presents the results for the variance decomposition using the formula above:

Table A.7: 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.7 confirms the results in the text. In particular, productivity growth accounts for 97% of the variance of output-per-worker growth between 1960 and 2000. This pattern is also observed for all decades.