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Determinants of Economic Growth in a Panel of Countries

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Growth rates vary enormously across countries over long periods of time. The reason for these variations is a central issue for economic policy, and cross-country empirical work on this topic has been popular since the early 1990s. The findings from cross-country panel regressions show that the differences in per capita growth rates relate systematically to a set of quantifiable explanatory variables. One effect is a conditional convergence term-the growth rate rises when the initial level of real per capita GDP is low relative to the starting amount of human capital in the forms of educational attainment and health and for given values of other variables that reflect policies, institutions, and national characteristics. For given per capita GDP and human capital, growth depends positively on the rule of law and the investment ratio and negatively on the fertility rate, the ratio of government consumption to GDP, and the inflation rate. Growth increases with favorable movements in the terms of trade and with increased international openness, but the latter effect is surprisingly weak. © 2003 Peking University Press

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1. INTRODUCTION

Growth rates vary enormously across countries over long periods of time. Figure 1 illustrates these divergences in the form of a histogram for the growth rate of real per capita GDP for 113 countries with available data from 1965 to 1995.[1] The mean value for the growth rate is 1.5 percent per year, with a standard deviation of 2.1. The lowest decile comprises 11 countries with growth rates below -1.2 percent per year, and the highest decile consists of the 11 with growth rates above 4.0 percent per year. For quintiles, the poorest performing 23 places have growth rates below -0.1 percent per year, and the best performing 23 have growth rates above 2.8 percent per year.

[1]The GDP data are the purchasing-power adjusted values from version 6.0 of the Penn-World Tables, as described in Summers and Heston (1993).

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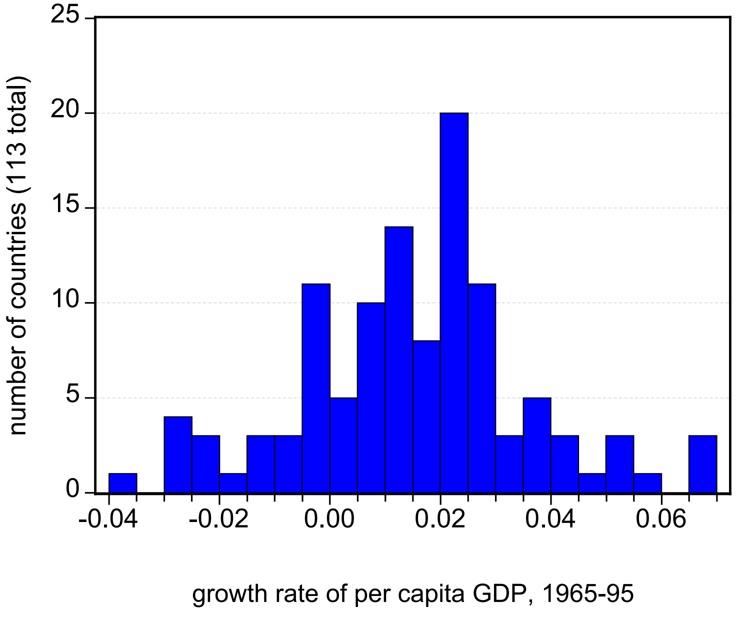

FIG. 1. Histogram for Growth Rate.
The figure shows the number of countries that lie in various ranges for the growth rate of real per capita GDP from 1965 to 1995. The data are from Penn-World Tables version 6.0, as described in Summers and Heston (1993). For the 113 countries, the mean growth rate is 0.015 per year and the standard deviation is 0.021. The highest growth rate is 0.069 and the lowest is −0.036.

The difference between per capita growth at -1.4 percent per year—the average for the lowest quintile—and growth at 4.3 percent per year—the average for the highest quintile—is that real per capita GDP falls by 34 percent over 30 years in the former case and rises by 260 percent in the latter. Even more extreme, the two slowest growing countries, the Democratic Republic of Congo (the former Zaire) and Mozambique, fell from levels of real per capita GDP in 1965 of $959 and $2251 (1995 U.S. dollars), respectively, to levels of $321 and $968 in 1995. Over the same period, the two fastest growing countries, South Korea and Singapore, rose from $1754 and $3506, respectively, to $13,773 and $27,020. Thus, although Mozambique was 28% richer per person than South Korea in 1965, in 1995, South Korea was richer by an amazing factor of 14. Over 30 years, the variations in growth rates that have been observed historically make dramatic differences in the average living standards of a country's residents.

2. SLOW-GROWTH AND HIGH-GROWTH ECONOMIES FROM 1965 TO 1995

Table 1 applies to low-growth countries, the 20 with the lowest per capita growth rates from 1965 to 1995. The countries are arranged in ascending order of growth rates, as shown in column 2. This group contains an astonishing 18 countries in sub-Saharan Africa and two in Latin America (Nicaragua and Bolivia). The table also shows per capita growth rates over the three ten-year sub-periods, 1965–75, 1975–85, and 1985–95. The fitted values shown for the various periods come from the regression systems discussed later.

TABLE 1.

Details of 20 Slowest Growing Economies

Country	Growth 65-95	Growth 65-75	Fitted	Growth 75-85	Fitted	Growth 85-95	Fitted	Growth 95-00
Congo, Dem. Repub.	−0.036	0.004	0.006	−0.039	−0.006	−0.074	−0.035	–
Mozambique	−0.028	−0.007	–	−0.071	–	−0.005	−0.011	0.067
Zambia	−0.027	0.002	0.004	−0.053	−0.007	−0.030	−0.003	−0.006
Angola	−0.025	−0.035	–	−0.008	–	−0.033	–	0.021
Niger	−0.024	−0.048	−0.012	−0.009	−0.005	−0.015	−0.006	0.004
Nicaragua	−0.022	0.007	−0.003	−0.026	−0.003	−0.048	−0.033	0.025
Cent. Afr. Repub.	−0.022	−0.013	–	−0.016	–	−0.037	–	0.004
Madagascar	−0.017	−0.003	–	−0.024	–	−0.022	–	0.005
Sierra Leone	−0.013	−0.001	−0.007	−0.014	−0.006	−0.024	−0.025	−0.083
Chad	−0.011	−0.008	–	0.003	–	−0.028	–	0.004
Togo	−0.010	−0.005	−0.018	0.022	0.005	−0.047	−0.003	0.007
Gambia	−0.008	0.002	–	−0.006	−0.029	−0.019	0.007	0.015
Senegal	−0.007	−0.011	−0.010	−0.001	−0.003	−0.010	0.004	0.030
Nigeria	−0.004	−0.005	–	−0.004	–	−0.005	–	−0.003
Mauritania	−0.004	0.028	–	−0.024	–	−0.017	–	0.013
Ethiopia	−0.003	0.004	–	−0.016	–	0.003	–	0.023
Guinea	−0.003	−0.013	–	−0.007	–	0.010	–	0.018
Ghana	−0.003	−0.005	0.017	−0.017	−0.001	0.012	0.006	0.018
Bolivia	−0.002	0.009	0.010	−0.019	−0.020	0.004	0.003	0.011
Tanzania	−0.001	0.026	–	0.000	–	−0.031	–	0.016

Table 2 provides a parallel treatment of high-growth economies, that is, the 20 with the highest per capita growth rates. These countries are arranged in descending order of growth rates, as shown in column 2. This group includes nine economies in East Asia (South Korea, Singapore, Tai-

TABLE 2.

Details of 20 Fastest Growing Economies

Country	Growth 65-95	Growth 65-75	Fitted	Growth 75-85	Fitted	Growth 85-95	Fitted	Growth 95-00
South Korea	0.069	0.070	0.047	0.060	0.044	0.076	0.051	0.038
Singapore	0.068	0.093	0.095	0.053	0.072	0.058	0.067	0.028
Taiwan	0.067	0.068	0.053	0.063	0.049	0.069	0.046	0.047
Botswana	0.055	0.081	–	0.048	0.026	0.037	0.006	0.043
Hong Kong	0.055	0.049	0.065	0.062	0.058	0.053	0.048	0.018
Thailand	0.053	0.043	0.039	0.041	0.038	0.076	0.051	−0.005
Indonesia	0.052	0.050	0.026	0.062	0.031	0.044	0.009	−0.007
Cyprus	0.046	0.015	0.034	0.073	0.029	0.051	0.010	0.029
China	0.043	0.017	–	0.054	0.051	0.058	0.038	0.070
Malaysia	0.043	0.033	0.027	0.044	0.046	0.050	0.041	0.022
Japan	0.041	0.065	0.055	0031	0.032	0.025	0.029	0.012
Portugal	0.039	0.057	0.057	0.018	0.029	0.041	0.020	0.036
Romania	0.037	0.076	–	0.042	–	−0.006	–	−0.015
Ireland	0.037	0.036	0.035	0.024	0.020	0.051	0.014	0.083
Mauritius	0.033	0.026	–	0.019	–	0.053	–	0.040
Norway	0.031	0.033	0.035	0.035	0.031	0.023	0.013	0.024
Spain	0.029	0.047	0.045	0.006	0.026	0.034	0.020	0.034
Brazil	0.029	0.061	0.033	0.016	0.009	0.010	−0.037	0.009
Italy	0.028	0.038	0.032	0.027	0.020	0.020	0.015	0.018
Paraguay	0.028	0.029	0.032	0.028	0.022	0.027	0.027	−0.022

Notes to Tables 1 and 2. The growth rates are for per capita GDP. Values up to 1995 are from Penn-World Tables version 6.0, as described in Summers and Heston (1993). Values for 1995-00 are from the World Bank, *World Development Indicators* (*WDI*) *2002*. The fitted values come from the regression system shown in column 2 of Table 3.

wan, Hong Kong, Thailand, Indonesia, China, Malaysia, and Japan), five in western Europe (Portugal, Ireland, Norway, Spain, and Italy), two in Latin America (Brazil and Paraguay), and two in sub-Saharan Africa (Botswana and Mauritius, which is actually an island off of Africa). In some cases, notably Japan and Brazil, the countries appear on the high-growth list mainly because of their strong performance in the first ten-year period, 1965-75.

The main regressions discussed below for per capita growth rates apply to the three ten-year periods 1965–75, 1975–85, and 1985-95. This econometric analysis can be viewed, in part, as a determination of which characteristics make it likely that a country will end up in the low-and high-growth lists shown in Tables 1 and 2. The fitted values indicated for the three ten-year periods (for countries that have the necessary data to be included in the statistical analysis) show how much of the growth rates can be explained by the regressions.

The correlations of growth rates across the 10-year periods are positive but not that strong–0.39 for growth between 1975-85 and that in 1965-75 and again 0.39 for the comparison between 1985-95 and 1975-85. Therefore, although there is persistence over time in which countries are slow or fast growers, there are also substantial changes over time in these groupings. If one examines 5-year intervals, then the correlations over time are somewhat weaker. For example, for the seven intervals from 1960-65 to 1995-00, the average correlation of one period's growth rate with the adjacent one is 0.24. The lower correlation applies because five-year growth rates tend to be sensitive to temporary factors associated with "business cycles." The last five-year period is particularly noteworthy in being virtually unrelated to the history–the correlation of growth rates in 1995-00 with those in 1990-95 is only 0.10.

3. AN EMPIRICAL ANALYSIS OF GROWTH RATES

This section considers the empirical determinants of growth; that is, the regression results that underlie the fitted values shown in Tables 1 and 2. The sample of 87 countries (constituting 240 observations for countries at 10-year intervals) covers a broad range of experience from developing to developed countries. The included countries were determined by the availability of data.

One hypothesis from the neoclassical growth model (Ramsey [1928], Solow [1956], Swan [1956], Koopmans [1965], and Cass [1965]) is absolute convergence: poorer economies typically grow faster per capita and tend thereby to catch up to the richer economies. For an exposition of the neoclassical model and the convergence result, see Barro and Sala-i-Martin (1995, Chs. 1 and 2). The convergence hypothesis implies that the growth rate of real per capita GDP from 1965 to 1995 would tend to be inversely related to the level of real per capita GDP in 1965. Figure 2 shows that this proposition fares badly in terms of the cross-country data. For the 113 countries with the necessary data, the per capita growth rate from 1965 to 1995 is basically unrelated to the log of per capita GDP in 1965. (The correlation is actually somewhat positive, 0.19.) Thus, any hope of reconciling the convergence hypothesis with the data has to rely on the concept of conditional convergence. The relation between the growth rate and the starting position has to be examined after holding constant some variables that distinguish the countries.

The present discussion uses an empirical framework that relates the real per capita growth rate to two kinds of variables. The first category comprises initial levels of state variables, such as the stock of physical capital

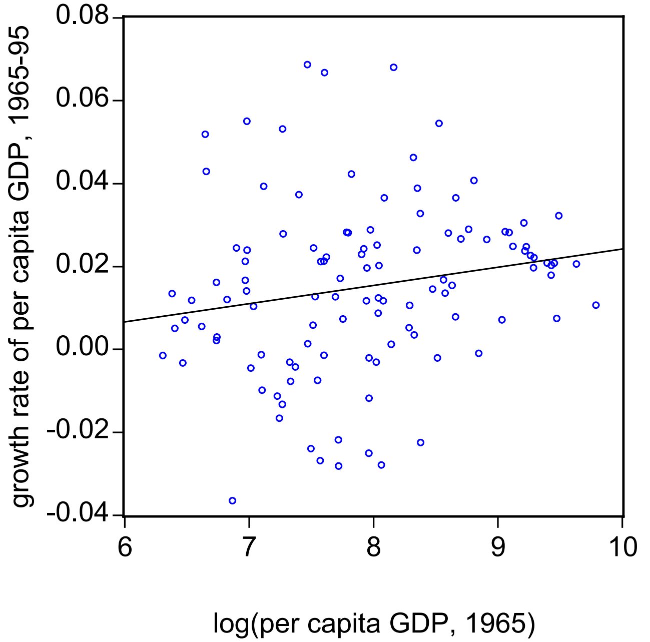

FIG. 2. Growth Rate versus Level of Per Capita GDP (simple relation). For 113 countries, the relation between the growth rate of per capita GDP from 1965 to 1995 and the log of per capita GDP in 1965 is close to zero. Hence, the cross-country data do not support the hypothesis of absolute convergence.

and the stock of human capital in the forms of educational attainment and health. The second group consists of policy variables and national characteristics, some of which are chosen by governments and some by private agents. These variables include the ratio of government consumption to GDP, the ratio of domestic investment to GDP, the extent of international openness, the fertility rate, indicators of macroeconomic stability, and measures of maintenance of the rule of law and democracy.

One of the state variables used in the empirical analysis is school attainment at various levels, as constructed by Barro and Lee (2001). Standard U.N. numbers on life expectancy at various ages are used to represent the level of health. Life expectancy at age one turns out to have the most explanatory power. The available data on physical capital seem unreliable, especially for developing countries and even relative to the measures of human capital, because they depend on arbitrary assumptions about depreciation and also rely on inaccurate measures of benchmark stocks and investment flows. As an alternative to using the limited data that are available on physical capital, the assumption is that, for given values of schooling and health, a higher level of initial real per capita GDP reflects a greater stock of physical capital per person (or a larger quantity of natural resources).

A country's per capita growth rate in period t, Dy_t, can be expressed as

$$Dy_t = F(y_{t-1}, h_{t-1}), \tag{1}$$

where y_{t-1} is initial per capita GDP and h_{t-1} is initial human capital per person (based on measures of educational attainment and health). The omitted variables, denoted by ..., comprise an array of control and environmental influences. These variables would include preferences for saving and fertility, government policies with respect to spending and market distortions, and so on.

3.1. Effects from State Variables

The neoclassical growth model predicts that, for given values of the environmental and control variables, an equiproportionate increase in y_{t-1} and h_{t-1} would reduce Dy_t in Eq. (1). That is, because of diminishing returns to reproducible factors, a richer economy—with higher levels of y and h—tends to grow at a slower rate. The environmental and control variables determine the steady-state level of output per "effective" worker in these models. A change in any of these variables, such as the saving rate or a government policy instrument or the growth rate of population, affects the growth rate for given values of the state variables. For example, a higher saving rate tends to increase Dy_t in Eq. (1) for given values of y_{t-1} and h_{t-1}.

Models that distinguish human from physical capital predict some influences on growth from imbalances between the two types of capital. In particular, for given y_{t-1}, a higher value of h_{t-1} in Eq. (1) tends to raise the growth rate. This situation applies, for example, in the aftermath of a war that destroys primarily physical capital. Thus, although the influence of y_{t-1} on Dy_t in Eq. (1) would be negative, the effect of h_{t-1} tends to be positive.

Empirically, the initial level of per capita GDP enters into the growth equation in the form $\log(y_{t-1})$ so that the coefficient on this variable represents the rate of convergence, that is, the responsiveness of the growth rate, Dy_t, to a proportional change in y_{t-1}.[2] In the regressions, the vari-

[2]This identification would be exact if the length of the observation interval for the data were negligible. Suppose that the data are observed at interval T, convergence occurs continuously at the rate β, and all right-hand side variables other than $\log(y)$ do not change over time. In this case, the analysis in Barro and Sala-i-Martin (1995, Ch. 2) implies that the coefficient on $\log(y_{t-T})$ in a regression for the average growth rate,

able h_{t-1} is represented by average years of school attainment and by life expectancy.

3.2. Policy Variables and National Characteristics

In the basic regression considered below, the policy variables and national characteristics are a measure of international openness,[3] the ratio of government consumption to GDP,[4] a subjective indicator of maintenance of the rule of law, a subjective indicator of democracy (electoral rights), the log of the total fertility rate, the ratio of real gross domestic investment to real GDP, and the inflation rate. The system also includes the contemporaneous growth rate of the terms of trade, interacted with the extent of international openness (the ratio of exports plus imports to GDP). The estimation takes account of the likely endogeneity of the explanatory variables by using lagged values as instruments. These lagged variables may provide satisfactory instruments because the error term in the equation for the per capita growth rate turns out to display little serial correlation.[5]

In the neoclassical growth model, the effects of the control and environmental variables on the growth rate correspond to their influences on the steady-state position. For example, an exogenously higher value of the rule-of-law indicator raises the steady-state level of output per effective worker. The growth rate, Dy_t, tends accordingly to increase for given values of the state variables. Similarly, a higher ratio of (non-productive) government consumption to GDP tends to depress the steady-state level of output per effective worker and thereby reduce the growth rate for given values of the state variables.

In the neoclassical model, a change in a control or environmental variable affects the steady-state level of output per effective worker but not the long-term per capita growth rate. The long-run or steady-state growth rate is given by the rate of exogenous technological progress. In contrast, in endogenous-growth models, such as Romer (1990) and Barro and Sala-i-Martin (1995, Chs. 6 and 7), variables that affect R&D intensity also influence long-term growth rates. However, even in the neoclassical model, if the adjustment to the new steady-state position takes a long time—as seems to be true empirically—then the growth effect of a variable such as

$(1/T) \cdot \log(y_t/y_{t-T})$, is $-(1-e^{-\beta T})/T$. This expression tends to β as T tends to 0 and tends to 0 as T approaches infinity.

[3]This variable is the ratio of exports plus imports to GDP, filtered for the usual relation of this ratio to country size as represented by the logs of population and area.

[4]The variable used in the main analysis nets out from the standard measure of government consumption the outlays on defense and education.

[5]Instead of including lagged inflation, the system includes dummy variables for whether the country is a former colony of Spain or Portugal or a former colony of another country other than Britain or France. These colonial dummies turn out to have substantial explanatory power for inflation.

the rule-of-law indicator or the government consumption ratio lasts for a long time.

The measures of educational attainment used in the main analysis are based on years of schooling and do not adjust for variations in school quality. A measure of quality, based on internationally comparable test scores, turns out to have much more explanatory power for growth. However, this test-score measure is unavailable for much of the sample and is, therefore, excluded from the basic system.

Health capital is proxied in the basic system by the reciprocal of life expectancy at age one. If the probability of dying were independent of age, then this reciprocal would give the probability per year of dying. A later section considers measures of infant mortality (up to age one), child mortality (for ages 1-5), and incidence of a specific disease, malaria.

The assumption is that the government consumption variable measures expenditures that do not directly affect productivity but that entail distortions of private decisions. These distortions can reflect the governmental activities themselves and also involve the adverse effects from the associated public finance.[6] A higher value of the government consumption ratio leads to a lower steady-state level of output per effective worker and, hence, to a lower growth rate for given values of the state variables.

The fertility rate is an important influence on population growth, which has a negative effect on the steady-state ratio of capital to effective worker in the neoclassical growth model. Hence, the prediction is for a negative effect of the fertility rate on economic growth. Higher fertility also reflects greater resources devoted to child-rearing, as in models of endogenous fertility (see Barro and Sala-i-Martin [1995, Ch. 9]). This channel provides another reason why higher fertility would be expected to reduce growth.

The effect of the saving rate in the neoclassical growth model is measured empirically by the ratio of real investment to real GDP. Recall that the estimation attempts to isolate the effect of the saving rate on growth, rather than the reverse, by using lagged values–in this case, the lagged investment ratio–as instruments.

The assumption is that an improvement in the rule of law, as gauged by the subjective indicator provided by an international consulting firm (Political Risk Services), implies enhanced property rights and, therefore, an incentive for higher investment and growth. The analysis also includes another subjective indicator (from Freedom House) of the extent of democracy in the sense of electoral rights. Theoretically, the effect of democracy on growth is ambiguous. Negative effects arise in political models that stress the incentive of electoral majorities to use their political power to transfer

[6]Ideally, the tax effects would be held fixed separately. However, the available data on public finance are inadequate for this purpose. See Easterly and Rebelo (1993) for attempts to measure the relevant marginal tax rates.

resources away from rich minority groups. On the other side, democracy may be productive as a mechanism for government to commit itself not to confiscate the capital accumulated by the private sector. The empirical analysis includes a linear and squared term in democracy and thereby allows for the possibility that the sign of the net effect would depend on the extent of democracy.

The explanatory variables also include a measure of the extent of international openness–the ratio of exports plus imports to GDP. Openness is well know to vary by country size–larger countries tend to be less open because internal trade offers a large market that can substitute effectively for international trade. The explanatory variable used in the analysis of growth filters out the normal relationship (estimated in another regression system) of international openness to the logs of population and area. This filtered variable reflects especially the influences of government policies, such as tariffs and trade restrictions, on international trade.

The empirical framework also includes the growth rate over each decade of the terms of trade, measured by the ratio of export prices to import prices. This ratio appears as a product with the extent of openness, measured by exports plus imports over GDP. This terms-of-trade variable measures the effect of changes in international prices on the income position of domestic residents. This real income position would rise because of higher export prices and fall with higher import prices. The analysis views the terms of trade as determined on world markets and, hence, exogenously to the behavior of an individual country. Since an improvement in the terms of trade raises a country's real income, the expectation is that domestic consumption would rise. An effect on production, GDP, depends, however, on a response of allocations or effort to the shift in relative prices. If an increase in the relative price of the goods that a country produces tends to generate more output, that is, a positive response of supply, then the effect of the terms-of-trade variable on the growth rate would be positive. One effect of this type is that an increase in the relative price of oil—an import for most countries—would reduce the production of goods that use oil as an input.

Finally, the basic system includes the average inflation rate as a measure of macroeconomic stability. Alternative measures can also be considered, including fiscal variables.

4. REGRESSION RESULTS FOR GROWTH RATES

4.1. A Basic Regression

Table 3 contains regression results for the growth rate of real per capita GDP. For the basic system shown in column 2, 71 economies are included for 1965–75, 86 for 1975-85, and 83 for 1985–95.

TABLE 3.

Basic Cross-Country Growth Regressions

(1) explanatory variable	(2) coefficient	(3) coefficient for low-income smpl	(4) coefficient for high-income smpl	(5) p-value*	(6) coefficient with data at 5-yr intervals
log(per capita GDP)	-0.0234 (0.0028)	-0.0211 (0.0053)	-0.0290 (0.0048)	0.27	-0.0239 (0.0028)
male upper-level schooling	0.0034 (0.0016)	0.0040 (0.0041)	0.0015 (0.0015)	0.57	0.0023 (0.0015)
1/(life expectancy at age 1)	-5.30 (0.81)	-6.21 (1.09)	-0.14 (1.46)	0.001	-5.68 (0.83)
log(total fertility rate)	-0.0132 (0.0047)	-0.0265 (0.0125)	-0.0213 (0.0050)	0.70	-0.0187 (0.0047)
govt. consumption ratio	-0.068 (0.028)	-0.119 (0.038)	-0.095 (0.037)	0.65	-0.048 (0.026)
rule of law	0.0196 (0.0058)	0.0308 (0.0090)	0.0182 (0.0060)	0.24	0.0139 (0.0057)
democracy	0.096 (0.029)	0.069 (0.051)	0.062 (0.036)	0.92**	0.029 (0.017)
democracy squared	-0.086 (0.024)	-0.080 (0.052)	-0.042 (0.030)	0.53	-0.028 (0.016)
openness ratio	0.0080 (0.0046)	0.0240 (0.0111)	0.0068 (0.0044)	0.15	0.0086 (0.0043)
change in terms of trade	0.304 (0.053)	0.375 (0.075)	0.202 (0.063)	0.074	0.125 (0.021)
investment ratio	0.053 (0.024)	0.052 (0.040)	0.063 (0.023)	0.81	0.055 (0.022)
inflation rate	-0.022 (0.010)	-0.011 (0.013)	-0.021 (0.008)	0.55	-0.029 (0.008)
constant	0.291 (0.032)	0.326 (0.051)	0.276 (0.049)	0.47***	0.329 (0.032)

TABLE 3—*Continued*

(1) explanatory variable	(2) coefficient	(3) coefficient for low-income smpl	(4) coefficient for high-income smpl	(5) p-value*	(6) coefficient with data at 5-yr intervals
dummy, 1975-85	-0.0073 (0.0027)	-0.0083 (0.0041)	-0.0054 (0.0032)	0.58	****
dummy, 1985-95	-0.0121 (0.0034)	-0.0199 (0.0053)	-0.0035 (0.0040)	0.014	
number of observations	71, 86, 83	29, 38, 35	42, 48, 48		70, 78, 86, 84 79, 80, 61
R-squared	.64, .52, .51	.81, .61, .54	.66, .46, .44		.56, .32, .24, .45, .47, .29, -.24

Notes to Table 3. Estimation is by three-stage least squares. In column 2, the dependent variables are the growth rates of per capita GDP for 1965-75, 1975-85, and 1985-95. Instruments are the values in 1960, 1970, and 1980 of the log of per capita GDP, the life-expectancy variable, and the fertility variable; averages for 1960-64, 1970-74, and 1980-84 of the government consumption variable, the openness ratio, and the investment ratio; values in 1965, 1975, and 1985 of the schooling variable and the democracy variables; the terms-of-trade variable (growth rates over 1965-75, 1975-85, and 1985-95, interacted with the corresponding averages of the ratio of exports plus imports to GDP); and dummies for Spanish or Portuguese colonies and other colonies (aside from Britain and France). The variances of the error terms are allowed to be correlated over the time periods and to have different variances for each period. Columns 3 and 4 separate the samples into countries with levels of per capita GDP below and above the median (for 1960, 1970, and 1980). Column 6 uses equations for economic growth for seven five-year periods, 1965-70, ..., 1995-00.

*The p-values refer to the hypothesis that the coefficients are the same for the two income groups.

**The p-value for democracy and democracy-squared jointly is 0.045.

***The p-value for the constant and two time dummies jointly is 0.070.

****The time dummies at the 5-year intervals are -0.0022 (0.0036) for 1970-75, -0.0011 (0.0038) for 1975-80, -0.0236 (0.0038) for 1980-85, -0.0145 (0.0037) for 1985-90, -0.0189 (0.0042) for 1990-95, and -0.0174 (0.0042) for 1995-00.

The estimation uses instrumental variables, as already discussed, and allows the errors terms to be correlated across the time periods and to have different variances for each period. The error terms are assumed to be independent across countries, and the error variances are not allowed to vary across countries. The system includes separate dummies for the different time periods. Hence, the analysis does not explain why the world's average growth rate changes over time. The following discussion of results refers to the system shown in column 2 of Table 3.

4.1.1. Initial per capita GDP

The variable log(GDP) is an observation of the log of real per capita GDP for 1965 in the 1965–75 regression, for 1975 in the 1975–85 regression, and for 1985 in the 1985-95 equation. Earlier values—for 1960, 1970, and 1980, respectively—are included in the list of instruments. This instrumental procedure lessens the tendency to overestimate the convergence rate because of temporary measurement error in GDP. (For example, if log[GDP] in 1965 were low due to temporary measurement error, then the growth rate from 1965 to 1975 would tend to be high because the observation for 1975 would tend not to include the same measurement error.)

The estimated coefficient on log(GDP), −0.023 (s.e.= 0.003), shows the conditional convergence that has been reported in various studies, such as Barro (1991) and Mankiw, Romer, and Weil (1992). The convergence is conditional in that it predicts higher growth in response to lower starting GDP per person only if the other explanatory variables (some of which are highly correlated with GDP per person) are held constant. The magnitude of the estimated coefficient implies that convergence occurs at the rate of about 2.3 percent per year.[7] According to this coefficient, a one-standard-deviation decline in the log of per capita GDP (0.98 in 1985) would raise the growth rate on impact by 0.023. This effect is very large in comparison with the other effects described below–that is, conditional convergence can have important influences on growth rates.

Figure 3 provides a graphical description of the partial relation between the growth rate and the level of per capita GDP. The horizontal axis shows the values of the log of per capita GDP at the start of each of the three ten-year periods: 1965, 1975, and 1985. The vertical axis refers to the subsequent ten-year growth rates of per capita GDP–for 1965-75, 1975-85 and 1985-95. These growth rates have been filtered for the estimated effects of the explanatory variables other than the log of per capita GDP that are

[7] This result is correct only if the other right-hand side variables do not change as per capita GDP varies.

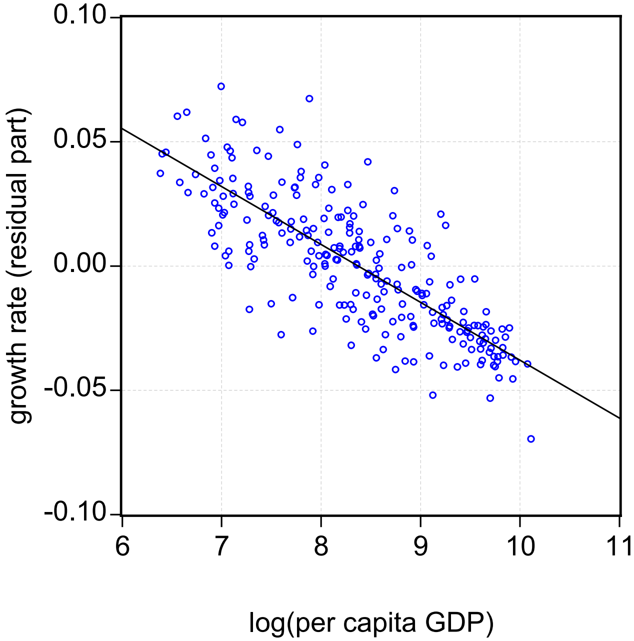

FIG. 3. Growth Rate versus Level of Per Capita GDP (partial relation). The log of per capita GDP for 1965, 1975, and 1985 is shown on the horizontal axis. The vertical axis plots the corresponding growth rate of real per capita GDP from 1965 to 1975, 1975 to 1985, and 1985 to 1995. These growth rates are filtered for the estimated effect of the explanatory variables other than the log of per capita GDP that are shown in column 2 of Table 3. The filtered values were then normalized to have zero mean. Thus, the diagram shows the partial relation between the growth rate of per capita GDP and the log of per capita GDP.

included in the system of column 2, Table 3. (The average value has also been normalized to have zero mean.) Thus, conceptually, the figure shows the estimated effect of the log of per capita GDP on subsequent growth when all of the other explanatory variables are held constant. The figure suggests that the estimated relationship is not driven by obvious outlier observations and does not have any clear departures from linearity. An analogous construction is used below for each of the other explanatory variables.

4.1.2. *Educational attainment*

The school-attainment variable that tends to be significantly related to subsequent growth is the average years of male secondary and higher schooling (referred to as upper-level schooling), observed at the start of each period, 1965, 1975, and 1985. Since these variables are predetermined, they enter as their own instruments in the regressions. Attainment of females and for both sexes at the primary level turn out not to be significantly related to growth rates, as discussed later. The estimated coefficient, 0.0034 (0.0016), means that a one-standard-deviation increase in male upper-level schooling (by 1.3 years in 1985) raises the growth rate on impact by 0.005. Figure 4 depicts the partial relationship between economic growth and the school-attainment variable.

4.1.3. *Life expectancy*

The life-expectancy variable applies to 1960, 1970, and 1980, respectively, for the three growth equations. In 1980, the mean of life expectancy at birth is 63.4, that for life expectancy at age one is 67.0, and that at age five is 69.2 (for a somewhat reduced sample). The regression systems include reciprocals of life expectancy. These values would correspond to the mortality rate per year if mortality were (counterfactually) independent of age. In 1980, the means of these reciprocals were 0.0163 for life expectancy at birth, 0.0152 for life expectancy at age one, and 0.0146 for life expectancy at age five. The basic system includes the reciprocal of life expectancy at age one–this measure has slightly more explanatory power than the others. (The reciprocals of life expectancy at age one also appear in the instrument lists.) The estimated coefficient of -5.3 (s.e.=0.8) is highly significant and indicates that better health predicts higher economic growth. A one-standard error reduction in the reciprocal of life expectancy at age one (0.0022 in 1980) is estimated to raise the growth rate on impact by 0.011. Figure 5 shows graphically the partial relation between growth and this health indicator.

4.1.4. *Fertility rate*

The fertility rate (total lifetime live births for the typical woman over her expected lifetime) enters as a log at the dates 1960, 1970, and 1980. These variables also appear in the instrument lists. The estimated coefficient is negative and significant: -0.013 (s.e.=0.005). A one-standard-deviation decline in the log of the fertility rate (by 0.54 in 1980) is estimated to raise

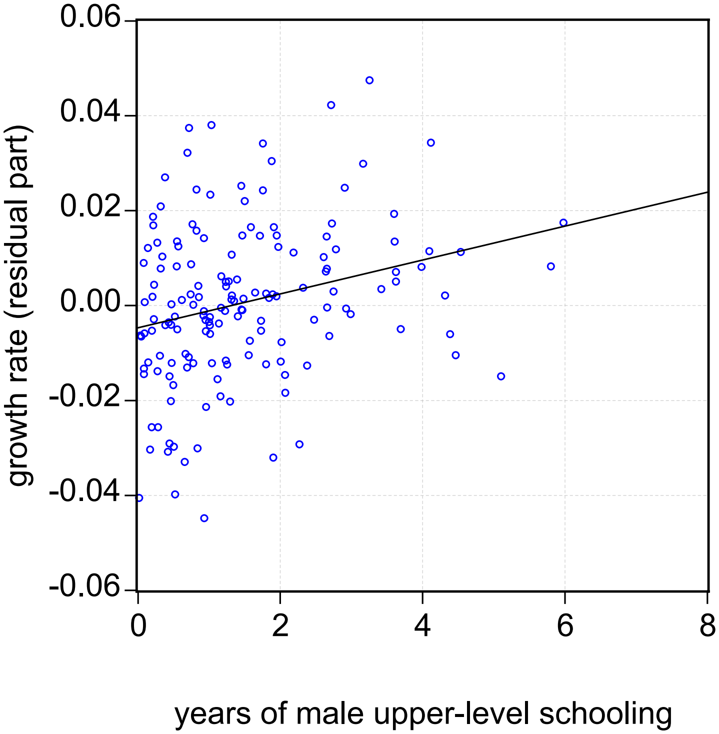

FIG. 4. Growth Rate versus Schooling (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the average years of school attainment of males at the upper level (higher schooling plus secondary schooling). The variable on the horizontal axis is measured in 1965, 1975, and 1985. See the description of Figure 3 for the general procedure.

the growth rate on impact by 0.007. The partial relation appears in Figure 6.

4.1.5. Government consumption ratio

The ratio of real government consumption to real GDP[8] was adjusted by subtracting the estimated ratio to real GDP of real spending on defense and non-capital real expenditures on education. The elimination of expenditures for defense and education—categories of spending that are

[8]These data are from Penn-World Tables version 6.0, as described in Summers and Heston (1993).

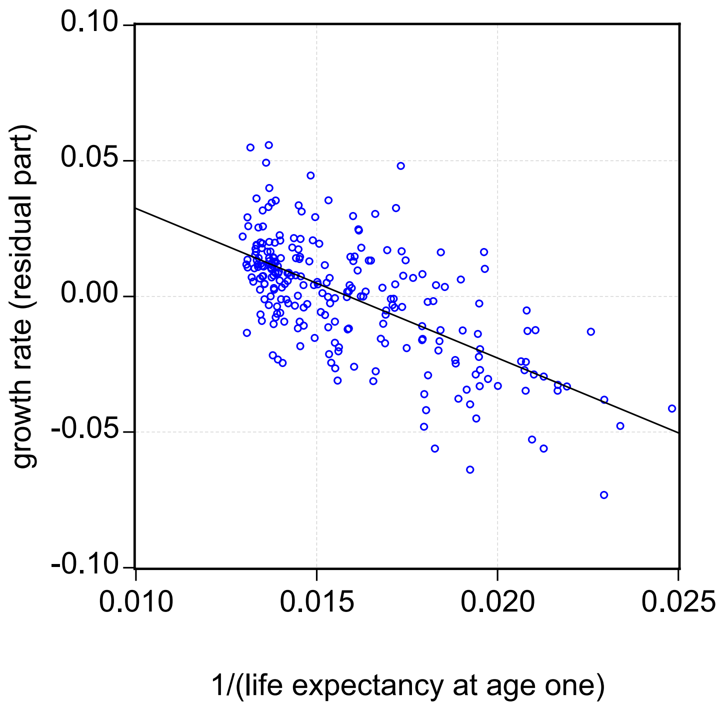

FIG. 5. Growth Rate versus Life Expectancy (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the reciprocal of life expectancy at age one. The variable on the horizontal axis is measured in 1960, 1970, and 1980. See the description of Figure 3 for the general procedure.

included in standard measures of government consumption—was made because these items are not properly viewed as consumption. In particular, they are likely to have direct effects on productivity or the security of property rights. The growth equation for 1965-75 includes as a regressor the average of the adjusted government consumption ratio for 1965-74 and includes the adjusted ratio for 1960-64 in the list of instruments. The analogous timing applies to the growth equations for the other two ten-year periods.

The estimated coefficient of the government consumption ratio is negative and significant: -0.068 (0.028). This estimate implies that a reduction in the ratio by 0.047 (its standard deviation in 1985-94) would raise the growth rate on impact by 0.003. The partial relation is shown in Figure 7.

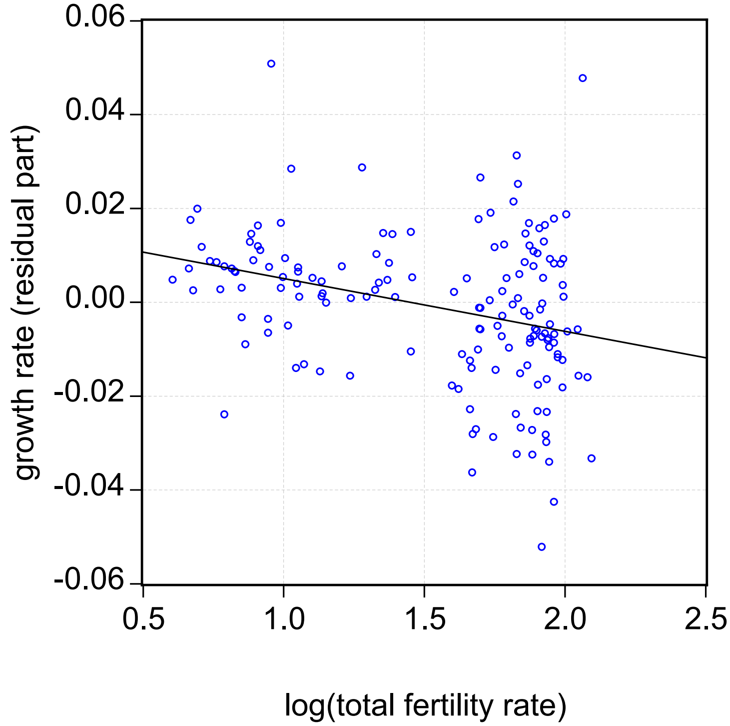

FIG. 6. Growth Rate versus Fertility Rate (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the log of the total fertility rate. The variable on the horizontal axis is measured in 1960, 1970, and 1980. See the description of Figure 3 for the general procedure.

4.1.6. Rule of law

This variable comes from a subjective measure provided in *International Country Risk Guide* by the international consulting company Political Risk Services. This variable was first proposed for growth analysis by Knack and Keefer (1995). The underlying data are tabulated in seven categories, which have been adjusted here to a zero-to-one scale, with one representing the most favorable environment for maintenance of the rule of law. These data start only in 1982. The estimation shown in Table 3 uses the earliest value available (usually for 1982 but sometimes for 1985) in the growth equations for 1965-75 and 1975-85. (This procedure may be satisfactory because the rule-of-law variable exhibits substantial persistence over time.)

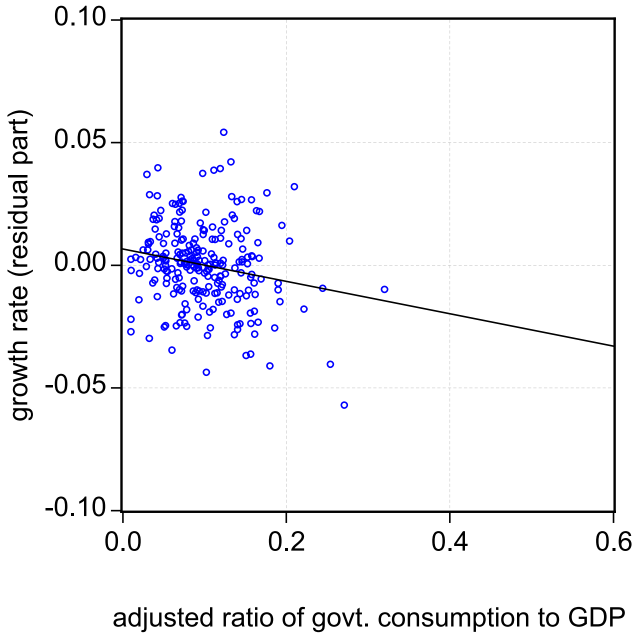

FIG. 7. Growth Rate versus Government Consumption (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the ratio of government consumption to GDP. The ratio involves the standard measure of government consumption less the estimated real outlays on defense and education. The variable on the horizontal axis is the average for 1965-74, 1975-84, and 1985-94. See the description of Figure 3 for the general procedure.

The third equation uses the average of the rule of law for 1985-94 as a regressor and enters the value for 1985 in the instrument list. The estimated coefficient is positive and significant: 0.020 (0.006). This estimate means that an increase in the rule of law by one standard deviation (0.26 for 1985-94) would raise the growth rate on impact by 0.005. The partial relation with growth is shown in Figure 8. (Note that many of the rule-of-law observations apply to one of seven categories. The averaging for 1985-94 generates the intermediate values.)

4.1.7. Democracy

This variable comes from a subjective measure provided by Freedom House. The variable used refers to electoral rights–an alternative measure

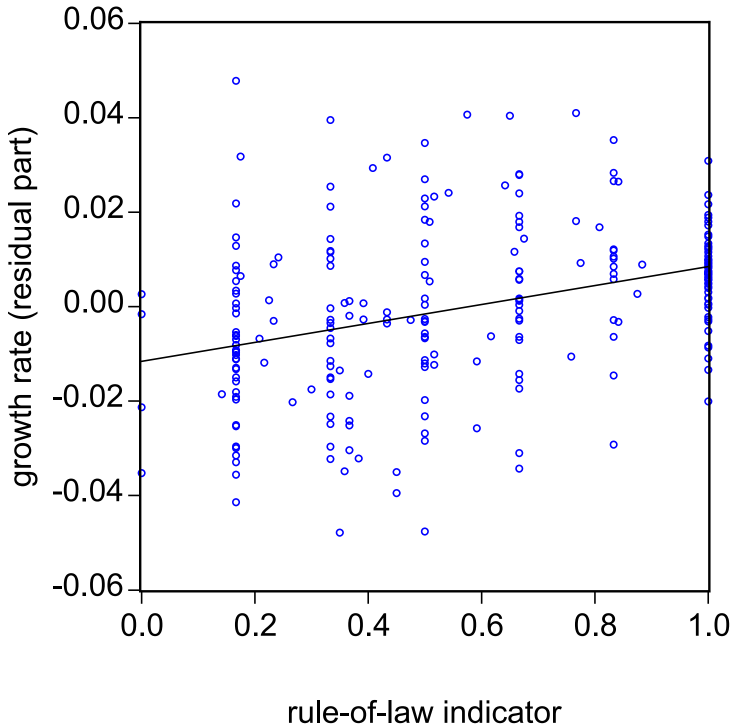

FIG. 8. Growth Rate versus Rule of Law (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the Political Risk Services indicator for maintenance of the rule of law. The variable on the horizontal axis associated with growth in 1965-75 and 1975-85 applies to 1982 or 1985. The value associated with growth in 1985-95 is the average for 1985-94. See the description of Figure 3 for the general procedure.

that applies to civil liberties is considered later. The underlying data are tabulated in seven categories, which have been adjusted here to a zero-to-one scale, with one indicating a full representative democracy and zero a complete totalitarian system. These data begin in 1972 but information from another source (Bollen [1990]) was used to generate data for 1960 and 1965. The systems include also the square of democracy to allow for a non-linear effect on economic growth. The first growth equation includes as regressors the average of democracy and the average of its square over the period 1965-74. The instrument list includes the level and squared value in 1965 (or sometimes 1960). The other two growth equations use as regressors the average values for 1975-84 and 1985-94, respectively, and include the values at the start of each period in the instrument lists.

The results indicate that the linear and squared term in democracy are each statistically significant: 0.096 (0.029) and -0.086 (0.024), respectively. The p-value for joint significance is 0.045. These estimates imply that, starting from a fully totalitarian system (where the democracy variable takes on the value zero), increases in democracy tend to stimulate growth. However, the positive influence attenuates as democracy rises and reaches zero when the indicator takes on a mid-range value of 0.56. (Note that the mean of the democracy variable for 1985-94 is 0.65.) Therefore, democratization appears to enhance growth for countries that are not very democratic but to retard growth for countries that have already achieved a substantial amount of democracy. This non-linear relation is shown by the diagram in Figure 9. The solid line shows the fitted values implied by the linear and squared terms in democracy.

4.1.8. International openness

The degree of international openness is measured by the ratio of exports plus imports to GDP. This measure is highly sensitive to country size, as large countries tend to rely relatively more on domestic trade. To take account of this relation, the ratio of exports plus imports to GDP was filtered for its relation in a regression context to the logs of population and area. A later section considers whether country size has itself a relation to economic growth.

The openness variable enters into each growth equation as an average for the corresponding ten-year period (1965-74 and so on). In the basic system, these variables also appear in the respective instrument lists. This specification is appropriate if the trade ratio is (largely) exogenous to economic growth. The estimated coefficient on the openness variable is positive but only marginally significant, 0.0080 (0.0046). Hence, there is only weak statistical evidence that greater international openness stimulates economic growth. The point estimate implies that a one-standard-deviation increase in the openness ratio (0.40 in 1985-94) would raise the growth rate on impact by 0.003. The partial relation between growth and the openness variable is shown graphically in Figure 10.

If the instrument list excludes the contemporaneous openness ratio and includes instead only lagged values (for 1960-64, 1970-74, and 1980-84, respectively), then the estimated coefficient on the openness variable becomes virtually zero. Therefore, it is possible that the weak positive effect found

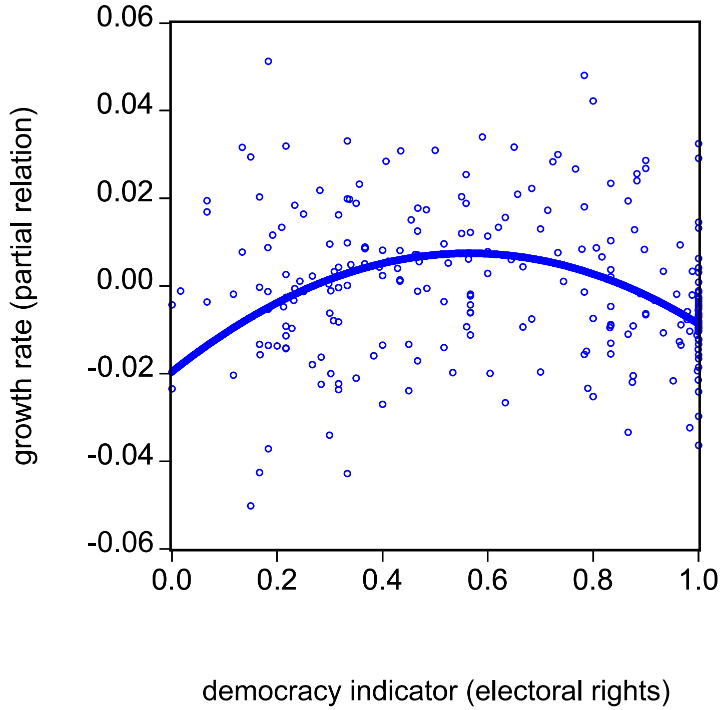

FIG. 9. Growth Rate versus Democracy (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the Freedom House indicator of democracy (electoral rights). The variable on the horizontal axis is the average for 1965-74, 1975-84, and 1985-94. The solid curve is the fitted relation implied by the estimated coefficients on the linear and squared terms for democracy. See the description of Figure 3 for the general procedure.

for the openness variable in column 2 of Table 3 reflects reverse causation from growth to the trade ratio, rather than the reverse.

4.1.9. The terms of trade

This variable is measured by the growth rate of the terms of trade (export prices relative to import prices) over each ten-year period (1965-75 and so on), multiplied by the average ratio of exports plus imports to GDP for the period (1965-74 and so on). These variables also appear in the instrument lists. The idea here is that movements in the terms of trade depend primarily on world conditions and would, therefore, be largely exogenous with

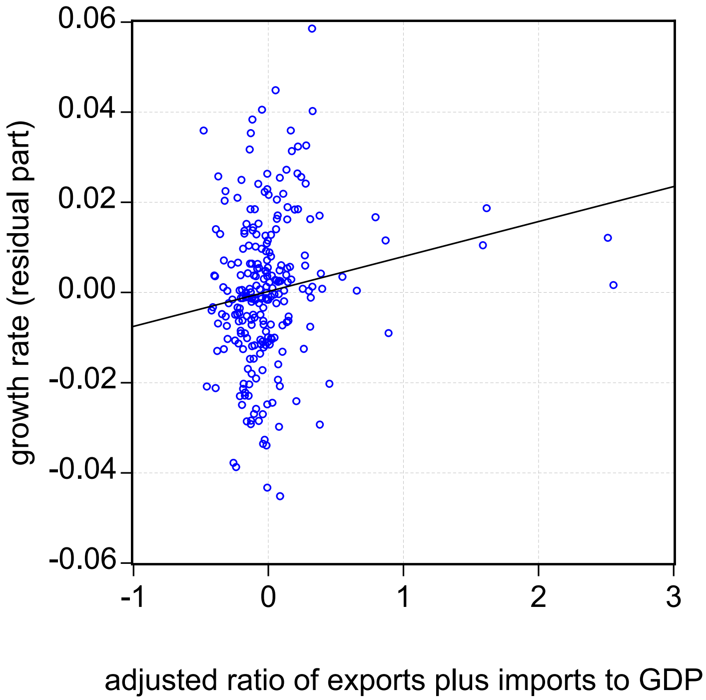

FIG. 10. Growth Rate versus Openness (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the openness ratio. This variable is the ratio of exports plus imports to GDP, filtered for the usual relation of this ratio to the logs of population and area. The variable on the horizontal axis is the average for 1965-74, 1975-84, and 1985-94. See the description of Figure 3 for the general procedure.

respect to contemporaneous economic growth for an individual country.[9] The estimated coefficient is positive and highly significant: 0.30 (0.05). Hence, changes in the terms of trade do matter for growth over ten-year periods. The results imply that a one-standard-deviation increase in the variable (by 0.017 in 1985-95) would raise the growth rate on impact by 0.005. Figure 11 shows the partial relation between growth and the terms-of-trade variable.

[9]The results are virtually the same if the instrument list includes the growth rate of the terms of trade interacted with the lagged ratio of exports plus imports to GDP, rather than the contemporaneous ratio.

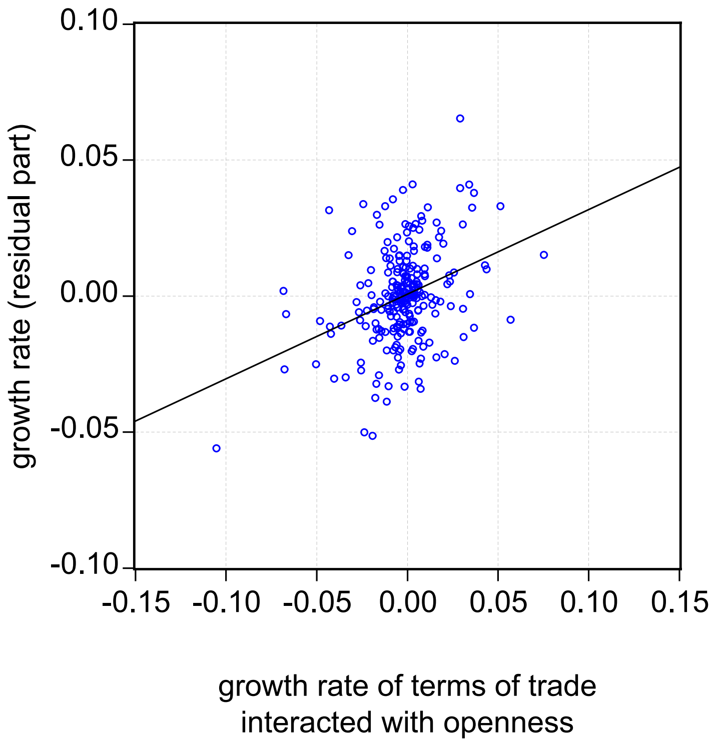

FIG. 11. Growth Rate versus Terms of Trade (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the terms-of-trade variable. This variable is the growth rate of the terms of trade (export prices relative to import prices) multiplied by the average ratio of exports plus imports to GDP. The growth rate of the terms of trade is for 1965-75, 1975-85, and 1985-95. The ratios of exports plus imports to GDP are averages for 1965-74, 1975-84, and 1985-94. See the description of Figure 3 for the general procedure.

4.1.10. Investment ratio

The ratio of real gross domestic investment (private plus public) to real GDP enters into the regressions as averages for each of the ten-year periods (1965-74 and so on).[10] The corresponding instrument is the average value of the ratio over the preceding five years (1960–64, 1970–74, and 1980-84). The estimated coefficient is positive and statistically significant, 0.053

[10]The data are from Penn-World Tables version 6.0, as described in Summers and Heston (1993).

(0.023). This point estimate implies that a one-standard-deviation increase in the investment ratio (by 0.078 in 1985-94) would raise the growth rate on impact by 0.004. The partial relation with growth is depicted graphically in Figure 12.

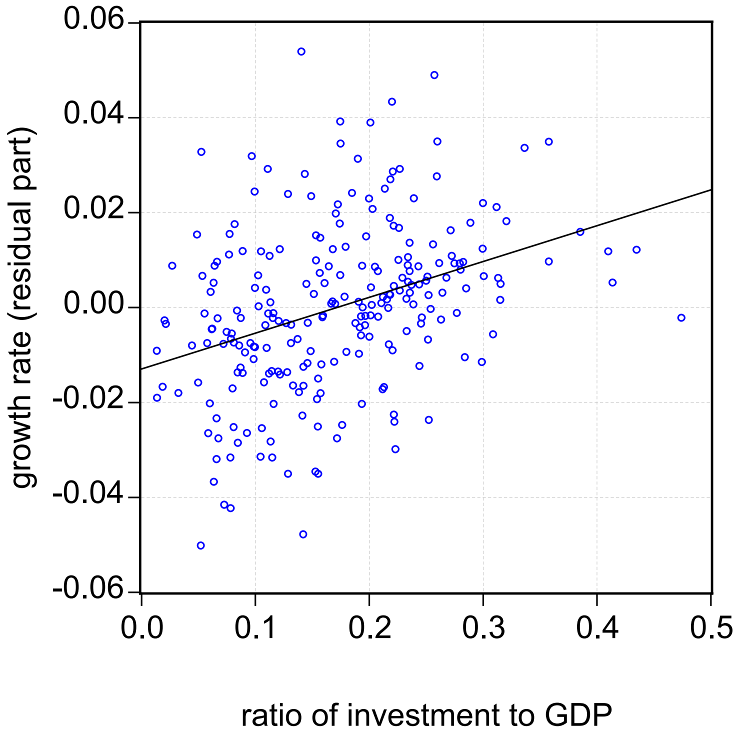

FIG. 12. Growth Rate versus Investment (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the ratio of investment to GDP. The variable on the horizontal axis is the average for 1965-74, 1975-84, and 1985-94. See the description of Figure 3 for the general procedure.

The investment variable provides another example in which the use of lagged, rather than contemporaneous, variables as instruments makes a substantial difference in the results. If the contemporaneous ten-year averages appear, instead of the lagged values, in the instrument lists, then the estimated coefficient on the investment ratio becomes 0.092 (0.020), almost twice as large as the value shown in column 2 of Table 3. A reasonable interpretation is that the larger coefficient reflects partly the positive effect of growth on the investment ratio, rather than the reverse. This difference in specification seems to explain why some researchers find larger effects of investment on growth than the one reported in Table 3–see, for example, Mankiw, Romer, and Weil (1992) and DeLong and Summers (1993).

4.1.11. Inflation rate

The inflation variable is the average rate of retail price inflation over each of the ten-year periods (1965-75 and so on). A cross-country analysis of inflation suggested as instruments dummies for prior colonial status. In particular, former colonies of Spain and Portugal and of other countries aside from Britain and France had substantial explanatory power for inflation. The results shown in column 2 of Table 3 apply when the instrument lists include these two colony dummies–former colony of Spain or Portugal and former colony of another country aside from Britain and France–but neither contemporaneous nor lagged inflation. The estimated coefficient, -0.022 (0.010), is negative and statistically significant. This coefficient implies that a one-standard-deviation increase in the inflation rate (0.33 in 1985-95) lowers the growth rate on impact by 0.007. However, the coefficient also implies that the moderate variations of inflation experienced by most countries–say changes on the order of 0.05 per year–affect growth rates by less than 0.001. Figure 13 shows graphically the partial relation between growth and inflation. This diagram makes clear that the main force driving the estimated relationship is the behavior at high rates of inflation–notably at rates above 20-30 percent per year.

The estimated coefficient of the inflation rate is similar, -0.021 (0.005), if contemporaneous inflation appears instead of the colony dummies in the instrument lists. However, the estimated coefficient is close to zero, 0.003 (0.009), if the instrument lists contain lagged inflation (for 1960-65, 1970-75, and 1980-85), rather that contemporaneous inflation. This result is surprising because lagged inflation does have substantial explanatory power for inflation.

4.1.12. Constant terms

The regressions include an overall constant term and a separate time dummy for the two later periods, 1975-85 and 1985-95. These two time dummies are significantly negative: -0.0073 (0.0027) and -0.0121 (0.0034),

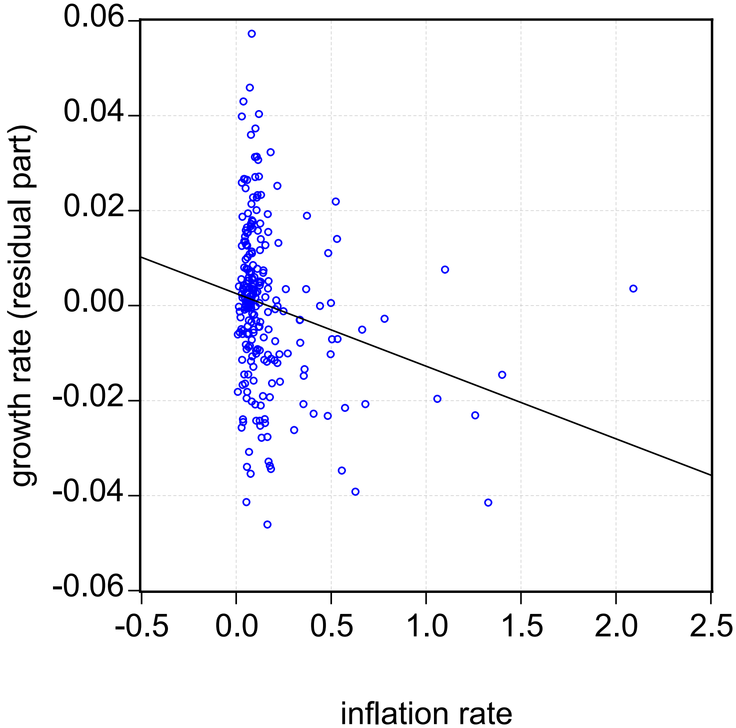

FIG. 13. Growth Rate versus Inflation (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the average rate of retail price inflation. The variable on the horizontal axis is for 1965-75, 1975-85, and 1985-95. See the description of Figure 3 for the general procedure.

respectively. Hence, the world's rate of economic growth seems to have declined from 1965 to 1995.[11]

4.2. Tests of Stability of Coefficients

Columns 3 and 4 of Table 3 shows results when countries with per capita GDP below the median for each period are separated from those above the median. The division was based on values of per capita GDP in 1960, 1970, and 1980, respectively. Since the median was calculated for all countries

[11] The mean growth rate for each decade also depends on the mean values of the regressors. For the 69 countries included in the regressions for all three ten-year periods, the average growth rates were 0.0251 for 1965-75, 0.0159 for 1975-85, and 0.0138 for 1985-95.

with GDP data, it turns out that more than half of the countries in the regression sample are in the portion with per capita GDP above the median. (Higher income countries are more likely to have data on the other variables needed for inclusion in the regression sample.)

A joint test for equality of all coefficients across the two income groups is rejected with a very low p-value. However, when considering variables individually, the results show considerable stability across the low and high income groups. In particular, for the p-values shown in column 5 of Table 3, the only values that are less than 0.05 are for the life-expectancy variable and the dummy for the 1985-95 period. Notably, the low-income countries exhibit substantial sensitivity of growth to life expectancy, whereas the high-income countries reveal an insignificant relation with life expectancy. Also, the decline in the growth rate from 1965-75 to 1985-95 applies mainly to the low-income group. There is also an indication at the 10 percent critical level that poor countries are more sensitive to changes in the terms of trade. Despite these exceptions, the most striking finding about the results in columns 3-5 of the table is the extent to which similar coefficients are found for poor and rich countries.

Column 6 of Table 3 shows the coefficient estimates when the data are employed at five-year intervals, instead of the ten-year periods used before. In the five-year case, there are seven equations, where the dependent variables are the rates of growth of per capita GDP from 1965-70 to 1995-00. In most cases, the coefficients shown for the five-year specification in column 6 are similar to those from the ten-year estimation, which are in column 2. The main exceptions are for the terms-of-trade variable (which has a smaller coefficient in the five-year sample) and the democracy variable (for which the magnitudes of the two coefficients are smaller in the five-year case). The fits of the equations in the five-year setting, as gauged by R-squared values, tend to be worse than those for the ten-year setting. This pattern suggests that growth outcomes over intervals as short as five years are influenced considerably by short-term and temporary forces ("business cycles"), which are not considered in the usual theories of long-term economic growth. One notable finding is the poor fit for the final five-year period, 1995-00. In this case, the R-squared value is actually negative. (This outcome is possible because the coefficients are constrained to be the same for the various periods.) One reason for this result is that several previous growth champions in East Asia did poorly in 1995-00 because of the Asian financial crisis.

TABLE 4.

Stability of Coefficients Over Time in Cross-Country Growth Regressions

(1)	(2)	(3)	(4)	(5)
explanatory variable	**coefficients by time period**			
	1965-75	**1975-85**	**1985-95**	**p-value***
log(per capita GDP)	-0.0187 (0.0038)	-0.0194 (0.0069)	-0.0342 (0.0066)	0.090
male upper-level schooling	0.0019 (0.0023)	0.0065 (0.0030)	0.0004 (0.0030)	0.20
1/(life expectancy at age 1)	-6.72 (1.13)	-2.91 (1.79)	-7.62 (1.94)	0.072
log(total fertility rate)	-0.0053 (0.0072)	-0.0237 (0.0121)	-0.0303 (0.0102)	0.12
govt. consumption ratio	-0.093 (0.046)	-0.029 (0.042)	-0.064 (0.062)	0.61
rule of law	0.0253 (0.0076)	0.0086 (0.0130)	0.0092 (0.0184)	0.48
democracy	0.120 (0.053)	0.125 (0.069)	0.156 (0.061)	0.90
democracy squared	-0.120 (0.043)	-0.120 (0.063)	-0.123 (0.053)	1.00
openness ratio	0.0146 (0.0099)	0.0042 (0.0103)	0.0000 (0.0073)	0.50
change in terms of trade	0.170 (0.081)	0.491 (0.133)	0.016 (0.146)	0.047
investment ratio	0.040 (0.032)	0.039 (0.050)	0.134 (0.055)	0.26
inflation rate	0.018 (0.024)	-0.073 (0.039)	-0.019 (0.014)	0.13
constant	0.264 (0.044)	0.235 (0.068)	0.406 (0.071)	0.10
number of observations	71	86	83	
R-squared	0.66	0.45	0.57	

Notes to Table 4. Columns 2-4 provide estimates of the regression system from column 2 of Table 3 when the coefficients are allowed to differ across the three time periods, 1965-75, 1975-85, and 1985-95.

*The p-values refer to the hypothesis that the coefficients are the same for all three time periods.

Table 4 allows for an array of different coefficients over the three ten-year time periods. (In the initial estimation, only the constant terms differed across the periods.) A joint test for equality of all coefficients across the time periods would be rejected with a low p-value. However, when the variables are considered individually, none of the p-values are less than 0.05–see column 5 of Table 4. At the 10 percent critical level, there is an indication of instability over time in the coefficients of log(per capita GDP), the life-expectancy variable, and the terms-of-trade variable. However, overall, the striking finding from Table 4 is the extent of stability of the estimated coefficients over time.

4.3. Additional Explanatory Variables

The empirical literature on the determinants of economic growth has become very large and has suggested numerous additional explanatory variables. Table 5 shows the estimated coefficients of some of these candidate variables when added one at a time to the basic regression system shown in column 2 of Table 3.[12]

The first variable, the log of population, is intended to see whether the scale of a country matters for its growth outcomes. This variable is entered for 1960, 1970, and 1980 and appears also in the instrument lists. The estimated coefficient is insignificant, 0.0004 (0.0009). Hence, there is no indication that country size matters for economic growth. Figure 14 shows the partial relation between growth and the log of population.

[12]Table 5 does not include any measures of inequality. However, a previous analysis (Barro [2000]) found little effect of inequality on growth.

TABLE 5.

Additional Explanatory Variables in Cross-Country Growth Regressions

(1) new explanatory variable	(2) coefficient	(3) additional new variable	(4) coefficient	(5) p-value*
log (population)	0.0004 (0.0009)			
log(per capita GDP)-squared	-0.0035 (0.0020)			
female upper-level schooling	-0.0034 (0.0041)			
male primary schooling	-0.0011 (0.0025)	**female primary schooling**	0.0007 (0.0024)	0.90
male college schooling**	0.0105 (0.0093)	**male secondary schooling**	0.0024 (0.0020)	0.075
student test scores***	0.121 (0.024)			
infant mortality rate	-0.001 (0.057)			
1/(life expectancy at birth)	-0.97 (2.52)			
1/(life expectancy at age 5)	0.90 (2.00)			
malaria incidence	0.0019 (0.0045)			
official corruption	0.0093 (0.0068)			
quality of bureaucracy	0.0076 (0.0088)			
civil liberties****	-0.045 (0.081)	**civil liberties squared**	0.003 (0.070)	0.36
Sub-Saharan Africa dummy*****	-0.0080 (0.0051)	**Latin America dummy**	0.0031 (0.0039)	0.011
East Asia dummy	0.0100 (0.0047)	**OECD dummy**	0.0004 (0.0054)	
population share < 15	-0.070 (0.070)	**population share > 64**	-0.080 (0.110)	0.61
govt. spending on education	-0.057 (0.068)	**govt. spending on defense**	0.064 (0.028)	0.069
log(black-market premium)	-0.0122 (0.0058)			

TABLE 5—*Continued*

(1) new explanatory variable	(2) coefficient	(3) additional new variable	(4) coefficient	(5) p-value*
private financial system credit	-0.0041 (0.0065)			
financial system deposits	-0.002 (0.011)			
British legal structure dummy	-0.0018 (0.0044)	**French legal structure dummy**	0.0047 (0.0045)	0.10
absolute latitude (degrees ÷100)	0.066 (0.027)	**latitude squared**	-0.085 (0.044)	0.036
land-locked dummy	-0.0088 (0.0032)			
ethnic fractionalization	-0.0080 (0.0059)			
linguistic fractionalization	-0.0084 (0.0050)			
religious fractionalization	-0.0088 (0.0058)			
British colony dummy******	-0.0064 (0.0043)	**French colony dummy**	0.0003 (0.0053)	0.39
Spanish/Port. colony dummy	-0.0019 (0.0053)	**other colony dummy**	-0.0055 (0.0075)	

Notes to Table 5. Each new explanatory variable or group of new variables is added to the system shown in column 2 of Table 3.
*p-value is for the test of the hypothesis that the coefficients of the new explanatory variables are jointly zero.
**Upper-level male schooling is omitted. p-value for equality of college and secondary variables is 0.44.
***Numbers of observations for this sample are 39, 45, and 44.
****This system is only for the two periods 1975-85 and 1985-95.
*****The four regional dummy variables are entered together.
******The four colony dummies are entered together.

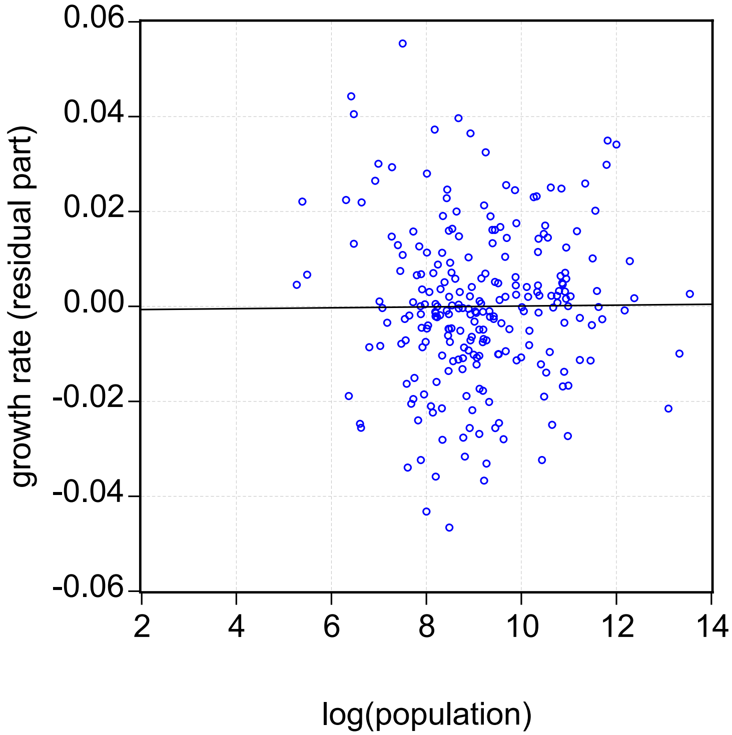

FIG. 14. Growth Rate versus Population (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the log of population. The variable on the horizontal axis applies to 1965, 1975, and 1985. See the description of Figure 3 for the general procedure.

The square of the log of per capita GDP was entered to see whether the rate of convergence depended on the level of per capita GDP. This new variable enters with the same timing as the linear term in log(per capita GDP). If the coefficient on the square variable were negative, then the rate of convergence would be increasing with per capita GDP. The empirical result is a negative but statistically insignificant coefficient, -0.0035 (0.0020). Hence, there is no clear indication that the rate of convergence depends on the level of per capita GDP.

A number of alternative measures of years of education were considered, all of which enter with the same timing as the male upper-level schooling variable. Female upper-level schooling has a negative but statistically insignificant coefficient, -0.0034 (0.0041). Schooling at the primary level for males or females also has statistically insignificant coefficients: -0.0011

(0.0025) and 0.0007 (0.0024), respectively. Hence, the main relation between growth and years of schooling involves the male upper-level component, the variable included in column 2 of Table 3. A separation of this male variable into college and high-school components generates two positive coefficients–0.0105 (0.0093) and 0.0024 (0.0020)–that are insignificantly different from each other (p-value for equality is 0.44).

All of these schooling variables refer to the quantity of education, as measured by years of schooling, rather than the quality. A possible measure of quality is the outcome on internationally comparable examinations. Of course, these test scores may reflect inputs other than formal education, for example, the influences of family members. In any event, the main problem here is that the data are available only for a sub-set of the countries and time periods from the original regression sample. Because of the limited data, a single cross section of test scores was constructed. This single value was used for the three time periods considered for growth. (Thus, the underlying test scores apply at different points in time in each equation, and some of the data refer to scores that post-date the measured rates of economic growth.) The estimated coefficient of the test-scores variable is positive and highly significant, 0.121 (0.024). According to this coefficient, a one-standard-deviation increase in test scores (by 0.092) would raise the growth rate on impact by 0.011, which is quite a large effect. The partial relation between growth and test scores is shown in Figure 15. The diagram makes clear that the sample size is much reduced from those considered before. Another result in this specification is that the estimated coefficient of male upper-level schooling becomes insignificant, 0.0011 (0.0014). Thus, the overall indication is that the quality of education is far more important for economic outcomes than the years of schooling. Unfortunately, the limited amount of international data on test scores makes it difficult to go further with this analysis.

Another set of results refers to alternative measures of health. Recall that the analysis previously included the reciprocal of life expectancy at age one. (This measure has more explanatory power than life expectancy at age one or the log of this life expectancy.) With this variable held fixed, the infant mortality rate (for 1960, 1970, and 1980) is insignificant, -0.001 (0.057). Also insignificant are the reciprocal of life expectancy at birth (-0.97, s.e.=2.52) or at age five. (0.90, s.e. = 2.00). (These variables all apply to 1960, 1970, and 1980.) Gallup, Mellinger, and Sachs (2002) have generated numerous measures of the effects of specific diseases. However, these additional health measures were not found to be important for growth, once the basic life expectancy variable was considered. As an ex-

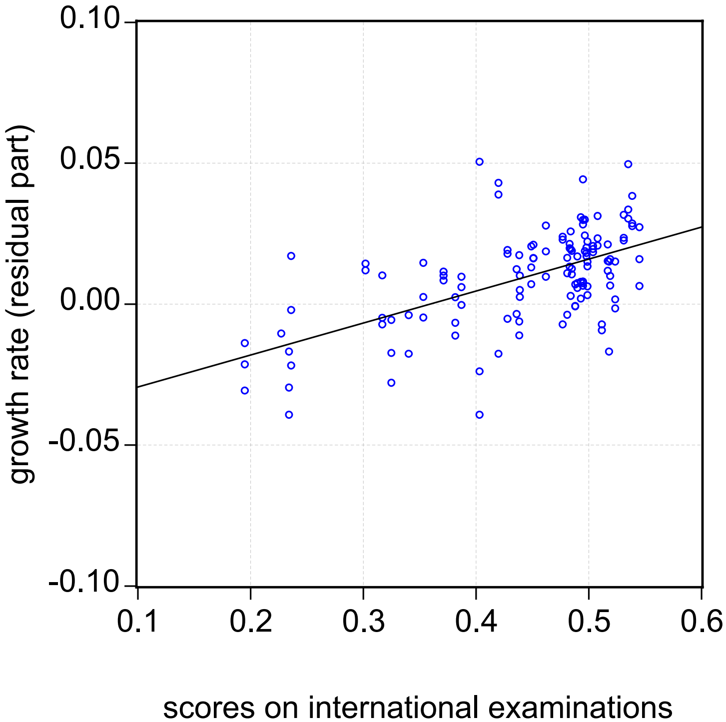

FIG. 15. Growth Rate versus Test Scores (partial relation)
The diagram shows the partial relation between the growth rate of per capita GDP and the scores on internationally comparable examinations administered to students. The variable on the horizontal axis takes on a single value over time for each country. See the description of Figure 3 for the general procedure.

ample, the variable for the incidence of malaria in 1966 was insignificant, 0.0019 (0.0045).

Alternatives to the rule-of-law indicator have also been proposed in the literature. With the rule-of-law measure (and the other explanatory variables, including democracy) held constant, an indicator from Political Risk Services of the extent of official corruption was positive but insignificant, 0.0093 (0.0068). (Note that, for this indicator, a higher value means a "better" system with less official corruption.) Also insignificant was an indicator from Political Risk Services for the quality of the bureaucracy, 0.0076 (0.0088). The corruption and bureaucratic quality indicators were entered with the same timing as the rule-of-law variable, which was discussed before.

The democracy variable included in column 2 of Table 3 is the Freedom House indicator of electoral rights. Because of the high degree of correlation, it turns out to be impossible to distinguish this measure empirically from the other Freedom House indicator, which refers to civil liberties. The linear and squared terms in civil liberties are insignificant if added to the system (p-value = 0.36).[13] However, the linear and squared terms in electoral rights are also jointly insignificant when the civil-liberties variables are already included (p-value = 0.14).

The earlier discussion indicated how the group of slowest growing countries was dominated by sub-Saharan Africa, whereas the fastest growing group was dominated by East Asia. A natural question is whether the low and high growth outcomes by region continue to apply after holding constant the explanatory variables included in the basic regression system shown in column 2 of Table 3. That is, the question is whether the included explanatory variables already measure the growth consequences of being located in a particular region. The regional dummy variables shown in Table 5 have estimated coefficients of -0.008 (0.005) for sub-Saharan Africa, 0.003 (0.004) for Latin America, 0.010 (0.005) for East Asia, and 0.000 (0.005) for the OECD.[14] Thus, only the East Asian dummy is significant at usual critical levels. The main observation here is that most of the consequences of an economy being included in any of these regions is already held constant by the explanatory variables included in the basic regression system.

A reasonable expectation is that productivity would depend on age structure–notably, output per person would be expected to be higher if a larger fraction of the population is in the prime-age category of 15-65 and less in the categories of under 15 and over 65. However, the two population share variables (for under 15 and over 65) are jointly insignificant if added to the regression system–the p-value for the two jointly is 0.61. (These age structure variables are observed in 1960, 1970, and 1980.)

The basic system includes as a measure of government spending the standard definition of government consumption less the outlays on defense and

[13] This system covers only the last two ten-year periods for growth, 1975-85 and 1985-95, because independent measures of electoral rights and civil liberties were unavailable before 1972. The timing for the civil-liberties variable is the same as that discussed before for the electoral-rights indicator.

[14] The OECD countries are those other than Turkey that have been members since the 1960s.

education. If these last two components of government spending are entered separately (each as estimated ratios of real spending to real GDP), then the estimated coefficients are -0.057 (0.068) for education and 0.064 (0.028) for defense. (The timing of these variables is the same as that discussed before for the government consumption ratio.) The p-value for joint significance is 0.07. The positive coefficient for defense is noteworthy.[15]

The black-market premium on the foreign exchange is sometimes entered into growth equations as a proxy for a class of market distortions. However, this indicator can also proxy more generally for macroeconomic instability, in particular, for instability that relates to the balance of payments. The estimated coefficient on the log of one plus the black-market premium is negative and marginally significant: -0.012 (0.006). (This variable enters as averages for 1965-74, 1975-84, and 1985-92. The instrument lists include values for 1960-64, 1970-74, and 1980-84.) Hence, there is an indication that this distortion measure has inverse predictive power for economic growth.

Other analyses, such as King and Levine (1993), have stressed the special role of the domestic financial system as an engine of growth. The present analysis considers two proxies for this financial development. One is the ratio of private financial system credit to GDP and the other is a measure of financial system deposits (the M3 aggregate less the transactions-related M1 aggregate, again as a ratio to GDP). These variables, available from the World Bank, are measured at the beginning of each ten-year period: 1965, 1975, and 1985. Of course, the development of the financial system is endogenous with respect to general economic development. Thus, these financial proxies would be expected to matter only to the extent that they take on values that are unusual for an economy's level of development–as measured empirically by per capita GDP and some of the other explanatory variables. In any event, when added to the basic regression system, the estimated coefficients of the financial proxies are insignificantly different from zero: -0.004 (0.006) for the credit measure and -0.002 (0.011) for the deposit measure.

The line of research exemplified by La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1997) stresses the role of legal structures. In particular, this literature argues that the British common-law tradition is superior as a basis for economic development to the French statute-law system. The

[15]Since the variable included in the basic system involves standard government consumption less outlays on education and defense, it is also possible to test whether the standard government consumption measure is the appropriate one to enter into the growth systems. This hypothesis is rejected with a p-value of 0.004.

data consist of dummy variables for five types of legal traditions: British, French, Scandinavian, German, and socialist. Dummy variables for British and French legal structure turn out to have little explanatory power for growth when added to the basic regression system: the coefficient on the British variable is -0.0018 (0.0044) and that on the French variable is 0.0047 (0.0045). The two variables jointly are marginally significant, with a p-value of 0.10–but, contrary to the basic hypothesis, the French system seems to be somewhat more favorable for growth than the British one. Note, however, that these legal structure variables are entered into the system of Table 3, column 2, which already holds constant measures of rule of law and democracy.

Geographical elements have been stressed in the research by Gallup, Mellinger, and Sachs (2002). One commonly used indicator is the absolute value of degrees latitude. The idea is that places too close to the equator have bad climate from the standpoint of excessive heat and humidity. Since too great a departure from the equator would signify excessive cold, the analysis also includes the square of latitude in the system. The result, when added to the basic regression system, is that the linear term (0.066, s.e.=0.027) and squared term (-0.085, s.e.=0.044) are jointly significant, with a p-value of 0.04. The point estimates imply that the optimal (absolute) latitude from the standpoint of growth promotion is 39 degrees. (It may be useful to point out that the latitude of Beijing is exactly 39 degrees. Shanghai is 31 degrees. Boston MA is 42 degrees.)

Another geographical factor, land-locked status, is likely to be important from the standpoint of discouraging trade and other communication with the rest of the world. (Note, however, that international openness is already held constant in the basic regression system.) A dummy for land-locked status, when added to the basic system, turns out to be significantly negative: -0.0088 (0.0032).

Various measures of ethnic, linguistic, and religious fractionalization have been argued to matter for political decision-making and conflict and, hence, for economic growth. A standard measure of fractionalization is one minus the Herfindahl index for membership shares (in ethnic, linguistic, or religious groups). This measure gives the probability that two randomly chosen persons in a country will come from different groups. The three measures of fractionalization considered in Table 5 each have negative but statistically insignificant coefficients when added to the growth equations.[16]

[16]The indices for ethnicity and language come from Alesina, et al (2002) and apply to the late 1990s. The index for religious denominations was computed from Barrett's (1982) data on religious affiliation in 1970 among ten major groups, including no religion.

Finally, colonial heritage has been argued to be important for growth. Sometimes these influences are thought to derive from inherited legal or monetary institutions–therefore, it is important to note the explanatory variables that are already included in column 2 of Table 3. In any event, if added to the basic system, dummies for four colonial categories (British, French, Spanish or Portuguese, and other) are jointly insignificant for growth. The p-value for joint significance is 0.39.[17]

4.4. Fitted Values for China and Other Countries

Table 6 shows how the empirical analysis fits or does not fit the experiences of China and some other illustrative countries. The table includes two OECD countries, Italy and the United States, two East Asian countries aside from China, Singapore and South Korea, one representative of Latin America, Chile, and one sub-Saharan African country, the former Zaire (now Democratic Republic of the Congo). The first part of the table applies to 1975-85, the second part to 1985-95, and the third part to a forecasting period, roughly 2000-2010.[18] All values shown in the table are expressed relative to the sample mean for the respective period. For 1975-85, the sample mean per capita growth rate was 0.0154, whereas that for 1985-95 was 0.0155.

[17]The system in Table 3, column 2 included in the instrument lists the dummies for Spanish or Portuguese and other colonies and excluded measures of inflation. The present system adds the colony dummies for British and French and also includes the lagged inflation rate.

[18]China was excluded from the statistical analysis for the 1965-75 period because of missing data on educational attainment.

TABLE 6.

Part 1 Actual and Fitted Values for Selected Countries, 1975-85
(all values relative to sample means).

	China	Chile	Italy	Singapore	S. Korea	U.S.	Zaire
growth rate	0.038	0.000	0.012	0.038	0.044	0.010	-0.055
fitted growth rate	0.036	-0.008	0.004	0.057	0.029	0.001	-0.021
residual	0.003	0.008	0.007	-0.019	0.015	0.009	-0.033
log(per capita GDP)	0.036	0.000	-0.025	-0.017	0.004	-0.034	0.034
education	0.000	0.001	0.001	0.001	0.005	0.011	-0.004
life expectancy	0.004	0.006	0.013	0.008	0.000	0.011	-0.018
fertility rate	-0.003	0.002	0.008	0.005	0.001	0.008	-0.004
govt. consumption ratio	0.002	-0.004	0.002	0.006	0.004	0.002	-0.003
rule of law	-0.001	0.006	0.006	0.009	-0.001	0.009	-0.007
democracy	-0.006	-0.008	-0.002	0.007	0.006	-0.007	-0.009
openness ratio	0.000	-0.001	0.000	0.020	0.001	0.000	-0.001
terms of trade	0.002	-0.002	0.000	-0.001	0.001	0.000	0.004
investment ratio	-0.001	-0.003	0.003	0.016	0.007	-0.001	-0.006
inflation rate	0.003	-0.004	0.001	0.003	0.001	0.002	-0.006

TABLE 6.

Part 2 Actual and Fitted Values for Selected Countries, 1985-95
(all values relative to sample means)

	China	Chile	Italy	Singapore	S. Korea	U.S.	Zaire
growth rate	0.044	0.043	0.007	0.045	0.063	0.004	-0.088
fitted growth rate	0.024	0.031	0.001	0.053	0.038	0.003	-0.049
residual	0.020	0.012	0.005	-0.009	0.025	0.001	-0.039
log(per capita GDP)	0.026	0.000	-0.029	-0.027	-0.007	-0.037	0.046
education	-0.001	0.000	0.002	-0.001	0.008	0.014	-0.005
life expectancy	0.005	0.007	0.010	0.007	0.003	0.010	-0.015
fertility rate	0.005	0.004	0.011	0.010	0.005	0.009	-0.008
govt. consumption ratio	-0.004	0.000	0.001	0.006	0.005	0.001	-0.006
rule of law	0.000	0.002	0.005	0.005	-0.001	0.008	-0.009
democracy	-0.012	0.009	-0.008	0.008	0.006	-0.008	-0.011
openness ratio	0.001	0.000	-0.001	0.020	0.000	0.000	0.000
terms of trade	0.000	0.007	0.002	0.006	0.003	0.000	0.000
investment ratio	0.002	0.001	0.003	0.014	0.011	0.001	-0.006
inflation rate	0.003	0.002	0.004	0.005	0.004	0.004	-0.036

TABLE 6.

Part 3 Forecasted Values for Selected Countries, 2000-2010
(all values relative to sample means)

	China	**Chile**	**Italy**	**Singapore**	**S. Korea**	**U.S.**	**Zaire**
forecasted growth rate	0.005	0.015	0.002	0.036	0.024	-0.006	–
log(per capita GDP)	0.011	-0.011	-0.029	-0.037	-0.023	-0.038	–
education	-0.001	0.000	0.003	0.003	0.010	0.014	-0.005
life expectancy	0.006	0.010	0.012	0.011	0.007	0.011	-0.027
fertility rate	0.004	0.003	0.010	0.008	0.008	0.003	-0.011
govt. consumption ratio	-0.005	0.003	0.000	0.006	0.005	0.002	0.006
rule of law	0.000	0.004	0.007	0.007	0.000	0.007	-0.009
democracy	-0.016	0.005	-0.006	0.006	0.005	-0.006	-0.016
openness ratio	0.002	-0.002	-0.001	0.016	0.000	-0.001	–
terms of trade	0.000	0.000	0.000	0.000	0.000	0.000	0.000
investment ratio	0.003	0.004	0.002	0.014	0.010	0.001	–
inflation rate	0.001	0.001	0.001	0.002	0.001	0.001	–

Notes to Table 6. The actual growth rates of per capita GDP for 1975-85 and 1985-95 in parts 1 and 2 of the table are expressed relative to the sample means, where the samples are the countries included in the regressions for the respective periods in column 2 of Table 3. The fitted values for the growth rate of per capita GDP, also expressed relative to sample means, apply to the corresponding systems. The residual is the difference between the actual and fitted per capita growth rates. The values shown for each explanatory variable (log of per capita GDP, etc.) refer to the contributions to the fitted values, expressed relative to the sample means, for each explanatory variable. These explanatory variables are the ones contained in the system of column 2, Table 3. In part 3 of the table, the forecasted per capita growth rates for 2000-2010 are the values obtained from the system estimated in column 2 of Table 3 when the explanatory variables take on their latest available values. These values apply to points in time between 1995 and 2001.

For 1975-85, the model accords well with China's observed per capita growth rate of 0.038 (relative to the mean of 0.015). Much of the empirical explanation comes from the convergence force–according to the fitted model, the low value of initial per capita GDP explains growth of 0.036 relative to the sample mean. The net of the other explanatory variables is about zero. Among these other forces, the most adverse element is -0.006 for low democracy.

As a contrasting case, for Singapore in 1975-85, the country started out richer than China and, hence, the convergence effect is negative (-0.017). However, other explanatory variables for Singapore were highly conducive to growth–for example, 0.020 from high international openness, 0.016 from high investment, 0.009 from strong rule of law, 0.008 from high life expectancy, and 0.007 from favorable democracy (which means a value close to the mid-range value of 0.5).

As another contrast, a country such as the former Zaire had a very favorable convergence effect (0.034) because of its low initial value of per capita GDP. However, this force was more than offset by unfavorable values of most of the other explanatory variables: -0.018 from low life expectancy, -0.009 from low democracy, -0.007 from weak rule of law, and -0.006 each from low investment and high inflation.

For the United States, an example of a rich OECD country, the convergence effect is strongly negative (-0.034). However, this negative influence on growth was more than offset by favorable values of most of the other explanatory variables–including 0.011 each for high education and life expectancy, 0.009 for strong rule of law, and 0.008 for low fertility. The value -0.007 for democracy arises because "too much" democracy is bad for growth in the fitted model.

In part 2 of Table 6, the model's fit for China for 1985-95 is no longer so good. The actual growth rate exceeded the sample mean (of 0.016) by 0.044, but the fitted value "predicted" a value of only 0.024. Again, the main element behind the fitted value is the convergence force, which is now only 0.026 because China in 1985 was much richer than it had been in 1975. The other elements behind the fitted growth rate for 1985-95 netted out roughly to zero, with the most prominent influence being -0.012 for low democracy. The model says that this low democracy would inhibit growth, but the strong growth outcomes for China for 1985-95 did not accord with this prediction. Again, the values shown for the other countries allow a contrast with the predictions for China.

The third part of Table 6 uses the fitted model and the latest observations on the explanatory variables to generate growth forecasts. The timing for the explanatory variables ranges from 1995 to 2001, and the forecasts can be viewed as applying roughly from 2000 to 2010. For China, the forecast of per capita growth is for 0.005 above the sample mean, which was 0.016 for 1985-95. This forecast is lower than the estimated value for 1985-95 (shown in part 2 of the table) mostly because the convergence force declined further as China became richer–to only 0.011 for the forecast period. The democracy variable, now contributing -0.016, is again a major reason for the low growth forecast. However, recent growth observations for China–including 0.070 for per capita growth from 1995 to 2000–were well above the projected value shown in part 3 of the table. Thus, the model seems to be underestimating China's growth potential under its current political and other institutions.

5. SUMMARY OBSERVATIONS ABOUT GROWTH

Differences in per capita growth rates across countries are large and relate systematically to a set of quantifiable explanatory variables. One element of this set is a convergence term, the positive effect on growth when the initial level of real per capita GDP is low. However, this effect is conditional on the starting amount of human capital in the forms of educational attainment and life expectancy and on a set of explanatory variables that capture policies and national characteristics.

The empirical findings on conditional convergence are consistent with the neoclassical growth model and with an imbalance effect for physical and human capital. That is, for given per capita GDP, high initial human capital predicts higher growth. For given values of per capita GDP and human capital, growth depends positively on the rule of law and international openness and negatively on the ratio of government consumption to GDP and the rate of inflation. Growth increases with favorable movements in the terms of trade and declines with increases in the fertility rate. The relation between growth and the investment ratio is positive but weak when the variables already mentioned are held constant.

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