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GOOD POLICY OR GOOD LUCK? COUNTRY GROWTH PERFORMANCE AND TEMPORARY SHOCKS

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ABSTRACT

Much of the new growth literature stresses country characteristics, such as education levels or political stability, as the dominant determinant of growth. However, growth rates are highly unstable over time, with a correlation across decades of .1 to .3, while country characteristics are stable, with cross-decade correlations of .6 to .9. Shocks, especially those to terms of trade, play a large role in explaining variance in growth. These findings suggest either that shocks are important relative to country characteristics in determining long-run growth, or that worldwide technological change determines long-run growth while country characteristics determine relative income levels.

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Introduction

Much of the new growth literature stresses country characteristics as the dominant determinant of growth performance. A vast empirical literature tests the effects of country characteristics on growth.[1] This paper presents a fact suggesting the emphasis on country characteristics is misguided: growth rates are highly unstable over time, while country characteristics are highly persistent. The correlation across decades of countries' growth rates of income per capita is around .1 to .3, while most country characteristics display cross-decade correlations of .6 to .9. Correlations of growth across periods as long as two decades -- period lengths comparable to those used in the cross-section empirical literature -- are similarly low. With a few famous exceptions, the same countries do not do well period after period; countries are "success stories" one period and disappointments the next.

The low persistence of growth rates reconciles the enormous variation in growth rates across countries with the remarkable stability of relative incomes across countries. For each of the last two decades the standard deviation of growth rates has been over 2.5, nearly the growth difference between Japan and the US. Yet the correlation of (Summers and Heston (1991)) GDP per capita in 1960 and 1988 was .92. Even more striking the rank correlation of GDP per capita for the 28 countries for which Maddison (1989) has data is .82 over 1870-1988. Major changes in country income rankings would have required large persistent differences in growth rates; in the event, income rankings did not change much and only a small fraction of the growth differences between countries were persistent.

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[1]Among the country characteristics this literature examines are policies affecting the price or quantity of equipment investment (De Long and Summers (1991, 1992, 1993), policies affecting research and development (Romer (1989, 1990)), investment in physical capital (Romer (1986, 1987)), human capital (Lucas (1988), Barro (1991), Barro and Lee (1993)), initial income (Barro (1991)), distortionary policy environments (Murphy, Shleifer, and Vishny (1991), Easterly (1993)), government spending (Barro (1990), tax policy (King and Rebelo (1990), Jones and Manuelli(1990)), financial policy (King and Levine (1993), Levine (1991), Greenwood and Jovanovic (1990), Gelb (1989)), trade policy (Young (1991), Grossman and Helpman (1991), Rivera Batiz and Romer (1991), Harrison (1991)), income distribution (Alesina and Rodrik (1991), Persson and Tabellini (1991)), macroeconomic policy (Fischer (1991, 1993)) and even ethnicity (Borjas (1992)), legal institutions (North (1989)) and religion (De Long (1988)).

This paper has three sections and a conclusion. The first section presents the basic facts about persistence of cross country growth differences and of country characteristics. The second section attempts to identify the temporary shocks important in explaining low persistence of growth rates across decades. The third section interprets low persistence under two types of growth models: models in which country characteristics determine long-run growth rates and models in which country characteristics determine relative levels of steady state income and long-run growth rates are determined by worldwide technological change. A conclusion summarizes the results.

I) Low Persistence of Growth Rate Differences Across Countries

(a) Basic facts

The persistence of growth rate differences across countries, even over long periods, is low. Table 1 presents correlations of the least-squares growth rate of GDP per worker between 1960-69, 1970-79 and 1980-88[2]. The R^2 obtained by regressing the current growth rate on the previous decade's growth was less than 10 percent. Little of the variation of growth rates is explained by past growth.[3] This low persistence result is robust over the choice of country sample, time period, and sectoral performance measure.

Figure 1 displays the scatterplot of the growth rates for 115 countries over two periods, 1960-73 and 1974-88. The dotted lines show the averages in each period. A large portion of the sample is contained in the off-diagonal quadrants: above-average in 1960-73 and below average in 1974-88, or vice versa. The rank correlation is .21 in the figure.

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[2]The data on real GDP per worker is taken from the Penn World Tables Mark 5 of Summers and Heston (1991). We obtained similar results using World Bank data on growth rates of output per worker valued at constant local prices.Results are also similar with GDP per capita; we used GDP per worker since it is a better measure of productivity change. The use of the least-squares growth rate reduces the sensitivity to end-points; conventional compound growth rates are even less persistent. We have a priori excluded high-income oil exporters, i.e. Kuwait and Saudi Arabia, because their growth depends entirely on variations in oil production. Including Kuwait would raise persistence (to about .35) because it has strikingly negative growth in all periods.

[3]Others who have previously noted this include De Long and Summers (1991), Levine and Renelt (1991), and Fischer (1987). Quah (1993) has recently presented a similar finding, notably the instability of growth across periods in Markov transition matrices.

The boxes in the corners represent the deciles of the period growth rates. The northeast box represents countries with growth in the top deciles in both periods. The southwest box shows the countries persistently in the bottom decile. The northeast box (persistent success) contains Botswana and the famous Asian Gang of Four (Hong Kong is actually just short of being in the top decile in the first period). The East Asian success story is well known, while Botswana has benefitted from extensive diamond mines and from a democratic government that has avoided some of its neighbors' economic mistakes. The widespread perception of strong country effects in growth is strongly influenced by the Gang of Four; without them and Botswana, the already low correlation of growth rates between periods is cut in half. In contrast, persistence is not raised much by deleting a small number of outliers.

Persistence is also low for several subsamples of countries. The second, third and fourth rows of Table 1 show the correlations for non-oil countries, the OECD countries, and the non-oil developing countries. The only exception is a high correlation between the 60's and 70's in the small sample of OECD countries, but this reverts to zero between the 70's and 80's.

Figure 2 shows that persistence stays low at various period lengths in the postwar data. This is confirmed by partial data on long-run growth rates for 30 year periods over 1870-1988 [4]. We have a total of 54 observations for 23 OECD and Latin American countries. Figure 3 shows growth plotted against lagged growth for these 30 year periods. Portugal is illustrative: decent growth in 1870-99, negative growth in 1900-29, average growth in 1930-59, and one of the highest growth rates in 1960-

[4]We have calculated the least-squares growth rate of per capita income data borrowed from Easterly and Rebelo (1993), who use mainly Maddison (1989). It need hardly be said that this data is even more subject to error than the recent data, including errors introduced by extrapolation over long periods.

88. The correlation of 30-year per capita growth with per capita growth in the previous 30 year period in this data is only .12.[5]

One possible explanation for low persistence in the recent data is instability in agriculture due to price and weather shocks. Figure 4 shows persistence coefficients for growth of value added per worker in agriculture, industry, and services. The rank persistence of agriculture is zero between the 70s and 80s and is low between the 60s and 70s. However, industry and services also have low persistence.

Table 2 shows the low contemporaneous correlations of growth rates across sectors (with the exception of services in the 70s, when it had about a one-half correlation with both industry and agriculture). The low correlations could mean that shocks to individual sectors, such as relative price movements that pull factors like capital and skilled entrepreneurs out of one sector and into others, are more important than shocks affecting all sectors, such as increases in economy-wide human capital.[6] However, another explanation for low cross-sector correlations could be that even economy-wide shocks cause sectoral shifts because of changing comparative advantage.

Measurement error in the level of GDP could create artificially low persistence in growth rates, by leading to an underestimate of growth in one period and an overestimate in the next, or vice versa. However, we do not believe that measurement error explains low persistence. First, growth rates are probably not constructed by estimating GDP in subsequent periods - more likely, growth estimates are prepared first, and GDP in the second period is estimated from these growth estimates. Second, we calculated persistence between periods that did not contain a common endpoint but instead

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[5]This correlation is from the pooled regression of the vector [G1960-88 G1930-59 G1900-29] on the vector [G1930-59 G1900-29 G1870-99] where each Gxx-yy has 23 elements representing growth from xx to yy for each country in the sample of 23 countries. Because the persistence coefficient is sensitive to outliers in small samples, this number jumps around from one set of periods and one set of countries to another. For example, for the 16 industrial countries in Maddison (1989), the correlations across his adjacent periods 1870-1913, 1913-50, 1950-73, and 1973-87 are .38, -.35, and .46.

[6]Our exercise is related to the analysis of Stockman (1988) that examines sector-specific and country-specific shocks at business-cycle frequencies.

were separated by a gap of one or several years. This left persistence unchanged or lowered it, rather than raising it as would occur if measurement error were important. Third, as Figures 2 and 3 show, persistence remains low even over long periods. Finally, while *iid* measurement error in levels would lower persistence, other types of measurement error -- such as country-specific tendencies to overreport growth rates -- would raise persistence.

b. Are Country Characteristics Persistent?

The most straightforward explanation of the low persistence of growth rates would be that the country characteristics usually thought to determine growth are themselves not persistent. This section shows this explanation to be untenable: country characteristics are persistent. Figure 5 shows persistence of country characteristics between the 60's and 70's, and between the 70's and 80's for a sample of 45 countries for which data is available for all variables and time periods. The variables chosen are those that appear in the classic growth regression of Barro (1991), as well as several others common in the literature. All of the country characteristics display far higher persistence than growth rates. Many other country characteristics, like culture and geography, must be even more persistent.

However, some aggregate index of policy variables could still have low persistence.[7] To construct such an index, we use the variables shown in Figure 5 with a pooled time-series cross-section regression on 10 year averages. Table 3 shows regressions using the Barro (1991) variables with the exception of his PPI60DEV (deviation of the relative price of investment from the sample mean), which is not available in individual decades for a sufficient sample. (Our government consumption variable does not exclude spending on defense and education as Barro's did, due to lack of decade data on the latter.) We allow the intercepts to vary across decades. We also perform a

[7]Since the persistence of a linear combination of variables depends on the positive or negative covariance among them, it is possible for an aggregate index of country policies to show lower persistence than any of its components.

second regression with a broader set of country characteristics. The fitted values from this regression (denoted Barro Index and Augmented Barro Index, respectively) are also far more persistent than growth rates, as shown in Figure 5.

Rates of factor accumulation are much more persistent than growth rates. To compute an index of factor accumulation, we regressed aggregate growth (not per capita) on investment and labor force growth, using a sample of 115 countries which have data for all three decades. Figure 6 shows that investment, labor force growth, and the fitted value of growth predicted by the two are much more persistent than growth. The residuals from this regression can be interpreted, under certain assumptions, as the deviations of total factor productivity growth for each country from the global mean.[8] As shown in the graph, TFP growth rates are even less persistent than growth rates.

II) Shocks and Policies

This section argues that shocks, especially shocks to the terms of trade, are an important determinant of variations in growth rates over ten year periods, and that they can help account for low persistence.

Below we test how much of the variation in growth rates between countries can be statistically explained in terms of differences in policies, and how much is due to differences in shock variables, such as the terms of trade, external transfers, the change in the number of war related casualties per capita on national territory, and the presence of a debt crisis. We show that much of the variance in growth rates, even over periods as long as a decade, can be directly explained by shocks.[9] Moreover,

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[8]The coefficients of the regression were as follows (t-statistics in parentheses): constant term -.004 (-.81), on investment share .073 (4.1), on labor force growth .65 (4.92), on a dummy for the 60's .030 (9.0), on a dummy for the 70s .019 (4.99). R-squared was .23 and there were 345 observations (decade averages for 60s, 70s, and 80s for 115 countries). As is well known, the regression can be interpreted as a cross-country estimate of a production function under the rather heroic assumptions of constant capital-output ratios across countries, exogenous capital and labor growth, and constant parameters across countries of the (Cobb-Douglas) production function. The coefficient on labor growth is the estimate of the labor share, which is a reasonable .65. However, the implied estimate of the capital-output ratio ((1-.65)/.073=4.87) seems too high.

[9]The finding that shocks play an important role in growth at long horizons is reminiscent of the importance attributed to technology shocks in the real business cycle literature (e.g. Long and Plosser (1983)).

shocks indirectly influence growth by changing policy variables. Thus the low persistence of shocks, particularly external shocks, helps explain the low persistence of growth rates.

Table 4 shows the simple correlations of three shock variables with growth rates.[10] The variables are (1) the growth in dollar export prices times the initial share of exports in GDP minus the growth in import prices times the initial share of imports in GDP (terms of trade change); (2) the change in war casualties per capita on national territory; and (3) a dummy measuring countries likely to have a debt crisis in the 1980s.[11] Growth is strongly correlated with terms of trade improvements and high external debt in the 80's, and with war in the 70's (and weakly with war in the 80's).

When shock variables are added to a regression with a small set of significant country characteristics from section I, they have substantial explanatory power compared to policy variables (Table 5). We add the three variables from the previous paragraph and, for completeness, the per annum increase in official transfers. The partial R^2 of the policy variables (enrollments, black market premium, M2/GDP) in the 1970s was .26 and of the shocks .14, while in the 1980s the partial R^2 of the policy variables was .10 versus .15 for shock variables.[12]

The terms of trade effect is large and strongly significant in both periods. In the 1980s a favorable terms of trade shock of 1 percentage point of GDP per annum raises the growth rate by .85 percentage point per annum. Recall that GDP is measured in constant prices, so there is no direct effect of a terms of trade shock on growth. This increase in growth is far larger than would be created simply through the effect of the increased income on savings. Even if all the shock passed

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[10]Our thinking about proper definitions of shock variables benefitted from the related work of McCarthy and Dhareshwar (1991)

[11]This is a dummy variable measuring whether the debt to GDP ratio was above 50 percent in 1980 in low and middle-income countries. We do not have comparable statistics for rich countries, but in any case no rich country experienced an external debt crisis. Data on terms of trade, exports, imports, external debt, and GDP are from the World Bank's internal database; data on war casualties are from Sivard (1991).

[12] The partial R^2 of x for y after partialling out z is the R^2 of the regression of the components of y and x orthogonal to z. This is not the incremental R^2 and the components do not sum to the total R^2. Both partial R^2s exclude the initial level of GDP.

into saving, and the rate of return to capital were (optimistically) 20 percent, growth would only increase by .2 percentage points.

Factor movements are one potential explanation of large growth effects from terms of trade shocks.[13] For example, labor or capital might flow within the country to the sector receiving a favorable shock, capital might flow in from abroad to the export sector, or domestic savings might respond to improved export opportunities. In order to generate large growth effects through factor movements, however, factors and export demand must be elastic, and terms of trade shocks must be at least somewhat persistent.

External shock variables other than the terms of trade have smaller effects on growth, partly reflecting substantial multicollinearity among the shocks and between shock and policy variables. The variable for the increase in war casualties is marginally significant in the 70's but not in the 80's; we fail to detect significant separate effects of transfers and debt crises. The magnitude of the coefficient on the war casualty variable implies relatively modest effects of wars in most cases. Violence in Chile associated with the overthrow of Allende and its aftermath are estimated to have cost .3 percentage points of growth per annum in the 70's. Israel's wars during the 70's are estimated to have lowered growth during the decade by .2 percentage points per annum. Highest casualties per capita in the sample were from the civil war in Uganda, which was estimated to have reduced growth in the 70's by 3 percentage points per annum. Given the distribution of various shock variables (with a few large values for casualties, transfers, and terms of trade movements) the results for individual variables are sensitive to choice of sample.

[13]Another way to explain a large growth response to terms of trade movements would be through two-gap models of the type popular in the 1960's, in which foreign exchange is a separate binding constraint on the economy. A more modern explanation might be that the social value of foreign exchange is higher than the private value, perhaps because it is used to import machines that carry externalities, as in De Long and Summers (1991, 1992, 1993). Finally, the high coefficient could reflect a Keynesian aggregate demand effect, which would be surprising at such a long period length.

The shocks help explain the low persistence of the observed growth rates. The correlation of the growth rates between the 1970s and 1980s is -.05 in this sample of countries, while the persistence of the component of predicted growth dependent on the non-shock variables was .63. The correlation between decades of the fitted growth component due to shocks was -.08 and the persistence of the fitted growth rates including all variables was .37[14].

The shock variables influenced growth not only directly, but also indirectly, through policy variables. Table 6 reports regression of the black market premium on shock variables. War is associated with a high black market premium and favorable terms of trade changes with a lower premium.

This casts doubt on the widespread interpretation of the black market premium as an indicator of bad policies. If shock variables are omitted, estimates of the effect of the black market premium on growth will falsely attribute externally-induced adversity to policy. Table 5 demonstrates that the inclusion of shock variables in the regression reduces the coefficient and significance levels on the black market premium, especially in the 1980's, when it cuts the coefficient in half.

To summarize, shocks are important over decade-long periods, they help explain the difference between the persistence of actual and predicted growth, and they influence "policy" variables, and thus estimates of the impact of policies.

III) Persistence and Growth Theory

This section examines the interpretation of low persistence under two types of growth models. In the first type of model, long-run growth depends on country characteristics. For example, in the AK model of Rebelo (1991), growth depends on tax rates. In closed economy versions of Romer (1990) or Aghion and Howitt (1992), technological change, and therefore economic growth, depend

[14] The estimated parameters of the 1970s were used to calculate the predicted growth components for the 1980s. Using the slope coefficients from a pooled regression the decade correlations follow roughly the same pattern: growth -.05, policy .736, shocks -.426, fitted values .243.

on a country's patent system and market size. In simple versions of these models, low persistence of growth rates implies that random shocks are important in determining the long-run path of output. In the second type of model, which includes both the neoclassical model with exogenous technological change and some models of technological diffusion, growth is a world-wide process, and country characteristics determine the relative level of income. In these models, low persistence is consistent with shocks of any size, and shocks may play only a minor role in determining the long-run path of output, despite being an important determinant of variance in decade-long growth rates.

a. Models in Which Country Characteristics Determine Long-Run Growth

In a simple model in which country characteristics determine growth, the persistence coefficient can be interpreted as reflecting the magnitude of variance in underlying growth rates across countries relative to the variance of random shocks. To see this, denote the long-run growth rate associated with the policies of country i as g_i. This can be represented as the world average growth rate, g, plus a country specific component ϵ_i, determined by country characteristics. Growth for country i in period t equals its underlying growth rate, plus a country-specific, period-specific shock. (A period specific aggregate shock could also be added, but would not affect the results.) Thus,

$$g_{it} = g + \epsilon_i + \epsilon_{it} \quad var(\epsilon_i) = \sigma_i^2 \quad var(\epsilon_{it}) = \sigma_{it}^2 \tag{1}$$

The simplest assumption one can make is that ϵ_i and ϵ_{it} are independent normal variables, and ϵ_{it} is serially uncorrelated. Under this assumption, the persistence coefficient, denoted ρ, is

$$\rho = \frac{E(g_{i,t}-\bar{g})(g_{i,t-1}-\bar{g})}{\sqrt{E(g_{i,t}-\bar{g})^2}\sqrt{E(g_{i,t-1}-\bar{g})^2}} = \frac{\sigma_i^2}{\sigma_i^2+\sigma_u^2} \quad (2)$$

This simple model of country fixed effects does not allow for changes in policy over time. However, since policies change only slowly, it may be a reasonable approximation over periods that are not too long. Under this model, the best forecast of a country's growth rate will be a weighted combination of its own past growth rate and the average growth rate of all other countries.[15]

Under this model of fixed country effects, low persistence bounds the potential R^2 that can be achieved in growth regressions. Even if policies were perfectly measured, and all policies and other factors affecting growth were taken into account, the expected R^2 in a thirty-year growth regression would be only about 0.6. To see this, note that the expected R^2 from regressing growth over n periods on a perfect measure of policies that determine the country's long-run growth rate will be

$$E[R^2(n)] = E\left[1 - \frac{(y-\beta x)^2}{(y-\bar{y})^2}\right] = 1 - \frac{n\sigma_u^2}{n^2\sigma_i^2+n\sigma_u^2} \quad (3)$$

This simplifies to

[15] Solving a signal extraction problem gives the best estimate of ϵ_i.

$$\hat{\epsilon}_i = \left(\frac{n\sigma_i^2}{\sigma_{i,t}^2+n\sigma_i^2}\right)\left(\frac{1}{n}\sum_{t=1}^{n} g_{it}\right)+\left(\frac{\sigma_{i,t}^2}{\sigma_{i,t}^2+n\sigma_i^2}\right)\left(\frac{1}{z}\sum_{i=1}^{z} g_{it}\right)$$

where z is the number of countries and n is the number of previous periods. Thus if there is little variation in growth rates between countries relative to the variation within countries over time, the country's past growth rate will be weighted less heavily.

$$E[R^2(n)] = \frac{\sigma_i^2}{\sigma_i^2 + \frac{\sigma_u^2}{n}} \tag{4}$$

From the definition of the persistence coefficient, $\sigma_u^2 = (1-\rho)\sigma_i^2/\rho$. Hence the expected R^2 from regressing growth over n periods on a perfect measure of the policies that determine the country-specific underlying growth rate, ϵ_i, will be

$$E[R^2(n)] = \frac{1}{1 + \left[\frac{1-\rho}{\rho n}\right]} = \frac{\rho n}{\rho n + 1 - \rho} \tag{5}$$

If one defines a period as ten years, then ρ is approximately 1/3, so the expected R^2 over a thirty-year period, given a perfect measure of policies is only 0.6. Thus if this model of fixed country effects describes the data, it is unlikely that we will see much increase over the current R^2 s in the literature. which are already in this range. For example, Levine and Renelt (1992, p. 947) report R^2s from .46 to .62 in their basic regressions for growth over 1960-89. Of course R^2 is a random variable, so in the process of many authors running regressions, it would not be surprising if some obtained higher R^2s. On the other hand, the expected R^2 given existing imperfect measures of policy would be less than 0.6.

The finding that in this model even a perfect measure of policies would explain only 60% of variance in growth rates over a thirty-year period has economic as well as econometric implications. In this simple model, low persistence implies that luck is important relative to policies in determining the long-run path of output. This model in which country characteristics determine long-run growth thus leaves much of growth unexplained.

This simple model assumes shocks are serially uncorrelated. If there were negative serial correlation in the shocks, or if growth came in spurts for deterministic reasons, persistence would be

lower for given variance in underlying growth rates across countries. Thus, policies would play a more important role in determining the long-run path of output. It is not clear why one should expect substantial negative serial correlation over successive ten-year periods. For the spurts hypothesis, it is interesting to note that for the countries that have four decades of data in the Summers and Heston (1991) sample, on average around 60% of their growth from 1950 to 1988 is achieved in the fastest-growing decade within that period. However, it is not clear whether this is due to deterministic spurts of growth or to high random variation.

b. Models in which Worldwide Technological Progress Determines Long-Run Growth

Under a different type of model, worldwide technological progress determines long-run growth and country characteristics determine steady state relative levels of income. This category includes not only the neoclassical model (Solow (1956)), but also some models of technological diffusion. Suppose, for example, that technological progress at some rate g is generated in a few advanced countries by a process of the type described by Romer (1990) or Aghion and Howitt (1992) and then diffuses to other countries with lags of various lengths. Let diffusion follow the process

$$\dot{B} = \lambda(p)(A-B) \tag{6}$$

where B is the level of technology in a backward country, p is the set of policies in that country, and A is the level of technology in the advanced countries. Thus countries that are further behind have more learning potential, and countries with better policies learn faster. Setting $\dot{B}/B = \dot{A}/A = g$ implies the steady state value of B/A will be $\lambda(p)/(g+\lambda(p))$.[16] In this model, the relative steady state level of income is determined by policy, but except for those countries large and advanced enough to generate a significant share of world technology, long-run growth is exogenously determined. Under either a neoclassical model of capital accumulation or models of technological diffusion which

[16]For a similar approach, see Nelson and Phelps (1966), Jovanovic and Lach (1991), or Benhabib and Rustichini (1993).

incorporate advantages of backwardness, persistence depends on the distribution of countries' incomes relative to their steady state income.

Adding an independent normal error term to a linearized version of these models allows persistence to be characterized. If there is a wide dispersion of distances between countries' initial incomes and their steady states, then transitional dynamics will dominate the effect of the random error term. The countries furthest below their steady state will grow the fastest. Relative growth rates will initially be highly persistent. However, as all countries approach their steady state levels of income, persistence will fall because transitional dynamics will become less important relative to the random error term. Asymptotically countries will converge to an ergodic distribution around the steady state, in which persistence will be negative since countries which receive a positive random shock one period will tend to fall back towards the steady state the next period.[17]

This can be easily seen in Barro and Sala-i-Martin's linearized version of the neoclassical model with an added random shock, but similar results hold in the diffusion model. In the neoclassical model, $y_{i,t+1} = y_{i,t}+v(y^*-y_{i,t})+\mu_{i,t}$ where $y_{i,t}$ denotes log income of country i at time t, y^* denotes steady state income, μ_{it} is a random shock, and $v \in (0,1)$ measures the speed of adjustment to the steady state, which depends on a host of parameters, including the capital share.[18] Thus growth between t and t+1, denoted $g_{i,t}$, equals $v(y^*-y_{i,t})+\mu_{i,t}$. Iterating, $g_{i,t+1} = v[y^*-(y_{i,t}+v(y^*-y_{i,t})+\mu_{i,t})]+\mu_{i,t+1}$. Given this, it is straightforward to write persistence as a

[17]We consider the impact of shocks to income, but shocks to policy would have similar consequences, since these alter the steady state level of income and transitional dynamics are determined by the difference between initial and the steady state level of income.

[18]See Barro and Sala-i-Martin (1992). v corresponds to $1-e^{\beta}$ in their notation. This example assumes that all countries have the same steady state and that there is no exogenous technological progress, but it would be straightforward to generalize the model.

function of the cross-section variance of income. Since $g_{i,t} - \bar{g}_t = \nu(\bar{y}_t - y_{i,t}) + \mu_{i,t}$ and

$g_{i,t+1} - \bar{g}_{t+1} = \nu[(\bar{y}_t - y_{i,t}) - \nu(\bar{y}_t - y_{i,t}) - \mu_{i,t}] + \mu_{i,t+1}$, the covariance of $g_{i,t}$ and $g_{i,t+1}$ is

$$E[(g_{i,t} - \bar{g})(g_{i,t+1} - \bar{g}_{t+1})] = (\nu^2 - \nu^3)\sigma_t^2 - \nu\sigma_\mu^2 \tag{7}$$

where σ_t^2 denotes the cross-sectional variance of log income at time t, and σ_μ^2 denotes the variance of the shock. As Barro and Sala-i-Martin show,

$$\sigma_{t+1}^2 = (1-\nu)^2\sigma_t^2 + \sigma_\mu^2 \tag{8}$$

since $y_{i,t+1} = y_{i,t} + \nu(y^* - y_{i,t}) + \mu_{i,t}$. Given the definition of persistence as $\text{cov}(g_{i,t}, g_{i,t+1})/\sigma_t\sigma_{t+1}$,

$$\rho = \frac{(\nu^2 - \nu^3)\sigma_t^2 - \nu\sigma_\mu^2}{\sigma_t\sqrt{(1-\nu^2)\sigma_t^2 + \sigma_\mu^2}} \tag{9}$$

Since the numerator increases more than proportionally in σ_t^2 and the denominator increases less than proportionally in σ_t^2, persistence increases with the cross-section variance of income. Barro and Sala-i-Martin show that as t goes to infinity, the cross-section variance monotonically[19] approaches the steady state value, $\sigma_-^2 = \sigma_\mu^2 / (2\nu - \nu^2)$. Thus if the initial cross-section variance is greater than its steady state value, persistence will decline over time. Persistence is asymptotically negative, since the limit of the covariance between a country's growth at t and at t+1 is

[19]This assumes an infinite number of countries. With a finite number of countries persistence would be a random variable.

$$\lim_{t\to\infty} cov(g_t, g_{t-1}) = \frac{(\nu^2-\nu^3)\sigma_\mu^2}{2\nu-\nu^2} - \nu\sigma_\mu^2 = \frac{-\nu\sigma_\mu^2}{2-\nu} \tag{10}$$

which must be negative.

Note that even if the random shocks are arbitrarily small, these models predict that persistence will asymptotically become negative. Under this model, a country's time path of income could be determined almost completely by worldwide technological change and its policies, but if it were close to its steady state income a large percentage of the time series variance in its growth rate would be explained by random shocks. In this case the growth rate would just represent fluctuations around a steady state income.

This model could be generalized by allowing each country to have its own steady state level of income depending on policies, and by allowing for exogenous technological change. In this case, persistence depends not on variance of income, but on variance in the gap between actual income and steady state income relative to the level of technology. If countries vary greatly in their distance from their relative steady states, persistence will be high. The countries far below their relative steady state income will initially have persistently high growth rates. As they approach the steady state, their growth rate will fall.

Asymptotically, there is a sharp distinction between models in which country characteristics determine long-run growth and models in which country characteristics determine relative steady state income. However, if countries are far from their steady states, models in which country characteristics determine income look similar to those in which country characteristics determine growth rates.

One difficulty with this type of model is that it does not explain why we observe countries outside the ergodic distribution around the steady state. Barro and Sala-i-Martin have suggested

countries may be outside this distribution due to large, infrequent shocks, such as wars, depressions, or industrial revolutions. Such shocks could plausibly affect only a subset of countries, thus creating a wide distribution of ratios of actual to steady state relative income.

This model has several testable implications for persistence. It predicts high and declining persistence following a large shock that displaces countries or regions differing distances from their steady states. It predicts low persistence in regions which are similar distances away from their steady states, which might plausibly be regions of a country. Finally, it predicts that controlling for initial income should generate very low persistence in samples of regions with similar steady states, since in these models persistence is due to transition dynamics.

Results from U.S. states and European provinces seem consistent with the predictions of the model, although the evidence is far from decisive. Negative persistence is much more common among states than among countries, as would be expected if states are more likely than countries to be similar distances away from their steady states. Growth rates of personal per capita income in the U.S. states, shown in Table 7, have negative persistence from the 20's to the 30's, probably reflecting the large shocks of the collapse of agricultural prices in the 20's and the Great Depression of the 30's, which adversely affected the poorest states which had been growing most quickly. In the next 3 decades, persistence was positive (although weaker between the 40's and 50's). Persistence then is zero between the 60's and 70's, and negative between the 70's and 80's, as would make sense if U.S. states were close to their steady states by then. Controlling for initial income makes persistence consistently low or negative, as predicted by the neoclassical model[20].

Data from 73 European provinces (covering Belgium, Denmark, France, Italy, the Netherlands, and the United Kingdom) provides further support for the model. Persistence across

[20]Barro and Sala-i-Martin (1991) find it to be important to control for oil shocks in their study of convergence among the U.S. states. We are grateful to Robert Barro for kindly sharing the data set on U.S. states and European provinces.

subsequent decades from the 50's to the 80's is low, with negative persistence again observed for the 80's.[21] Controlling for initial income makes persistence even lower. However, it is difficult to explain why persistence was low from the 1950's to 1960's, since different European countries were probably different distances away from their steady state then.

We also have a small amount of regional data from developing countries. The data is on gross rather than per capita product for provinces in China, India, and Indonesia, and on per capita product for provinces in Colombia.[22] We found negative persistence for 25 Chinese provinces across subsequent periods of 1952-63, 1963-74, and 1974-85, negative persistence for 24 Colombian provinces for periods of 1950-60, 1960-70, 1970-80, and 1980-90, and essentially zero persistence for 20 Indian provinces between 1970-77 and 1978-83. These results seem consistent with the neoclassical model. Indonesia, on the other hand, had strongly positive persistence for 26 provinces between 1975-79 and 1979-84, but the time period was short, and oil-producing Indonesia had just received a strong shock with differential effects across provinces: the oil price increase of 1973-74.

Just as these models predict high persistence following a large shock to the income of a group of countries, such as a war, they predict high persistence following a large shock to the policies of a country, such as a major policy reform. As mentioned earlier, a group of East Asian countries and Botswana had consistently high growth. It seems plausible that many of them adopted policies at the beginning of the period that led to steady state levels of income far above their initial income levels. On the other hand, few countries were consistent bad performers. This may indicate that countries with high levels of income do not often change to policies that give them a low level of steady state income.

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[21]The 80's here is just 1980-85.

[22]The data sources are Government of India (1984), Central Bureau of Statistics of Indonesia (various years), State Statistical Bureau of China (1987), and Cardenas et al. (1992) for Colombia.

In sum, under the simplest model in which country characteristics determine long run growth rates, low persistence implies that there are large random shocks. This, in turn, implies that such theories, if correct, leave much of growth unexplained, and that a country's income level will be determined in large part by its luck in the past. These models could be reconciled with a dominant role for policy in determining the long-run path of income if there were large negative serial correlation in shocks, if growth came in spurts, or if policies changed rapidly. On the other hand, under models in which growth is determined by a worldwide process of technological change and by transitional dynamics, luck may determine only fluctuations in income around a long run trend. Under these models, low persistence implies that countries must be at similar enough distances from their steady states that shocks are important relative to transitional dynamics. Non-negative persistence implies that countries must not yet be in an ergodic distribution around their steady states.

Conclusion

Relative growth rates of output per worker across countries are not very persistent. This low persistence is robust to choice of sample, is not an artefact of changes in oil prices or of agricultural disturbances, and it extends over long periods. In contrast to growth rates themselves, the country characteristics which are often thought of as determinants of growth are highly persistent. Shocks, especially terms of trade shocks, statistically explain as much of the variance in growth rates over 10 year periods as do country policies.

Models in which country characteristics determine long-run growth can be reconciled to these facts only if they generate spurts in growth or if there are large random shocks. In contrast, models in which worldwide technological change determines long-run growth predict low persistence if countries are near the steady state relative income levels determined by their policies.

The finding that much variation in growth rates is due to random shocks should induce caution in attributing high growth rates to good policy (or to a good "work ethic"). Just as a baseball star is dubbed a clutch hitter after a lucky hit, some so-called economic miracles are likely due to random variation.

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Table 1: Simple and rank correlations of growth rates across periods		60's with 70's correlation coefficient:		70's with 80's correlation coefficient:	
Sample:	Sample Size:	Simple	Rank	Simple	Rank
All Countries	100	.212	.233	.313	.157
All non-oil	89	.153	.227	.301	.187
OECD	22	.729	.701	.069	.086
Developing countries, non-oil	67	.099	.150	.332	.251

Table 2: Cross-Sector rank correlations of per worker growth rates	*Decades*		
	60's	70's	80's
Agriculture, Industry	.09	.29	.14
Agriculture, Services	.10	.45	.31
Industry, Services	.20	.57	.27
Sample Size	67	67	39

Table 3: Pooled Cross-section Time Series Regressions of Long-Term Growth on Policy Variables with Decade Averages

Dependent Variable: Growth Rate of GDP Per Worker [1/]		
Independent Variables:	Barro regression	Augmented Barro regression
GDP Per Worker (Initial)	-.013 (-2.62)	-.012 (-2.93)
Primary Enrollment (Initial Lagged 10 years)	.019 (2.16)	.013 (1.63)
Secondary Enrollment (Initial Lagged 10 years)	.026 (2.12)	.0097 (0.86)
Assassinations per million (Avg)	-.013 (-1.19)	-.013 (1.40)
Revolutions and coups (Avg)	-.0029 (-0.52)	.004 (0.90)
Share of Government Consumption in GDP (Avg)	-.0089 (-0.29)	.035 (1.18)
Log Black Market Premium (Avg)		-.038 (-3.74)
Inflation (Avg)		.0042 (0.92)
Share of trade in GDP (Initial)		-.0059 (1.18)
Ratio M2/GDP (Initial)		.025 (3.88)
Summary Statistics		
N	135	135
R^2	.43	.58

Notes:
[1/] Absolute values of t-statistics calculated with MacKinnon-White (1985) heteroskedasticity consistent standard errors in parentheses. Dependent variable is the least-squares growth rate of Summers-Heston (1991) output per worker.
[2/] Pooled regression has separate decade constant terms, not reported.

Table 4: Simple correlations of growth and shocks

Correlation of growth with:	1970's	1980's
Terms of trade change	.10	.45***
Change in war casualties	-.31***	-.12*
Dummy for high external debt, 1980		-.19**

*significant at 10% level
**significant at 5% level
***significant at 1% level

Table 5: Growth regressions with shock variables

Dependent variable: Per annum growth rate of GDP per worker				
Independent variables:	1970's		1980's	
GDP per worker (initial)	-.0023 (.349)	-.0047 (0.74)	-.021 (2.06)	-.016 (1.74)
Primary enrollment (initial, lagged 10 years)	.00019 (1.27)	.00033 (1.97)	.00003 (.180)	.00002 (.123)
Secondary enrollment (initial,lagged 10 years)	-.00039 (2.10)	-.00033 (1.83)	.00053 (2.09)	.0003 (1.38)
Black market premium (average, log)	-.041 (2.51)	-.032 (2.11)	-.017 (1.51)	-.009 (0.64)
Ratio M2/GDP (initial)	.016 (.980)	.026 (1.92)	.030 (2.29)	.023 (2.03)
Shock variables				
Per annum terms of trade gain as share of GDP		.0042 (2.36)		.0085 (2.24)
Per annum transfers increase as share of GDP		.015 (1.43)		-.014 (1.69)
War related casualties per capita (average)		-1.40 (1.83)		-0.78 (0.69)
Heavily indebted (initial)				-.007 (0.82)
Summary statistics				
Number observations	80	80	80	80
R^2	.265	.369	.257	.371

Note: T-statistics, in parentheses, are computed using MacKinnon-White (1985) heteroskedasticity-consistent standard errors.

Table 6: Shocks and the black market premium

Dependent variable: Black market premium (log average)		
Variables:	1970s	1980s
Terms of trade change	.021 (1.34)	-.122 (-2.67)
External transfers change	.012 (0.21)	-.092 (-0.75)
Change in war casualties	36.4 (1.72)	73.1 (2.07)
External debt dummy		.186 (1.29)
Summary statistics		
Observations	80	80
R^2	.158	.360

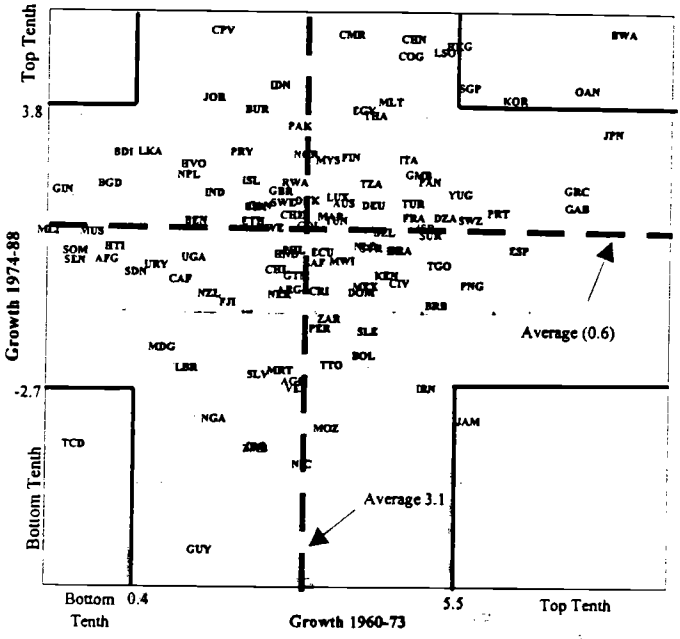
Note: T-statistics computed using MacKinnon-White (1985) heteroskedacity-consistent standard errors.

Table 7: Persistence Among U.S. States and European Provinces

48 U.S. States	Raw Data	Controlling for Initial Income
1920's with 30's	-.47	-.13
1930's with 40's	.41	.13
1940's with 50's	.17	-.40
1950's with 60's	.49	.27
1960's with 70's	.02	-.26
1970's with 80's	-.68	-.62
73 European Provinces		
1950's with 60's	.10	-.13
1960's with 70's	.29	.20
1970's with 80's	-.33	-.19

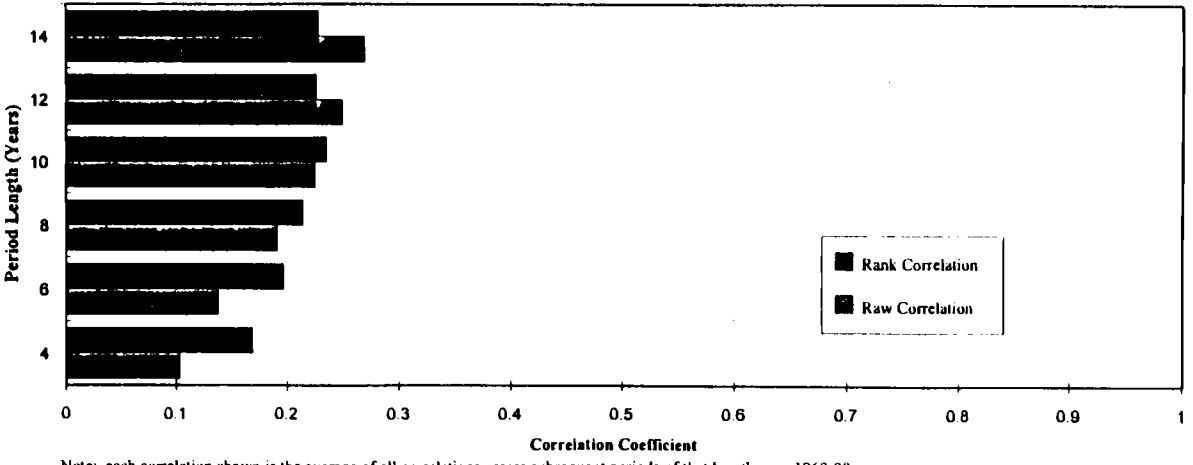
Note: In the regression of growth rates on initial income for the European provinces, we allow a different intercept for each country.

Figure 1: Per Worker Growth Rates Per Year, 1960-73 and 1974-88



Note: Growth rates are least-squares growth per worker for each country for periods shown. The three letter World Bank codes for country names, which are also used in Summers and Heston (1991) and Barro and Wolf (1989), are used for each point.

Figure 2: Correlations of Per Worker Growth Rates Across Periods by Length of Period



Note: each correlation shown is the average of all correlations across subsequent periods of that length over 1960-88.

Figure 3: Persistence of per capita growth rates across successive 30-year periods, 1870-1988

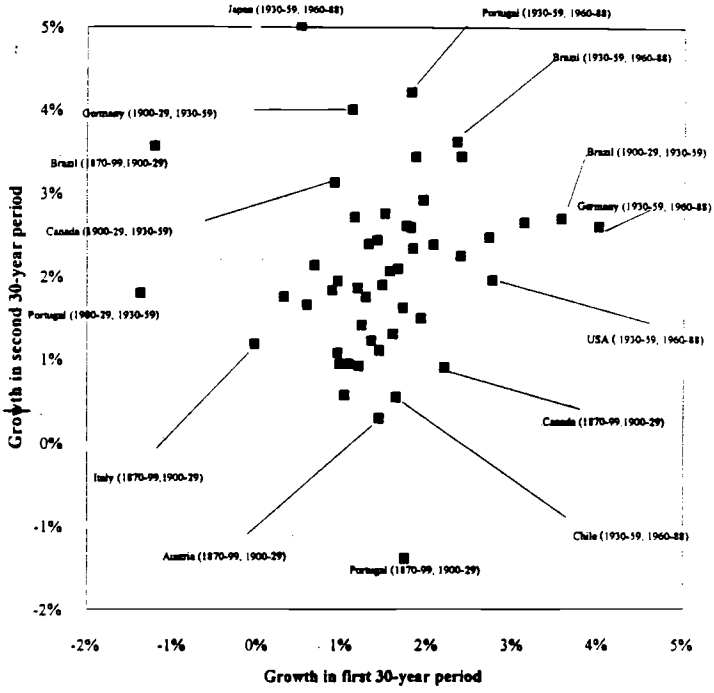


Figure 4: Rank Correlation Coefficients of Per Worker Growth by Sector

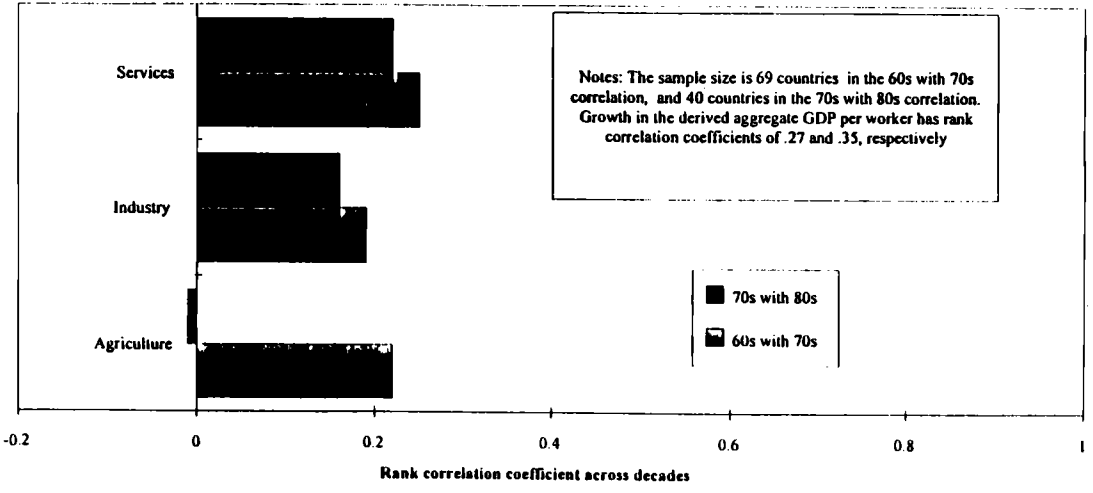
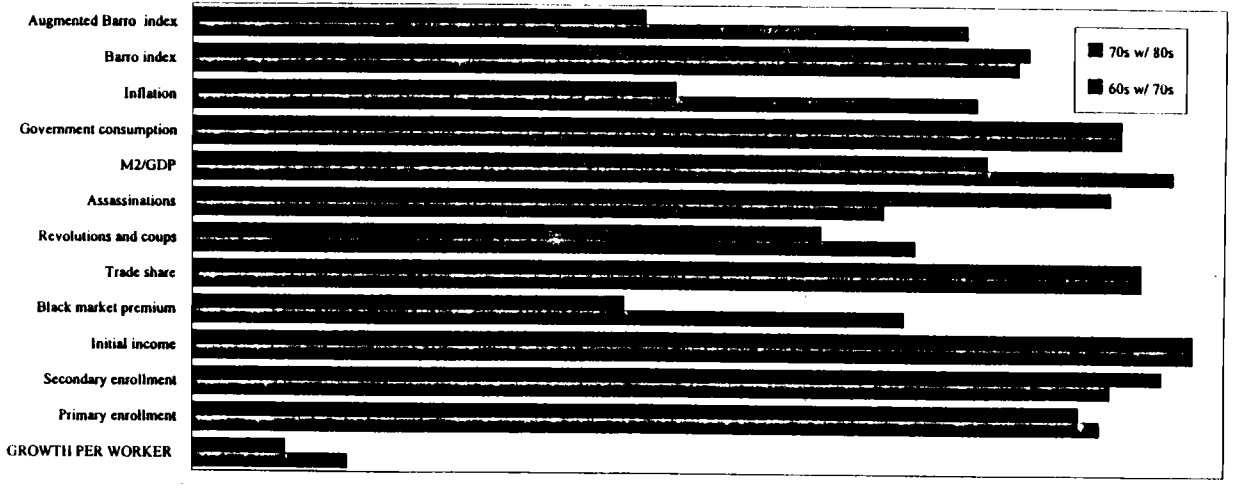
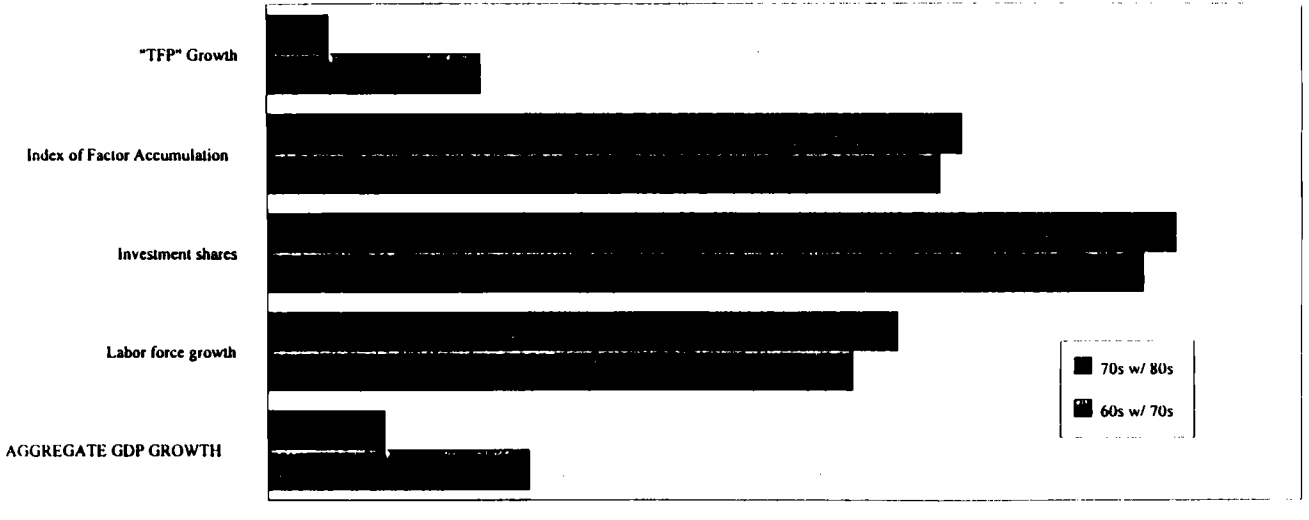


Figure 5: Persistence Coefficients of Country Characteristics



Note: Persistence coefficients are the cross-decade correlations of the variables indicated for the sample of 45 countries for which data are available on all variables.

Figure 6: Persistence of Factor Accumulation Across 115 Countries



Notes: Persistence coefficient is cross-decade correlation of variable shown. Index of factor accumulation is the fitted value from a regression of growth on investment shares and labor force growth. "TFP" growth is the residual in this reg