The Anatomy of Start-Stop Growth*

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ABSTRACT

This paper investigates the remarkable extremes of growth experiences within countries and examines the changes that occur when growth starts and stops. We find three main results. First, virtually all but the very richest countries experience both growth miracles and failures over substantial periods. Second, growth accounting reveals that physical capital accumulation plays a negligible role in growth take-offs and a larger but still modest role in growth collapses. The implied role of productivity in these shifts is also directly reflected in employment reallocations and changes in trade. Third, growth accelerations and collapses are asymmetric phenomena. Collapses typically feature reduced manufacturing and investment amidst increasing price instability, whereas growth takeoffs are primarily associated with large and steady expansions in international trade. This asymmetry suggests that the roads into and out of rapid growth expansions may not be the same. The results stand in contrast to much growth theory and conventional wisdom: despite much talk of poverty traps, even very poor countries regularly grow rapidly, and the role of aggregate investment in growth accelerations is negligible.

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1. Introduction

Since World War II, economic development has witnessed a few distinct "miracles" and a larger number of "failures". A few countries, such as Singapore and Botswana, experienced consistently high rates of growth. Meanwhile, many countries found themselves only modestly more developed, if not poorer, at the close of the 20th century then they were several decades before. Explaining the variation across countries has motivated an enormous range of research that seeks to unlock key mechanisms and causes of growth and draw lessons that can guide policy.

This paper explores a less common approach to growth that emphasizes the variation of the growth experience *within* countries. We first show that growth "miracles" and "failures" appear to be ubiquitous at ten and fifteen year time scales, with only the very richest countries immune from these dramatic fluctuations. Despite talk of poverty traps, almost all countries in the world have experienced periods of growth lasting a decade a longer during which they appeared to be growing fast enough to converge to the United States. Conversely, nearly all countries have experienced sustained periods of abysmal growth.

Given the ubiquity of these substantial shifts in growth, understanding the transitions between different growth regimes is a critical question. In this paper, we employ growth accounting to investigate what actually occurs during the transitions. In order to systematically identify the events to be studied, we identify structural breaks in the growth series for individual countries using the methodology of Bai and Perron (1998, 2003) and data from the Penn World Tables (Heston et al. 2002).

The analysis suggests that changes in the rate of factor accumulation explain relatively little of the growth reversals, especially for accelerations. Instead, the growth reversals are largely due to shifts in the growth rate of productivity. We find very similar results if we use independent data on electricity consumption to infer total capital utilization rather than relying on investment data from the national accounts. The electricity data not only implies that the results are not being driven by changes in the intensity with which capital is used, but also assuages potential concerns about the quality of investment data. The results survive a host of robustness checks, including alternative methods of selecting break dates and excluding growth “recoveries” from the analysis.

The weak role of capital accumulation in these growth transitions suggests an efficiency story. In fact, further analysis suggests that reallocations across sectors may be an important mechanism through which these productivity changes take place. Accelerations, for example, are coincident with major expansions in international trade (both imports and exports), which suggests that efficiency boosts may be coincident with sectoral reallocations to exploit a country’s comparative advantage. Both accelerations and decelerations are coincident with changes in the growth rate in the manufacturing labor force, suggesting reallocations into and out of higher-productivity manufacturing sectors.

We also find that accelerations and decelerations are asymmetric events. Accelerations are associated with substantial increases in trade, and relatively little change in investment, monetary policy or levels of conflict. Decelerations, on the other hand, show much sharper changes in investment (though still explaining a modest portion of the growth transition), increases in monetary instability, and increases in conflict. This asymmetry suggests that the problem of sustaining growth – i.e., preventing a deceleration – is a different problem in kind from the problem of engineering a growth takeoff. The roads into and out of rapid growth expansions are both well-trodden. But they are different roads.

Given these results, we reconsider several popular ideas in growth. Three main themes emerge. First, the classic “poverty trap” is not a first-order description of the growth process. Simply, most countries, including very poor countries and most Sub-Saharan African countries, have grown very quickly over some sustained period. Second, the missing role of investment in growth accelerations is inconsistent with many views of growth, particularly those that emphasize poverty traps, since most rely on investment mechanisms. One example is the big push view of development (Rosenstein-Rodan 1943; Rostow, 1960; Murphy et al. 1989). Institutional stories that emphasize property rights and credit constraints as essential obstacles to growth also seem inconsistent with these growth accelerations, if, as typically understood, improvements in property rights and credit markets would accelerate growth by expanding aggregate investment. Third, the asymmetry in the mechanics of collapses and accelerations poses a challenge to many unified models of growth. The limited set of existing models that feature medium-run cycles generally do not possess the types of asymmetries found in the data.

The remainder of the paper is organized as follows. Section 2 presents benchmark facts that characterize the variation in growth within countries. Section 3 applies the Bai & Perron (2003) methodology to identify structural breaks in growth. Section 4 employs growth accounting to investigate the mechanics of growth takeoffs and collapses and also considers plausible sources of efficiency gains. Section 5 considers the existing theoretical literature in light of the facts presented here. Section 6 concludes.

2. Growth Extremes within Countries

Several papers have argued that there is significant volatility in growth within countries and characterized aspects of this volatility. Easterly et al. (1993), for example, showed that correlation of growth across decades within countries is very low – averaging only 0.3 in a worldwide sample. This implies that most of the variation in growth comes *within* individual countries, rather than across countries. Pritchett (2000) has categorized different growth regimes qualitatively, documenting "hills", "plateaus", and "mountains", and suggested that countries typically feature abrupt and sustained changes in growth regimes rather than a consistent convergence process. Building on these insights, the literature has recently begun to further investigate this volatility.[1]

[1] Aguiar and Gopinath (2004) show that the variation in growth rates in a sample of emerging markets is characterized by shifts in growth trends rather than variations in growth around a single trend. Ben-David and Papell (1998) identify a statistically significant single structural break in the growth series for a broad set of countries. Jerzmanowski (2004) has built on Pritchett's observations and estimated a Markov switching model between three different growth states, controlling for convergence effects. Hausmann et al. (2004) look at the empirical determinants of growth accelerations, and Easterly (2005) argues that these events are not driven by foreign aid or investment. For the OECD, a vast literature has also noted and sought to explain the growth slowdowns noted in the 1970s (e.g. Griliches 1980; Wolff 1996), and recent work has begun to examine medium-term fluctuations in output in developed countries more generally (Comin and Gertler 2004).

In this section we build on the existing literature by demonstrating the magnitude of the shifts in growth within countries. In the same way that cross-country comparisons do not capture the substantial part of growth variations, long-run averages within countries mask patterns of extreme success and extreme failure. In particular, we show that growth "miracles" and "failures" over ten year periods (and longer) appear within the historical experiences of most countries.

To begin, Figure 1 presents the best 10-year growth episode and the worst 10-year growth episode for all 125 countries in the Penn World Tables with at least 20 years of growth data. Countries are ranked from the poorest to richest based on their income level in 1960. For comparison, the graph highlights the best 10-year average in the United States (3.3% per annum) and the worst 10-year average in the United States (1.0% per annum).

Figure 1 indicates a remarkable degree of heterogeneity within national growth experiences, with sustained periods of both high and low growth. Nearly all countries have experienced a growth episode substantially better than the U.S. best and a different episode substantially worse than the U.S. worst. Moreover, extreme highs and extreme lows in growth are common across the income spectrum. Only among the very richest countries is there a drop in the magnitude of the extremes.

The capacity of countries across the income spectrum to produce sustained episodes of high growth suggests that rapid increases in welfare have been within the reach of most economies. This point is clarified in Figure 2, which compares the income level at the end of the best 10-year growth episode to the prior peak level of income. We see that large income expansions are quite common. In fact, 80% of the episodes show income expansions of at least 25%, with 50% showing expansions of at least 50% and many examples where per-capita income doubled or more. Meanwhile, in only 6% of the cases do countries arrive at income levels equal to or below their prior peak. The 10-year growth booms in Figure 2 are not simply recovery after bad episodes, but rather represent new growth.[2] The medium run variation in growth exposes large shifts in welfare.

[2] Since the growth data is truncated (typically in 1960 for developing countries), it is possible that in some cases there is recovery from an un-witnessed pre-period. However, when examining the subset of those

A different way to view these growth extremes is through the lens of convergence. It is well known that income levels of poor countries have typically diverged from the wealthiest countries, with some notable exceptions (Jones, 1997; Pritchett, 1997). For example, since 1960, among those countries with initially below median income, only 24% have grown faster on average than the United States while the other 76% have grown slower. As indicated in Figure 1, however, the story over the medium run is considerably richer.

Table 1 analyzes whether countries have converged to US income levels and diverged from US income levels over 10-year periods. By convergence and divergence, we mean that average growth is higher or lower than average US growth over the same 10-year period.[3] As before, the analysis includes all 125 countries in the Penn World Tables with at least 20 years of growth data. The mean number of growth observations for all countries in this sample is 44, so 10 year periods are typically about one-quarter of their growth history.

The striking fact is that 90% of all countries have converged on the US over some 10-year period, while 94% have diverged over some 10-year period. Dividing countries by region or by initial income level, we find that a high propensity for medium-run convergence and divergence are general phenomena. Among the poorest 1/3rd of countries in 1960, 92% have experienced a sustained episode of convergence. Even the majority of countries in Sub-Saharan Africa, most of which are considered long-run growth "failures", have converged on the US over sustained periods.[4]

These facts suggest that both miracles and failures in the medium run are within the experience of the *same* country – growth within countries is a "start-stop" process. Put another way, average growth over a 40-year period is typically a bad description of

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growth accelerations in Figure 2 that come later in a country's data series, we find similar patterns. Recovery has little to do with these 10-year growth booms.

[3] One might be concerned that convergence and divergence are made more likely due to U.S. growth volatility. However, as seen in Figure 1, similar results still obtain even comparing to the best and worst U.S. experiences.

[4] In results not reported, we find that convergence and divergence are also common over longer-periods. For example, 85% of countries experienced convergence and 87% experienced divergence over some 15-year period.

that country's experience at any particular point in time. Understanding the variation within countries' experiences can produce specific insights for theory and policy.

3. Identifying Regime Shifts in Growth

Multiple structural breaks in a growth series can be identified using the econometric methods of Bai and Perron (1998, 2003). This section will identify these breaks and classify them into "up-breaks", representing accelerations of growth, and "down-breaks", representing growth collapses. The following sections analyze the mechanics of these accelerations and collapses and relate them to existing growth theory. Other methods of identifying growth transitions will also be considered below.

The Bai and Perron method locates and tests for multiple structural breaks within a time series. In our case, we look at a growth series within a country,

$$g_t = a_R + e_t$$

where g_t is the annual growth rate in purchasing-power-parity per-capita income, a_R is the mean growth rate during regime R, and e_t is an error term drawn from a common distribution across regimes. Data is taken from the Penn World Tables v6.1.

The intuition for the Bai and Perron method is straightforward. First, an algorithm searches all possible sets of breaks (up to a maximum number of breaks) and determines for each number of breaks the set that produces the maximum goodness-of-fit (R^2). The statistical tests then determine whether the improved fit produced by allowing an additional break is sufficiently large given what would be expected by chance (due to the error process), according to asymptotic distributions the authors derive. Starting with a null of no breaks, sequential tests of k vs. $k+1$ breaks allow one to determine the appropriate number of breaks in a data series. Bai and Perron determine critical values for tests of various size and employ a "trimming" parameter, expressed as a percentage of the number of observations, which constrains the minimum distance between consecutive breaks. For our main results, we focus on a specification with 10% asymptotic size and a

10% trimming parameter, although the main conclusions in following sections are robust to various choices. We will employ a number of robustness checks as we proceed.[5]

Since these are asymptotic tests while our time-series typically have between 40 and 50 observations, we undertake a Monte-Carlo exercise to assess how accurately the Bai and Perron method detects breaks in synthetic data series of similar length. In particular, we model a growth process with 40 years of data, an autocorrelation parameter of 0.1 (similar to what is present in actual growth data), and structural mean shifts equal to 0.5, 1, and 2 times the standard deviation in the error term.[6] Not surprisingly, the Bai & Perron method is more successful the larger the break. For example, a single break 2 standard deviations in size will be detected 91% of the time, but a single break 0.5 standard deviation in size will be detected only 24% of the time. The method is therefore conservative in detecting breaks, capturing only major accelerations and collapses, as opposed to every growth turnaround suggested by Figure 1.[7] We also find that the size of the test is appropriate in small samples, with a test that has 10% asymptotic size producing false positives in about 11% of the cases.

When implementing the Bai & Perron method on the real growth data, we detect a total of 73 structural breaks in 48 of the 125 countries that have at least 20 years of Penn World Table data. We classify these breaks as either "up-breaks" or "down-breaks" depending on whether the average growth rate in the regime after the break is above or below the average growth rate before. Table 2 lists the countries and years with structural growth breaks. Figure 3 presents four illustrative examples, plotting the log of PPP per-capita income over time for China, Mozambique, Cote d'Ivoire and Indonesia. Vertical lines mark the break years determined by the method, and we see that they are picking up substantial changes in growth rates – and well-known historical episodes. The

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[5] The smaller the size parameter, the fewer the number of breaks, and the exact dates of the estimated breaks can shift within countries. We have estimated the set of breaks using various size and various trimming parameters, and have also considered other estimation methods based on the Schwarz criterion of Liu et al. (1997) or the Bayesian Information Criterion (BIC) of Yao (1998), as implemented by Bai and Peron (2003). Bai and Peron argue that their method has superior properties under some circumstances than these other methods. The behavior of economies in the vicinity of these breaks, examined in Section 4, is robust to the break methodology and parameters (size, trimming) chosen.

[6] Bai & Perron (forthcoming) also present Monte Carlo results for finite samples, but their simulated samples sizes are larger then we have in our growth series; hence, we run our own simulations.

[7] We will examine broader sets of growth turnarounds as part of our robustness checks below.

acceleration in China in 1978 is coincident with Deng's ascension and an opening of the economy. The collapse in 1973 in Mozambique follows the onset of major internal military conflict, and the turn-around in 1986 marks a sharp move away from Marxist economic policies and towards peace. Indonesia's growth begins with the Suharto's ascension and defeat of the communists in 1967 and ends with the Asian financial crisis in 1997. Cote d'Ivoire's collapse in 1979 marks the end of the "Ivorian Miracle" as coffee and cocoa prices fall precipitously.

Table 3 presents summary statistics about these breaks. First, we see that down-breaks are somewhat more common than up-breaks, accounting for 59% of the cases. Second, structural breaks are common across regions of the world and widely different income levels – a fact that should not be surprising given the evidence of Figure 1. If anything, we detect fewer breaks in very poor countries and in Sub-Saharan Africa. Third, structural breaks occur in all decades, although there is an unusual propensity for down-breaks in the 1970s, which is consistent with a large literature on the 1970s slowdown.

4. The Mechanics of Start-Stop Growth

In this section we use growth accounting techniques to analyze the mechanical sources of growth accelerations and collapses. The standard assumption in growth and development accounting is a neoclassical production function with constant returns to scale in aggregate physical capital and quality weighted labor (e.g. Barro 1999a; Caselli forthcoming). Here, we will generalize the standard production function slightly to include utilization parameters that account for possible changes in the intensity with which factors are used. We write,

$$Y = F(A, K, H) \tag{1}$$

where K is aggregate physical capital in use, H is aggregate human capital in use – i.e. quality weighted labor, and A captures Total Factor Productivity (TFP), a measure of how efficiently the aggregate stocks are employed in the production of national output. We further decompose capital stocks into two parts,

$$K = u_K \overline{K}$$

$$H = u_H \overline{H} \qquad (2)$$

where $\overline{K}$ and $\overline{H}$ are the total aggregate physical and human capital in the economy, and u_K and u_H are the intensity with which these factors are employed. Since we are looking at medium-run changes in growth rates, it will be useful to relax the full employment assumption in standard growth accounting and attempt to estimate factor utilization as well. Taking logs in (1) and differentiating with respect to time we find

$$g_Y = g_{TFP} + \frac{F_K K}{Y} g_K + \frac{F_H H}{Y} g_H \qquad (3)$$

If factors are paid their marginal products, and output is exhausted in factor payments, then $\alpha \equiv F_K K/Y$ is simply the capital share of income and $F_H H/Y = 1 - \alpha$ is the human capital (labor) share of income. In the analysis, we will assume $\alpha = 1/3$ as our main specification, although the implications of variations in this parameter will be considered.[8]

Subtracting the growth rate of population from both sides of equation (3), and using equation (2) to decompose factor growth rates into growth in the total factor available and growth in the factor's utilization, yields,

$$g_y = g_{TFP} + \alpha g_{\bar{k}} + (1-\alpha) g_{\bar{h}} + \alpha g_{u_K} + (1-\alpha) g_{u_H} \qquad (4)$$

where lower-case variables are averages per-capita.

Having identified structural breaks in the growth rate of per-capita income, g_y, we use equation (4) to account for the sources of that structural change in growth. The accounting exercise tells us whether observable factors, such as the accumulation of physical capital, human capital, or changes in factor intensity, can account for significant parts of the structural change, or whether TFP, the unobserved residual, is left to explain the growth breaks.

[8] Gollin (2002) estimates income shares across countries and find that the traditional assumption of approximately 1/3rd for the capital share is not unreasonable on average, although there is some variation. The implied estimates for the capital share lie mostly in a range between 0.15 and 0.4.

In the simplest specification, the utilization of existing factors can be incorporated as part of TFP. This approach has been followed in studies that consider growth and development accounting over large sets of developing countries (Easterly & Levine, 2001; Hall & Jones, 1999). Here we will consider the results of that approach, as well as, further below, the implications of specific controls for factor intensity using electricity consumption and labor force data.

The growth rate in the physical capital stock per-capita is defined as

$$g_{\bar{k}} = \frac{I}{\overline{K}} - \delta - n \qquad (5)$$

where *I*, gross investment, and *n*, the population growth rate, are taken from the Penn World Tables. The depreciation rate, δ, is assumed to be 7%.[9] The initial aggregate capital stock is determined by the perpetual inventory method.[10]

Estimating the growth rate in human capital is more challenging because data is not available on an annual basis and methods for determining the human capital stock differ across authors. We will focus on education and make the increasingly standard assumption of Mincerian returns to schooling,

$$\bar{h} = e^{r(s)}$$

where *s* is years of schooling. We take $r(s) = 0.1s$, which implies a 10% return in wages to an additional year of schooling.[11] Then

$$g_{\bar{h}} = 0.1\frac{ds}{dt}$$

[9] Authors differ in their choices of the depreciation rate for aggregate capital, with 6% (e.g. Hall and Jones, 1999, Caselli forthcoming), 7% (e.g. Easterly and Levine, 2001), and 10% (e.g. Aguiar and Gopinath, 2004) among the typical choices. We take 7% and will comment further on the role of this parameter below; our conclusions are not sensitive to this choice.

[10] The initial capital stock for each country in the Penn World Tables is determined assuming that investment grows in the unobserved pre-period at the same average rate as in the first ten years of the sample. The core results are not sensitive to how the initial capital stock is imputed.

[11] Our conclusions will not be sensitive to any reasonable assumption about *r(s)* based on existing estimates of this function. Essentially, human capital growth rates do not move sharply enough to have much explanatory power for structural breaks in growth; hence, fine tuning assumptions about human capital parameters and measures (see Psacharopoulos 1994; Bils & Klenow 2000) will not affect our results.

Using the Barro-Lee data set (2000), which presents panel data for average schooling data at 5-year intervals, we calculate the growth rate in human capital over each 5-year period using the trend in average schooling in the population of those at least 15 years in age.

4.1 Factor Accumulation

Tables 4A and 4B present the basic results of growth accounting around the structural breaks defined in Section 3. The first table considers "up-breaks" where the trend growth rate increases at the breaks, and the second considers "down-breaks" where the trend growth rate falls. Each table considers both short-run growth accounting, comparing the 5-years before the break with the 5-years after the break, and medium-run growth accounting, where we compare behavior in the entire prior growth regime with behavior in the entire posterior growth regime.[12]

The first panel of each table shows growth rates before and after the break. Looking first at the up-breaks, we see that the trend growth rate increases by an average of 7.2% per annum in the short run and 6.8% in the medium run. These up-breaks on average mark the end of mild contractions (-1.8% per year) and the beginning of rapid expansions (+5.3% per year).[13] These are substantial changes with large implications for per-capita income.

The next panel of the table considers the role of physical and human capital accumulation in explaining these up-breaks. The most striking result is that, while physical capital accumulation accelerates, this acceleration is very modest, increasing by only 1.5% in the short-run and 1.4% when looking over the entire regime. Human capital accumulation is even more modest, seeing essentially no change.[14]

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[12] For up-breaks, the mean length of the growth regimes is 13.3 years prior to the break and 16.7 years after the break. For down-breaks, the mean regime length is 19.7 years (prior) and 18.4 years (after).

[13] One potential concern is that these up-breaks represent recoveries from periods of negative growth, rather than true growth accelerations. However, as discussed in Section 4.5 below, the results are similar – and in fact show an even smaller change in capital accumulation – if we restrict attention to cases where growth in the pre-period was already positive.

[14] Recall that data for human capital is only available at 5-year intervals, leading to a slightly different approach than that used with the annual data. The "short-run" for human capital compares growth rates in the last complete 5-year interval prior to the break with the first complete 5-year interval after the break. The regime averages consider growth rates over the longest period observable within the prior and posterior regimes.

The third panel of the table indicates how much of the change in growth is explained by factor accumulation. Given the modest changes in the growth rates of the physical and human capital, the answer is not very much. Assuming the standard factor share for physical capital of 1/3, physical capital accumulation explains only 6.9% of the growth change in the short run and 7.1% in the medium run. In other words, increased rates of capital accumulation – i.e. increased investment – do not play a substantial role in growth accelerations.

Table 4B considers "down-breaks" in growth. As with growth accelerations, we see large changes in income growth rates: a decline of 7.0% in the short run and 6.0% in the medium run. These down-breaks on average represent the end of rapid expansions of about 5% per year and the onset of contractions of about -1.5% per year. In this sense, they are the mirror opposite of the up-breaks. Unlike the up-breaks, however, we now see a reasonably large decline in the rate of capital accumulation, by 4.0% in the short run and 4.6% over the regime averages. Human capital, as before, shows only modest changes.[15]

Given the more substantial decline in the rate of capital growth, factor accumulation can now explain a larger portion of the structural break in the growth trend. Assuming a capital share of 1/3, the contribution of capital is still somewhat modest – about 25% or 30%. While modest, this effect is statistically much larger than seen in growth accelerations.

Table 5 compares the results from the up-breaks and the down-breaks. For both up-breaks and down-breaks, we report a p-value from a one-sample t-test of the null hypothesis that there was no change in the growth rate of each variable across the break. With up-breaks, we cannot reject the hypothesis that there was no increase in the growth rate of physical capital. We also report the p-value from a two-sample t-test of the null hypothesis that the changes were symmetric. As indicated in Table 5, these t-tests strongly reject the null that up-breaks and down-breaks are symmetric events.

[15] Interestingly, human capital moves in the opposite direction of growth, with a slight acceleration in the rate of schooling.

4.2 Factor Utilization

The intensity of factor utilization, beyond total factor quantities, may be particularly important when examining short and medium run fluctuations in growth.[16] In this section, we employ measures of labor force participation and electricity consumption to assess factor intensity.

The second panels of Tables 4A and 4B present changes in labor force participation (LFP) around structural growth breaks. Labor force participation, the ratio of total workers to the total national population, can serve as a measure for u_H in equation (4). The data indicates only modest changes; neither up-breaks nor down-breaks appear to be related to swings in the intensity with which labor is employed, at least on the margin of the number of individuals.[17, 18] While labor force participation is not the ideal measure of labor intensity, electricity consumption measures can help with concerns about inadequate employment measures.

Analyzing electricity consumption data has two primary benefits in analyzing the mechanics of structural breaks in growth. First, shifts in the intensity with which a given stock of physical capital is employed will be reflected in electricity consumption per unit of capital. Second, the total amount of electricity consumption can capture the aggregate use of capital, incorporating both factor utilization and factor accumulation effects. Therefore, we can also use electricity consumption data as a substitute measure for the role of physical capital and reconsider growth accounting without relying on imputations of physical capital stocks from aggregate investment data.

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[16] Even over the longer run, changes in utilization may matter. For example, labor force participation rates may shift substantially, as suggested in a study of East Asian growth miracles (Young 1995).

[17] Labor force participation is calculated from the Penn World Tables by comparing GDP per worker to GDP per capita. The Penn World Table data come from the International Labor Organization, which is also the source of the employment data used in the World Development Indicators.

[18] Labor force measures include those unemployed who are actively seeking work, so changes in unemployment rates will not be reflected in changes in the labor force measures used here. However, the impact of shifts in unemployment rates on growth is unlikely to be large enough to explain the changes in growth we observe. To see this, suppose there was a dramatic reduction in unemployment – say, from 25% to 10%. This would yield a *one-time* increase in output of plausibly no more than 15%, which assumes optimistically that capital is also idle and waiting for these workers, and that these workers find jobs that are equal to the average productivity of the already employed. By contrast, the mean expansion in output is 5.2% *per year* for the 16.7 years in the medium-run, or an increase in output of 240% for the entire period. Thus the contribution of changes in unemployment is likely to be negligible.

To focus on capital utilization, we define a linear relationship between electricity use and physical capital as

$$e = Bu_K \bar{k} \tag{6}$$

where e is electricity use per-capita. The linear relationship finds support in regression analysis.[19] Then,

$$g_{u_K} = g_e - g_{\bar{k}} \tag{7}$$

so that the difference between electricity consumption and capital growth defines growth in the intensity of capital use. Further, growth accounting can now be performed looking at electricity data in place of the imputed data on the capital stock. With (7), the analog of equation (4) is:

$$g_y = g_A + \alpha g_e + (1-\alpha)(g_h + g_{u_H}) \tag{8}$$

Here the growth rate in electricity use is capturing changes in both the accumulation and utilization of physical capital.

The results of this capital utilization analysis are presented in Tables 4A and 4B, which show little change in capital utilization around either up-breaks or down-breaks. Note that electricity consumption moves in a similar manner as the imputed capital growth, for both accelerations and collapses, which helps reaffirm the imputed capital growth rates. Combining the utilization results for capital and the labor force, we can recalculate the contribution of accumulation and utilization to the growth change. The earlier conclusions are not altered by incorporating these utilization measures.[20]

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[19] If we generalize equation (6) as $e = B(u_K \bar{k})^{\omega}$, then we can estimate ω by running the following regression for a cross-section of countries,

$$\log e = \log B + \omega \log k + \varepsilon$$

OLS confirms a linear relationship, estimating $\hat{\omega}$=1.04 with a standard error of 0.04 and a remarkably high R^2 of 0.9 in 1995 data. Results are very similar for other years.

[20] The electricity consumption data also helps inform labor utilization. If workers are paired with machines, then the application of more labor should also be reflected in increased electricity consumption. If there is an unobserved labor effect, then it must be coming largely in industries that do not use electricity intensively.

The primary conclusion is that capital accumulation and utilization do not appear to explain large portions of the change in economic performance. Up-breaks in growth are little associated with changes in capital accumulation or intensity. Down-breaks are more closely associated with observable factors and particularly a collapse in physical capital accumulation and electricity consumption – yet still they explain no more than 1/3 of the total change in growth. Finally, as shown in Table 5, the asymmetry of collapses and accelerations appears real and statistically significant.

4.3 Sources of Productivity Gains

Total factor productivity, as the residual in growth accounting, is left as the primary explanation for structural breaks in growth, particularly accelerations. The missing role of investment, as a negative result, can help substantially limit theory and policy, as we will discuss in Section 5 below. As is always the case when dealing with TFP, however, a natural question is where these changes in productivity come from.

Generally speaking, changes in TFP would come from the reemployment of existing factors in more or less productive combinations. A more precise view of the national production function would acknowledge, in place of (1), that aggregate output is the summation of the value of various outputs produced using different production processes. Specifically,

$$Y = \sum_j p_j F_j(A_j, K_j, H_j)$$

where *j* represents different types of production. Increases in TFP could come from reallocating human and physical capital to the more productive processes, or alternatively, by increasing the productivity of a particular process. In this section we examine two types of effects that suggest that the reallocation of resources across sectors may be an important reason why TFP changes so dramatically across these growth breaks. First, we consider international trade. Second, we consider shifts in labor employment by focusing on the manufacturing sector within countries.

4.3.1 International Trade

A basic source of efficiency gains may be increased trade openness, for classic Ricardian reasons among others.[21] The first panel of Table 7 shows changes in the trade share across up-breaks and down-breaks. We see several important results. First, the share of GDP that is traded rises substantially with up-breaks, by about 13% over a 5-year period and by 25% over the regime average. This large increase in trade is due, in equal parts, to expanding shares of *both* exports and imports in GDP, with no shift in the trade balance.

Incorporating trade expansions in growth accounting is difficult, since we do not observe sector-level panel data for these economies. However, the trade literature has shown broadly that greater trade shares are associated with greater per-capita income. Taking Frankel and Romer's (1999) instrumental variables estimates for the causal effect of the trade share, the 25% expansion in the trade share would imply a 50-75% expansion in per-capita income. This type of calculation, while highly approximate, suggests that expanding trade may be a central feature of up-breaks in growth.

Meanwhile, growth collapses show no systematic changes in the trade share. The average change is small and not statistically different from zero. The two-sample t-tests presented in Table 6 confirm the asymmetry in the trade patterns between growth accelerations and collapses. We reject the hypothesis that trade share changes are of similar magnitude with well over 99% confidence.

Given the large trade expansions found with up-breaks, one may then ask whether these events are associated with terms of trade shocks, as suggested by Easterly et al. (1993). Table 6 further shows that terms of trade changes are modest. We see a small and statistically insignificant improvement in the terms of trade by about 6% with up-breaks and an insignificant decline of about 2% with down-breaks. Results for the immediate 5-year changes (not reported) are even more modest, showing only a 1.5%

[21] Beyond the cross-sector reallocation of factors toward comparative advantage, openness may increase productivity through increased scale economies, enhanced technology spillovers, and efficiency improvements within tradable sectors (see Tybout 2000 for a review). Micro-studies suggest that trade openness leads to productivity improvements through inter-firm reallocations within tradable industries (e.g. Bernard and Jensen 1999, Aw, Chung, and Roberts 2000) as well as intra-firm or intra-plant improvements in productivity (Pavcnik 2002; Fernandes 2003).

improvement with up-breaks a 0.5% decline with down-breaks. The growth accelerations are not related to sharp changes in the terms of trade, suggesting that trade policy is a more likely driver of these changes than the luck of international prices.

4.3.2 Manufacturing

There is a long-standing view that growth, particularly among poor nations, may come from moves out of agriculture and into manufacturing (e.g., Kuznets 1953; also Matsuyama 1992, Golin et al. 2002). Manufacturing may be intrinsically more productive and may also provide learning-by-doing spillovers (e.g., Krugman 1987). We investigate labor reallocations into or away from the manufacturing sector using UNIDO panel data. In particular, we focus on changes in the growth rate of the manufacturing labor share (i.e., manufacturing labor divided by total employment in the economy.)

As reported in Table 6, structural growth breaks are associated with large shifts in the accelerations or decelerations in the allocation of labor to manufacturing. For down-breaks, the growth rate of the share of the population in manufacturing drops by 4.8% per year. Conversely, for up-breaks, growth in the manufacturing labor share accelerates by 3.6% per year. This suggests that there may be substantial changes in the rate of sectoral allocations associated with these breaks.[22] The changes in the growth rate of manufacturing output exceed the changes in national output and confirm that these shifts in labor into and out of manufacturing were also associated with changes in overall manufacturing output of the same direction.

We can also look at the 9 2-digit SIC sub-sectors that collectively constitute the manufacturing sector. In results not reported, we find that up-breaks see increased manufacturing employment as a fraction of economy-wide employment in 8 of the 9 sub-sectors, with increased output growth rates in all 9 sub-sectors. For down-breaks, the employment share and output growth rates fall on average in all 9 sub-sectors. Regime shifts therefore see broad moves into and out of manufacturing rather than intra-manufacturing reallocation. Interestingly, as shown in Table 7, there is slightly more

[22] While in theory this could reflect a change in overall unemployment, rather than the share in manufacturing, as discussed above, these changes are too large to be due to a one-time change in overall unemployment.

movement in the manufacturing of advanced products than in simple products, which may suggest particular productivity gains.[23, 24]

Overall, the results in this section – showing dramatic changes in trade associated with up-breaks and substantial moves into and out of manufacturing associated with both types of breaks – provide additional evidence that changes in the allocation of resources lie behind the changes in growth. The changes in efficiency we observe may be driven in large part by reallocations of resources towards and away from higher productivity sectors.

4.4 Associated Changes

The previous analysis has demonstrated the presence of structural growth breaks and documented the primary role of changes in productivity in these events. To improve our understanding of structural growth breaks, it is also useful to consider how other important variables behave around these events. We consider three types of variables – variables that reflect the country's monetary policy, the level of conflict (either internal or external), and the country's institutions**.** The purpose of this section is not to make statements about the direction of causality between the events examined here and the dramatic changes in growth we observe; rather, by examining how other variables change during these transitions, we will be able to further our understanding of what these events actually entail.

To examine price stability, we examine changes in the growth rate of the GDP deflator (i.e., the inflation rate) as well as changes in the growth rate of the nominal and real exchange rates. The results are presented in Table 7. The table shows that down-breaks are associated with substantial increases in inflation. In fact, the point estimates suggest an average 14 percentage point increase in the inflation rate across down-breaks.

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[23] The "simple" sectors include food, clothing, and textiles (what Tybout (2000) calls "light manufacturing") as well as wood products, furniture, and paper products (SIC codes 311-342). The "advanced" sectors include chemicals, rubber and plastic products, metal products, machinery, transport equipment, and professional and scientific equipment among others (SIC codes 351-385). The split between simple and advanced manufacturing is about 60%-40% for the labor employment share and 55%-45% for the output share on average for the countries in the sample.

[24] Given that capital accumulation and electricity consumption rise little with up-breaks, the broad if often insignificant increases in manufacturing employment shares and output with up-breaks suggests a further retargeting of investments and electricity use in line with a productivity-based story.

This includes a number of hyperinflation episodes (e.g. Brazil, Zaire, and Nicaragua), as well as a large number of increases in inflation in the range of 10-30% per year. Overall, of the 39 down-breaks in the sample, 33 show increases in inflation. The results for exchange rates show that the nominal exchange rate also adjusts (through devaluation) during these episodes, so that real exchange rates remain approximately constant. Note that the typical contraction would present deflationary pressures rather than inflationary ones, which suggests that the inflationary price instability is more likely to be a cause than a consequence of the contraction. Up-breaks, by comparison, show very modest (and statistically insignificant) declines in inflation. In fact, examining the data country-by-country, only two (Mexico and Indonesia) of the 23 up-breaks are associated with substantial declines in inflation.

A second, relevant factor in producing these dramatic shifts in growth may be the beginning or end of violent conflict. To examine this possibility, we use annual conflict data from the PRIO / Uppsala Armed Conflict Dataset (Gleditsch et al 2002). The conflict variable takes a value of 0 if there is no conflict, 1 if there is a minor armed conflict, 2 if there is a intermediate armed conflict, and 3 if there is a major armed conflict.[25] We examine changes in two variables, one that captures all conflicts and one restricted to internal conflicts. The results in Table 7 confirm that conflict may play an important role for down-breaks.[26] For 7 of 41 countries, the down-break is almost exactly coincident with the outbreak of civil war. By contrast, growth takeoffs are not obviously related to reductions in conflict. The coefficients suggest only mild decreases in conflict on average, and these decreases are far from statistically significant.

Finally, we examine data on institutional quality using measures of corruption and the rule of law from Political Risk Services (see the description in Barro (1999b) for more detail). These measures range from 0 to 1, where 1 is the best outcome (least corrupt, strongest rule of law), and 0 is the worst. Although sample sizes on the rule-of-law and corruption variables are small -- panel data is only available since 1982 -- the

[25]. Minor conflict is defined to be at least 25 deaths per year but no more than 1,000 total deaths; intermediate is defined to be between 25 and 1,000 deaths per year but no more than 1,000 total deaths; major is defined to be more than 1,000 deaths per year.

[26] Of course, both directions of causality are possible. Obviously, civil war can cause economic collapse, but Miguel, Satyanath and Sergenti (2004) demonstrate that economic collapse can cause conflict as well.

results suggest little change. Both up-breaks and down-breaks are associated with mild increases in the rule-of-law variable, with the up-break result not quite significant. The corruption measures show no pattern.

4.5 Robustness

In this section we consider the robustness of the growth accounting results to various assumptions. We will discuss robustness to the set of break dates, concerns that accelerations may be “recoveries” rather than new growth, the implications of lagged investment effects, and assumptions about depreciation rates and return to scale.

First, we consider the robustness of the results to the way we identify structural breaks in growth. To do so, we examine an entirely different and transparent method for defining growth breaks. In Tables 8A and 8B, we reconsider the basic growth accounting exercise around years that mark the maximum “acceleration” and “deceleration” within each country. In particular, we calculate the change in growth across consecutive 10-year periods for every year in a country’s growth series and then define accelerations as the year in which the growth increase is greatest and decelerations as the year in which the growth decrease is greatest. Tables 8A and 8B report the basic growth accounting results for all countries in the sample, as well as, separately, episodes where accelerations and decelerations were exceptionally large – by more than 5% per annum. As is clear in the table, the results of this analysis are once again similar to the results using precisely identified dates of structural breaks. Accelerations are at most weakly associated with increased investment or electricity use, while decelerations are coincident with more substantial declines in capital accumulation and electricity consumption.

The results are further robust to variations in the structural break method. Recall that the structural breaks in the main analysis were identified using the Bai and Perron method, with a size of 10% and a trimming parameter of 10%. In results not reported, we have repeated the analysis using a variety of other size and trimming parameters and find consistent results. The consistency of the results across different sets of break dates suggests that the findings of the paper are likely to be quite robust to the particular methodology chosen.

A second, related concern is that the accelerations may be recoveries after bad growth episodes, rather than new growth. If this were the case, then the weak investment results may be less surprising. In fact, however, the growth takeoffs in Table 4A represent new growth on average, with income 20% higher five years after the break than it was five years before. In results not reported, we repeat the growth accounting using only those accelerations where growth in the pre-period was greater than 0%, as well as using other criteria to rule out recoveries. That analysis show very similar results: capital accumulation plays a negligible role.[27]

Third, a central result of our analysis is that capital accumulation plays little role in growth breaks, especially accelerations. One possible objection to our method may be that capital investment may influence GDP with a substantial lag. Then investment rates might rise prior to the growth break, making investment changes at the break itself an inappropriate gauge of capital's impact on the transition. However, such lag effects are unlikely to be important here for several reasons. First, electricity consumption – a flow measure of capital use – is determined *ex-post* of any lag effects in installation and does not change at the up-breaks. Second, unlike up-breaks, down-breaks are associated with substantial, simultaneous collapses in investment. If lag effects were important, they would presumably be felt in both cases. Third, the up-break results are similar whether we look at 5-year periods or the longer regime-averages, yet the regime averages would be more immune to lag effects if they were important.

A fourth issue is the capital depreciation rate. The greater the depreciation rate, the smaller the estimated capital stock, and smaller capital stock estimates will amplify the effects of investment changes. Therefore, the greater the depreciation rate, the larger the change in g_k around growth breaks. In the analysis in Tables 4A and 4B, we choose $\delta=7\%$, but larger choices, such as 10% – which is very high – do not alter the basic results. Moreover, the electricity approach to growth accounting in equation (8) is independent of any assumptions about capital depreciation, and the conclusions from that method are substantially the same.

[27] This result is again confirmed when looking at growth in electricity consumption. It is also robust to many ways of defining growth accelerations – whether we use Bai and Peron under various specifications, the best 10-year growth differential discussed above, or other methods such as the growth expansion criteria in Hausmann et al (2004).

Finally, a basic assumption in all growth and development accounting exercises is the shape of the production function, which is typically taken to have constant returns to scale. Allowing increasing returns to physical and human capital will amplify their role and thereby reduce the role of TFP, altering the results. In the analysis above, differing assumptions about the elasticity of output to human capital will have little effect on the growth accounting, since the changes seen in g_h are modest. The changes seen in g_k are likewise modest for growth up-breaks; even with substantial positive spillovers to capital accumulation, we would have to reach beyond any standard theory or empirical evidence before the accumulation of physical capital played an important role in growth accelerations. For down-breaks, the conclusion may be less clear: the collapse in capital accumulation explains a modest portion of the down-break assuming a capital elasticity of 1/3 but virtually all of the down-break with an elasticity of 1.

5. Implications

A common view of development is that many poor countries stagnate and a minority experience sustained growth. Broadly speaking, this appears to be a good description of long-run trends in the data, either when looking at growth averages over the entire postwar period (e.g. Jones 1997) or over even longer horizons (Pritchett 1997). This stylized fact has led many to suggest that poor countries are in a poverty trap, where some intrinsic aspect of poverty itself prevents growth. Unlike the standard neo-classical growth model, poverty trap models all feature some type of non-convexity in the aggregate production function, which generates multiple stable equilibria (e.g. Murphy et al. 1989). This type of argument has been used historically to justify large-scale government investments to escape from the trap (Rosenstein-Rodan, 1943; Nurkse 1953), is the rationale for much modern work in development economics, and has recently been brought again to the fore of macroeconomic policy debates on how to eliminate global poverty (Sachs, 2005).

The evidence presented here, however, conflicts with several aspects of this view. First, just because countries are diverging on average does not mean that a particular country is 'stuck' in a poverty trap without growth. Instead, most countries, including most countries in Sub-Saharan Africa, are capable of experiencing rapid growth. For example, in Figure 1 the average growth difference between a country's best 10 years and worst 10 years is 7 percentage points for the poorest 90% of countries, which implies an income shift by a factor of two after only a decade. And, as discussed above, 90% of countries have experienced sustained growth for 10 years or more at a rate that put them on a path of convergence towards the United States. Only the very richest countries seem immune from these dramatic swings in growth. The issue is therefore not that poor countries are unable to grow at a rapid rate, but rather the probability that these growth episodes begin and the probability that they are sustained. While this point has been recognized to some extent in parts of the literature (e.g., Quah (1993, 1996), Kremer et al. (2001), and others), the view that poverty traps prevent countries from growing at all does not seem borne out in the data. Moreover, this suggests that even large amounts of foreign aid are unlikely to boost developing countries to the point where they are immune to growth disasters or on the path of stable growth.

Second, most views of poverty traps – even those that think about poverty traps probabilistically, rather than deterministically – focus on investment as the key component in the poverty trap. Models differ as to the source of the non-convexity in aggregate production, but in the typical model, low-capital per-capita is an attractor that investment is required to overcome. The results presented here, by contrast, find little if any role for investment in major growth accelerations. Policies that focus on increasing aggregate investment do not appear to be addressing what has, at least historically, been critical to growth accelerations – increasingly efficient allocation of resources.

The implications of this result are not limited to models of poverty traps, but also apply to growth models more generally. In a neoclassical growth model, growth in the long-run comes from improvements in TFP, while countries far from their steady state can grow largely through capital accumulation. The literature on decomposing the relative roles of factor accumulation and TFP has focused primarily on the long run[28]; the results in this paper suggest that TFP is much more important for growth than capital

[28] See, for example, Mankiw, Romer, and Weil (1992) and Young (1995) on the importance of factor accumulation, and Hsieh (2002), Hall and Jones (1999), and Caselli (forthcoming) on the importance of TFP.

accumulation, even in the short and medium run – where factor accumulation could have, in theory, played a large role.

To see the potential role for capital accumulation clearly, consider an economy initially in steady-state with a neoclassical production function and diminishing returns to capital, where $\alpha < 1$ is the elasticity of income to capital, g is the growth rate in TFP, and δ is the depreciation rate. Then the instantaneous effect of an increased investment rate (s) on per-capita income growth (g_y) is:[29]

$$\Delta g_y = \alpha\left(\frac{\Delta s}{s}\right)(g+\delta) \qquad (9)$$

while the long run effect of an increased investment rate is zero, since in the long-run $g_y = g$ for any investment rate s. The instantaneous investment effect could therefore potentially be enormous if the percentage change in the investment rate, $\Delta s / s$, is large. Therefore, while it is true *a priori* that capital accumulation cannot influence long-run growth rates in this standard model, it is conversely quite plausible that capital could play a leading role in the types of growth accelerations and collapses we examine here. Yet we find that, even for these dramatic short and medium run changes in growth, capital accumulation played only a very small role.

Third, the asymmetries between accelerations and decelerations found in the data are not found in most models of growth. While models of poverty traps and growth volatility more broadly can have asymmetric features, few (if any) would predict accelerations driven almost entirely by changes in TFP and decelerations that feature at least some role for investment.[30] Moreover, the expansion of trade that occurs with accelerations and the monetary instability that occurs with decelerations suggest the need for a yet richer and more nuanced theory of the growth process, or, alternatively, that

[29] The change in per-capita income growth due to a change in capital growth is simply $\Delta g_Y = \alpha \Delta g_K$. The instantaneous change in the rate of capital accumulation is $\Delta g_K = \Delta sY/K$, which follows directly from the capital accumulation equation, $dK/dt = sY - \delta K$. Finally, in the initial steady state, $I = sY$ and $K = I/(g + \delta)$, so that $Y/K = (g + \delta)/s$. Hence the result in the text.

[30] For example, a typical poverty trap model would feature two stable equilibria. Asymmetries in the distance between the state of the economy and each of the two stable equilibria can generate asymmetric transition dynamics and different probabilities of escaping from each of the two steady states. Models that emphasize volatility along the growth path, such as Acemoglu and Zilibotti (1997) or Aghion et al (2004), capture possible key reasoning for starts and stops, and yet do not feature the types of asymmetries found in the data.

reaching for a unified model that captures both accelerations and decelerations may be a misleading exercise, as has been argued by Pritchett (2003).

The weak role for investment in growth accelerations, and the expansion of trade that occurs alongside these accelerations, point towards theories (and policies) that emphasize the reallocation of resources. Vested interests, for example, may implement protectionist policies that limit trade, inhibit factor reallocation, and prevent the adoption of new technologies (Krusell and Rios-Rull 1996, Acemoglu and Robinson 2000). Opening to international trade, by allowing for a reallocation of resources according to comparative advantage, stimulating international knowledge spillovers and learning-by-doing, and improving within-industry and within-firm productivity through competition, can improve efficiency without factor accumulation (see, e.g., Tybout 2000). Similarly, reducing obstacles to internal trade and labor market rigidities, either through changes in regulation, avoidance of civil conflict, improved arms-length contracting, or other mechanisms, can improve efficiency. The results here suggest that focusing on these obstacles to efficient allocation of resources may be more promising than focusing on increasing aggregate investment.

6. Conclusion

This paper has presented a number of stylized facts to describe the mechanics of start-stop growth. We have shown that dramatic changes in growth are common features of the growth experience for many countries. As a result, long-run views of growth, including ideas about convergence and poverty traps, may miss an important part of the picture. Over substantial periods – ten years or more – the typical poor country has proven capable of both rapid expansions and rapid collapse. If the long-run is the summation of a few medium-run experiences, than the difference between a country that converges and one that stagnates (or worse) over the post-war period may be a single break in the growth process.

After systematically identifying the dates of growth transitions, we use growth accounting to decompose the growth changes into changes in their constituent parts. We find that most of the growth transition is due to changes in TFP, with relatively little role for changes in capital accumulation (particularly for accelerations) and virtually no apparent role for changes in utilization of existing factors. The fact that this exercise can be replicated using electricity data suggests that the phenomenon is unlikely to be driven by problems in measuring investment. Growth in TFP may therefore be responsible not only for long-run differences in growth and incomes, as several other papers have argued, but also for these shorter run changes in growth, where theory suggests a potentially more prominent role for capital accumulation. We provide several types of evidence – on manufacturing employment and trade – that suggest changes in sectoral allocations may be an important mechanism behind these changes in TFP.

The results also suggest that growth decelerations and accelerations are asymmetric events. Accelerations show very little increase in investment, and are associated with substantial increases in trade. Declines in growth are associated with declines in investment (although these explain only 30% of the growth decline by themselves), a reallocation of labor away from manufacturing, increasing inflation, devaluation and, in several cases, a rise in internal conflict.

The results in this paper suggest two natural next steps. First, as discussed in Section 5, focusing on ways to improve the efficient use of resources may be a more promising avenue than focusing on increasing aggregate investment in pursuit of triggering growth. Second, the ubiquity of growth extremes suggests that the traditional empirical approach to growth, which seeks to explain the average level of growth, may be a poor description of the actual growth process. Instead, empirical approaches that seek to understand the triggers of these long-lasting accelerations and decelerations may be more promising.

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Table 1: Everybody's Doing It: Convergence and Divergence over the Medium Term

		Convergence over 10-year Period					
		Region			*Income in 1960*		
	All	Sub Saharan Africa	Latin America & Caribbean	Asia	Poorest 1/3rd	Middle 1/3rd	Richest 1/3rd
Percentage of Countries	90%	76%	93%	100%	92%	79%	97%

		Divergence over 10-year Period					
		Region			*Income in 1960*		
	All	Sub Saharan Africa	Latin America & Caribbean	Asia	Poorest 1/3rd	Middle 1/3rd	Richest 1/3rd
Percentage of Countries	94%	100%	89%	81%	100%	92%	97%
Country Observations	125	42	28	16	37	38	37

Notes: Convergence is defined by whether country has average growth rate that is higher than US growth over indicated number of years. Divergence is defined by having lower average growth rate than US. Growth calculations made from the Penn World Tables v6.1. Countries with less than 20 years of available GDP data are not included in this table. Observation counts by income trecile do not sum to 125 because 13 countries have growth series that begin after 1960.

Table 2: Structural Breaks in Growth

Country	Year of Break by Type UP	DOWN	Country	Year of Break by Type UP	DOWN
Algeria		1981	Jamaica	1976	1972
Austria		1974	Japan	1959	1970, 1991
Bangladesh	1973		South Korea	1962	
Belgium	1958	1974	Luxembourg	1983	
Botswana	1966		Mauritius	1960	
Brazil		1980	Mexico	1995	1981
Burkina Faso	1966		Mozambique	1986	1973
Cameroon	1993	1987	Nicaragua		1977
China	1978		Papua New Guinea	1991	1994
Congo, Dem. Rep.		1974	Philippines	1986	1956, 1981
Cote d'Ivoire		1979	Poland	1981	1977
Ecuador	1971	1977	Portugal	1966	1973
Egypt	1975	1970, 1980	Puerto Rico		1972
El Salvador	1983, 1991	1978	Romania		1985
Equatorial Guinea	1995	1974	Sierra Leone		1990
Finland		1973	South Africa		1981
France		1973	Spain		1974
Greece		1973	Sweden		1970
Guatemala	1955, 1987	1980	Switzerland		1973
Hungary		1979	Thailand	1955, 1986	1995
Indonesia	1967	1996	Tunisia	1967	1972
Iran	1981	1976	Venezuela		1970
Ireland	1994		Zambia		1964
Italy		1974	Zimbabwe		1976

Notes: Structural breaks are determined using the Bai and Perron (2003) methodology with a size of 10% and a trimming parameter of 10%. UP breaks are those where the growth rate in the regime after the break is larger than in the regime before. DOWN breaks are the opposite cases. The break year marks the final year of the prior growth regime.

Table 3: Summary Statistics for Structural Breaks

	Structural Breaks by Initial Income				
	All	Poorest 1/3rd	Middle 1/3rd	Richest 1/3rd	Other
Up-Breaks	30	7	11	10	2
Down-Breaks	43	6	15	18	4
Total Breaks	73	13	26	28	6
% of Growth-Year Observations	1.4%	0.8%	1.6%	1.5%	1.9%

	Structural Breaks by Region				
	Sub Saharan Africa	Latin America	Asia	Western Europe	Other
Up-Breaks	6	7	9	4	4
Down-Breaks	9	8	7	10	9
Total Breaks	15	15	16	14	13
% of Growth-Year Observations	0.9%	1.3%	2.2%	1.6%	1.5%

	Structural Breaks by Decade				
	1950s	1960s	1970s	1980s	1990s
Up-Breaks	4	7	5	8	6
Down-Breaks	1	1	27	9	5
Total Breaks	5	8	32	17	11
% of Growth-Year Observations	0.8%	0.7%	2.7%	1.4%	0.9%

Notes: Structural Breaks are determined by the Bai & Perron (2003) methodology, using tests with 10% size and a 10% trimming parameter, as explained in the text. Up-breaks are those structural breaks where growth in the regime after the break is greater than growth before, and down-breaks are defined conversely. The percentage of growth-year observations is the percentage of growth-year observations in the designated subgroup (e.g. "Latin America") where a structural break is detected.

Table 4A: Growth Accounting around Structural Accelerations

	Growth Rate in	Short-Run (5 Year) Averages Before	Short-Run (5 Year) Averages After	Short-Run (5 Year) Averages Change	Long-Run (Regime) Averages Before	Long-Run (Regime) Averages After	Long-Run (Regime) Averages Change	Number of Countries
	y (GDP per-capita)	-1.8 (0.8)	5.3 (0.8)	7.2 (0.9)	-1.7 (0.8)	5.2 (0.8)	6.8 (0.9)	30
Factor Accumulation	k (Capital per capita)	3.3 (0.8)	4.8 (1.3)	1.5 (0.8)	3.5 (0.9)	4.9 (1.1)	1.4 (1.2)	30
Factor Accumulation	h (Human Capital per capita)	0.8 (0.1)	0.8 (0.1)	0.1 (0.2)	0.7 (0.1)	0.8 (0.1)	0.2 (0.2)	17
Factor Utilization	LFP	-0.2 (0.1)	0.0 (0.1)	0.2 (0.1)	-0.2 (0.1)	0.1 (0.1)	0.3 (0.1)	29
Factor Utilization	e (Electricity use)	3.3 (1.2)	4.1 (1.4)	0.9 (1.5)	3.2 (1.3)	4.8 (0.8)	1.6 (1.0)	17
Factor Utilization	Implied k utilization	2.0 (1.2)	2.1 (1.1)	0.1 (1.3)	1.9 (1.2)	1.9 (0.5)	0.0 (1.2)	17
	<u>Contribution to Growth</u>		Percent of Growth Change Explained			Percent of Growth Change Explained		
	Capital Accumulation (k)		6.9% (3.5)			7.1% (4.5)		30
	Factor Utilization		-2.8% (10.0)			-0.8% (9.4)		17

Notes: Growth accelerations are defined using Bai & Perron methodology, as explained in the text. The size of the Bai & Perron test was set at 10%, and the trimming parameter set to 10%, so that consecutive breaks must be at least 10% of the series length in distance from each other. Growth, imputed capital stocks, and labor force participation data come from the Penn World Tables v6.1. The sub-sample of human capital data comes from Barro & Lee (2000). The Barro & Lee data is only available at five year intervals and for a sub-sample of countries. The "Short-Run (5 Year) Averages" in this case compare 5-yr growth rates for the periods that stand closest to the break but entirely before and after the break. Electricity consumption data comes from the World Development Indicators. The contribution of various factors to growth are computed assuming a physical capital share of 1/3rd. Capital stocks are imputed assuming a depreciation rate of 7%. Standard errors are in parentheses.

Table 4B: Growth Accounting around Structural Collapses

	Growth Rate in	Short-Run (5 Year) Averages Before	After	Change	Long-Run (Regime) Averages Before	After	Change	Number of Countries
	y (GDP per-capita)	5.1 (0.5)	-1.9 (0.7)	-7.0 (0.8)	4.6 (0.3)	-1.4 (0.6)	-6.0 (0.6)	43
Factor Accumulation	k (Capital per capita)	5.5 (0.5)	1.6 (0.4)	-4.0 (0.3)	5.3 (0.5)	0.7 (0.3)	-4.6 (0.5)	43
Factor Accumulation	h (Human Capital per capita)	0.7 (0.1)	0.9 (0.1)	0.2 (0.2)	0.6 (0.1)	0.9 (0.1)	0.3 (0.1)	35
Factor Utilization	LFP	-0.1 (0.1)	0.2 (0.1)	0.3 (0.1)	-0.3 (0.1)	0.3 (0.1)	0.5 (0.1)	39
Factor Utilization	e (Electricity use)	7.3 (0.7)	2.5 (0.6)	-4.8 (0.6)	7.6 (0.6)	1.6 (0.5)	-5.9 (0.5)	34
Factor Utilization	Implied k utilization	1.4 (0.7)	0.9 (0.5)	-0.5 (0.6)	1.5 (0.6)	0.9 (0.4)	-0.6 (0.6)	34

Contribution to Growth	Short-Run: Percent of Growth Change Explained	Long-Run: Percent of Growth Change Explained	Number of Countries
Capital Accumulation (k)	24.4%[a] (3.4)	32.3% (3.4)	43
Factor Utilization	-1.8% (4.1)	-4.6% (3.6)	32

[a] Only 42 observations.

Notes: Growth accelerations are defined using Bai & Perron methodology, as explained in the text. The size of the Bai & Perron test was set at 10%, and the trimming parameter set to 10%, so that consecutive breaks must be at least 10% of the series length in distance from each other. Growth, imputed capital stocks, and labor force participation data come from the Penn World Tables v6.1. The sub-sample of human capital data comes from Barro & Lee (2000). The Barro & Lee data is only available at five year intervals and for a sub-sample of countries. The "Short-Run (5 Year) Averages" in this case compare 5-yr growth rates for the periods that stand closest to the break but entirely before and after the break. Electricity consumption data comes from the World Development Indicators. The contribution of various factors to growth are computed assuming a physical capital share of 1/3rd. Capital stocks are imputed assuming a depreciation rate of 7%. Standard errors are in parentheses.

Table 5: Asymmetry Tests

	UP-BREAKS				DOWN-BREAKS				Asymmetry
	Change Across Break		One-Sample Test		Change Across Break		One-Sample Test		Two-Sample Test
	Mean Change	Standard Error	P-value	Obs	Mean Change	Standard Error	P-value	Obs	P-value
Growth in									H_0: UP=-DOWN
k (Capital per capita)	.0144	.0120	.2376	30	-.0464***	.0046	.000	43	.007
e (Electricity consumption per capita)	.0163	.0097	.1122	17	-.0594***	.0049	.000	34	.000
Contribution to Growth Change									H_0: UP=DOWN
Factor Accumulation	7.08%	4.52%	.1280	30	32.28%***	3.39%	.000	43	.000
Factor Accumulation and Utilization	7.33%	13.18%	.5859	17	32.14%***	3.81%	.000	32	.001

Notes. Results are for regime averages before and after structural growth breaks. Results for immediate 5-year periods before and after breaks are qualitatively similar.

Table 6: Trade and Manufacturing

	UP-BREAKS				DOWN-BREAKS				Asymmetry
	Change Across Break		One-Sample Test		Change Across Break		One-Sample Test		Two-Sample Test
	Mean Change	Standard Error	P-value	Obs	Mean Change	Standard Error	P-value	Obs	P-value
Trade Shares (%GDP)									H_0: UP=-DOWN
Exports	12.2***	3.4	.001	30	2.0	1.9	.283	43	.002
Imports	12.8**	5.2	.020	30	0.4	3.0	.886	43	.000
Exports + Imports	25.1***	8.3	.005	30	2.5	4.3	.572	43	.021
Exports - Imports	-0.6	2.9	.837	30	1.6	2.5	.524	43	.796
Terms of Trade (% change)	6.48	12.2	.599	30	-2.38	6.96	.735	43	.756
Manufacturing (growth in)									H_0: UP=-DOWN
Share of Total Population	.036	.024	.151	18	-.048***	.008	.000	32	.564
To simple manufacturing	.026	.028	.368	18	-.034***	.008	.000	32	.708
To advanced manufacturing	.051***	.018	.010	18	-.072**	.011	.000	32	.289
Value Added Output	.083*	.040	.055	17	-.095***	.017	.000	32	.747

Notes. Results are for regime averages before and after structural growth breaks. Results for immediate 5-year periods before and after breaks are qualitatively similar. Trade shares show more modest increases in the short-run, so that expanding trade shares occur steadily over time. Terms of trade are normalized to be 100 in the year prior to a break; the data is imputed form the Penn World Tables. Using terms of trade data from the World Development Indicators produces similar results. Manufacturing data comes from the UNIDO INDSTAT3 database.

Table 7: Associated Events

	UP-BREAKS				DOWN-BREAKS				Asymmetry	
	Change Across Break		One-Sample Test		Change Across Break		One-Sample Test		Two-Sample Test	
	Mean Change	Standard Error	P-value	Obs	Mean Change	Standard Error	P-value	Obs	UP=DOWN	UP=-DOWN
Prices (growth rates)										
GDP Deflator	-0.038	0.044	0.400	23	0.141	0.041***	0.002	39	0.007	0.109
Nominal Exchange Rate	-0.010	0.042	0.814	29	0.146	0.036***	0.000	42	0.007	0.017
Real Exchange Rate	0.013	0.017	0.445	19	-0.001	0.017	0.955	33	0.582	0.633
War (level)										
Any Conflict	-0.108	0.176	0.547	28	0.185	0.118	0.127	40	0.157	0.708
Internal Conflict	-0.072	0.152	0.641	28	0.275	0.114**	0.021	40	0.067	0.279
Institutions (level)										
Rule of Law	0.083	0.054	0.160	10	0.042	0.057	0.492	7	0.620	0.143
Corruption	0.018	0.054	0.746	10	-0.008	0.047	0.869	7	0.735	0.899

Notes: Results are for regime averages before and after structural growth breaks. Data sources are described in the text.

Table 8A: Growth Accounting: Growth Accelerations

	Growth Rate in	All Growth Accelerations Before	After	Change	Num Countries	Growth Accelerations > 5% Before	After	Change	Num Countries
	y (GDP per-capita)	0.05	3.44	3.39	124	-2.65	4.69	7.35	24
		(0.26)	(0.23)	(0.24)		(0.5)	(0.55)	(0.4)	
Factor Accumulation	k (Capital per capita)	2.9	3.48	0.58	124	2.64	3.46	0.82	24
		(0.42)	(0.41)	(0.37)		(1.31)	(1.16)	(1.45)	
	h (Human Capital per capita)	0.8	0.7	-0.1	71	0.9	0.8	-0.1	13
		(0.1)	(0.1)	(0.2)		(0.2)	(0.2)	(0.2)	
Factor Utilization	LFP	-0.07	0.2	0.27	116	-0.26	0.22	0.48	22
		(0.07)	(0.08)	(0.08)		(0.13)	(0.23)	(0.21)	
	e (Electricity use)	3.5	4.19	0.68	60	1.41	3.45	2.04	12
		(0.56)	(0.49)	(0.58)		(1.28)	(0.83)	(1.61)	
	Implied k utilization	1.33	1.87	0.54	60	0.06	1.52	1.46	12
		(0.5)	(0.39)	(0.55)		(1.3)	(0.81)	(1.19)	
	<u>Contribution to Growth</u>					Percent of Growth Change Explained			
	Capital Accumulation (k)					2.27%			24
						(5.33)			
	Factor Utilization					12.35%			12
						(5.8)			

Notes: Growth accelerations are defined as the year in each country's growth history where the average growth rate over the ensuing ten years minus the average growth rate in the prior ten years is largest. The second set of results considers the subset of the first where this growth acceleration averages at least 5% per annum. Growth, imputed capital stocks, and labor force participation data come from the Penn World Tables v6.1. The sub-sample of human capital data comes from Barro & Lee (2000). Electricity consumption data comes from the World Development Indicators. The contribution of various factors to growth is computed assuming a physical capital share of 1/3rd. The contributions to growth are calculated only for large accelerations, since the full set includes cases where growth changes are essentially zero, resulting in outliers that drive the averages. Capital stocks are imputed assuming a depreciation rate of 7%. Standard errors are in parentheses.

Table 8B: Growth Accounting; Growth Decelerations

	Growth Rate in	All Growth Decelerations Before	All Growth Decelerations After	All Growth Decelerations Change	Num Countries	Growth Decelerations < -5% Before	Growth Decelerations < -5% After	Growth Decelerations < -5% Change	Num Countries
	y (GDP per-capita)	4.02	-0.46	-4.49	124	4.68	-2.45	-7.14	45
		(0.19)	(0.25)	(0.22)		(0.36)	(0.42)	(0.27)	
Factor Accumulation	k (Capital per capita)	5.04	1.35	-3.69	124	5.1	0.16	-4.94	45
		(0.35)	(0.28)	(0.34)		(0.65)	(0.5)	(0.67)	
	h (Human Capital per capita)	1.1	0.7	-0.3	85	1.3	0.5	-0.7	26
		(0.1)	(0.1)	(0.2)		(0.4)	(0.2)	(0.4)	
Factor Utilization	LFP	-0.05	0.15	0.2	117	-0.28	0.06	0.34	43
		(0.06)	(0.07)	(0.07)		(0.09)	(0.12)	(0.13)	
	e (Electricity use)	7.37	2.55	-4.82	74	9.37	1.45	-7.92	24
		(0.46)	(0.35)	(0.47)		(1.11)	(0.81)	(1.09)	
	Implied k utilization	2.35	1.48	-0.88	74	3.97	1.84	-2.13	24
		(0.42)	(0.28)	(0.48)		(1.08)	(0.71)	(1.28)	
	<u>Contribution to Growth</u>						Percent of Growth Change Explained		
	Capital Accumulation (k)						22.8%		45
							(3.2)		
	Factor Utilization						6.6%		24
							(5.6)		

Notes: Growth decelerations are defined as the year in each country's growth history where the average growth rate over the ensuing ten years minus the average growth rate in the prior ten years is smallest. The second set of results considers the subset of the first where this growth deceleration averages less than -5% per annum. Growth, imputed capital stocks, and labor force participation data come from the Penn World Tables v6.1. The sub-sample of human capital data comes from Barro & Lee (2000). Electricity consumption data comes from the World Development Indicators. The contribution of various factors to growth is computed assuming a physical capital share of 1/3rd. The contributions to growth are calculated only for large decelerations, since the full set includes cases where growth changes are essentially zero, resulting in outliers that drive the averages. Capital stocks are imputed assuming a depreciation rate of 7%. Standard errors are in parentheses.

Figure 1: Amazing Highs, Amazing Lows
The Best and Worst 10-Year Average Growth Rates Within Countries

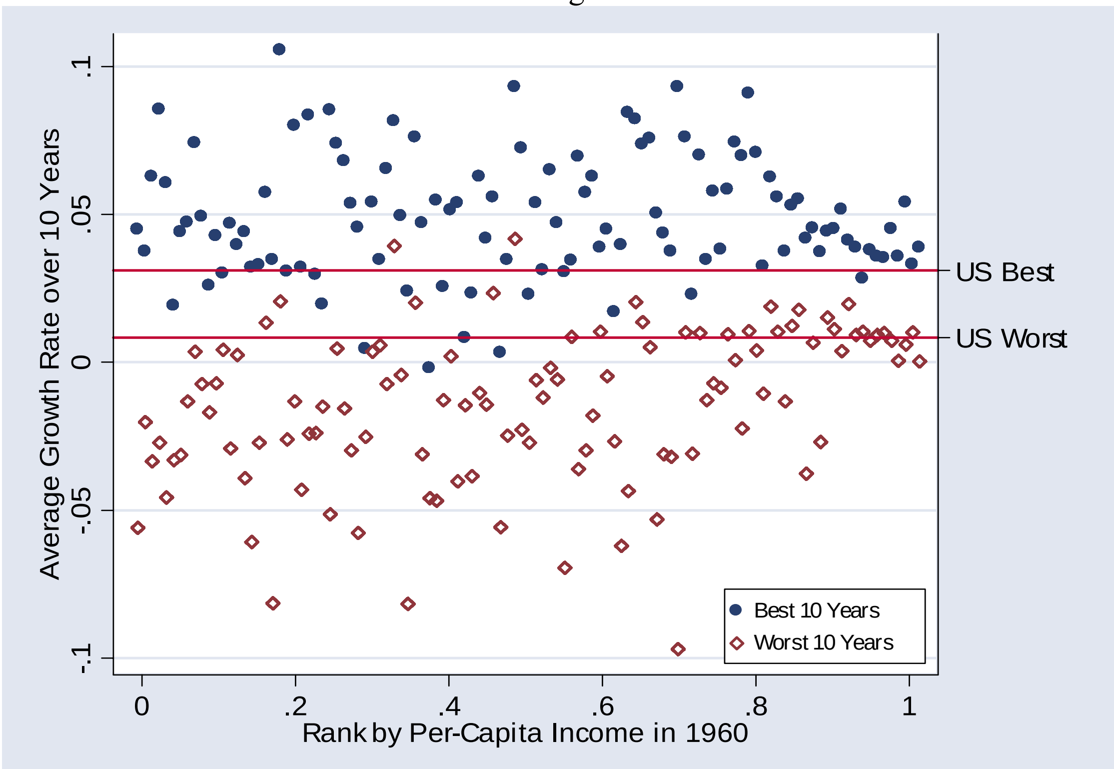

Figure 2: Growth Spurts are not Pure Recovery
Income after Best 10-Yr Growth Episode Relative to Prior GDP Peak

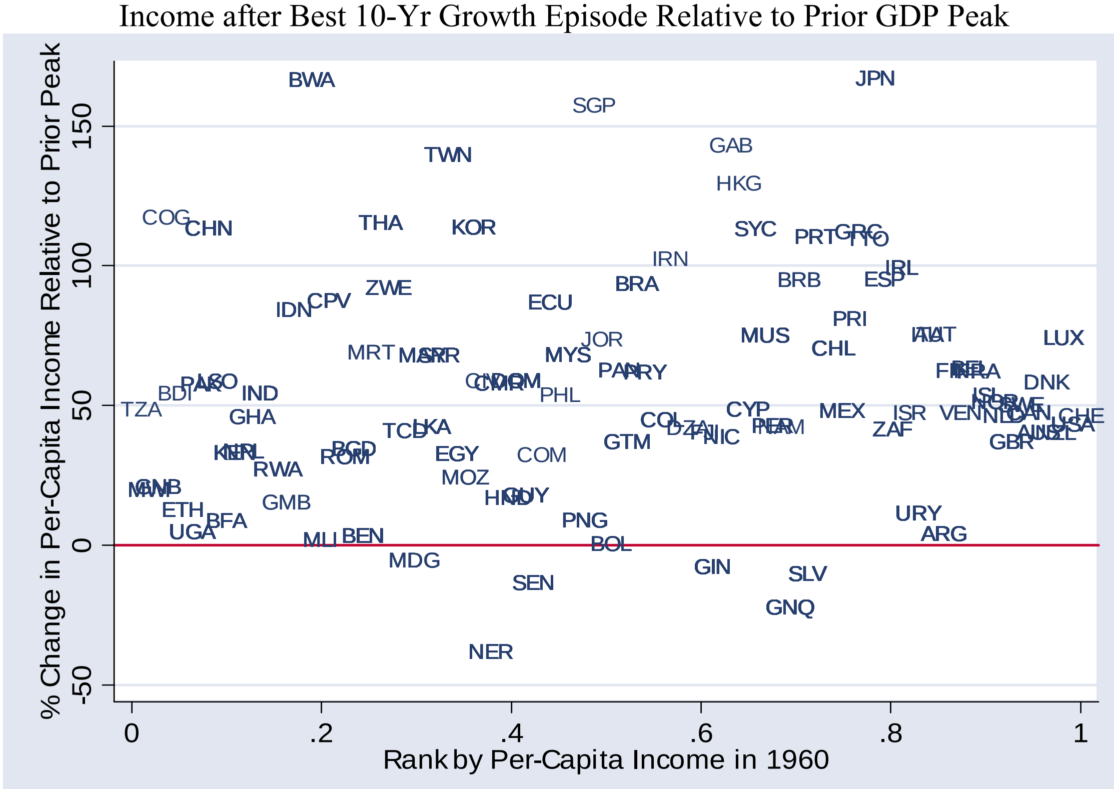

Figure 3: Example of Structural Breaks