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The Evolution of International Output Differences (1970-2000): From Factors to Productivity*

Pedro C. Ferreira, Samuel A. Pessoa, and Fernando A. Veloso

Abstract

This article presents a group of exercises of level and growth decomposition of output per worker using cross-country data from 1970 to 2000. It is shown that in the early seventies 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 the mid-eighties did the prominence of productivity start to show up in the data, as the majority of the literature has found. The growth decomposition exercises show that the reversal of relative importance of productivity vis-à-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 factor accumulation, its variance is explained by productivity.

KEYWORDS: cross-country income inequality, development accounting, total factor productivity, aggregate production function, growth accounting

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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 the variance of 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. However, subsequent papers by Klenow and Rodriguez-Clare (1997), Prescott (1998), Hall and Jones (1999), Easterly and Levine (2001) and Caselli (2005), among others, have established what now seems to be a consensus that total factor productivity is more important than factors of production in explaining output differences.

Most articles in the literature use data for one single year, which usually is 1985 or some year later. In this paper we perform development accounting exercises for all years between 1970 and 2000. The main question here is whether the prominent role played by productivity in recent periods is also a feature of previous decades.

It turns out that the picture for earlier years is very different from the one that has emerged from the literature. In the early seventies, factors (human and physical capital) were the main source of output-per-worker dispersion. By the mid-eighties, factors and productivity had roughly the same importance and from 1990 on productivity explained the bulk of international differences in output per worker.

The relevant question, thus, is how one goes from a world where 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. Specifically, the variance of factors of production was cut in 36% between 1970 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 1970 to 2000, while the behavior of productivity explains the variance of growth rates in the period. In particular, inputs explain at least 86% of the growth of output per worker, whereas the contribution 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.

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 presents growth accounting results for cultural and regional groups. Section 6 concludes and provides an interpretation of the stylized facts documented in the paper.

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 formulation of returns to schooling 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. In that sense, 31 variance-decomposition exercises, for the years from 1970 to 2000, are performed. For the sake of comparability, 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. The production function is thus 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 of a given variable between two periods.

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 the 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:

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

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 the capital share, α, and the depreciation rate used to construct the capital series, δ. 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).[1]

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

[1] Most studies in the literature, such as Klenow and Rodriguez-Clare (1997), Hall and Jones (1999), Bosworth and Collins (2003) and Baier et al (2006), also assume that the capital share does not vary across countries and over time and they use similar values for α.

at market prices, I, as well as the law of motion of capital to estimate the implicit depreciation rate according to:[2]

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

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 1970-2000.[3] 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 $K_0 = I_0/[(1+g)(1+n) - (1-\delta)]$, 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. 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 this calculation we follow the standard assumption that all economies were in a balanced growth path at time zero.[4] To minimize the impact of economic fluctuations we used the average investment of the first five years as a measure of I_0. For the 54 countries for which investment data were available since 1950, we constructed the capital stock series taking 1950 as the initial year, in order to reduce the effect of K_0 in the capital stock series. In the other

[2]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.

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

[4]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 (2005)). We will discuss in detail the sensitivity of our results to the initial capital stock in Subsection 3.2.

cases we started with 1960 data, so that we have at least a ten year-difference between the initial year and 1970, when our decompositions start.

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:

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

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

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

3 Development Accounting

3.1 Baseline Results

In this section we perform development-accounting exercises, based on variance decompositions of output per worker for each year from 1970 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., $X_{it} = \kappa_{it}^{\frac{\alpha}{1-\alpha}} H_{it} = \kappa_{it}^{\frac{\alpha}{1-\alpha}} e^{\frac{\theta}{1-\psi} h_{it}^{1-\psi}}$), with that of productivity. From (3), we have:

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

We will first use Klenow and Rodriguez-Clare (1997)´s variance decomposition procedure, which is given by:

$$\frac{var(\ln y_{it})}{var(\ln y_{it})} = 1 = \frac{cov(\ln y_{it}, \ln A_{it})}{var(\ln y_{it})} + \frac{cov(\ln y_{it}, \ln X_{it})}{var(\ln y_{it})} \tag{9}$$

Figure 1 displays, for each year of our sample, the relative contribution of the two components of the variance of (the log of) output per worker.

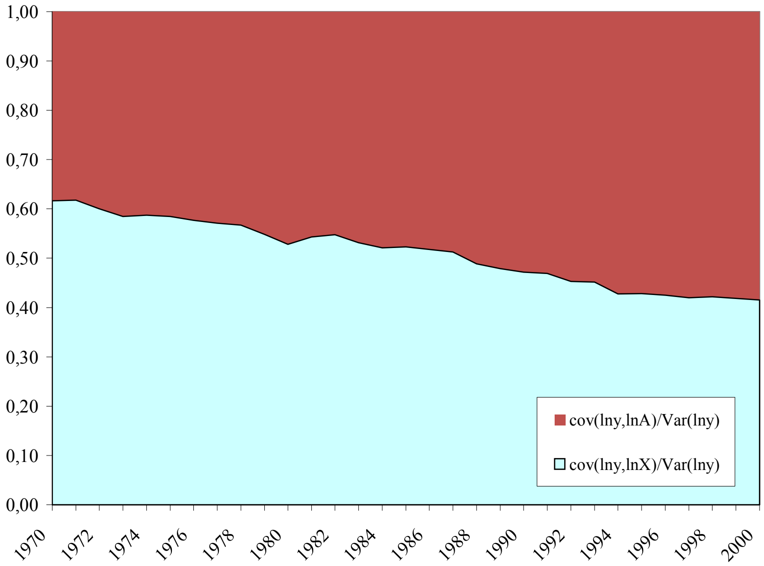

Figure 1: Output-per-worker variance decomposition (1970-2000)

Figure 1 reveals that there was a continuous reduction of the relative importance of factors in accounting for output dispersion between 1970 and 2000. While in 1970 factors accounted for 62% of the variance of output per worker, in 2000 they explained just 41% of output dispersion. It is only after the mid-eighties that the predominance of TFP - as found by Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999), for instance - showed up in the data.

As shown in Table 1, during this period there was a decline in the relative importance of both physical and human capital in accounting for output dispersion. In 1970, physical and human capital each explained roughly one third of the variance of output per worker. By 2000, the contributions of physical and human capital were 40% and 28% smaller, respectively.

Table 1: Variance Decomposition 1970-2000

	$\text{cov}(\ln Z, \ln y)\,/var(\ln y)$			
year	$Z = A$	$Z = X$	$Z = \kappa^{\frac{\alpha}{1-\alpha}}$	$Z = H$
1970	0.38	0.62	0.30	0.32
1975	0.42	0.58	0.28	0.30
1980	0.47	0.53	0.24	0.29
1985	0.48	0.52	0.24	0.28
1990	0.53	0.47	0.21	0.26
1995	0.57	0.43	0.19	0.24
2000	0.59	0.41	0.18	0.23

In order to better understand this process we decompose the variance of $\ln y$ according to its mathematical expression, allowing for a covariance term between factors and productivity:

$$var(\ln y_{it}) = var(\ln A_{it}) + var(\ln X_{it}) + 2cov(\ln A_{it}, \ln X_{it}). \tag{10}$$

Table 2 presents the values of all the components of expression (10) at five-year intervals.

Table 2: Variance Decomposition 1970-2000 (Baseline)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2cov($\ln X, \ln A$)
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

A number of important facts call our attention. First, output-per-worker dispersion increased throughout the period, especially in the nineties. In particular, the variance of $\ln y$ increased from 0.92 in 1970 to 1.11 in 1990 and 1.32 in 2000. Second, there was a continuous reduction of the absolute importance of factors in accounting for output dispersion. Specifically, between 1970 and 2000 the variance of $\ln X$ declined 36%. Hence, while a strong process of output divergence was observed, factor levels converged throughout the period. Third, the variance of $\ln A$ was relatively stable until 1985. By 2000, however, its value was 69% larger than its value in 1970.

The previous two facts explain the increase (decrease) of the relative importance of TFP (factors) in accounting for the variance of output per worker, as displayed in Figure 1 and Table 1. In 1970 the contribution of the variance of factors of production to the variance of output per worker was 60% 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.[5]

[5] As noted by several authors, the importance of factors vis-a-vis productivity for output-per-worker dispersion depends on the way the covariance term is split between each component. For instance, the variance-decomposition formula used by Klenow and Rodriguez-Clare (1997) amounts to dividing the covariance term equally between $\ln A_{it}$ and $\ln X_{it}$. Caselli (2005), on the other hand, measures the contribution of factors by the term $var(\ln X)$,

Finally, the covariance between factors and productivity increased continually. In 1970 it was almost zero, but by 2000 productivity, capital intensity and education were positively correlated across countries. Figure A.1 in the Appendix displays, for each year of our sample, the relative contribution of the three components of the variance of (log) output per worker.

To better understand this process it is useful to examine separately the contribution of human capital and that of physical capital. For both human and physical capital, there was a sharp variance decline between 1970 and 2000. Specifically, in 2000 the variance of the physical capital component was 48% smaller than in 1970, while the corresponding reduction for human capital was 29%.

In the case of human capital, one observes that education in poor countries increased markedly in the period, while in the rich regions it was already relatively high, so that it evolved at a slower pace. For instance, in many poor countries in Sub-Saharian Africa mean adult education more than tripled in the period, and in almost all it more than doubled. For instance, in Botswana it increased from 1.34 to 5.35 years from 1970 to 2000, in the Central African Republic from 0.46 to 2.11 and in Zambia from 2.03 to 5.43.

In contrast, Portugal and Turkey are the only European countries in which mean adult education increased by more than 100% in the period (102% and 122%, respectively). At the same time, mean education growth from 1970 to 2000 in the "advanced countries" (Barro-Lee classification) was only 41%. Hence, although there were still large differences, the human capital of poor countries in 2000 was much closer to that of the advanced economies than it was in 1970. A similar phenomena was observed for the capital-output ratio, as we will discuss in section 5.

Table 2 presents the evolution over time of the covariance between productivity and $\ln X$, that is, the combination of physical and human capital. It is important to note, however, that the same pattern is observed if we consider the separate covariances between $\ln A$, on the one hand, and $\ln \kappa^{\frac{\alpha}{1-\alpha}}$ and $\ln H$, respectively, on the other. Specifically, the covariance between the capital-output ratio component and productivity increases continually between 1970

which amounts to computing what would be the output dispersion if all countries had the same productivity. A recent paper by Baier et al. (2006), on the other hand, computes lower and upper bounds for the contribution of each component of the variance of output per worker growth (rather than its level), depending on whether the covariance term is totally atributted to one component or another. Regardless of the method used, our result that factors accounted for the bulk of the variance of output per worker in the early seventies does not change, since the covariance between factors and productivity was nearly zero at the time.

and 2000, as well as the covariance between human capital and productivity.

The picture that emerges from the results above is that in 1970 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. As a result, there was an increase over time in the relative importance of productivity as a source of output-per-worker dispersion.

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), Easterly and Levine (2001) and Caselli (2005), 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 1970 quite the opposite occurred, and factors, not productivity, explained most of the output-per-worker variation.

3.2 Robustness and Measurement Error

One could argue that our claim that the importance of TFP is increasing over time is driven by measurement error. In particular, since the initial capital-stock figures are only rough approximations, one may argue that our finding that factor differences accounted more for income differences in 1970 than TFP may simply reflect the fact that we are measuring K_{1970} with a large error.

Before we verify the robustness of our results, it is important to remind, however, that for a subsample of 54 countries (out of a sample of 83 countries), the initial year for the capital stock series is 1950, so that for these countries we have a twenty-year difference between the initial year and 1970, when our decompositions start.

In order to verify the sensitivity of the results to the capital-stock series, we performed several robustness exercises. First, in order to reduce the role of the initial capital stock, we perform calculations focusing on the subsample of 54 countries for which there is complete investment data starting in 1950. This subsample is also less subject to measurement error in income and investment data, since it includes a higher fraction of countries with better data quality in comparison to our main sample.[6]

[6]Each country in PWT 6.1 is assigned a letter grade according to its data quality, where A denotes the highest score and D the lowest score. In our subsample of 54 countries the sample composition is as folows: A (30%), B (17%), C (44%) and D (9%). For the main sample of 83 countries, we have the following composition: A (20%), B (15%), C (52%) and D (13%).

Table 3 below presents the results using the methodology given by equation (10):

Table 3: Variance Decomposition 1970-2000 (Subsample)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2cov($\ln X, \ln A$)
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

The results are qualitatively similar to those obtained with the main sample. The contribution of the variance of the factors of production to the variance of output per worker was 67% higher than that of productivity in 1970, 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 second exercise, we reconstructed the capital stock series 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, as we can see from Table 4 below for the case of $\delta = 7\%$:

Table 4: Variance Decomposition 1970-2000 ($\delta = 7\%$)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2cov($\ln X, \ln A$)
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

We can observe above the same pattern as in our baseline calibration. The variance of $\ln X$ dominates from 1970 until the mid-eighties, when productivity starts to take over as the main source of output dispersion. We obtained a similar result with $\delta = 10.5\%$. The contribution of var($\ln X$) to output dispersion was 50% larger than that of var($\ln A$) in 1970, but 30% smaller in 2000 (see Table A.1 in the Appendix).

With higher depreciation rates the surviving portion of the initial capital stock as a fraction of the capital stock in 1970 is considerably smaller than in our baseline calibration. This is particularly true for the subsample which includes only countries with investment data starting in 1950. Following Caselli (2005), we can compute the remaining portion of the initial capital stock at time t, η_t, as follows:

$$\eta_t = \frac{(1-\delta)^t K_0}{(1-\delta)^t K_0 + \sum_{i=0}^{t}(1-\delta)^i I_{t-i}}.$$

In 1970, the cross-country average of this statistic was 0.24 for $\delta = 3.5\%$ and around 0.11 when the capital stock series was constructed with a 7% depreciation rate. For the 10.5% depreciation rate, the residual of K_0 in the 1970 capital stock was only 0.07. In 1975 the surviving portion of the guessed initial capital stock as a fraction of the estimate of the capital stock was 0.14 in our baseline especification and just 0.03 when the initial capital stock was constructed with a 10.5% depreciation rate, so that the impact of measurement error is very small. Since, as shown above, our results are robust to higher depreciation rates, this provides further evidence that they are are not being driven by our guess of the initial capital stock.

We also notice that, for several economies, the procedure we use to calculate the initial capital stock yields capital-output ratios far above the observed ratio in the US in the initial year. 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.

For the above economies, the balanced-growth hypothesis used in the construction of the initial capital stock may not be appropriate. For these countries we constructed yet another alternative measure of K_0 so that the marginal productivity of capital in the initial year for these economies was 20% above that of the US. This value seems high enough to be consistent with the investment rates observed in the post-war period and to prevent the capital-output ratio from declining in some countries.[7] Table 5 presents development accounting results based on this measure of the initial capital stock.

[7] 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 5: Variance Decomposition 1970-2000 (other K_0)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2cov($\ln X, \ln A$)
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 results are similar to those reported in all previous exercises and the numbers almost match those of Table 2. Hence, the balanced-growth hypothesis used to construct K_0 does not seem to be driving the results.

Finally, and again using the smaller 54-country subsample which has investment data starting in 1950, we constructed a counterfactual capital-stock series in which the initial capital-output ratio was equal to 2 in 1950 for all countries. Of course, this is an extreme assumption that biases the results against our findings. Table 6 presents a development-accounting exercise for this counterfactual capital stock series.

Table 6: Variance Decomposition 1970-2000 ($\frac{K_0}{Y_0} = 2$)

year	var($\ln y$)	var($\ln X$)	var($\ln A$)	2cov($\ln X, \ln A$)
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

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 increased since 1975.

We provide an additional evidence of the robustness of our results by examining the correlation over time between the capital-output ratio and the price of investment relative to consumption (obtained from the Penn-World Table, version 6.1). Standard neoclassical growth theory predicts a negative correlation between the capital-output ratio, κ, and the relative price of investment,

p.[8]

As can be observed in Figure 2 below, between 1970 and 2000 there is a highly negative (around -0.7) and relatively stable correlation between the capital-output ratio and the relative price of investment. To the extent that the relationship between the constructed capital-output ratio and the relative price of investment is consistent with standard growth theory, this provides further evidence that the results are not being driven by measurement error.

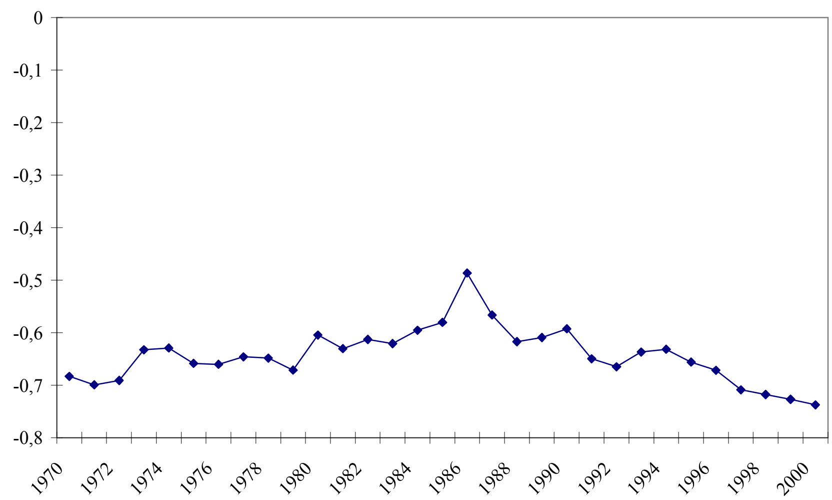

Figure 2: Correlation between the capital-output ratio and the relative price of investment (1970-2000)

However, as shown before, the covariance between factors and productivity increased continually between 1970 and 2000. We can also use data on the relative price of investment in order to shed light on this pattern. As shown in Figure 3, 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.

[8]See Restuccia and Urrutia (2001) and Hsieh and Klenow (2007).

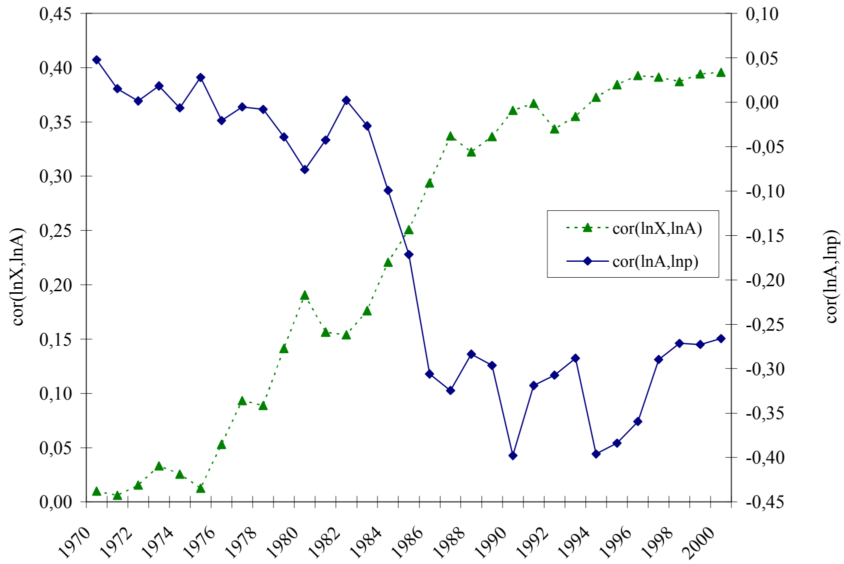

Figure 3: Correlations between productivity, factors and the relative price of investment (1970-2000)

In 1970, the correlation between A and X (in logs) was close to zero, whereas the correlation between A and p (in logs) was 0.05. In 2000, on the other hand, the correlation between A and X was 0.40, whereas the correlation between A and p was -0.27. In other words, in the early seventies high-productivity countries had a slightly higher relative price of investment, which is consistent with the very small correlation between factors and productivity observed during these years. As the correlation between productivity and the relative price of investment became smaller and eventually negative over time, there was a marked increase in the correlation between factors and productivity.

Figure 3 also shows that there was a sharp drop in the correlation between productivity and the relative price of investment (and a simultaneous sharp increase in the correlation between factors and productivity) in the early eighties, when its sign became negative. In 2000 the high-productivity countries had a lower relative price of investment on average and higher capital-output ratios (and factors in general).

Figure A.2 in the Appendix shows that the correlation between output per worker and the relative price of investment displayed a similar pattern between 1970 and 2000. It was negative and relatively small in magnitude in the early seventies, but after the early-eighties the negative relationship

became stronger.

These patterns are compatible with the negative correlation between the capital-output ratio and the relative price of investment that is shown in Figure 2. Hence, the increase in the covariance of factors and productivity over time is consistent with standard neoclassical growth theory. What is not clear is why the correlation between productivity and the relative price of investment changed over time according to the pattern displayed in Figure 3.

One likely explanation is that in the early seventies governments in many developing countries subsidized capital accumulation, which may have artificially reduced the relative price of investment in these countries at the time. After the debt crisis in the early eighties and the subsequent reduction in government subsidies, a negative correlation between productivity and the relative price of investment showed up in the data. We discuss this interpretation in greater detail in the conclusion.

Hence, we conclude that our main findings are robust to different assumptions about the initial capital stock, depreciation rates and country sample. Moreover, data on the relative price of investment give further evidence that our results are consistent with standard neoclassical growth theory and support our findings on the evolution over time of the covariance between factors and productivity. It should be noted 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 previous decades.

The relevant question is how one goes from a world where output dispersion is 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 1970 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,[9] the capital-output ratio and human capital per worker.

[9] 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.

In our sample average output per worker went from US$ 10,333 in 1970 to US$ 14,683 in 2000, growing only 42% in the period.[10] Table 7 presents some descriptive statistics using 1970 and 2000 figures (we set $A = 100$ for the US in 1970):

Table 7: Descriptive Statistics (1970-2000)

	y_{70}	y_{00}	A_{70}	A_{00}	κ_{70}	κ_{00}	H_{70}	H_{00}
sample mean	US$ 10,333	US$ 14,683	60	55	1.68	2.24	3.8	5.3

Between 1970 and 2000, mean productivity decreased in our sample of countries. Median productivity, however, went from 65 to 69 in the same period. As we will see later, the discrepancy between mean and median TFP is due to its steep fall in Sub-Saharan Africa and Latin America. On average, economies became more capital-intensive, with an increase in the capital-output ratio of 33%. A vigorous increase in schooling (h) was also observed, jumping on average from 3.5 years in 1970 to 6.1 years in 2000. As a consequence, our measure of human capital (H) increased by 39% in the period.

In Table 8 we divide the economies in 5 groups, according to their growth rates of output per worker, which are described in the Appendix. In the economic "Miracles" group (11 economies), the growth rate of output per worker ranged from 3.74% to 6.78% per year; in the "Fast Growth" group (19 economies), it ranged from 1.98% to 2.91%; in "Medium Growth" (20 economies), from 1.03% to 1.94%; in "Slow Growth" (17 economies), from 0.22% to 0.98%; and in the economic "Disasters" group (16 economies), the average growth rate ranged from -5.31 % to 0.09% per year. This procedure is somewhat arbitrary but it serves our purpose of calling attention to different patterns of growth across economies.

Table 8: Annual Growth Rates (1970-2000)

country groups	y	A	H	κ
Full Sample	1.36%	-0.32%	0.98%	0.97%
Miracles	4.61%	2.46%	1.01%	1.36%
Fast Growth	2.34%	0.50%	1.19%	1.05%
Medium Growth	1.47%	0.24%	0.95%	0.68%
Slow Growth	0.52%	-1.18%	0.84%	0.96%
Disasters	-1.32%	-3.01%	0.89%	0.97%
correlation w/ y	100%	85%	22%	-3%

[10] All figures are in 1996 values, corrected for PPP. 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. We used the geometric average because it allows for an exact decomposition of growth into its different sources for country groups.

The average capital-output ratio grew at 0.97% per year, while average productivity decreased 0.32% annually. The last result is driven mostly by the TFP behavior in the "Disasters" group: average annual productivity growth excluding these countries is 0.27%. Table 8 shows that productivity growth increases monotonically with the average growth rate of output per worker. While for the "Miracles", productivity growth averaged 2.46% per year, for the "Slow Growth" countries and 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 (85%).

Table 8 also shows that the capital-output ratio increased in all groups, even in the "Disasters" economies. 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.

It can also be observed that average human capital increased almost 1.00% annually, but its correlation with y growth is small (22%). In fact, the growth rate of H is very similar across groups. This result is consistent with the small importance of human capital in explaining growth differences among countries found in Benhabib and Spiegel (1994) and Pritchett (2001).

Table 9: Growth Decomposition (1970-2000)

country groups	y	κ	H	A
Full Sample	1.36%	0.65%	1.03%	-0.32%
		(48%)	(76%)	(-24%)
Full Sample without Disasters	1.94%	0.63%	1.04%	0.27%
		(32%)	(54%)	(14%)
Miracles	4.61%	0.91%	1.24%	2.46%
		(22%)	(27%)	(53%)
Fast Growth	2.34%	0.70%	1.15%	0.50%
		(31%)	(53%)	(21%)
Medium Growth	1.47%	0.46%	0.77%	0.24%
		(31%)	(53%)	(16%)
Slow Growth	0.52%	0.64%	1.06%	-1.18%
		(123%)	(203%)	(-227%)
Disasters	-1.32%	0.65%	1.05%	-3.01%
		(-49%)	(–80%)	(229%)

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

Table 9 presents the growth decomposition exercises for each group between 1970 and 2000. The table shows the important role played by factors to explain

growth rates. Even when excluding from the sample the economic disasters, on average 86% of the observed growth of output per worker can be accounted for by human- and physical-capital accumulation, while only 14% is due to productivity growth.[11] Human capital alone accounts for 54% of output-per-worker growth, or 76% when including the "Disasters" countries. Hence, even though human capital does not account for much of the variation of growth across countries, it is very important to explain the average growth rate of output per worker in the world between 1970 and 2000.

Notice, however, that the sample average hides a lot of variation across different country groups. In the faster-growth group, the "Miracles" economies, 53% of output-per-worker growth is explained by productivity growth. This number falls monotonically with the average growth rate in each group: it is 21% in the "Fast Growth" group, 16% for the "Medium Growth," and -227% for the "Slow Growth". For the "Disasters", the fall in productivity accounts for 229% 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.

The results presented in Tables 8 and 9 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, 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:

$$var\left(\Delta \ln y\right) = var(\Delta \ln A) + var(\Delta \ln X) + 2cov(\Delta \ln A, \Delta \ln X). \qquad (11)$$

Table 10 presents the variance-decomposition results for the growth rate of output per worker. The table shows that productivity growth accounted

[11] Baier et al (2006) also 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. However, there are two important differences from our procedure. First, 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. Second, their main measure of the capital stock was the capital-labor ratio. When they used the capital-output ratio and unweighted observations, as in our case, they obtained a startling value of -162% for the contribution of TFP.

for the bulk of the variance of output-per-worker growth between 1970 and 2000. Specifically, the variance of A growth accounted for 126% of the growth variance, whereas the variance of factor growth accounted for only 37% of the dispersion of output-per-worker growth.

Table 10: Variance Decomposition of Growth Rates

period	$\text{var}(\Delta \ln y)$	$\text{var}(\Delta \ln X)$	$\text{var}(\Delta \ln A)$	$2\text{cov}(\Delta \ln X, \Delta \ln A)$
1970-2000	0.35	0.13	0.44	-0.22
1970-1980	0.06	0.03	0.10	-0.07
1980-1990	0.06	0.02	0.09	-0.05
1990-2000	0.08	0.03	0.10	-0.05

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 is given by:

$$var(\Delta \ln y) = cov(\Delta \ln y, \Delta \ln A) + cov(\Delta \ln y, \Delta \ln X) \qquad (12)$$

This formula amounts to splitting the covariance term, giving half to $\Delta \ln(X)$ and half to $\Delta \ln(A)$. Using the same formula, we obtain that the variance of A growth accounts for 95% of the variance of y growth between 1970 and 2000.

From Table 10 we can observe a negative covariance between the growth rates of A and X between 1970 and 2000. A similar result has been obtained in the literature. For instance, Klenow and Rodriguez-Clare (1997) obtain a correlation of -0.42 between the growth rates of productivity and the capital-output ratio. Bosworth and Collins (2003) also obtain a negative correlation between the growth rate of TFP and the capital-output ratio, whereas Baier et al (2006) obtain a correlation of -0.68 between factors and TFP growth.

One likely explanation for this result is that governments in many developing countries had an important role in these countries' factor accumulation, either directly or through distortionary policies, such as subsidies and tax credits. To the extent that these government interventions created important sources of inefficiency, this may have reduced total factor productivity growth in these countries. We will return to this discussion in the conclusion.

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 1970, and most probably before, 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-growth countries experienced a significant increase in productivity, while slow-growth 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 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 (1997) 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 physical capital, technology and education and that perform better in protecting property rights and the fruits of these investments. In these countries, incentives are better and productivity is higher, and so are investment and growth.

In this section, countries are divided into broad groups on a cultural or geographical basis. 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.[12] 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 countries in the Middle East, 9 in South Asia 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-Saharan Africa

[12] It should be mentioned that our sample of Sub-Saharan countries is 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.

Tables 11a and 11b present averages and growth rates for some variables by cultural and regional groups (we still set $A = 100$ for the US in 1970). The Asian Tigers, on average, experienced very high productivity growth between 1970 and 2000. Whereas in 1970 the level of A for the Asian Tigers was only 55% 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 around 35% in both cases. It should be noticed that the level of productivity in Latin America in 1970 was close to that observed in the advanced countries. However, by 2000 Latin America productivity had shrank to only 51% of the productivity of the English-speaking countries.[13]

Table 11a: Average levels and growth rates (1970-2000)

country groups	Δy	A_{1970}	A_{2000}	ΔA
English-speaking	70%	81	106	31%
Western Europe	66%	78	95	22%
South Europe	99%	79	87	11%
Asian Tigers	267%	45	80	79%
Middle East	76%	85	84	-2%
South Asia	91%	48	45	-8%
Latin America	9%	82	54	-34%
Caribbean	22%	53	54	3%
Sub-Saharan Africa	12%	37	24	-35%

Table 11b: Average levels and growth rates (1970-2000)

country groups	κ_{1970}	κ_{2000}	$\Delta\kappa$	H_{1970}	H_{2000}	ΔH
English-speaking	2.58	2.96	15%	6.31	7.51	19%
Western Europe	3.41	3.93	15%	5.79	7.14	23%
South Europe	2.22	3.02	36%	3.91	5.49	40%
Asian Tigers	1.82	3.30	81%	4.73	6.58	39%
Middle East	1.73	2.01	16%	3.29	5.33	62%
South Asia	1.11	1.75	58%	2.96	3.49	48%
Latin America	1.58	2.11	33%	3.77	5.13	36%
Caribbean	2.33	2.33	0%	4.70	5.75	22%
Sub-Saharan Africa	0.98	1.39	42%	2.56	4.39	36%

[13] 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).

As Table 11a shows, there is no tendency for productivity to converge among regions between 1970 and 2000. With the exception of the Asian Tigers, regions with low levels of productivity in 1970 experienced very small or negative growth rates of A, whereas regions with high productivity, such as Western Europe and the English-speaking countries, had growth rates greater than 20%.

The regional pattern of factors growth during the period was very different, however. In particular, the regions that had the highest growth rates of human capital between 1970 and 2000, such as the Middle East and South Asia, had relatively small human capital levels in 1970. Latin America and Sub-Saharan Africa also had significant growth rates of human capital during the period.

A similar pattern was observed for the capital-output ratio. With the exception of the Caribbean countries, in all groups the capital-output ratio increased in the period, with the Asian Tigers countries experiencing the biggest boost in capital intensity. There was an increase in the capital-output ratio even in groups, such as the English-speaking and Western Europe, where capital deepening in 1970 was relatively high by international standards (2.58 and 3.41, respectively). However, the highest growth rates of the capital-output ratio were observed in regions that had relatively small capital deepening in 1970, such as the Asian Tigers, South Asia and Sub-Saharan Africa.

These results confirm that the period between 1970 and 2000 was characterized by factor convergence and productivity divergence, now taking cultural or geographical factors as our standpoint.

As a result of the significant increase in the capital-output ratio, the marginal product of capital declined substantially for all country groups between 1970 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 MPK for selected groups throughout the period, using the measure constructed according to equation (7).[14]

[14] In a recent study, Caselli and Feyrer (2007) found that, adjusting for differences in the relative price of investment and the share of natural capital (land and other natural resources) in output, the marginal product of capital in 1996 was very similar across countries.

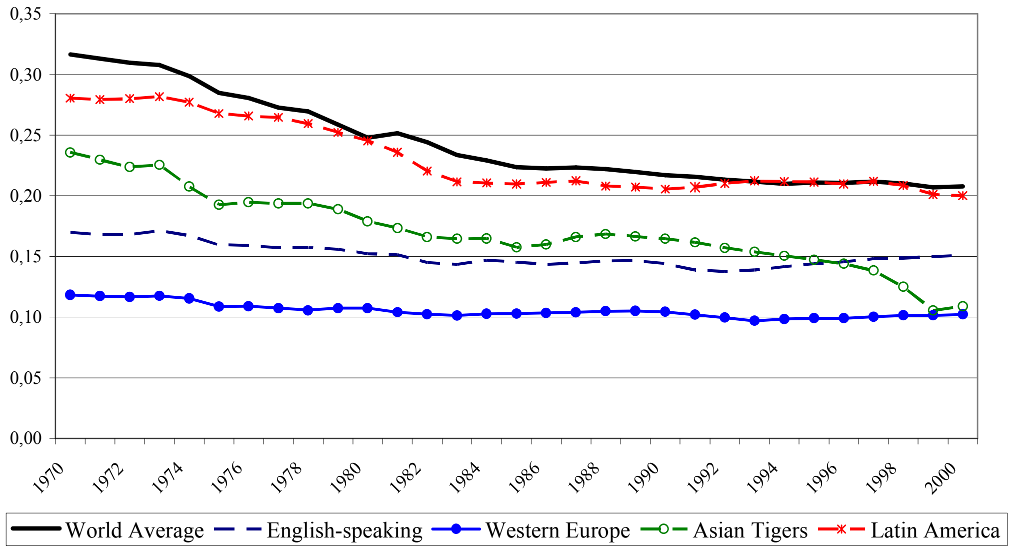

Figure 4: The evolution of the marginal product of capital, selected country groups (1970-2000)

Table 12 summarizes the growth-decomposition exercises for each regional group. Even though average productivity growth in the sample accounted for a small fraction (or even a negative fraction, if we include the disasters) of output-per-worker growth, as showed in Table 9, the relative importance of productivity growth varies considerably among regional groups. In particular, the contribution of productivity to output-per-worker growth was between 40% and 50% for the Asian Tigers, Western Europe and English-speaking countries. On the other hand, it was negative for the Middle East, South Asia, Latin America and Sub-Saharan Africa.

Table 12: Growth Decomposition (1970-2000), Cultural and Regional Groups

country groups	y	κ	H	A
English-speaking	1.78%	0.30%	0.57%	0.90%
		(17%)	(32%)	(50%)
Western Europe	1.69%	0.31%	0.70%	0.67%
		(19%)	(42%)	(40%)
South Europe	2.40%	0.66%	1.31%	0.42%
		(28%)	(55%)	(18%)
Asian Tigers	4.41%	1.34%	1.11%	1.97%
		(30%)	(25%)	(45%)
Middle East	1.89%	0.33%	1.61%	-0.05%
		(18%)	(85%)	(-3%)
South Asia	2.17%	1.02%	1.42%	-0.27%
		(47%)	(65%)	(-12%)
Latin America	0.28%	0.64%	1.02%	-1.39%
		(230%)	(368%)	(-498%)
Caribbean	0.67%	-0.01%	0.59%	0.09%
		(-1%)	(88%)	(13%)
Sub-Saharan Africa	0.35%	0.80%	1.05%	-1.49%
		(225%)	(298%)	(-423%)

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

It should also be noticed that regions that had a particularly large productivity decline between 1970 and 2000, such as Latin America and Sub-Saharan Africa, also experienced strong human and physical capital accumulation. This confirms the finding that productivity and factor accumulation growth were negatively related across countries during this period.

6 Conclusions

This paper presented a group of exercises on level and growth decomposition for a representative sample of countries from 1970 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), Easterly and Levine (2001) and Caselli (2005), 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 in the early seventies factors of production, namely human and physical capital, were the main source of income dispersion and that productivity variance was considerably smaller than in later years. Only after the mid-eighties the prominence of productivity started to show up in the data. The increase in the importance of productivity relative to factors was 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.

Another important result is that the covariance between factors and productivity was very small in the early seventies and increased continually during the period. Moreover, the regions that experienced a sharp decline in productivity, such as Latin America and Sub-Saharan Africa, also had strong factor accumulation growth rates.

We showed that our main findings are robust to different assumptions about the initial capital stock, depreciation rates and country sample. Moreover, data on the relative price of investment give further evidence that our results are consistent with standard neoclassical growth theory and support our findings on the evolution over time of the covariance between factors and productivity.

We offer one caveat to our results. The evidence presented in this paper hinges on the quality of the Penn-World Table income and investment data. One concern might be that the quality of data for some variables, such as the investment rate, may vary across countries and over time. Our results are qualitatively similar when we focus on a subsample of 54 countries for which there is complete investment data starting in 1950, which includes a higher fraction of countries with better data quality in comparison to our main sample. However, measurement error due to data quality problems might still be present.

Our main purpose was to document these stylized facts so that they can be used to evaluate growth and development theories. For this reason, a full explanation of these patterns is beyond the scope of this paper. In any case, we believe that one likely interpretation is as follows.

As we showed, even though factor accumulation was widespread between 1970 and 2000, the highest growth rates of physical and human capital were

observed in developing regions, such as Latin America and Sub-Saharan Africa. At least until the early-eighties, governments in many developing countries had an important role in these countries' factor accumulation, either by investing directly[15] in physical and human capital or by using distortionary policies, such as subsidies and targeted tax credits, to induce an increase in private investments.[16] To the extent that government intervention created important inefficiencies, this may have reduced total factor productivity growth in these countries.

These considerations are consistent with the observed convergence of physical and human capital between 1970 and 2000, as well as the small covariance between factors and productivity in the early seventies and the negative covariance between factor accumulation and productivity growth.

Another stylized fact documented in this paper is the increase in the covariance between factors and productivity over time. As we showed, the increase in the covariance of factors and productivity is consistent with the reversion over time in the correlation between productivity and the relative price of investment from slightly positive to negative. The relevant question is why did the correlation between productivity and the relative price of investment change over time according to the pattern displayed in Figure 3. One likely explanation is that, since in the early seventies governments in many developing countries subsidized physical capital accumulation, this may have artificially reduced the relative price of investment in these countries at the time. After the debt crisis in the early eighties and the subsequent reduction in government intervention,[17] a negative correlation between productivity and the relative price of investment showed up in the data, as would be expected in economies with market-oriented incentives.

This interpretation is consistent with Hsieh and Klenow (2007)'s finding that differences in the relative price of investment among countries are not driven by distortionary government policies, using data from 1980, 1985 and 1996. Moreover, their evidence that the high relative price of investment in poor countries results from low TFP in producing investment goods is compatible with our interpretation that government intervention in developing countries's capital accumulation, either directly or through distortionary poli-

[15]Schmitz (2001) shows that the negative effects of government production of investment goods on aggregate TFP and labor productivity can be quantitatively important.

[16]See Easterly (2001) for a description of several government policies adopted in developing countries in the last decades aimed at increasing physical and human capital accumulation.

[17]See Kuczynski and Williamson (2003) for an account of market-oriented reforms implemented in Latin America since the early eighties.

cies, is important to account for the pattern of factor convergence and TFP divergence among countries over time. The investigation of this and other possible explanations for the stylized facts documented in this paper will be the object of future research.

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.

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, Korea, Hong-Kong, Mauritius, Thailand, Ireland, Malaysia, Cyprus, Indonesia, Singapore.

Fast Growth: Syria, India, Pakistan, Portugal, Dominican Republic, Japan, Barbados, Finland, Norway, Tunisia, Malawi, Lesotho, Turkey, Nepal, Austria, Italy, Bangladesh, Jordan, Israel.

Medium Growth: Iceland, Belgium, Spain, United Kingdom, France, USA, Germany, Chile, Greece, Uganda, Denmark, Canada, Australia, Ecuador, Sweden, Netherlands, Brazil, Panama, Uruguay, Trinidad & Tobago.

Slow Growth: Guatemala, Fiji, Kenya, Philippines, Mexico, Cameroon, Paraguay, South Africa, New Zealand, Papua New Guinea, Guyana, Switzerland, Colombia, Costa Rica, Argentina, El Salvador, Iran.

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

C Development Accounting (Alternative Variance Decomposition)

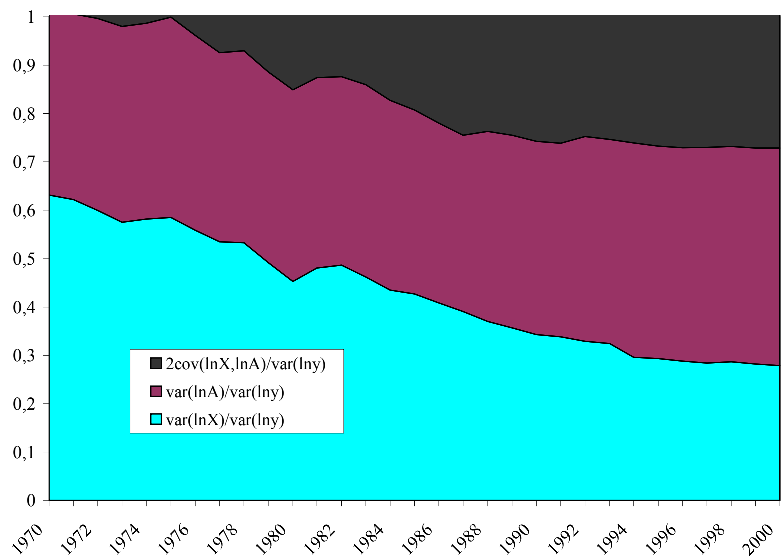

Figure A.1: Output-per-worker alternative variance decomposition (1970-2000)

D Correlation Between Output Per Worker, Productivity and The Relative Price of Investment

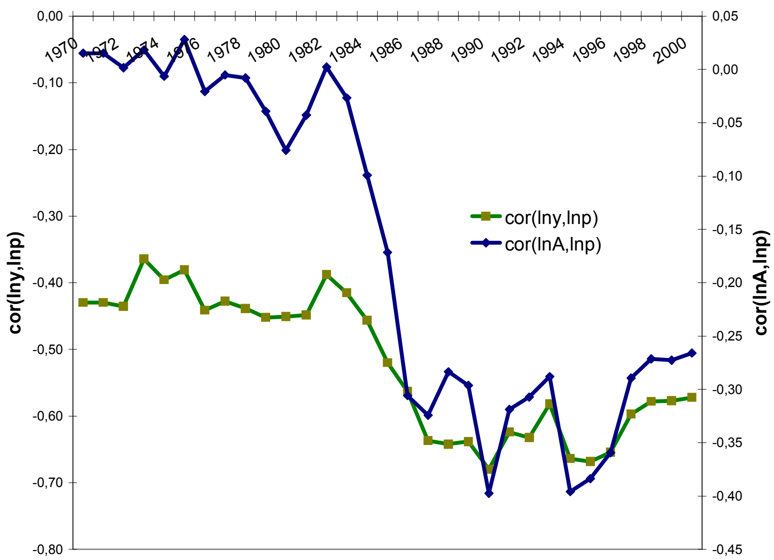

Figure A.2: Correlations between output per worker, productivity and the relative price of investment (1970-2000)

E Development Accounting Results Using a 10.5% Depreciation Rate

Table A.1: Variance Decomposition 1970-2000 ($\delta = 10.5\%$)

year	$\text{var}(\ln y)$	$\text{var}(\ln X)$	$\text{var}(\ln A)$	$2\text{cov}(\ln X, \ln A)$
1970	0.92	0.54	0.36	0.02
1975	0.93	0.52	0.39	0.02
1980	0.99	0.42	0.39	0.18
1985	0.99	0.40	0.36	0.23
1990	1.11	0.37	0.41	0.33
1995	1.25	0.36	0.49	0.39
2000	1.32	0.37	0.53	0.40

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