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How do National Policies Affect Long-run Growth?

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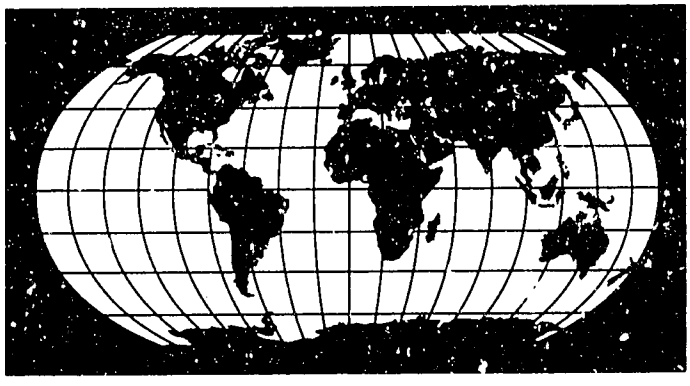

William Easterly, World Bank
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"Good Policy or Good Luck? Country Growth Performance and Temporary Shocks"

Discussants:

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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 as the dominant determinant of growth. This paper presents a fact suggesting this emphasis is misguided: growth rates are highly unstable over time, while country characteristics are highly persistent. The correlation across decades of countries' growth rates of output per worker is only .1 to .3, while most country characteristics display cross-decade correlations of .6 to .9. Failure to appreciate low persistence leads to overestimation of prospects of countries which had high growth in the past. Models in which country characteristics determine long run growth rates, such as the AK model, can only be reconciled with observed low persistence through large random shocks. Models in which country characteristics determine steady state levels of relative income, and externally generated technological change determines long-run growth predict low persistence if countries are close to their steady state levels of relative income. Shocks, especially those to terms of trade, play a much larger role in explaining variance in growth rates than previously acknowledged.

Introduction[1]

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.[2] 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. Failure to appreciate low persistence leads to major errors in evaluating countries' prospects. Well-known examples include Korea-pessimism and Africa-optimism after the 1950s.

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) GDP per capita in 1960 and 1988 was .92. Even more striking the rank correlation of GDP per capita for the 23 countries for which Maddison (1989) has data is .82 over 1870-1988. If even a small fraction of cross-sectional

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

variance of growth rates reflected long-term growth differences, the rankings would be much less stable.

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; it also draws out the implications for forecasting, and for the potential explanatory power of cross-country growth regressions. 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 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 reasonably long periods, is low. Table I presents correlations of the least-squares growth rate of GDP per worker between 1960-69, 1970-79 and 1980-88[3]. The R^2 (the square of the correlation coefficient) of 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 behavior.[4] This low persistence result is robust over the choice of country sample, time period, and sectoral performance measure.

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[3]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 economies are virtually nothing but oil. Including Kuwait would raise persistence (to about .35) because it has strikingly negative growth in all periods.

[4]Others who have previously noted this include DeLong and Summers (1991) , Levine and Renelt (1991), and Fischer (1987).

Table I: 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
LDC, non-oil	67	.099	.150	.332	.251

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.

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 opposite corners represent countries that went from high to low growth or low to high growth. 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 I show the correlations for non-oil countries (as the oil shock may have induced large changes for the oil exporters), the OECD countries, and the non-oil developing countries. The only

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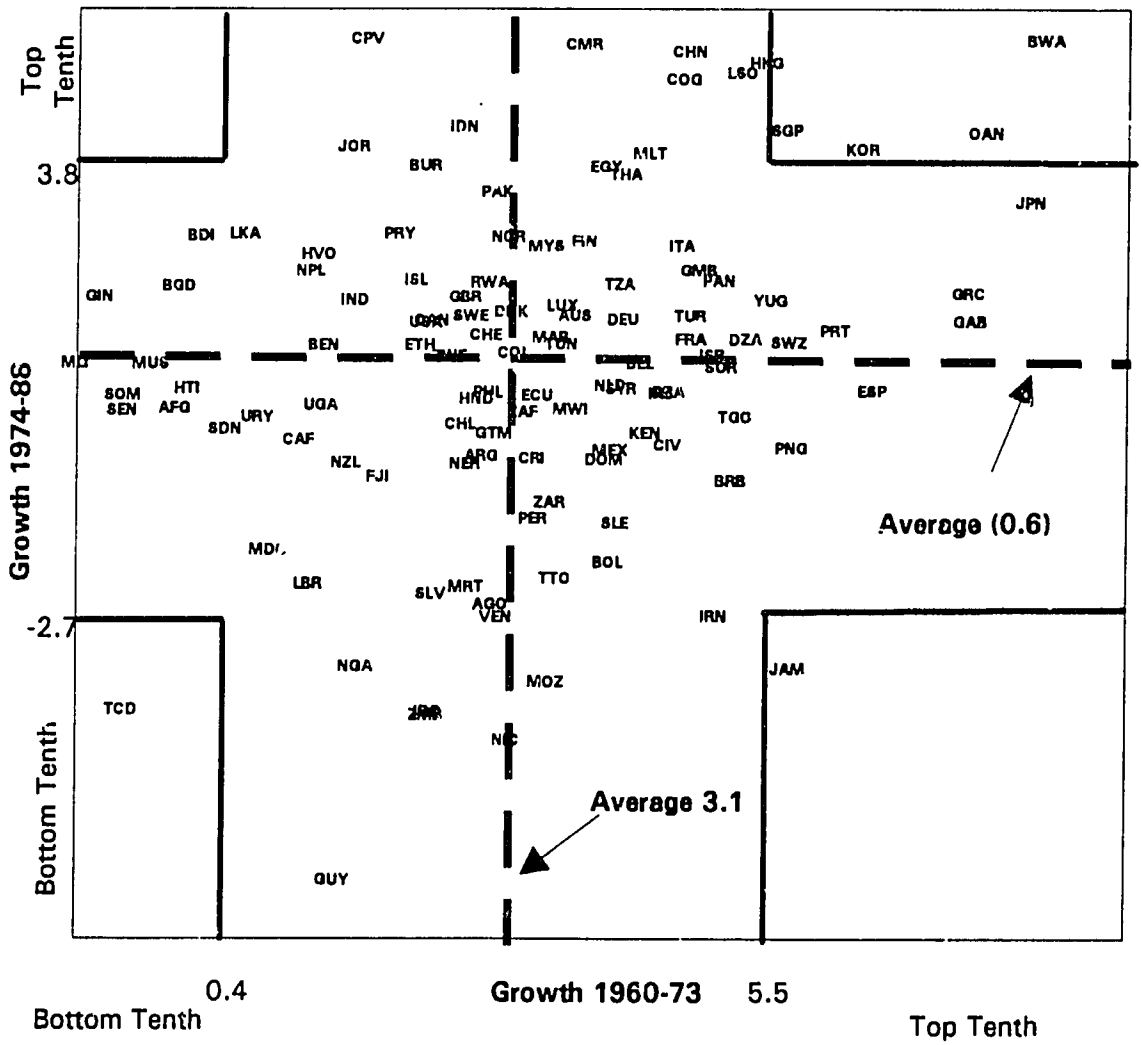
Figure 1: Per Capita Growth Rates, 1960-73 and 1974-88



exception is a high correlation between the 60's and 70's in the small sample of OECD countries, which reverts to zero between the 70's and 80's. Figure 2 shows that persistence stays low at various period lengths.

We have a bit of evidence for persistence over the very long-run in data collected for 16 industrial countries by Maddison (1989). Persistence was strongly positive (.47) from 1870-1913 to 1913-50. However, it was strongly negative (-.6) from 1913-50 to 1950-73. Persistence was then modestly positive (.3) between 1950-73 and 1973-88.

One possible explanation for low persistence is instability in agriculture due to price and weather shocks. Figure 3 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 II shows the low contemporaneous correlations of growth rates across sectors. The table suggests 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.[5]

Table II: Cross-Sector Correlations of per worker growth rates	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

Theoretically, measurement error at the end of one period and the beginning of the next could create artificially low persistence, by leading to an underestimate of growth in one period

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

FIGURE 2: CORRELATIONS OF GROWTH RATES ACROSS PERIODS BY LENGTH OF PERIOD

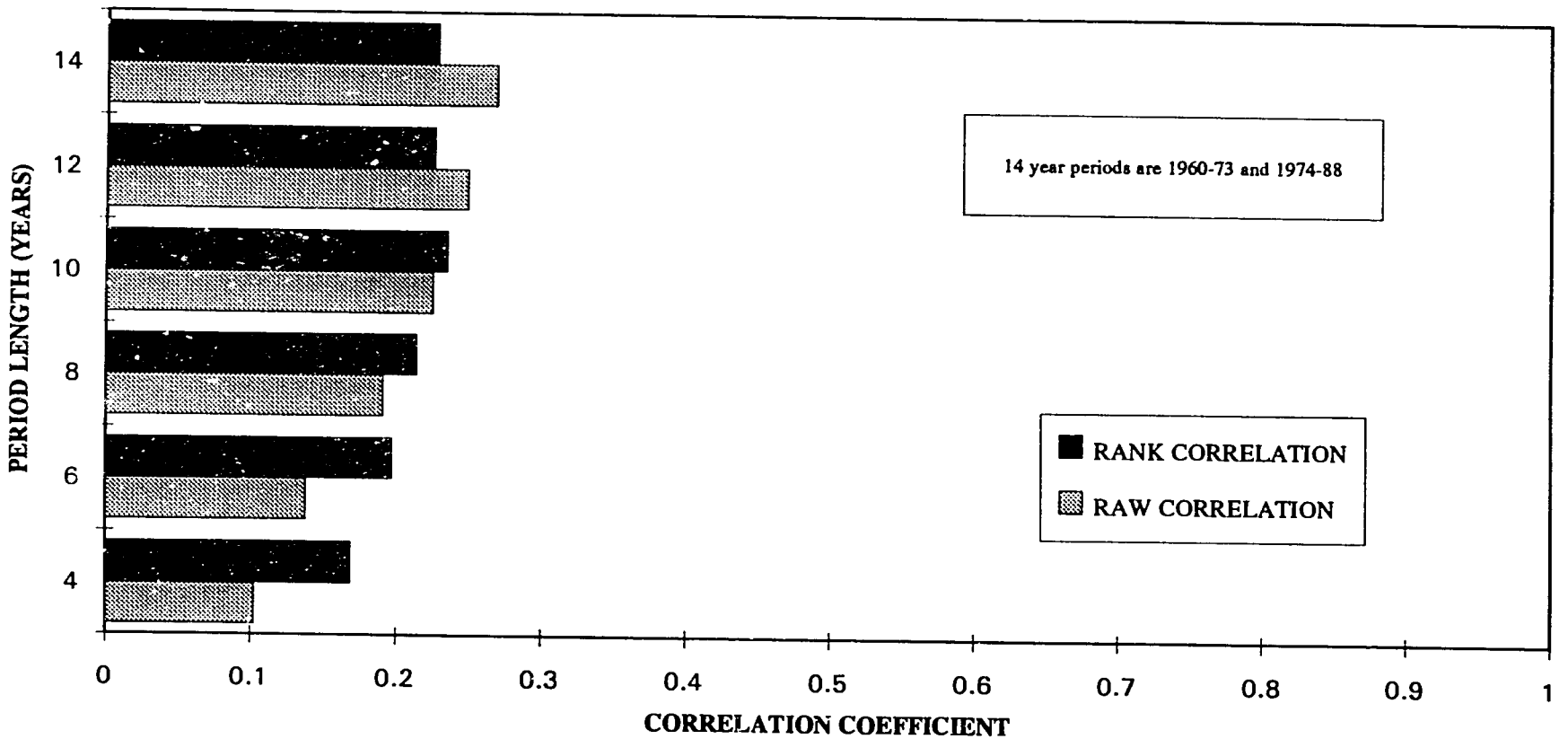
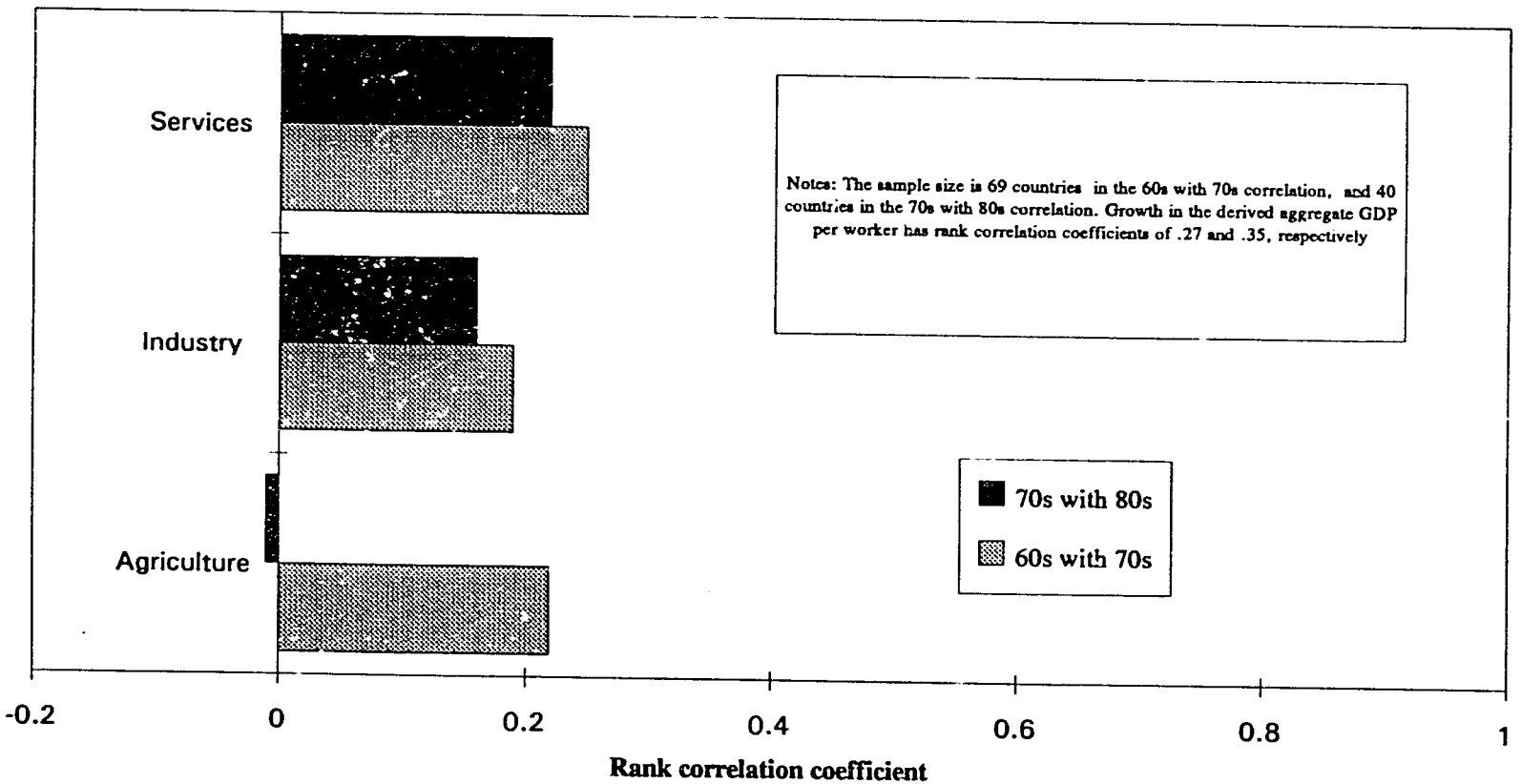


FIGURE 3: RANK CORRELATION COEFFICIENTS OF PER WORKER GROWTH BY SECTOR



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 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 Figure 2 shows, persistence remains low even over long periods. Finally, while iid measurement error would lower persistence, other types of measurement error -- such as country-specific tendencies to overreport growth rates -- would raise persistence.

b. Persistence and forecasting

The erroneous assumption that persistence is high often leads to overestimation of prospects for countries that have had high growth, and underestimation for countries that have had low growth.[6] Even the most skilled economists have too often made the mistake of extrapolating from past performance as the following set of quotes indicates:

[6]The tendency to assume excessive persistence is not limited to economics. In sports, fans and sportswriters often express surprise that a championship team does much worse the following year. In major league baseball, the persistence of rankings and wins is only around .31 An analogous phenomenon is the so-called "sophomore jinx" whereby the rookie of the year in any given sport tends to have a worse year in the second year of his career. It's not hard to think of other examples: bad movie sequels, disappointing second novels, and mediocre second terms of popular presidents. For an entertaining collection of such examples, see Innumeracy by John Allen Paulos (1988).

Table III: Predictions about country growth	
Prediction	Actual outcome
"There can be no doubt that this development program {GDP growth of 7.1 percent over 1962-66} far exceeds the potential of the Korean economy." { World Bank report on Korea in early 1960s, quoted in World Bank (1992)}	GDP growth over 1962-66 was 7.3 percent; the rest is history
"The age-long influence of the West ... failed with only few exceptions to instill its economic activity and enterprise into the minds and habits of these peoples. The Western apparatus of ... production remained an ... indigestible element in Southeast Asia ... the economic energy necessary for a vigorous resurgence {was} lacking." {Quoted in Hoselitz (1952), p. 215)	Thailand, Indonesia, Singapore, and Malaysia all grew over 4 percent per capita over 1960-88.
"In her first 10 years of independence, Burma has made remarkable economic progress...Burma's long-run potential compares favorably with those of other countries in South East Asia" {World Bank report, 1958, quoted in World Bank (1992)}	The countries listed in the previous line grew 2 to 3 times faster than Burma
"I am confident that for most of Africa, the economic future before the end of the century can be bright ... {Gabon, Guinea, Liberia, Zambia, Nigeria, Congo-Leopoldville (Zaire), and Rhodesia (Zimbabwe)} clearly have the potential to reach or surpass a 7 percent rate of growth ". {A. Kamarck (1967)}	All of the countries listed had negative per capita growth over 1970-88
The "outlook for peaceful development is poor ... The history of the island has led to an association in the mind of the underdog between manual work and slavery ... Outside {producing} sugar..., enterprise and good management are sadly lacking in Mauritius." (J. Meade (1967) quoted in Summers and Easterly (1992)}	Mauritius was in the top quintile of per capita growth rates, 1970-88

Today's euphoria about East Asia and despair about Africa and the former Soviet Union may be similarly exaggerated.

In discussing forecasting it is useful to consider two simple, stylized models, although neither fits the data perfectly. In the first model, each country i, has its own long-run growth rate, g_i, which can be represented as the world average growth rate, g, plus a country specific component ϵ_i. We assume growth for country i in period t can be written as:

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

where ϵ_i and ϵ_{it} are independent normal variables, and ϵ_{it} is serially uncorrelated. It is straightforward to estimate the parameters from the data. The variance of each country's T period

growth rate, denoted σ_T^2, equals σ_i^2/T. The estimated value of ϵ_i, the best forecast of country i's future growth rate, is then a weighted combination of the country's past growth rate and the growth rate's of all other countries:

$$\hat{\epsilon}_i = \theta\left(\frac{1}{T}\sum_{t=1}^{T} g_{it}\right) + (1-\theta)\bar{g} \tag{2}$$

where θ, the weight on past performance, is

$$\theta = \frac{\sigma_i^2}{\sigma_T^2 + \sigma_i^2} \tag{3}$$

If there is little variation in growth rates between countries relative to the variation within countries over time, then the country's past growth rate will be weighted less heavily.[7] This can also be expressed as the analytically equivalent concept of regression towards the mean. When persistence is low and random variation is dominant, we know a high growth rate probably reflects a fortuitous outcome; it is optimal to project a strong decline in growth in the next period.

Under this model, the country fixed effect does not change over time, so

$$cov(g_{i,t}, g_{i,t+1}) = cov(g_{i,t}, g_{i,t+k}) = \epsilon_i^2 \tag{4}$$

for any k. In the data, however, growth rates in adjacent periods have higher correlations than growth rates from periods separated by a gap. This suggests a different model in which the underlying growth rate slowly changes over time:

[7]This result is familiar in the literature from Lucas' (1974) classic "islands" model of price determination in which firms have to interpret price variation as representing either time series variation or cross-sectoral variation.

$$g_t - \bar{g} = \rho(g_{t-1} - \bar{g}) + \epsilon \qquad 0 < \rho < 1 \tag{5}$$

There is no explicit country effect in this model, but countries that grow quickly in one period are more likely to grow quickly in the future. (This could be justified in the AK model if countries had slowly changing mean-reverting policies, and under a broadened neoclassical model as the effect of transition dynamics.) In this model, the persistence coefficient is

$$cor(g_{i,t}, g_{i,t+1}) = \rho \tag{6}$$

so the optimal forecast of $g_{i,t+1}$ is

$$\bar{g} + \rho(g_{i,t} - \bar{g}) = \rho g_{i,t} + (1-\rho)\bar{g} \tag{7}$$

Thus under either model, the optimal forecast of growth next period is a weighted average of the country's past growth, and the average growth of all countries in the past. The difference is that under the first model, all past growth rates of the country are weighted equally, whereas under the second model, the country's growth rate last period contains all the information available.

Like the first model, this second model is overidentified, as it implies the variance of growth over a cross-section is the same as the variance over a time-series:

$$var(g_{i,t}) = E(\epsilon_{i,t} + \rho\epsilon_{i,t-1} + \rho^2\epsilon_{i,t-2}\ldots)^2 = \frac{\sigma_\epsilon^2}{1-\rho^2} \tag{8}$$

This seems to be rejected by the data as well. This suggests an intermediate model, which would allow both for an i.i.d. shock, and for slowly changing policies. Such a model would put slowly declining weights on more distant periods, unlike the two models here, which either weight all periods equally, or use only the information from the previous period. However, it would be difficult to estimate such a model because of the short time dimension of the data.

Appendix I examines the extent to which World Bank forecasting allows for low persistence. It finds that World Bank forecasts do incorporate low persistence. While the persistence in the World Bank forecasts (the ρ estimated from equation (5)) is higher than that in the actual data, the difference is not statistically significant. However, World Bank forecasts have significantly stronger persistence for countries whose past growth was above average; there is no such significant distinction in the actual data.

c. *Bounding the R^2 in growth regressions*

Under the model of fixed country effects, low persistence bounds the potential R^2 that can be achieved in growth regressions. To see this, assume again that growth is given by (1).The persistence coefficient, denoted ρ, is then

$$\rho \equiv cor(g_{it}, g_{i,t-1}) = \frac{\sigma_i^2}{\sigma_i^2 + \sigma_{it}^2} \tag{9}$$

The expected R^2 from regressing growth over an n year period on a perfect measure of policies that determine ϵ_i will be

$$E[R^2(n)] = E\left[1 - \frac{(y-\beta x)^2}{(y-\bar{y})^2}\right] = 1 - \frac{n\sigma_{it}^2}{n^2\sigma_i^2 + n\sigma_{it}^2} \tag{10}$$

This simplifies to

$$E[R^2(n)] = \frac{\sigma_i^2}{\sigma_i^2 + \frac{\sigma_{it}^2}{n}} \tag{11}$$

Using the definition of the persistence coefficient, ρ, it is possible to write

$$\sigma_{it}^2 = \left[\frac{1}{\rho} - 1\right]\sigma_i^2 \tag{12}$$

The expected R^2 from regressing growth over an n year period on a perfect measure of the policies that determine ϵ_i will therefore be

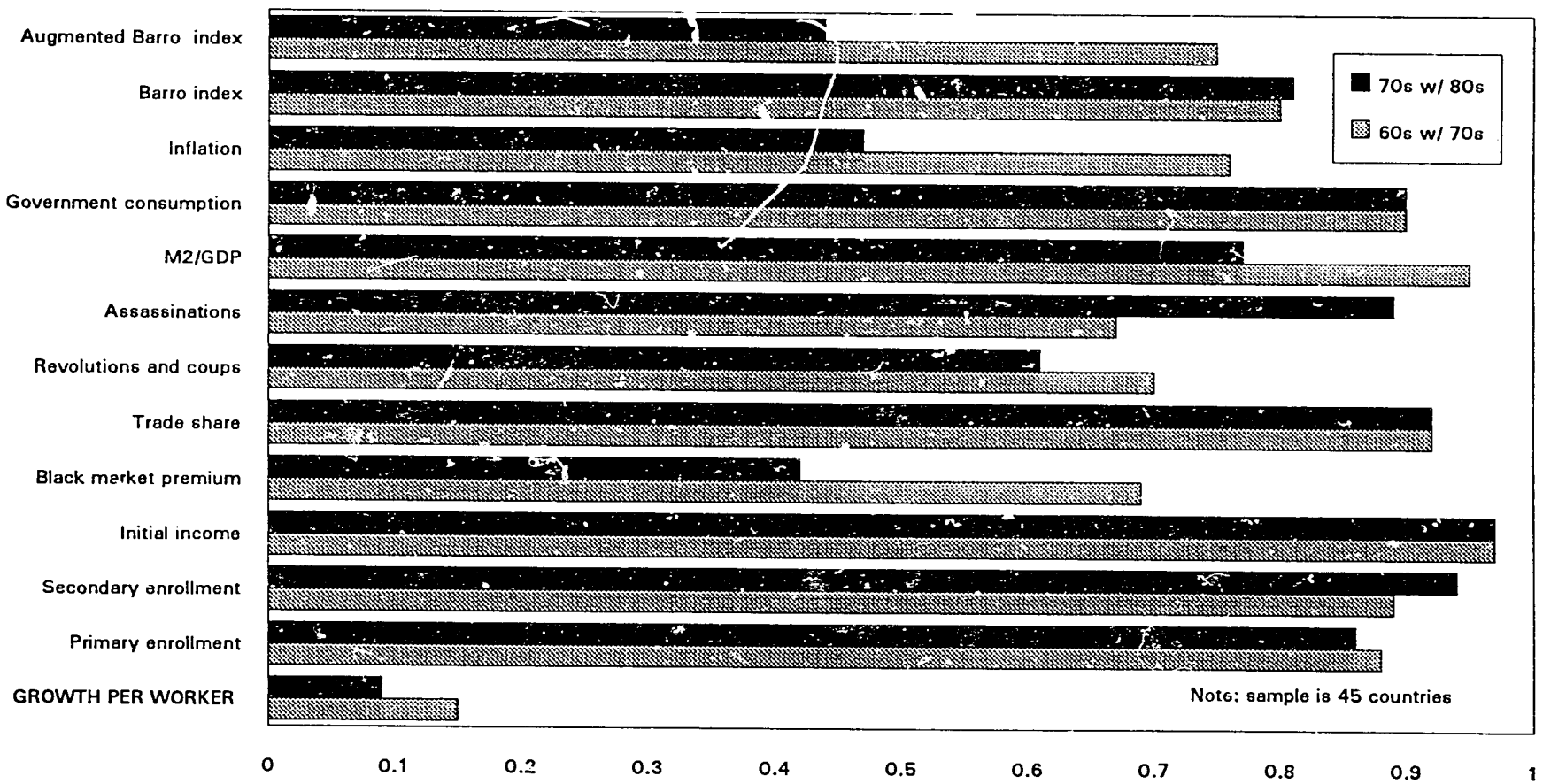
$$E[R^2(n)] = \frac{1}{1+\left[\frac{1-\rho}{\rho n}\right]} = \frac{\rho n}{\rho n + 1 - \rho} \tag{13}$$

If one defines a period as ten years, then ρ is approximately 1/3. Thus over a thirty year period, even assuming policies are perfectly measured and that policies perfectly determine the country specific growth rate, the expected R^2 will be only .6. If this model of fixed country effects describes the data, then it is unlikely that we will see much increase over the current R^2 s in the literature, which are in this range (unless it is due to data mining) .

d. Are Country Characteristics Persistent?

This section argues that low persistence of growth rates is not explained by low persistence of policies or rates of factor accumulation. Figure 4 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.

FIGURE 4: PERSISTENCE COEFFICIENTS OF COUNTRY CHARACTERISTICS



However, it still could be the case that some aggregate index of policy variables could display low persistence.[8] To construct such an index, we use the variables shown in Figure 4 with a pooled time-series cross-section regression on 10 year averages. Table IV 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 second regression with a broader set of country characteristics. The fitted values from this regression (denoted Barro Index and Augmented Barro Index, respectively) are far more persistent than growth rates, as shown in Figure 4.

Rates of factor accumulation are also much more persistent than growth rates. To compute an index of factor accumulation, we regressed growth on investment and labor force growth, using a sample of 115 countries which have data for all three decades.[9] Figure 5 shows that investment, labor force growth, and the fitted value of growth predicted by the two are much more persistent than growth.

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[8]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.

[9]The coefficients of the regression were as follows: on investment share .071 (4.2), on labor force growth -.36 (-2.95), on a dummy for the 60's .028 (9.04), on a dummy for the 70s .018 (4.99). R-squared was .24 and there were 345 observations (decade averages for 60s, 70s, and 80s for 115 countries).

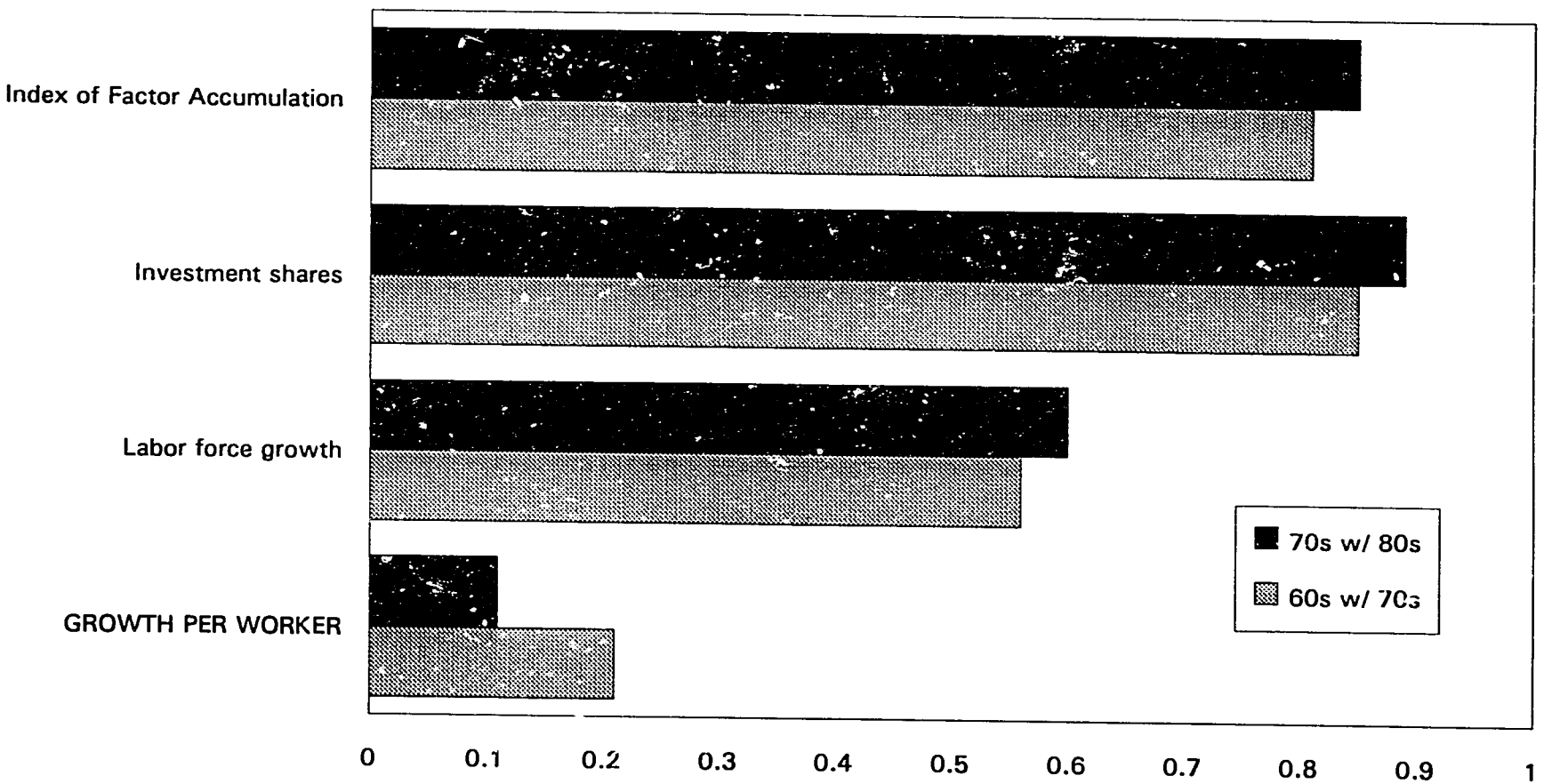
Table IV: Pooled Cross-section Time Series Regressions of Long-Term Growth on Policy Variables with Decade Averages

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 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.

FIGURE 5: PERSISTENCE OF FACTOR ACCUMULATION ACROSS 115 COUNTRIES



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. Moreover, 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 V 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]

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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.

Table V: 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

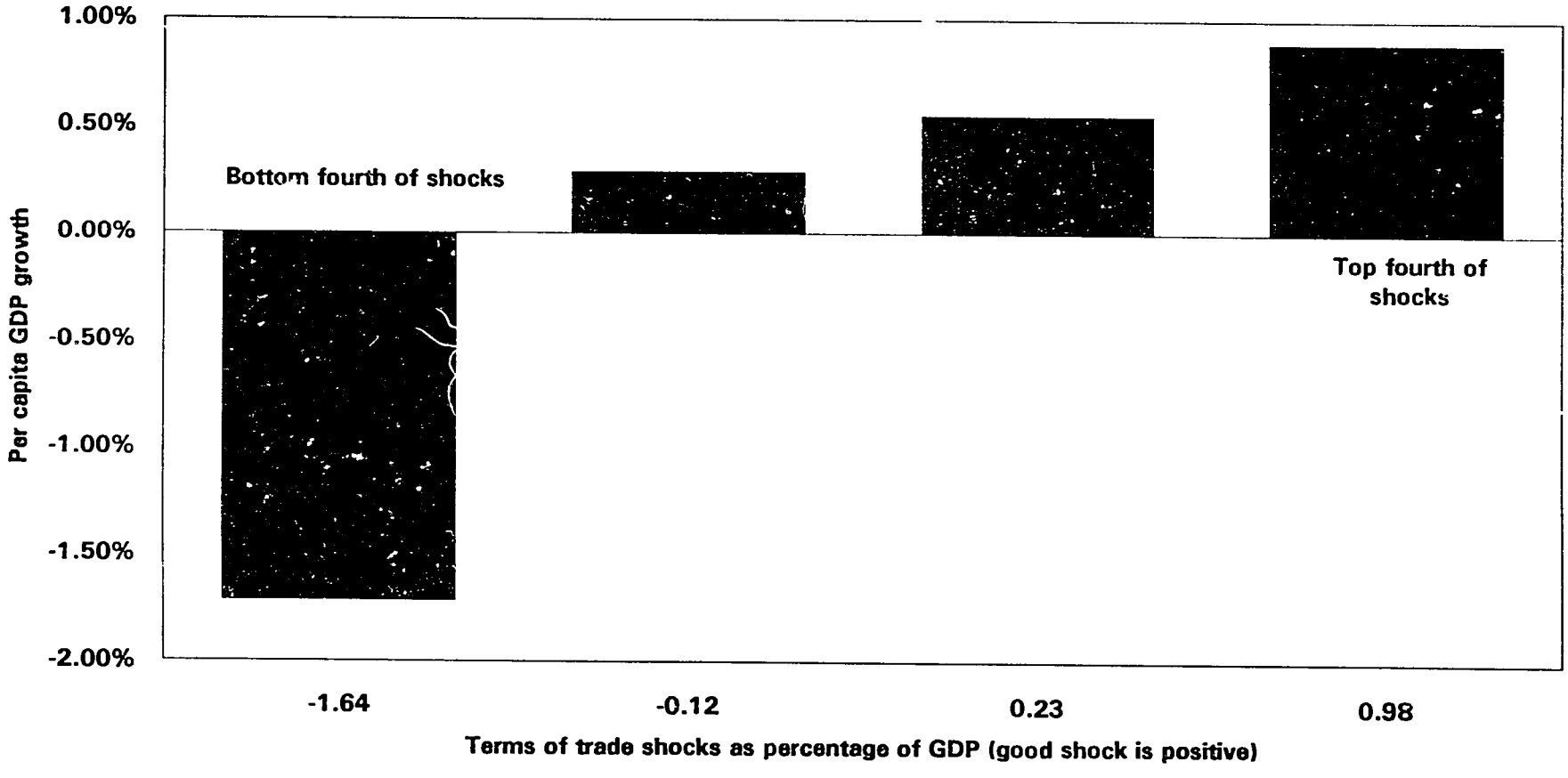
Growth is strongly correlated with terms of trade improvements and high external debt in the 80's, and with war in the 70's (and weakly with war in the 80's). Figure 6 dramatizes the strong correlation between per capita growth and terms of trade shocks in the 80s. The fourth of the sample with the worst shocks had per capita growth 2.5 percentage points lower than the fourth with the best shocks.

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 VI). 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

[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.

FIGURE 6: EXTERNAL SHOCKS AND ECONOMIC GROWTH IN THE 1980'S



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 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

[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 Delong and Summers (1991, 1992). Finally, the high coefficient could reflect a Keynesian aggregate demand effect, which would be surprising at such a long period length.

a few large values for casualties, transfers, and terms of trade movements) the results for individual variables are sensitive to choice of sample.

Table VI: Growth regressions with shock variables[14]

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

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

[14]T-statistics, in parentheses, are computed using MacKinnon-White (1985) heteroskedasticity-consistent standard errors.

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[15].

The shock variables influenced growth not only directly, but also indirectly, through policy variables. Table VII 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 VI 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.

Table VII Shocks and the black market premium [16]

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

[15] 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.

[16] T-statistics computed using White heteroskedacity-consistent standard errors.

The inclusion of shock variables in a regression identifying determinants of growth rates over a ten year period (generally taken to be "long-run") illustrates three points. First, shocks (which are often transitory) are important even over these time horizons. Second, a large part of the difference between the persistence of actual and predicted growth rates is explained by the influence of shocks. Third, variables taken to proxy policy environment may in fact be driven by shocks themselves, which influence the estimates of "policy" impact.

III) Persistence and Growth Theory

This section argues that models in which country characteristics drive long-run growth, low persistence imply that there are large random shocks, and that these shocks are a major determinant of welfare. Under models in which growth is a world-wide process, and country characteristics determine the relative level of income, low persistence is consistent with shocks of any size, and shocks may play only a minor role as a determinant of welfare, despite being an important determinant of growth rates.

Models in which country characteristics determine growth can only be reconciled with low persistence through the assumption of large random shocks. Examples of such models would be the AK model of Rebelo (1991), in which growth depends on tax rates, and models of technological change within a single country, in which growth may depend on research incentives or market size. In these models, low persistence of growth rates implies that relatively persistent country characteristics such as taxes, research subsidies, and education policies explain only a modest proportion of growth relative to random shocks. Thus under these models, the future level of income of a country will depend heavily on these shocks.

In contrast, in another set of models, worldwide technological progress determines long-run growth and country characteristics determine steady state relative levels of income. For example, in the neoclassical model, country characteristics determine relative levels of income in the steady state, and exogenous technological progress determines long run growth. More generally, technological progress may be generated by a worldwide process of the type described in Romer (1990), Aghion and Howitt (1992) or Grossman and Helpman (1991), and technology may then flow to countries with lags of various lengths. If

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

where B is the level of technology in the backward country, p is the set of policies in that country, and A is the level of technology in the advanced country, which is assumed to grow exogenously at rate g, then the ratio B/A will tend to a constant which will be a function of the country's policies. If the level of technology starts below this ratio, it will converge towards it. For all but the largest countries, it may be possible to take worldwide technological change as exogenous. Under either of these models persistence would depend on the distribution of countries incomes relative to their steady state income.

Appendix II shows that if an independent normal error term is added to a linearized version of the deterministic neoclassical model, as in Barro and Sala-i-Martin (1992), the country-specific element of growth will be given by the random error term, and by transitional dynamics, which will depend on the distance of each country's initial income from its steady state value. 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] Thus the neoclassical model predicts that persistence will asymptotically become negative, even if the random shocks are arbitrarily small. Persistence starts out high, but falls as the steady state is approached. Under this model, a country's level of income could be determined almost completely by worldwide technological change and its policies, but a large percentage of the variance in its growth rate could be explained by random shocks. In this model the growth rate would just represent fluctuations around a steady state level of relative income.

Countries could be far from the ergodic distribution around the steady state due to a large, infrequent shock, such as a war, depression, or industrial revolution. Such shocks could plausibly affect only a subset of countries, thus creating a wide distribution of ratios of actual to steady state income.

The model 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 clear. Negative persistence is much more common among states than among countries, as would be expected if states are more likely to be similar distances

[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.

away from their steady states. Growth rates of personal per capita income in the U.S. states, shown in Table VIII, 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[18].

Data from 73 European provinces (covering Belgium, Denmark, France, Italy, the Netherlands, and the United Kingdom) provides further support for the model. Persistence across subsequent decades from the 50's to the 80's is low, with negative persistence again observed for the 80's.[19] 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.

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[18]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.

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

Table VIII: 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[20]		
1950's with 60's	.10	-.13
1960's with 70's	.29	.20
1970's with 80's	-.33	-.19

We also have a small amount of regional data from developing countries, although it is on gross rather than per capita product. We found negative persistence for 25 Chinese provinces across subsequent periods of 1952-63, 1963-74, and 1974-85, and essentially zero persistence for 20 Indian provinces between 1970-77 and 1978-83. Indonesia had strongly positive persistence for 26 provinces between 1975-79 and 1979-84, but the time period was short, and Indonesian provinces are extremely heterogeneous. (Data and sources for these comparisons are available on request.)

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 were consistently high performers. 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, no countries were consistent bad performers. This may indicate that

[20]/ In the regression of growth rates on initial income for the European provinces, we allow a different intercept for each country.

countries with high levels of income do not often change to policies that give them a low level of steady state income.

In sum, under theories in which country characteristics determine long run growth rates, low persistence implies large unmodelled shocks to growth. This, in turn, implies that such theories, if correct, can explain only a small fraction of growth. On the other hand, under theories in which growth is determined by a worldwide process of technological change and by transitional dynamics, low persistence implies countries must be at similar enough distances from their steady states that random elements are important relative to transitional dynamics. Non-negative persistence implies that countries must not yet have reached an ergodic distribution around their steady state.

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 to longer periods. In contrast to growth rates themselves, the country characteristics which are often thought of as determinants of growth are highly persistent. Thus models in which country characteristics determine long-run growth can be reconciled to the data only through large random shocks. In contrast, models in which worldwide technological change determines long-run growth, and country policies determine the relative level of income predict low persistence when countries are near their steady states. Under models in which country characteristics determine growth, a country's level of income will be determined in large part by its luck in the past, whereas in models of worldwide technological change, a country's luck may only determine fluctuations around a trend.

Low persistence does not rule out the <u>potential</u> importance of policy to determine growth in either type of model. If the variation in policies were increased due to drastic policy reforms in some

countries, then policy would explain a correspondingly larger fraction of growth even in models in which country characteristics determine long-run growth rates. In the models in which worldwide technological change determines long-run growth, the proportion of variation in growth among countries due to shocks will depend on the frequency of policy changes. Low persistence could have resulted because major policy reforms were rare over our sample period.

Empirically, we find that shocks, especially terms of trade shocks, statistically explain as much of the variance in growth rates over 10 year periods as do country policies. The finding that much of the variation of growth rates in our sample is due to random shocks should induce caution in attributing high growth rates to good policy (or to a "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.

Appendix I: World Bank Forecasting

To assess whether World Bank forecasts followed the rule described in section I, we examine a sample of 78 countries for which the World Bank has recently computed forecasts of growth for 1990-2000.[21]

In the text of the paper we use the concept of persistence. In discussing forecasting it will sometimes be convenient to use the analytically equivalent concept of regression to the mean. We regress the projected change in each country's deviation from the world growth rate against its deviation from the mean growth rate in the 80's. Regression to the mean would imply a negative coefficient: high growth in period 1 means the growth rate should fall in period 2. The coefficient will be equal to β-1 where β is the coefficient from the regression of period 2 on period 1 growth (and recall that β is approximately equal to persistence). The table shows the results. Surprisingly, World Bank forecasts do seem to embody strong regression to the mean, as follows from the optimal forecast rule when growth displays low persistence. For comparison, we also show the tendency to regress to the mean in the actual data in the table, which shows the coefficients from regressing the change in growth from the 70's to the 80's against the deviation of each country's growth from the global mean in the 70's. (A coefficient of -1 implies zero persistence and full regression to the mean, so that any deviation from the world average in one period tends to completely disappear in the next. A coefficient of 0 would imply deviations from world average growth are maintained unchanged across successive periods.) The table shows that the estimated coefficient (β-1) for regression to the mean in the actual data (-.77) is stronger than that in the projection (-.64), although the difference is not statistically significant. The World Bank coefficient is particularly lower (in absolute value) for above average countries, but again the difference between the forecast and the actual data is not significant.

Regression to the mean coefficients in forecasts and actual data	*70's with 80's actual data*			*80's actual data with 90's projections*		
Sample breakdown	Coefficient	T-stat	#obs	Coefficient	T-stat	#obs
Complete sample	-0.77	-6.3	78	-0.64	-7.8	78
Above average growth in first period	-0.78	-2.5	42	-0.39	-3.8	35
Below average growth in first period	-1.21	-5.2	36	-0.97	-5.9	43
Difference below average and above average	0.43	1.1	78	0.58	3.0	78

[21]The sample is from the Unified Survey of January 1992 (kindly supplied in convenient form by Robert Lynn). For a few countries that were not included in the Unified Survey, we have used the projections from the June 1991 version of the SAVEM tables. Robert Lynn also supplied projections for Japan and the United States, which are the only two non-developing countries whose growth is projected by the Bank.

The last line of table 4 shows that World Bank projections feature significantly stronger regression toward the mean for countries that began below the global average. In fact, countries whose growth was below average are projected to return completely to the world average growth rate. In contrast, countries that began above average are projected to have only a moderate tendency to return to the mean. The difference between the two forecast coefficients is statistically significant; there is no such statistically significant tendency in the actual data.

In summary, the optimal forecast rule under low persistence is to forecast strong reversion towards the mean. The World Bank forecasting exercise seems to incorporate this principle, but inappropriately make it weaker for "successful" countries.

Appendix II: Persistence in the neoclassical model

If countries are a wide range of distances away from their steady state in a neoclassical model with a random error term, then transitional dynamics will be the dominant influence in growth, and persistence will be high. As countries approach the steady state, the error term will become more important relative to the transitional dynamics, and persistence will fall. Barro and Sala-i-Martin (1990) show that countries will approach a steady state cross-sectional distribution of income in which the tendency for reduced cross-sectional variance from transitional dynamics is just balanced by the tendency for increased variance due to the error term. This appendix demonstrates that there is negative persistence in this steady state because countries will tend to return to the steady state level of income.

We follow the approach of Barro and Sala-i-Martin (1991) in linearizing a deterministic neoclassical model around the steady state and adding a random error term. They show that:

$$\log[\hat{y}(t)] = \log[\hat{y}(0)]e^{-\beta t} + \log(y^*)(1-e^{-\beta t}) \tag{15}$$

where y hat is income per effective worker, y^* is the steady state level of income, and β is an adjustment speed parameter.

As Barro and Sala-i-Martin show, this implies that the growth rate of per capita income over the interval between t and t+1 is

$$g_t \equiv \log[y(t+1)/y(t_0)] = x + (1-e^{-\beta})\left[\log\left[\frac{\hat{y}^*}{\hat{y}(t_0)}\right]\right] + \mu_t \tag{16}$$

where μ_t is an error term that we will assume is spherical.[22]

This equation can be used to find the persistence measure we use:

$$\frac{cov(g_{i,t}, g_{i,t+1})}{\sqrt{var(g_{i,t})}\sqrt{var(g_{i,t+1})}} \tag{17}$$

For notational convenience, define

$$v \equiv 1 - e^{-B} \tag{18}$$

[22]Of course the assumption of zero covariance of the error term across time or observations is wrong, but we wanted to start with a simple case. The time period could presumably be chosen long enough so that there is no correlation of the error term across time periods, but this may be too long a period to check for persistence.

To solve for the covariance of growth rates across time, it is helpful to express income in period t+1 as a function of income at t.

$$\log(y_{i,t+1})=\log(y_{i,t})+g+v[\log(\frac{y^*}{y_{i,t}})]+\mu_{i,t} \tag{19}$$

Given income at period t+1, it is possible to solve for growth at t+1.

$$g_{i,t+1}=g+v\left[\log(y^*)-\left(\log(y_{i,t})+g+v\left[\log\left(\frac{y^*}{y_{i,t}}\right)\right]+\mu_t\right)\right]+\mu_{t+1} \tag{20}$$

To calculate the covariance we need the deviation from the mean growth rate in each period:

$$g_{i,t}-\bar{g}_t=v[\log(\bar{y}_t)-\log(y_{i,t})]+\mu_{i,t} \tag{21}$$

$$g_{i,t+1}-\bar{g}_{t+1}=v[[\log(\bar{y}_t)-\log(y_{it})]-v[\log(\bar{y}_t)-\log(y_{it})]-\mu_t]+\mu_{t+1} \tag{22}$$

Thus the covariance of growth across time can be written as a function of the initial cross-sectional distribution of income levels and the variance of the shock. Letting σ_t^2 denote the cross-sectional variance of log income at time t,

$$E(g_{it}-\bar{g}_t)(g_{i,t+1}-\bar{g}_{t+1})=(v^2-v^3)\sigma_t^2-v\sigma_\mu^2 \tag{23}$$

Since the covariance of growth rates over time is a function of the cross-section variance of income, its time-path can be found by tracking the time path of the cross-section variance of income. Barro and Sala-i-Martin show that σ_t^2, the cross-section variance of $\log(y_t)$, evolves according to

$$\sigma_t^2=(e^{-2\beta})\sigma_{t-1}^2+\sigma_{ut}^2 \tag{24}$$

and that it therefore approaches the steady state value

$$\sigma^2 = \frac{\sigma_\mu}{(1-e^{-2\beta})} \tag{25}$$

At this point the increase in cross-section variance due to new shocks is exactly counterbalanced by the decrease in variance due to convergence.

Since the covariance of growth over time depends on the cross-section variance of income, it is possible to calculate the steady state level of this covariance. The covariance of growth across time approaches the steady state value

$$\lim_{t\to\infty}(v^2-v^3)\sigma_t^2 - v\sigma_\mu^2 = v\sigma_\mu^2\left[\frac{v^2-v^3}{1-e^{-2\beta}}-1\right] \tag{26}$$

This steady state covariance of growth across time will be negative if $v^2-v^3 < 1-e^{-2\beta}$. Substituting in the definition of v, this condition becomes

$$1-2e^{-\beta}+e^{-2\beta}-1-2e^{-\beta}+e^{-2\beta}+2e^{-2\beta}-e^{-3\beta} < 1-e^{-2\beta} \tag{27}$$

This condition simplifies to

$$e^{-\beta}-e^{-2\beta}+e^{-3\beta}<1 \tag{28}$$

Since $e^{-\beta} < 1$, and $e^{-2\beta} > e^{-3\beta}$, this condition is satisfied, and the covariance of growth rates across periods is therefore negative in steady states.

Showing that the covariance of growth rates declines over time if $\sigma_0^2 > \sigma^2$ is not equivalent to showing that persistence declines over time. The measure of persistence used in the text was

$$\frac{cov(g_{i,t}, g_{i,t+1})}{\sqrt{var(g_t)}\sqrt{var(g_{t+1})}} \tag{29}$$

The denominator of this expression declines over time if countries start out of steady state.

It is possible, if slightly messy, to show that this measure of persistence increases monotonically in σ_t^2 (check), but it is convenient to use a slightly different measure of persistence, p', defined as

$$p' \equiv \frac{cov(g_{i,t}, g_{i,t+1})}{var(g_{i,t})} \tag{30}$$

The cross section variance of growth at time t is

$$E(g_{i,t} - \bar{g}_t)^2 = E[\nu(\log(\bar{y}_t) - \log(y_{i,t})) + \mu]^2 \tag{31}$$

or,

$$var(g_{i,t}) = \nu^2 \sigma_t^2 + \sigma_\mu^2 \tag{32}$$

so

$$p' = \nu \left(\frac{\sigma_t^2(\nu - \nu^2) - \sigma_\mu^2}{\sigma_t^2 \nu^2 + \sigma_\mu^2} \right) \tag{33}$$

Unsurprisingly, persistence decreases in σ_μ^2, the variance of the shock. Differentiating shows that persistence increases in σ_t^2, the cross-section dispersion of log income.

$$\frac{dp'}{d\sigma_t^2} = \nu \left(\frac{(\nu - \nu^2)[\sigma_t^2 \nu^2 + \sigma_\nu^2] - \nu^2[\sigma_t^2(\nu - \nu^2) - \sigma_\mu^2]}{[\sigma_t^2 \nu^2 + \sigma_\mu^2]^2} \right) \tag{34}$$

The denominator is positive, and the numerator can be rewritten as

$$\nu\left[\nu\sigma_\mu^2 + [(\nu - \nu^2) - (\nu^3 - \nu^4)]\sigma_t^2\right] > 0 \tag{35}$$

Since this is positive, persistence increases with cross-sectional dispersion. As discussed earlier, Barro and Sala-i-Martin show that cross-section dispersion will decline over time if countries start with greater cross-sectional variance than in the steady state. Therefore, persistence will decline over time if countries start with greater cross-sectional variance than in the steady state.

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