NBER WORKING PAPER SERIES

LOSERS AND WINNERS IN ECONOMIC GROWTH

Robert J. Barro

Jong-Wha Lee

Working Paper No. 4341

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 1993

We have benefited from comments by Zvi Griliches, Michael Sarel, and Andrei Shleifer. The research by Barro was supported by a grant from the National Science Foundation. This paper is part of NBER's research programs in Growth and Economic Fluctuations. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #4341
April 1993

LOSERS AND WINNERS IN ECONOMIC GROWTH

ABSTRACT

For 116 countries from 1965 to 1985, the lowest quintile had an average growth rate of real per capita GDP of -1.3%, whereas the highest quintile had an average of 4.8%. We isolate five influences that discriminate reasonably well between the slow and fast-growers: a conditional convergence effect, whereby a country grows faster if it begins with lower real per capita GDP relative to its initial level of human capital in the forms of educational attainment and health; a positive effect on growth from a high ratio of investment to GDP (although this effect is weaker than that reported in some previous studies); a negative effect from overly large government; a negative effect from government-induced distortions of markets; and a negative effect from political instability. Overall, the fitted growth rates for 85 countries for 1965-85 had a correlation of 0.8 with the actual values. We also find that female educational attainment has a pronounced negative effect on fertility, whereas female and male attainment are each positively related to life expectancy and negatively related to infant mortality. Male attainment plays a positive role in primary-school enrollment ratios, and male and female attainment relate positively to enrollment at the secondary and higher levels.

Robert J. Barro
Department of Economics
Littauer Center 120
Harvard University
Cambridge, MA 02138
and NBER

Jong-Wha Lee
Korea University
Department of Economics
Anam-Long, Sunbuck-ku
Seoul 136-701, Korea

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 116 countries from 1965 to 1985.[1] The mean value is 1.7% per year, with a standard deviation of 2.2. The maximum growth rate is 8.6% per year (for Singapore) and the minimum is –5.0% per year (for Kuwait). The lowest decile comprises 12 countries with growth rates below –0.64% per year, and the highest decile consists of the 12 with growth rates above 4.35% per year. For quintiles, the poorest performing 23 places have growth rates below 0.023% per year, and the best performing 23 have growth rates above 3.2% per year.

The difference between per capita growth at –1.3% per year—the average for the lowest quintile—and growth at 4.8% per year—the average for the highest quintile—is that real per capita GDP falls by 23% over 20 years in the former case and rises by 161% in the latter. Thus, for example, two low-growth countries, Sudan and Jamaica, fell from levels of real per capita GDP in 1965 of $729 and $1807 (1980 U.S. dollars), respectively, to levels in 1985 of $540 and $1725. Over the same period, two high-growth countries, Botswana and Korea, rose, respectively, from $530 and $797 to $1762 and $3056. Thus, even over periods as short as 20 years, the variations in growth rates made dramatic differences in the average living standards of a country's residents.

The key challenge for economists is to understand why growth outcomes differ so much and, hopefully, to use this knowledge to recommend policy changes that would increase the chances of the lagging countries to perform better. This challenge defines the objectives of this paper and our ongoing research.

We build in this work on previous cross-country empirical analyses to isolate major determinants of growth rates for about 100 countries from 1965 to 1975 and 1975 to

---

[1]The GDP data are the purchasing-power adjusted values reported by Summers and Heston (1988).

1985. We then summarize these results in a framework of "sources of growth" to show how the explanatory variables for the countries in the lowest quintile of growth rates differed systematically from those in the highest quintile. We describe our findings in terms of five key determinants of growth: 1. A conditional convergence effect, whereby a country grows faster if it begins with lower real per capita GDP *relative* to its initial level of human capital in the forms of educational attainment and health; 2. A positive effect on growth from a high ratio of investment to GDP (although this effect is weaker than that reported in some previous studies); 3. A negative effect from overly large government, represented by the ratio of government consumption (exclusive of defense and education) to GDP; 4. A negative effect from government-induced distortions of markets, proxied by the black-market premium on foreign exchange; and 5. A negative effect from political instability, represented by the propensity to experience revolutions. Overall, the fitted growth rates for 1965–85 that are derived from these five influences have a correlation with the actual growth rates of about 0.8; in particular, knowledge of these explanatory variables goes a long way toward determining whether a country ends up in the low- or high-growth group.

The final sections of the paper provide preliminary evidence on the determinants of fertility, health (measured by life expectancy and infant mortality), and school enrollment. Our results confirm the key role of female education in generating reductions in fertility and hence, population growth. We also find that female and male attainment are each positively related to life expectancy and negatively related to infant mortality. Male attainment plays a positive role in primary-school enrollment ratios, and male and female attainment relate positively to enrollment at the secondary and higher levels. We plan to explore these relationships further in future research, especially to detail the linkages between the fertility/health/school-enrollment effects and our results about the determinants of economic growth.

Losers and Winners from 1965 to 1985

The left section of Table 1 shows the growth rates of real per capita GDP from 1965 to 1985 for the 23 countries in the lowest quintile of growth rates. This group contains 16 countries in Sub-Saharan Africa; 5 in Latin America (El Salvador, Jamaica, Nicaragua, Guyana, and Venezuela); and 2 in the Mideast (Iraq and Kuwait).

The left part of the table is based on the purchasing-power adjusted GDP data reported in the Penn-World Table version 4 by Summers and Heston (1988), subsequently referred to as S/H v.4. The selection of the lowest quintile is, however, similar if one relies on two alternative (and somewhat independent) sources of data: the updated version 5 figures from Summers and Heston (1991)—henceforth, S/H v.5—or the World Bank data (which are based only on own-country information on real output).

The S/H v.5 data, used for the center columns of Table 1, indicate that 17 out of the 24 countries in the lowest quintile of growth rates are in Sub-Saharan Africa—most of these are also on the S/H v.4 list. The S/H v.5 data add Argentina, Peru, Afghanistan, and Papua New Guinea, and eliminate El Salvador, Jamaica, Venezuela, and Iraq. (Data on Afghanistan are unavailable in S/H v.4.)

The World Bank figures, used on the right part of Table 1, have 14 of the 22 slowest growers in Sub-Saharan Africa. Haiti, Afghanistan, and Bangladesh are added here to the S/H v.4 selections. (Note that data on Guyana and Iraq are unavailable in the World Bank source that we used.)

Table 2 provides a parallel treatment of winners, that is, the 23 countries in the upper quintile of growth rates. The list based on S/H v.4 includes five countries in Sub-Saharan Africa (Botswana, Cameroon, Gabon, Lesotho, and Rwanda); one in North Africa (Tunisia); three in Latin America (Barbados, Brazil, and Ecuador); eight in East Asia (Hong Kong, Indonesia, Japan, Korea, Malaysia, Singapore, Taiwan, and

Thailand); and six members of the OECD (Austria, Cyprus, Greece, Malta, Norway, and Portugal).

The composition of the fast-growers list is similar if the alternative data sources are used. Summers-Heston v.5 adds Algeria, Congo, Egypt, China, and Syria, and eliminates Barbados, Ecuador, Austria, and Norway. (Note that data on China are unavailable in S/H v.4 or from our World Bank data.) The World Bank list includes Burundi, Egypt, Saudi Arabia, Finland, and Italy, but not Cameroon, Gabon, Lesotho, Rwanda, Ecuador, and Austria. (Note that the World Bank data exclude Taiwan.)

We focus now on the low- and high-growth lists as designated by the Summers-Heston version 4 data set.[2] In particular, we try to isolate some of the factors that determine growth and thereby affect the probability of a country turning out to be a slow or fast grower.

Tables 3 and 4 provide a preliminary overview of the prospects for this enterprise. The first column of each table indicates whether the country is in the regression sample for growth that we use later: 14 of the 23 low-growth countries are included for 1965–75 and 15 of the 23 for 1975–85, whereas 20 of the 23 high-growth countries are included for 1965–75 and 22 of the 23 for 1975–85. The fitted values for 1965–75 and 1975–85 show how much of the growth rates purport to be explained by the decadal regressions. Numbers shown in parentheses are for countries that were not included in the regressions; these fitted values are based on estimates of missing data on one or more explanatory variables.

[2]We use version 4 of Summers and Heston rather than version 5 because we were already set up with the earlier figures throughout the analysis and because a comparison with some of the regressions that used the later figures showed little change in the results. We also experienced some minor problems with bugs in version 5, such as errors in the data for the United States. These difficulties have apparently been eliminated in a later version, 5.5, which has recently become available.

For the 20-year period, 1965–85, the average growth rate for the slow growers is –.013 per year, and the average of the fitted values is –.002 per year. In contrast, for the fast growers, the average growth rate is .048 per year, and the average of the fitted values is .039 per year. The typical fast grower therefore grew by 6.1 percentage points per year more than the typical slow grower, and 4.1 percentage points of this gap was captured on average by the fitted values. Hence, the fitted values show a wide difference between the slow and fast growers, and it is worthwhile to assess the factors that underlie the differences in the fitted growth rates between the two groups. (For all 85 countries that are included in the regressions for 1965–75 and 1975–85, the correlation between the actual and fitted growth rates for 1965–85 is 0.81.)

Tables 3 and 4 also show projected growth rates for 1985–95. The average of these projected values for the slow growers is 0.008 per year and that for the fast growers is 0.033 per year. In other words, the model predicts that the average gap between the two groups will decline from 6.1 percentage points from 1965 to 1985 to 2.5 percentage points from 1985 to 1995. Thus, the classification into slow and fast growers, based on data for 1965–85, is predicted to attenuate but to persist to a significant extent.[3]

Setup of the Empirical Analysis of Growth Rates

We study in this section the empirical determinants of growth, that is, we provide the regression results that underlie the fitted values and projections contained in Tables 3 and 4. We use a sample of 95 countries, listed in the appendix, which provide a wide array of experiences from developing to developed countries. The included countries

[3]Easterly, et al (1993) argue that growth rates for individual countries do not persist very much over time. For the 85 countries that were included in our growth regressions for both decades, the correlation of the growth rate for 1965–75 with that for 1975–85 is 0.44. The correlation of the projected value for 1985–95 with the growth rate for 1965–85 is 0.42.

were determined by the availability of data.[4] We study growth rates over two decades, 1965–75 and 1975–85. Thus, our panel data set includes a limited amount of time-series variation.

The basic empirical framework relates the real per capita growth rate to two kinds of variables: first, initial levels of state variables, such as the stock of physical capital and the stock of human capital in the forms of educational attainment and health; and second, control or environmental variables (some of which are chosen by governments or private agents), such as the ratio of government consumption to GDP, the ratio of domestic investment to GDP, the fertility rate, the black-market premium on foreign exchange, changes in the terms of trade, measures of political instability, the amounts of political freedom and civil liberties, tariff rates, and so on.

One of the state variables that we use is the measure (or measures) of school attainment constructed by Barro and Lee (1993); a sketch of these data appears below. We use standard U.N. numbers on life expectancy at birth to represent the initial level of health. 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, we assume 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). Therefore, for given values of the contemporaneous determinants of growth, we write a function for the per capita growth rate in period t, Dy_t, as

[4] The only country with available data that we omitted from the regressions is Kuwait. We thought that this country—with a reported real per capita GDP of $40700 in 1965 and $14900 in 1985, a population of only 473,000 in 1965 and 1,712,000 in 1985, a strong reliance on oil, and the subject of a large flow of immigrants—was too unusual to include. The regression results are, however, insensitive to the inclusion of Kuwait in the sample.

$$(1) \qquad Dy_t = F(y_{t-1}, e_{t-1}, h_{t-1}; \dots)$$

where y_{t-1} is initial per capita GDP, e_{t-1} is initial schooling per person, h_{t-1} is a measure (life expectancy) of the typical person's health, and ... denotes the array of control and environmental influences that are being held constant.

If there are diminishing returns to reproducible factors, as in the usual neoclassical growth model for a closed economy (Solow [1956], Cass [1965], and Koopmans [1965]), then an equiproportionate increase in y_{t-1}, e_{t-1}, and h_{t-1} would reduce Dy_t in equation (1).[5] However, a number of theories, summarized in Barro and Sala–i–Martin (1993, Ch. 4), suggest important influences on growth from imbalances between physical and human capital. A high ratio of human capital (e_{t-1} or h_{t-1} in equation [1]) to physical capital tends to induce rapid growth in physical capital and output. This situation applies, for example, in the aftermath of a war that destroys primarily physical capital. Other theories have stressed the positive influences of human capital on the ability to absorb new technologies; hence, Dy_t would rise with e_{t-1} and h_{t-1} on this count. Thus, although the influence of y_{t-1} on Dy_t in equation (1) would be negative, the effects of e_{t-1} and h_{t-1} are likely to be positive.

In the basic regression that we consider below, the control and environmental variables are the ratio of real gross domestic investment to real GDP, denoted I/Y; the ratio of government consumption (measured net of spending on defense and education) to GDP, denoted G/Y; the black-market premium on foreign exchange; and the country's average number of revolutions per year. We take account of the likely endogeneity of these variables by using lagged values as instruments.

[5]Note that the omitted variables, denoted by ... in the equation, determine the steady-state level of output per "effective" worker in the neoclassical growth model of a closed economy. A change in any of these variables, such as the saving rate, affects the growth rate for given values of the state variables. But we assume for now that these other variables are held constant.

In the neoclassical growth model, the effects of the control and environmental variables on the growth rate can be ascertained from their influences on the steady-state position. For example, a higher value of I/Y raises the steady-state ratio of output to effective worker; the growth rate, Dy_t, accordingly tends to rise for given values of the state variables. Similarly, if G/Y does not directly affect productivity, but is associated with greater distortions (because of the governmental activities themselves or because of the associated public finance), then a higher G/Y implies a lower steady-state position and hence, a lower growth rate for given values of the state variables.

We view the black-market premium on foreign exchange as a proxy for market distortions, whether due to exogenous government policies or to reactions to external shocks, such as changes in the terms of trade. (The black-market premium is also a desirable variable because it is objectively measurable and widely available.) Thus, we anticipate that a higher black-market premium, like other governmental distortions, lowers the steady-state level of output per effective worker and therefore reduces the growth rate for given values of the state variables.

We view an increase in political instability, represented say by the propensity to experience revolutions, as equivalent to a decline in the security of property rights. As with an increase in tax rates or other governmental distortions, the worsening of property rights tends to lower the steady-state level of output per effective worker and, consequently, reduce the growth rate for given values of the state variables.

The Data on Educational Attainment

The figures on educational attainment are the ones that we assembled previously (Barro and Lee [1993]). Briefly, these data begin with census/survey information on schooling of the adult population (aged 25 and over[6]) by sex and level. The seven levels

[6]The restriction to age 25 and over was dictated by the available data, but is unfortunate

are no-schooling, incomplete and complete primary, incomplete and complete secondary, and incomplete and complete higher. The data are, however, more plentiful at the four-way classification that does not distinguish incomplete from complete education at each level.

The census information fills about 40% of the possible cells for a panel data set that consists of over 100 countries observed at 5–year intervals from 1960 to 1985. We use information on adult illiteracy to expand the coverage of the no-schooling category beyond this 40% figure. The remaining cells are filled at the four-level classification by a perpetual-inventory method. This method treats the census values as benchmark stocks and uses lagged values of school-enrollment ratios to measure the flows of persons into the various categories of attainment. This procedure introduces errors because the enrollment ratios are well known to be unreliable; for example, the available data are mainly gross figures that overcount school repeaters. Our use of census figures does, however, minimize the reliance on the enrollment numbers. The breakdown into incomplete versus complete attainment at each level is based on the limited information that is available about completion percentages.

The data on school attainment at the various levels are used to measure the average years of attainment by sex for each country and each date (at five-year intervals). This construction takes account of the variations across countries in the typical duration of primary and secondary schools. We should stress, however, that the data do not take account of differences in the quality of schooling across countries or over time. We believe that no useful measures of quality are available for the broad

---

because much of the labor force in developing countries consists of younger persons. The main error, in comparison with say the attainment of the population aged 15 and over, would be in the timing of changes in years of schooling for countries that are experiencing rapid changes in school-enrollment ratios.

sample that we are using. (Information is widely available only on pupil-teacher ratios and public spending on education.)

Regression Results for Growth Rates

A Basic Regression

Table 5 contains the regression results for the growth rate of real per capita GDP. For the basic formulation, 85 countries are included for 1965–75 and 95 countries for 1975–85. Column 1 estimates by the seemingly-unrelated (SUR) technique. This procedure allows for country random effects that are correlated over time. Note, however, from the table that the correlation of the residuals from the growth-rate equations across the two time periods is essentially zero. We discuss later estimation by instrumental procedures.

The variable log(GDP) is an observation for 1965 in the 1965–75 regression and for 1975 in the 1975–85 regression. The estimated coefficient, –.0264 (s.e. = .0030), shows the tendency for conditional convergence that has been reported in previous studies, such as Barro (1991a). 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 coefficient implies that convergence occurs at the rate of 3.1% per year.[7]

The school-attainment variable that turns out to be positively related to subsequent growth is years of male secondary schooling (observed in 1965 and 1975, respectively). The estimated coefficient, 0.0134 (s.e. = 0.0041), means that an

[7]The formula for the convergence coefficient β is $(1-e^{-\beta T})/T = .0264$, where T = 10 years is the observation interval, and .0264 is the magnitude of the estimated coefficient; see Barro and Sala–i–Martin (1992). This formula imples $\beta = .031$ per year.

additional year of secondary schooling raises the growth rate by 1.34 percentage points per year. (The mean of male secondary schooling was 0.73 years (s.d. = 0.69) in 1965, and 1.05 (s.d. = 0.94) in 1975.)

A puzzling finding, which tends to recur, is that the initial level of female secondary education enters negatively in the growth equations; the estimated coefficient is –0.0084 (s.e. = 0.0045). One possibility is that a high spread between male and secondary attainment is a good measure of backwardness; hence, less female attainment signifies more backwardness and accordingly higher growth potential through the convergence mechanism.

We measure life expectancy at birth by an average of values prevailing over the five years prior to the start of each decade: 1960–64 in the first case and 1970–74 in the second. (The results are essentially the same if the values reported for 1965 and 1975 are used instead.) The variable is entered in the form log(life expectancy). This variable is highly significant in the growth regressions: the estimated coefficient is 0.0727 (s.e. = 0.0132). The mean of the life-expectancy variable was 3.99 (s.d. = 0.21) in 1965, corresponding to a mean life expectancy of 55.4 years (s.d. = 11.7), and 4.05 (s.d. = 0.20) in 1975, or a mean life expectancy of 58.7 years (s.d. = 11.2). Therefore, in the 1965–75 equation, a one-standard-deviation increase in life expectancy is estimated to raise the growth rate by 1.5 percentage points per year.

It seems likely that life expectancy has such a strong, positive relation with growth because it proxies for features other than good health that reflect desirable performance of a society. For example, higher life expectancy may go along with better work habits and a higher level of skills (for given measured values of per capita product and years of schooling).

The ratio of real gross domestic investment to real GDP, I/Y, is entered into the regressions as a decade average for 1965–75 and 1975–85, respectively. (The data are from Summers and Heston [1988].) The estimated coefficient is significantly positive, 0.120 (s.e. = 0.020), as is typical of growth regressions. The size of the coefficient means that a rise in I/Y by 10 percentage points raises the growth rate by 1.2 percentage points per year. (The mean of I/Y was 0.19 (s.d. = 0.09) in 1965 and 0.20 (s.d. = 0.07) in 1975.) Even if the decade average of I/Y were regarded as exogenous with respect to the growth rate (see below), it is difficult to use the estimated coefficient to infer a rate of return on capital. Some assumptions about depreciation are required for this calculation.

The variable G/Y is the average over each decade of the Summers and Heston (1988) ratio of real government consumption to real GDP less the ratio of nominal spending on defense and non-capital expenditures on education to nominal GDP.[8] (We do not have deflators available for spending on defense and education.) The elimination of expenditures for defense and education was made because these outlays are not properly viewed as consumption; in particular, they are likely to have direct effects on productivity or the security of property rights. The estimated coefficient of G/Y, –0.170 (s.e. = 0.026), is significantly negative. The mean of G/Y was 0.10 (s.d. = 0.06) in 1965–75 and 0.11 (s.d. = 0.06) in 1975–85. Thus, a one standard-deviation increase in G/Y is associated with a fall in the growth rate by 1.0 percentage points per year.

The variable log(1+BMP), where BMP is the black-market premium on foreign exchange,[9] is measured as an average for each decade. The estimated coefficient is significantly negative, –0.028 (s.e. = 0.005). This variable takes on the value zero for some countries (24 out of 85 for 1965–75 and 22 out of 95 for 1975–85) and has an overall mean of 0.15 (s.d. = 0.20) in the first decade and 0.23 (s.d. = 0.36) in the

---

[8]The data on defense spending are from issues of International Monetary Fund, *Government Finance Statistics*, and *SIPRI Yearbook*. The educational spending numbers are from issues of UNESCO, *Statistical Yearbook*.

[9]These data are from Wood (1988).

second. Thus, a one-standard-deviation increase in the BMP variable in the first decade is estimated to reduce the growth rate by 0.6 percentage points per year.

The revolution variable is the average number of successful and unsuccessful revolutions per year over the full sample, 1960–85.[10] We view this variable as representing the probability of revolution; in this sense, it influences property rights and thereby affects the incentive to invest in various activities. The variable averaged over the full sample turns out to have more explanatory power for growth than the average for each decade entered separately into each decadal equation. This result may indicate that the true probability of revolution is roughly constant over time for an individual country—in this case, the longer average would be better than the decadal figure as an estimate of the probability in each decade.

The estimated coefficient of the revolution variable is significantly negative, –0.0171 (s.e. = 0.0082). For many countries, the variable takes on the value zero (27 out of 85 in the first decade and 30 out of 95 in the second). Overall, the mean of the variable is 0.15 (s.d. = 0.18). Thus, a one-standard-deviation increase in the revolution propensity is associated with a decline by 0.3 percentage points per year in the growth rate. It is, of course, likely that the revolution probability responds to economic outcomes, that is, that the variable is endogenous to growth (see Londregan [19xx]). We consider later an instrumental estimate of this coefficient.

The regressions also include different constant terms for each decade. One notable result is that the excess of the constant for the first period over that of the second period is 0.014 with a t–value of 5.4. Thus, for given values of the explanatory variables, the

[10]The data are from Banks (1979). If a country's observations were missing for part of the period, then we used the average of the numbers for the years that were available.

estimated growth rate for 1975–85 is lower than that for 1965–75 by 1.4 percentage points per year.[11]

Instrumental Estimates

The regression in column 2 of Table 5 is the same as that in column 1 except that lagged values of some of the explanatory variables are used as instruments. The instruments are the five–year lag of log(GDP) (the 1960 value in the first decade and the 1970 value in the second) and the averages of I/Y, G/Y, and log(1+BMP) during the five years preceding each decade. The absence of serial correlation in the residuals of the growth equation suggests that these lagged variables would be good instruments in the present context.

The use of an earlier value of log(GDP) as an instrument lessens the tendency to overestimate the convergence effect because of measurement error in GDP. The use of a lagged value of I/Y as an instrument would tend to lower the estimated coefficient on I/Y if there is reverse causation from growth to investment opportunities and hence, to the investment ratio. The variable G/Y may be negatively related to contemporaneous growth from the mechanical effect whereby an increase in Y lowers G/Y for given G. Wagner's Law—the idea that government spending is a luxury good—would go the other way, but Wagner's Law does not actually hold for government consumption as defined. (It holds well for transfers and educational spending.) The use of the lag of G/Y as an instrument should eliminate these problems. Finally, it is possible that the black-market premium would relate negatively to growth and thereby bias downward

---

[11]The mean growth rate for each decade depends also on the mean values of the regressors. For the 85 countries that were included in the regressions for both decades, the average growth rate in the first period exceeded that in the second period by 1.7 percentage points per year.

the estimated coefficient of the log(1+BMP) variable. The use of the lag of log(1+BMP) as an instrument should correct this problem.

The system in column 2 of Table 5 uses the starting values of school attainment and life expectancy as their own instruments. This procedure seems satisfactory because these variables are predetermined. The revolution variable is also used as its own instrument in column 2 (see below).

A comparison of columns 1 and 2 shows that the changes in the coefficient estimates are minor overall. The main change is a reduction in the estimated coefficient of I/Y from 0.120 (s.e. = 0.020) to 0.077 (s.e. = 0.027). Thus, it is likely that the effect of investment on growth is overstated in the SUR regression of column 1 because of reverse causation from growth to the propensity to invest. For subsequent purposes, we use the instrumental estimates.

Column 3 of the table uses the average number of revolutions per year in the preceding five years (1960–64 for the first decade and 1970–74 for the second) as instruments for the revolution variable. This change has little effect on the results, including the point estimate of the revolution coefficient, but does necessitate a significant reduction in the sample size due to missing data on revolutions in the early part of the sample (see n.10 above). Reverse causation would be important for revolutions, but the linkage is likely to be more from the level of income to the propensity to revolt than from the growth rate to this propensity. Therefore, it is conceivable that economic adversity would promote revolutions, and yet the estimated coefficient of the revolution variable would not be seriously biased in the specification of column 2. In order to avoid the substantial falloff in the number of observations, we therefore return in the subsequent analysis to the specification in which the revolution variable is used as its own instrument.

Columns 4 and 5 of Table 5 show the results when the countries with 1965 per capita GDP below the median ($1350 in 1980 prices) are separated from those above the median. Some differences show up from a comparison of the two columns; for example, the schooling and life-expectancy variables have coefficients with larger magnitude for the poorer countries, whereas the reverse holds for the investment ratio and the black-market premium. The most striking observation, however, is the degree of similarity between the two sets of coefficients, despite the great difference in average levels of real per capita GDP between the two groups ($693 versus $3788 in the first decade and $926 versus $5087 in the second). For example, the estimated coefficient on initial log(GDP) is –0.0239 (s.e. = 0.0078) for the poorer countries and –0.0255 (s.e. = 0.0052) for the richer countries. Thus, the estimated rates of conditional convergence are about the same for the two groups. A likelihood-ratio test for the hypothesis that all eight coefficients are the same between the two groups is not rejected at the remarkably high p-value of 0.96. This result strongly supports the idea of incorporating a broad range of country experience in a single empirical model.

Additional Explanatory Variables

Columns 6–8 of Table 5 add some additional measures of educational attainment. Column 6 shows that the initial values of male and female attainment at the higher level are each insignificant for growth. (The same holds for initial attainment at the primary level.) Theories that rely on discoveries of new kinds of goods as a driving force for technological progress, such as Romer (1990), predict a strong role for human capital in the form of higher education. It is not surprising that this kind of basic innovation—the type of technological progress that would most likely be linked to college education—would be unimportant for most countries, which tend to adopt leading technologies rather than invent fundamentally new things. The higher-education variables are still insignificant, however, if the sample is limited to countries with initial values of real per capita GDP above the median or even to a group of 21 main developed countries.

Column 7 adds the contemporaneous growth rate of male and female secondary schooling over each decade.[12] These variables, rather than the initial levels of schooling that we discussed before, would appear in standard growth-accounting exercises. The exogeneity of the growth rates of attainment can be questioned, although they are largely predetermined by prior years of school enrollment. In any event, the results in column 7 use the growth rates of attainment as their own instruments.

The estimated coefficient of the growth rate of male secondary schooling is significantly positive, 0.29 (s.e. = 0.12), a notable achievement since some previous growth-accounting exercises with different measures of schooling for a broad group of countries fail to find this kind of positive effect (see, for example, Benhabib and Spiegel [1992]). On the other hand, the growth rate of female secondary attainment enters negatively, –0.45 (s.e. = 0.19). Note that the coefficients of the initial levels of secondary attainment remain positive for males and negative for females; in fact, these coefficients each rise in magnitude from the values shown in column 2. We do not have a convincing story to explain the apparently negative growth effect from an increase in female attainment.

Column 8 shows the results when male and female secondary-school enrollment ratios (from issues of UNESCO, *Statistical Yearbook*) are added to the basic regressions. These variables have been frequently used by previous researchers who did not have access to data on stocks of school attainment. The main point of column 8 is that the

[12]The variable for the first decade is $0.1 \cdot \log[(1+\text{secondary attainment in } 1975)/(1+\text{secondary attainment in } 1965)]$ and analogously for the second decade. The inclusion of the 1 avoids problems with very low levels of secondary attainment. The specification means that individuals are effectively endowed with skills equivalent to one year of secondary schooling before they start secondary school.

school-enrollment ratios are insignificant, whereas the measures of starting stocks of attainment enter in about the same way as in column 2.

Columns 9–11 enter U.N. measures of fertility and population growth, variables that have a negative effect on the steady-state level of output per effective worker in the neoclassical growth model. This effect is strengthened in models that introduce time costs of having and raising children. Thus, the usual view is that higher fertility and population growth would lower the growth rate of per capita GDP for given values of the explanatory variables that we have already considered.

Column 9 includes the total fertility rate, the typical woman's prospective number of live births over her lifetime. The form used is the log of the average of fertility rates over each decade, and this variable is used as its own instrument. The estimated coefficient is negative, but marginally insignificant. Column 10 adds the growth rate of population over each decade to the basic regressions. This variable is also entered as its own instrument. The estimated coefficient is negative, but less significant than the fertility variable.

These results differ from those in some other studies because the life-expectancy variable is already included in the equations. The log of life expectancy at the start of each period is negatively correlated with the log of average fertility over the period (–0.83 in the first decade and –0.86 in the second) and population growth (–0.63 in the first period and –0.75 in the second). If life expectancy is omitted from the regressions, then the fertility variable or the growth rate of population have significantly negative coefficient estimates.

Column 11 includes simultaneously the fertility variable and the growth rate of population, with life expectancy also present in the equations. The estimated coefficient on the log of average fertility is now significantly negative, whereas that on the population growth rate is positive and marginally insignificant. For given fertility, a higher population growth rate signals higher net immigration or lower mortality, elements that would plausibly be positively related to growth. (Population growth would, however, also depend on age structure and the ages at which mothers typically have children.)

Column 12 includes as an alternative demographic variable the change in the share of the population that is under age 15 (from U.N. data). An increase in this share tends to lower the per capita growth rate partly because of the increase in the number of persons of non-working age and partly because the work effort of adults would be directed more toward child-rearing. (These effects have been stressed by Sarel [1992].) This population-share variable is significantly negative in the regressions. Also, when this variable is included, the fertility and population-growth variables are insignificant, as is a variable that measures the change in the share of the population aged 65 and over.[13]

Lee (1992) estimated growth equations that included a measure of tariff rates on capital goods and intermediate products. The tariff rate was interacted with an economy's natural openness, which depends on area and distance from other markets. The idea is that an economy that would naturally be more open—because it is small or near to other markets—suffers more when international trade is distorted. Column 13 of Table 5 includes Lee's tariff-rate variable, which is observed only for the single year 1980 for each country. The variable serves as its own instrument. The estimated coefficient is negative, but insignificant. (The sample is also much smaller than before because of the limited availability of the tariff-rate data.)

---

[13]The old-age variable has, however, two offsetting effects. First, if the older people do not work, then an increase in the fraction of the population that is elderly would tend to lower the per capita growth rate. But second, an increase in the old-age fraction would signal an improvement in health (for a given starting value of life expectancy), and this change is likely to be positively correlated with the growth rate.

It is frequently argued that countries, especially developing countries that export mainly primary products, are substantially affected by shocks to the terms of trade. The theoretical effects from changes in the terms of trade on GDP—as opposed to real national income or consumption—are, however, ambiguous. For example, if a drop in the relative price of a country's principal export leads to no change in physical production, then GDP would not change (although the country would be worse off). GDP would fall if the country responded to the shock by lowering production, but it is conceivable that a worsening of the terms of trade would have the opposite impact. In any event, the effects on GDP growth depend on the responses of domestic production to the changed incentives implied by the shift in the terms of trade. One likely influence, for example, 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.

We have computed the growth rate of the ratio of export prices (or export unit values) to import prices (or import unit values) over the two decades, 1965–75 and 1975–85. The data, from *International Financial Statistics*, are limited to about half the countries in the sample. This terms-of-trade variable is entered and used as its own instrument in column 14 of Table 5. The estimated coefficient is positive, but insignificant. (Note that the number of observations falls to 40 in the first decade and 54 in the second.) We think, however, that the analysis of growth effects from changes in the terms of trade warrants further exploration with more and better data.

We have included government-policy variables that relate to consumption spending, market distortions, and political stability. Governments can also influence economic performance by altering various individual rights, such as freedom of speech and the press, freedom to run for office and vote, and so on. Gastil (1987) provides measures of these kinds of civil liberties and political rights in the form of subjective indexes for each country from 1 (most freedom) to 7. (This source unfortunately does not provide good measures of economic freedom or property rights.) We use here the average of the indexes for political rights and civil liberties for each country from 1973, the earliest year available, to 1985.

In an earlier study (Barro [1991b]), the political-rights variable was insignificantly related to growth, once a group of other explanatory variables was held constant. That conclusion still applies in the present setting. Since the measures of political rights and civil liberties are highly correlated (0.96 for the 94 countries with data that are also included in the growth regressions[14]), it is not surprising that the index of civil liberties also turns out to be insignificant if it is added to the basic growth regression. We were surprised to find, however, that the two variables are each statistically significant if they are entered simultaneously into the growth regressions, as shown in column 15 of Table 5. The political-freedom variable is significantly negative, meaning that more freedom is good for growth, whereas the civil-liberties variable is significantly positive, meaning that more liberties are bad for growth. If the two indexes of freedom rise by the same amount, then the net effect on growth is roughly zero, a result that is consistent with prior findings.

It is unclear what effects are picked up in the sample by the differential between political rights and civil liberties. One might argue that political freedoms hold governments in check, whereas civil liberties promote transaction costs. But we do not find any clear linkage between the political-freedom variable and the observable measures of government activity that we used in the regressions: the government-consumption ratio, the black-market premium, and the revolution propensity. (If more political-freedom had negative effects on these variables, then we would have found it plausible that more freedom also had negative effects on unobservable components of

[14]The two variables have nearly the same means; 3.77 for civil liberties and 3.82 for political rights in the sample of 94 countries.

government intervention.) We therefore claim only that the results on political freedom and civil liberties are an interesting topic for further research.

We have already discussed the growth effects of revolution, which we took as a measure of domestic political stability. Economies are also affected by wars with other countries. Our only data on external wars comes from two measures previously constructed by Barro (1991b): WARDUM, a dummy variable for countries that participated in at least one external war over the period 1960–85, and WARTIME, an estimate of the fraction of time over 1960–85 that the country was involved in an external war. Neither of these variables measures the seriousness of the wars (reflected, for example, in expenditures, casualties, or destruction of property) or the outcomes. For the 85 countries in the 1965–75 sample, WARDUM has a mean of 0.39 and WARTIME a mean of 0.058. For the 95 countries in the 1975–85 sample, the means are 0.37 and 0.055, respectively.

Column 16 of Table 5 includes the variable WARDUM, entered as its own instrument. The estimated coefficient is negative, but insignificant. Column 17 includes the variable WARTIME, also entered as its own instrument. The estimated coefficient of this variable is roughly zero. We think, however, that our failure to find important growth effects from external wars involves the poor quality of our data, rather than the unimportance of war.

Finally, column 18 includes regional dummy variables for Sub-Saharan Africa, Latin America, and East Asia. For the countries included in the regressions, the average per capita growth rate from 1965 to 1985 in Sub-Saharan Africa was 1.2 percentage points below that of the overall mean, whereas that in Latin America was 1.0 percentage points below the mean and that in East Asia was 3.2 percentage points above the mean. Significant coefficients on the dummies indicate that the model does not adequately explain the systematic variation in growth rates across these regions.

The estimated coefficients of the Africa and Latin America dummies are significantly negative, −.0116 (s.e. = .0051) and −.0087 (s.e. = .0037), respectively. The estimated coefficient of the East Asia dummy is positive but insignificant, .0040 (s.e. = .0057). Thus, although the Africa and Latin America dummies are smaller and less significant than in some previous research, such as Barro (1991a), the results indicate that the model still does not fully explain why the countries in Sub-Saharan Africa and Latin America experienced below-average growth rates. We return to this issue in the next section. The model does capture the high average growth rates in East Asia.

Sources of Growth for Slow and Fast Growers

The basic equation in column 2 of Table 5 is the source of the fitted values for 1965–75 and 1975–85 for the slow and fast growers that are shown in Tables 3 and 4. The projected growth rates for 1985–95 come from the same estimated model, where the values of the explanatory variables are those applying in 1985 for log(GDP) and secondary schooling and as averages for 1980–84 for G/Y, I/Y, and log(life expectancy). The revolution variable takes on the same value as in the regression samples.[15] We already noted that the fitted values for 1965–75 and 1975–85 explain a substantial part of the observed differences in per capita growth rates between the slow and fast growers. Therefore, although the remaining residual errors in individual country growth rates are also substantial, it is worthwhile to examine the differences in the explanatory variables that generate the differences in the fitted growth rates.

We can break down the fitted and projected values of growth rates into the contributions from each of the eight explanatory variables that appear in the basic

---

[15]The projected growth rates, but not the deviations of these projections from sample means, depend also on the constant term. We used the average of the constants estimated for 1965–75 and 1975–85 to construct the forecasted growth rates shown in Tables 3 and 4. The subsequent discussion deals with deviations from means and therefore does not depend on the constant term.

model shown in Table 5, column 2. This exercise provide a form of "growth accounting" in which the determining variables are, unlike the growth rates of factor inputs, arguably exogenous influences. One observation from this exercise is that the fitted growth rates depend on the combined influence of several factors, rather than from one or two key elements. To bring out some general tendencies, however, we combine the results into regional groups of slow- or fast-growing countries in Table 6. The contributions of the explanatory variables to the fitted growth rate are averaged for six groups. For the slow growers (from Table 3), we examine 14 Sub-Saharan-African countries and 5 Latin-American countries. For the fast growers (from Table 4), we consider four Sub-Saharan-African countries, three Latin-American countries, eight East-Asian countries, and six OECD countries.

To ease the presentation, Table 6 combines the contributions from the initial values of log(GDP), male and female secondary schooling, and life expectancy into a net convergence effect. That is, this variable shows the contribution to the fitted growth rate (as a deviation from the sample mean) for initial per capita GDP, when conditioned on the initial values of human capital per person. The table shows separately the contributions to the fitted growth rate from the investment ratio, I/Y, the government consumption ratio, G/Y, the black-market premium variable, and the revolution variable. The sum of the individual contributions gives the fitted growth rate (as a deviation from the sample mean), as shown in the next to last column of the table. The final column shows the actual average growth rate for the group (also as a difference from the sample mean).

Begin with the 14 slow-growing Sub-Saharan African countries in the period 1965–75. The net convergence effect is close to zero, that is, the positive effect on growth from low initial income is roughly canceled on average by the negative effects from low secondary-school attainment and low life expectancy. The negative value for fitted growth of –0.023 then reflects the contributions from low investment (–0.006), high government consumption (–0.011), moderate distortions as reflected in the black-market premium variable (–0.002), and an adverse effect from political instability as represented by the revolution variable (–0.003). The average of the actual growth performance, –0.028, is somewhat worse than that indicated by the fitted value.

In the 1975–85 decade, the net convergence term switches to positive territory (0.006), basically because levels of per capita GDP fell in the previous decade in relation to secondary attainment and life expectancy. The negative contributions from I/Y and G/Y are about the same as in the previous period (and the contribution from revolutions is the same by construction), but the black-market premium term becomes more adverse (–0.009). This change likely reflects an increase in governmental distortions, possibly triggered by adverse movements in the terms of trade (which we have not held constant). In any event, the fitted growth-rate term is now –0.022, which is well above the actual value of –0.039 (all in relation to sample means).

This failure to explain the extent of the poor growth performance in the slow-growing African countries in 1975–85[16] is the source of the significance of the Africa dummy variable in the regressions discussed before (Table 5, column 18). A likely reason for the underestimate of the extent of the adversity is that the variables included to measure governmental distortions and political instability—G/Y, the black-market premium, and revolutions—understate these difficulties in Africa. A better measure of terms-of-trade shocks—entering partly as a direct effect on growth and partly as a stimulus to bad government policies—might also help in this context.

---

[16]It is not surprising that countries selected for low (or high) growth rates tend also to have negative (or positive) residuals on average. The observations about the slow-growing Sub-Saharan African countries still hold qualitatively, however, if we consider all of Sub-Saharan Africa as a group.

The clearest contrast for the group of 14 slow-growing Sub-Saharan-African countries is the group of 8 fast-growing East-Asian economies. Table 6 shows that the contribution from the net convergence term is substantially positive (0.016) for the East-Asian group in 1965–75. In other words, the initial levels of real per capita GDP were low on average relative to the levels of secondary attainment and life expectancy. The other four terms are also positive: 0.002 for I/Y, 0.006 for G/Y, 0.003 for the black-market premium, and 0.001 for revolutions. In other words, there were favorable growth effects from moderately high investment, markedly low government consumption, a lack of distortions as indicated by a low or zero black-market premium, and the presence of political stability as reflected in a low propensity to revolt. These factors therefore operate all in the direction opposite to that in the slow-growing African countries. Overall, the fitted growth rate for the eight East Asian fast growers in 1965–75 is 0.028, compared with the actual value of 0.031.

For 1975–85, the contribution from the net convergence term for the East-Asian countries falls to 0.008, because GDP rose in relation to the levels of secondary attainment and life expectancy. Three of the other terms become more favorable, however. The contributions are now 0.006 from I/Y, 0.010 from G/Y, and 0.006 from the black-market premium. That is, in 1975–85, the East-Asian economies had even greater positive contributions to growth from high investment, low government consumption, and absence of distortions as reflected in a low or zero black-market premium. The overall fitted growth rate of 0.030 is below the actual value of 0.042 (see n. 16 above).

Finally, the projected growth rates for the eight East-Asian countries in 1985–95 continue the previous trend: the net convergence effect becomes smaller (–0.001), but the other terms maintain or enhance their contributions. Consequently, the projected growth rate for 1985–95, relative to the sample mean, is still the high value of 0.023.

Another natural comparison is between the group of 14 slow-growing Sub-Saharan-African countries and the group of 4 fast-growing Sub-Saharan-African countries. Table 6 shows for 1965–75 that the 14 African slow growers differ from the 4 fast growers most clearly in the net convergence term, which is –0.002 for the former group and 0.022 for the latter.[17] That is, the fast growers have particularly low values of initial GDP in relation to their levels of secondary schooling and life expectancy. The fast growers also get better contributions from I/Y (–0.004 versus –0.006), G/Y (–0.006 versus –0.011), the black-market premium (0.000 versus –0.002), and revolutions (0.002 versus –0.003). In other words, the fast growers have less tendency to have big governments, distortions, and political instability, and have somewhat higher investment ratios. Basically similar conclusions apply for the 1975–85 period.

Two of the African fast growers, Botswana and Lesotho, are neighbors or enclaves of South Africa, and the adjacency of this developed country could provide spillover benefits, such as ready access to capital and skilled managers, which would spur economic growth. Chua (1993) has made this point and has provided some empirical support for its importance. This idea could explain, for example, why the average residual for Botswana for 1965–85 is 0.034 and that for Lesotho is 0.017.[18]

---

[17]The convergence term for Rwanda, one of the fast growers, would be too high if its true real per capita GDP for 1965 were greater than the remarkably low reported value of $152 (1980 U.S. prices), compared with $244 in 1960 and $268 in 1970. If Rwanda is excluded from the group of fast-growing Sub-Saharan-African countries, then the mean contribution from the net convergence effect falls from .022 to .015 for 1965–75, from .010 to .007 for 1975–85, and from .004 to .000 for 1985–95.

[18]An alternative view is that Botswana grew rapidly because of its natural resources, especially diamonds, and similarly that Gabon—another African fast-grower—did well (until 1986) because of its oil. Natural resources do not appear, however, to be a key determinant of economic growth in a broad sample of countries. In particular, if these resources were the key to growth, then the relatively poor performances of Zaire and Nigeria would be hard to explain. (Nigeria is not in the regression samples because of the lack of census data on educational attainment.)

A possible counter claim is that other neighbors of South Africa, such as Mozambique, have not performed well.[19] Mozambique appears on the slow-growers list in Table 3 with growth rates relative to the sample means of –0.038 in 1965–75 and –0.053 in 1975–85. The remarkable thing, however, is that the residuals for Mozambique are strongly positive: 0.021 and 0.032, respectively. For example, in 1965–75, the contributions to the fitted growth rate are –0.024 for net convergence, –0.009 for I/Y, –0.007 for G/Y (estimated from the mean behavior for Sub-Saharan Africa because of missing data), –0.004 for the black-market premium, and –0.015 for revolutions. Thus, a possible interpretation is that, if not for the proximity of South Africa, Mozambique might have grown at 6 percentage points per year below the mean rate (of 2.9% per year) in 1965–75 instead of only 4 percentage points below. Similarly, in 1975–85, it might have grown at 8 percentage points per year below the mean rate (of 1.3% per year), instead of only 5 percentage points below.

Table 6 also allows a comparison between five slow-growing and three fast-growing Latin-American countries (see Tables 3 and 4).[20] For 1965–75, the main differences are the greater contributions from the net convergence term and the black-market premium for the fast growers. In 1975–85, the net convergence effects are similar for the two groups, but the fast growers do better in terms of higher investment, substantially smaller government consumption, and much lower distortions as proxied by the black-market premium. For 1985–95, the net convergence term for the slow growers is larger than that for the fast growers: 0.002 versus –0.007. Nevertheless, the inferior positions

---

[19]Another enclave of South Africa, Swaziland, has a positive residual of 0.014 in the growth regression for 1975–85, but is missing data and was therefore not included in the regression for 1965–75. Another neighbor, Zimbabwe, has a residual of 0.004 for 1965–75, but –0.004 for 1975–85.

[20]Note, however, that two of the fast growers, Brazil and Ecuador, had notably high growth rates only in the 1965–75 period.

of the other variables result in an average projected growth for the slow growers (in relation to the sample mean) of –0.029, compared to –0.002 for the fast growers.

Especially noteworthy are the contributions from the black-market premium for the slow growers of –0.010 in 1975–85 and –0.016 in 1985–95. These effects proxy for a remarkable degree of market distortion in the slow-growing Latin-American countries. The significance of the Latin-American dummy in the growth-rate regressions (Table 5, column 18) likely reflects the failure of the explanatory variables that we have been able to measure to capture fully the extent of the market distortions in this region.

Finally, Table 6 includes the group of six fast-growing OECD countries. In 1965–75, the net convergence effect is positive (0.005), because the relatively high levels of initial per capita GDP are more than offset by the relatively high values of secondary attainment and life expectancy. The other main positive contributions to growth are from high investment (0.008) and low distortions as reflected in low or zero black-market premia (0.004). Overall, the fitted growth rate is 0.020 above the sample mean, compared with an actual value of 0.016.

In 1975–85, the net convergence term for the six OECD countries remains at 0.005. The contribution from investment declines, but that from low distortions (small or zero black-market premia) rises slightly to 0.005. Overall, the fitted growth rate is now 0.017 above the sample mean, compared to an actual value of 0.025.

For 1985–95, the rise in GDP in relation to schooling and life expectancy reduces the net convergence term for the six OECD countries to –0.005. This change lowers the average projected growth rate for the six OECD countries to 0.008 above the sample mean.

<u>Determinants of Fertility, Health, and School Enrollment</u>

The results presented thus far are somewhat disappointing in terms of demonstrating an important role for educational attainment in the growth process. The secondary attainment of males has a significantly positive effect on growth rates, but that of females has a puzzling negative effect. Also, attainment at the primary and higher levels does not have significant explanatory power for growth.

This section provides a preliminary analysis of the influences of educational attainment on the quantity and quality of children, where quantity is measured by the fertility rate and quality by schooling and two health indicators, infant mortality and life expectancy at birth. Previous discussions of these kinds of linkages in developing countries appear in Behrman (1990) and Schultz (1989). Bhalla and Gill (1992) have some preliminary findings for a panel of countries.

Fertility

The first column of Table 7 shows an estimated model for the fertility rate. We use a system of two equations with a wide spacing in time; the variables are observed in 1965 and 1985. In column 1, the coefficients (aside from constants that are not shown) are constrained to be the same for each period. Estimation is by the seemingly-unrelated (SUR) technique, that is, the panel estimation allows each country to have random effects that are correlated over time.

The dependent variable is the log of the total fertility rate, observed in 1965 and 1985. In 1965, the mean of the dependent variable was 1.60, corresponding to a fertility rate of 5.0, and in 1985 the mean was 1.31, or a fertility rate of 3.7.

The independent variables are real per capita GDP (from Summers-Heston [1988]), the total years of female and male school attainment (from Barro and Lee [1993]), the log of life expectancy at birth, and the infant mortality rate (from the U.N.). These variables are also observed in 1965 and 1985. The specification includes a linear and squared term for each regressor, that is, log(fertility) is allowed to respond non-linearly to the contemporaneous values of income, schooling, life expectancy, and infant mortality. (The fits improve somewhat if lagged values of the explanatory variables are also entered into the regressions, but the general nature of the results does not change.)

The terms in brackets in the table indicate the p–values for the joint significance of the linear and squared term for each of the independent variables. Therefore, the first observation from the regressions is that fertility depends significantly on the five pairs of explanatory variables that have been included.

For income, the linear term of 0.69 (s.e. = 0.25) and squared term of –0.053 (s.e. = 0.017) are each significantly different from zero. This configuration of coefficients means that fertility initially rises with income, but subsequently falls. The implied breakpoint is at a real per capita GDP of $665 per year (in 1980 U.S. dollars); hence, only the very poor countries operated in the range in which more income—for given values of the other explanatory variables—meant more fertility. The fraction of countries included in the regressions that were in this range was 25% in 1965 and 21% in 1985.

An interpretation of these results is that at very low incomes—observed for 20–25% of the countries, many of which are in Sub-Saharan Africa—the Malthusian effect dominates, and more income leads to more children (for given education, life expectancy, and infant mortality). For the majority of countries, the effect of more income on fertility is negative. This relation can reflect the increased value of time of parents (for given levels of educational attainment), a substitution of quality of children for quantity as income rises, and increased knowledge about birth control.

The estimated effect on fertility from female years of schooling involves the linear term, –0.119 (s.e. = 0.040), and the squared term, 0.0121 (s.e. = 0.0040). Hence, fertility is estimated to be negatively related to female schooling when the average years of attainment are below 4.9 years, but the relation thereafter becomes positive. The fractions of the sample that fall below the break point were 81% in 1965 and 59% in 1985. Thus, the negative portion of the relation between fertility and female schooling applies for developing countries, in which women have traditionally been the main rearers of children. The relation in this range would reflect the increased value of alternative uses of time for women and perhaps also the women's increased awareness about birth control. It is surprising, however, that the estimated relation between fertility and female schooling is positive for high values of schooling.

For male attainment, the linear term is 0.155 (s.e. = 0.044) and the squared term is −0.0145 (s.e. = 0.0042). The implication is that fertility initially rises with male education, but then declines when the average years of schooling exceed 5.3. The fraction of the countries that fall below this critical value were 69% in 1965 and 52% in 1985. The positive portion of the relation between male schooling and fertility can derive from an income effect. Since males in developing countries presumably spend a small fraction of their time in child-rearing, the substitution effect on fertility from a higher value of male time would not be important.

The results indicate that female and male education have very different effects on fertility. In less-developed countries, more female schooling lowers fertility, whereas more male schooling raises it. These relations appear to reverse for countries with high levels of education.

Fertility choice would also depend on life expectancy and infant mortality. Greater life expectancy raises fertility by increasing the survival rate of mothers and by making children more attractive. On the other hand, a higher life expectancy means that a smaller number of births is required to generate a given number of children who survive to adulthood. Similarly, a higher infant mortality rate makes child creation more costly—which deters fertility—but also raises the number of births required to achieve a given number of survivors.

For life expectancy, the estimated coefficients in Table 7, column 1—14.5 (s.e. = 5.9) on the linear term and –1.88 (s.e. = 0.76) on the squared term—imply that the effect on fertility is positive at low life expectancy, but becomes negative when life expectancy exceeds 47 years. The fractions of countries with life expectancy below this number was 31% in 1965 and 12% in 1985. Thus, the pattern, except for the countries with the lowest life expectancy, is for higher life expectancy to be associated with lower fertility.

For the infant mortality rate, the estimated coefficients are 7.2 (s.e. = 2.5) on the linear term and –25.7 (s.e. = 10.7) on the squared term. The implication is that higher mortality is associated with higher fertility if the mortality rate is less than 14.0%, a condition that holds for 74% of the sample in 1965 and 96% in 1985. Thus, the typical pattern in recent years is that lower infant mortality—like higher life expectancy—goes along with lower fertility.

The fit of the regressions can be gauged by the R^2 values for each of the periods: 0.81 for 1965 (81 countries) and 0.89 for 1985 (89 countries). The residual errors retain some positive correlation even over the 20–year span: the first-order serial correlation coefficient for the residuals is 0.30.

Cross-Sectional and Time-Series Results

The panel regressions reported in column 1 of Table 7 combine cross-sectional and time-series information. We can divide this information into cross-sectional observations, say data for each country on levels of variables for a single year or for sample averages from 1965 to 1985, and time-series observations, say data on the first-differences of variables for 1985 relative to 1965. The latter procedure corresponds to fixed-effects estimation of the panel (if we continue to use only the observations in 1965 and 1985).

Column 2 shows estimates of the equation for fertility from the cross-section of data on levels of variables for 1985, and column 3 shows the estimates from first-differences of the data for 1985 relative to 1965. The coefficients (including the constants, which are not shown) are allowed to differ across the two equations. The system is, however, estimated by the SUR technique, which allows for correlation of the error terms across the equations. In this form, the random-effects model of column 1 amounts to the restricted case of the specification in columns 2 and 3 in which the coefficients of the explanatory variables (other than the constants) across the two equations are constrained to be the same.

Cross-sectional estimates can cause problems because of omitted-variable bias, and the introduction of fixed effects (in this case, for countries) are sometimes thought to alleviate this problem. The time-series estimates, which correspond to the first-differences of the data, can also cause problems, however. For example, measurement errors are exacerbated, especially because the timing of relationships is not precisely known and because the short-term fluctuations in income and other variables may have different effects from the longer-run changes. The confidence in the results increases if the cross-sectional and time-series data provide similar results.[21] Thus, we are particularly interested in tests of the hypothesis that the coefficients estimated for the cross section in column 2 are the same as those estimated for the time series in column 3.

The results for fertility shown in columns 2 and 3 of Table 7 are broadly similar, although the point estimates naturally differ, and the estimated coefficients tend to look less significant than those estimated in column 1. A likelihood-ratio test of the hypothesis that all ten coefficients in columns 2 and 3 are the same indicates that the

[21]The coincidence between the cross-sectional and time-series results does not, of course, guarantee the absence of problems. For example, the bias due to omitted variables could happen to be the same in the cross section and the time series.

hypothesis of equality would not be rejected at conventional significance levels: the p–value is 0.26. We did not anticipate this result, because earlier estimates that used the data on fertility and the other variables at five-or ten-year intervals rejected the hypothesis. In other words, it is only when we use the long-term first-differences at the 20–year interval that we find similarity between the time-series and cross-sectional estimates. Data observed more frequently are no doubt affected much more by problems of timing, distinctions between temporary and permanent changes, measurement error, and so on.

Infant Mortality and Life Expectancy

Columns 4–9 of Table 7 view infant mortality and life expectancy as endogenous variables to be determined by income and education. For example, higher income would lead to improved nutrition, sanitation, and health care, and would thereby tend to reduce infant mortality and raise life expectancy. Similarly, greater education of parents ought to improve the health outcomes of children. Our initial expectation was that this linkage would be greater for female education than for male, again because the mothers are more likely to be involved with child-rearing. An offsetting force, however, is that greater educational attainment may motivate parents, especially females, to shift attention away from children and toward market activities, a response that could weaken or reverse the positive relation between schooling and child health.

The random-effects, panel estimates shown in column 4 of Table 7 imply that infant mortality is significantly related to income and to female and male schooling. The non-linear effects are unimportant for income and female education; in particular, infant mortality is negatively related to per capita GDP and to female years of attainment throughout the sample range. For male schooling, the effect switches from negative to positive when male schooling reaches 6.6 years. The fraction of countries below the critical point was 85% in 1965 and 69% in 1985. It is unclear what effect is picked up by the positive relation between infant mortality and male education for the countries with high levels of school attainment.

Columns 5 and 6 report the separate estimates for cross-sectional and time-series data. In this case, the test of the hypothesis of equal coefficients is rejected; the p–value is 0.00. Our inference is that the estimated coefficients for infant mortality are less likely than those for fertility to represent some kind of causal influences from the independent variables to the dependent variable.

For life expectancy, the results from random-effects, panel estimation in column 7 are broadly similar to those for infant mortality in column 4. Life expectancy is significantly related to income and to female and male schooling. The non-linear effects are again unimportant for income and female education; in particular, life expectancy is positively related to per capita GDP and to female years of attainment throughout the sample range. For male schooling, the effect switches from positive to negative when male schooling reaches 6.5 year, that is, about the same point at which the switch occurs for infant mortality. It is again puzzling that life expectancy would be negatively related to male education for countries with high levels of schooling.

School–Enrollment Ratios

Tables 8–10 report preliminary findings about the determinants of school-enrollment ratios at the three levels, primary, secondary, and higher. We examine here the dependence of a current gross school-enrollment ratio (the number of children enrolled at each level divided by the population of persons of the designated school age) on income and levels of educational attainment. The effects of the school-attainment variables in these equations represent the relation between the stock of education of adults (aged 25 and over) and the current flow of education in the sense of the enrollment ratios for the school-age population. We would like to interpret these relations in terms of the impact of parental schooling on children's choices of schooling, but the aggregate data limit these possibilities. In addition, the enrollment-ratio data are notoriously bad (see Barro and Lee [1993]) and tend especially to overstate the flow of schooling at the primary level in developing countries.

The equations for primary-school enrollment in Table 8 use the same non-linear form that we estimated for infant mortality and life expectancy in Table 7. In the present case, however, the non-linear effect may just capture the overstatement of primary enrollment in developing countries and the consequent tendency of the numbers all to approach 100% or higher by the end of the sample.[22] In any event, the random-effects, panel estimates in column 1 of Table 8 indicate that female primary enrollment is significantly positively related to income and male school attainment for most of the sample range. The estimated effects become negative (probably because of the way the data on primary enrollment are generated) at the upper ends of the variables. The estimated effect of female attainment is also positive throughout most of the range, but these coefficients are only marginally significant (p–value = 0.08). The hypothesis that the cross-sectional and time-series coefficients are the same would not be rejected at usual significance levels; the p–value is 0.21 (see columns 2 and 3).

For male primary enrollment in column 4, income and male schooling are significant, and the effects are again positive throughout most of the sample range. The effects of female attainment are insignificant here. The hypothesis of equality of the cross-sectional and time-series coefficients would not be rejected at conventional significance level; the p–value is 0.18 (see columns 5 and 6).

---

[22]The reported enrollment ratios can exceed 100% because of repeaters and other attendees whose age falls outside of the designated range for the schooling level. We truncated all values that were reported above 100% to 100%.

Overall, the biggest surprise in the results in Table 8 is that male school attainment looks more important than female attainment in the determination of the primary enrollment ratios, even of females. We had anticipated that the schooling of women—that is, of mothers—would be especially important for the schooling decisions of children. This effect does not show up, however, in the aggregate primary-school enrollment ratios.

Table 9 shows regressions for secondary-school enrollment ratios. Since the non-linear terms were unimportant, we report only the results in linear forms. The estimates shown in columns 1 and 4 indicate that, aside from income, female attainment is the key determinant of female enrollment, whereas male attainment is the key determinant of male enrollment. The hypothesis that the cross-sectional and time-series coefficients are the same is not rejected at usual levels (p-values of 0.99 and 0.12, respectively). But, nevertheless, the positive links between enrollment and attainment by sex could reflect the influences of omitted variables that make places more or less conducive to female or male schooling, respectively.

Similar observations apply to the results on higher-school enrollment ratios in Table 10. Some differences, however, are that income has little explanatory power for female enrollment, and female and male attainment are equally significant in the equation for male enrollment.

Summary and Conclusions

Differences in growth rates across countries are large and relate systematically to a set of quantifiable explanatory variables. One element of this set is a net convergence term, the positive effect on growth when initial real per capita GDP is low relative to the starting levels of secondary-school attainment and life expectancy. Growth depends negatively on a group of variables that reflect distortions and the size of government:

the ratio of government consumption to GDP, the black-market premium on foreign exchange, and the frequency of revolutions. Growth depends positively on the ratio of gross investment to GDP, but not as strongly as in some previous studies.

This set of explanatory variables discriminated reasonably well between the countries that grew slowly on average from 1965 to 1985—for example, the 23 countries in the lowest quintile of growth rates—and those that grew quickly—such as the 23 countries in the highest quintile. Although the tendency to grow slowly or quickly attenuated over time, there was enough persistence so that the projected growth rates for 1985–95 had a correlation of over 0.4 with the actual growth rates for 1965–85.

Successful positive analysis of economic performance is a prerequisite for the design of policies that would improve a country's well-being. Thus, an important objective is to use our results on the determinants of economic growth to construct useful policy recommendations, especially for the slow-growing, developing countries that were the focus of much of our discussion.

Many economists jump readily from regression results to policy proposals, although valid inferences of this type are difficult to make. For example, the observation that investment ratios and growth rates are positively related—even when lagged investment ratios are employed as instruments in the growth-rate regressions—does not imply that investment has super-normal returns that warrant government subsidies or additional public projects. Similarly, the positive effects on growth from initial human capital in the forms of educational attainment and health do not necessarily mean that governments are underinvesting in education and health. We think that the safest policy implications that can be drawn at this point from our results involve the harmful effects on growth from distortions of markets (represented in the regressions by the black-market premium variable) and from excessive government spending on consumption items. The results also support the idea that political instability is harmful for growth, although the policy implications are unclear because we do not provide instruction on how governments would enhance political stability.

→ Secondary-school attainment plays a significant role in the growth regressions, but a less important one than life expectancy. Preliminary research shows more important influences of schooling on choices of the quantity and quality of children, effects that should impact on growth in the long run. In particular, female attainment relates inversely to fertility, and female and male attainments relate negatively to infant mortality and positively to life expectancy. We also find that male attainment plays a positive role in primary-school enrollment ratios, whereas male and female attainment each relate positively to enrollment at the secondary and higher levels.

We plan to investigate further the role of school attainment, especially of women, in the determination of fertility (and hence, population growth), health, and schooling of children. Then we shall consider how these channels of effect relate to economic growth, in particular, to the behavior of growth rates that we isolated in the empirical work in the present paper.

Figure 1 Histogram for Growth Rate

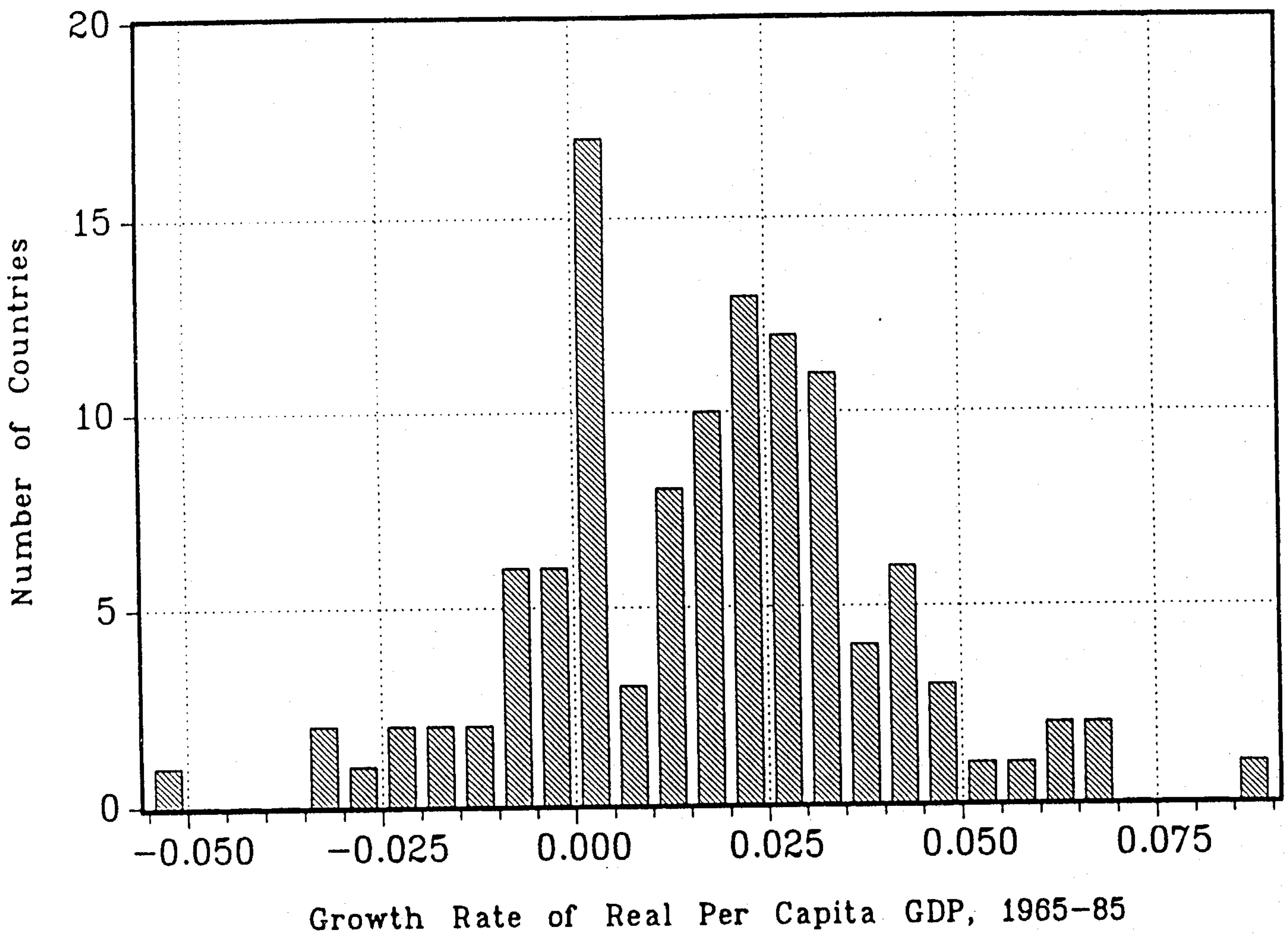

Table 1: Countries in Lowest Quintile of Growth Rates

Summers-Heston v.4		Summers-Heston v.5		World Bank	
country	growth rate	country	growth rate	country	growth rate
Angola	-.025	Angola	-.028	Angola	-.021
Benin	-.009	Benin	-.004	Cent. Afr. Rep.	.000
Cent. Afr. Rep.	-.003	Cent. Afr. Rep.	-.004	Chad	-.022
Chad	-.033	Chad	-.016	Ghana	-.014
Ethiopia	-.002	Gambia	-.010	Liberia	-.005
Ghana	-.021	Ghana	-.012	Madagascar	-.014
Guinea**	.000	Guinea**	.000	Mauritania	.003
Liberia	-.006	Liberia	-.008	Niger	-.020
Madagascar	-.011	Madagascar	-.018	Senegal	-.003
Mozambique**	-.025	Mauritania	-.002	Sudan	.003
Senegal	-.003	Mozambique**	-.029	Tanzania	.002
Somalia	-.006	Niger	-.007	Uganda	-.027
Sudan	-.015	Senegal	-.004	Zaire	-.012
Togo	-.006	Sierra Leone	-.008	Zambia	-.011
Zaire	-.019	Sudan	.002	El Salvador	.000
Zambia	-.019	Zaire	-.011	Haiti	.001
El Salvador	-.004	Zambia	-.022	Jamaica	.000
Jamaica	-.002	Nicaragua	-.018	Nicaragua	-.008
Nicaragua	-.005	Argentina	.001	Venezuela	-.011
Guyana**	-.003	Guyana**	-.005	Afghanistan*	-.003
Venezuela	-.030	Peru	.001	Bangladesh	.002
Iraq**	-.006	Afghanistan*	-.003*	Kuwait	-.062
Kuwait	-.050	Kuwait	-.065		
		Papua New Guinea	.000		

*Data are unavailable in Summers-Heston v.4.

**Data are unavailable from World Bank.

Note: Growth rates refer to real per capita GDP from 1965 to 1985. Summers-Heston v.4 are the purchasing-power adjusted data from Summers and Heston (1988). Summers-Heston v.5 are the purchasing-power adjusted data from Summers and Heston (1991). World Bank values are own-country real growth rates from the World Bank data files, as provided by Ross Levine.

Table 2: Countries in Highest Quintile of Growth Rates

Summers-Heston v.4		Summers-Heston v.5		World Bank	
country	growth rate	country	growth rate	country	growth rate
Botswana	.060	Algeria	.036	Botswana	.087
Cameroon	.034	Botswana	.077	Burundi	.034
Gabon	.044	Cameroon	.039	Congo	.050
Lesotho	.046	Congo	.049	Egypt	.036
Rwanda	.040	Egypt	.052	Tunisia	.036
Tunisia	.040	Gabon	.041	Barbados	.033
Barbados	.044	Lesotho	.060	Brazil	.037
Brazil	.043	Rwanda	.038	Hong Kong	.066
Ecuador	.033	Tunisia	.034	Indonesia	.045
Hong Kong	.061	Brazil	.035	Japan	.052
Indonesia	.048	China* **	.051	Korea	.068
Japan	.051	Hong Kong	.056	Malaysia	.046
Korea	.067	Indonesia	.049	Saudi Arabia	.034
Malaysia	.048	Japan	.045	Singapore	.080
Singapore	.086	Korea	.061	Thailand	.044
Taiwan**	.058	Malaysia	.041	Cyprus	.057
Thailand	.041	Singapore	.068	Finland	.034
Austria	.032	Syria	.037	Greece	.039
Cyprus	.042	Taiwan**	.060	Italy	.034
Greece	.037	Thailand	.037	Malta	.077
Malta	.068	Cyprus	.041	Norway	.036
Norway	.036	Greece	.035	Portugal	.040
Portugal	.035	Malta	.060		
		Portugal	.037		

*Data are unavailable in Summers-Heston v.4.

**Data are unavailable from World Bank.

Note: See Table 1.

Table 3: Details of Low-Growth Countries (based on Summers-Heston v.4)

country	in sample?	growth rate 1965-85	fitted value 1965-85	growth rate 1965-75	fitted value 1965-75	growth rate 1975-85	fitted value 1975-85	proj. growth rate 1985-95	S/H v.5 growth rate 1965-85	World Bk. growth rate 1965-85
Angola	no	-.025	--	-.032	--	-.018	--	--	-.028	-.021
Benin	yes	-.009	.014	-.007	.011	-.012	.019	.038	-.004	.003
C.A.R.	yes	-.003	.003	.006	.008	-.012	-.002	.017	-.004	.000
Chad	no	-.033	(-.022)	-.007	(-.026)	-.060	(-.017)	(.012)	-.016	-.022
Ethiopia	no	-.002	(.013)	.003	(.025)	-.006	(.001)	(.018)	.004	.005
Ghana	yes	-.021	-.006	-.006	.028	-.035	-.037	-.039	-.012	-.014
Guinea	no	.000	--	-.010	--	.010	--	--	.000	--
Liberia	yes	-.006	.012	.020	.016	-.033	.008	.028	-.008	-.005
Madagascar	no	-.011	(.013)	-.003	(.020)	-.018	(.006)	(.029)	-.018	-.014
Mozambique	no	-.025	(-.051)	-.009	(-.030)	-.040	(-.072)	(-.033)	-.029	--
Senegal	yes	-.003	-.004	-.005	-.001	-.001	-.006	.003	-.004	-.003
Somalia	no	-.006	(-.008)	.003	(-.003)	-.016	(-.012)	(.011)	.007	.007
Sudan	yes	-.015	-.017	-.012	-.015	-.018	-.017	.004	.002	.003
Togo	yes	-.006	.024	.019	.027	-.030	.023	.050	.007	.012
Zaire	yes	-.019	.009	.015	.023	-.052	-.001	.028	-.011	-.012
Zambia	yes	-.019	-.006	.003	.009	-.041	-.022	.001	-.022	-.011
El Salvador	yes	-.004	-.002	.014	.009	-.021	-.014	-.011	.004	.000
Jamaica	yes	-.002	.020	.024	.043	-.028	-.003	.014	.004	.000
Nicaragua	yes	-.005	-.011	.010	.010	-.021	-.033	-.035	-.018	-.008
Guyana	no/yes	-.003	(.008)	.029	(.026)	-.036	-.010	-.014	-.005	--
Venezuela	yes	-.030	.002	-.028	.005	-.032	-.002	.013	.006	-.011
Iraq	yes	-.006	-.012	.021	-.011	-.033	-.012	.020	.005	--
Kuwait	no*	-.050	-.029	-.058	-.036	-.043	-.023	.009	-.065	-.062
mean		-.013	-.002	.001	.006	-.028	-.013	.008	-.008	-.007
(no. obs.)		(21)	(21)	(21)	(21)	(21)	(21)	(21)	(21)	(18)

*Data are available, but country was excluded from regressions.

Table 4: Details of High-Growth Countries (based on Summers-Heston v.4)

country	in sample?	growth rate 1965-85	fitted value 1965-85	growth rate 1965-75	fitted value 1965-75	growth rate 1975-85	fitted value 1975-85	proj. growth rate 1985-95	S/H v.5 growth rate 1965-85	World Bk. growth rate 1965-85
Botswana	yes	.060	.026	.074	.039	.046	.013	.020	.077	.087
Cameroon	yes	.034	.026	.031	.028	.037	.026	.032	.039	.030
Gabon	no	.044	--	.088	--	.000	--	--	.041	.030
Lesotho	yes	.046	.028	.056	.043	.036	.014	.018	.060	.026
Rwanda	yes	.040	.038	.083	.063	-.003	.016	.024	.038	.021
Tunisia	yes	.040	.024	.049	.028	.030	.021	.035	.034	.036
Barbados	no/yes	.044	(.030)	.048	(.046)	.039	.019	.028	.025	.033
Brazil	yes	.043	.025	.062	.038	.024	.012	.015	.035	.037
Ecuador	yes	.033	.021	.055	.035	.010	.008	.018	.029	.033
Hong Kong	yes	.061	.055	.051	.065	.070	.045	.043	.056	.066
Indonesia	yes	.048	.031	.042	.033	.054	.031	.034	.049	.045
Japan	yes	.051	.050	.065	.063	.037	.040	.046	.045	.052
Korea	yes	.067	.055	.083	.058	.051	.053	.060	.061	.068
Malaysia	yes	.048	.047	.054	.049	.042	.045	.055	.041	.046
Singapore	yes	.086	.064	.086	.077	.087	.051	.038	.068	.080
Taiwan	yes	.058	.056	.058	.064	.057	.047	.051	.060	--
Thailand	yes	.041	.041	.045	.051	.037	.033	.036	.037	.044
Austria	yes	.032	.032	.041	.028	.024	.035	.036	.030	.032
Cyprus	no/yes	.042	(.048)	.008	(.056)	.076	.043	.032	.041	.056
Greece	yes	.037	.048	.057	.060	.017	.034	.042	.035	.039
Malta	yes	.068	.046	.083	.065	.054	.026	.024	.060	.077
Norway	yes	.036	.029	.032	.034	.039	.027	.023	.033	.036
Portugal	yes	.035	.033	.050	.050	.020	.015	.026	.037	.040
mean (no. obs.)		.048 (22)	.039 (22)	.055 (22)	.049 (22)	.040 (22)	.030 (22)	.033 (22)	.045 (22)	.047 (21)

Notes to Tables 3 and 4: The countries selected are those in the lowest and highest quintiles for growth rates of real per capita GDP from 1965 to 1985, according to Summers-Heston v.4 (Summers and Heston [1988]); see Tables 1 and 2. The classification "in sample" refers to countries included in the growth regressions for the decades 1965-75 and 1975-85, as discussed later. The designation no/yes means that the country is in the second decadal sample but not the first. Growth rates for 1965-85, 1965-75, and 1975-85 are for real per capita GDP as reported in Summers and Heston (1988). The fitted values are from the regressions discussed later. The projected growth rates for 1985-95 are also based on these regressions. Figures shown in parentheses are based in part on approximations to missing data (see Tables 6-11). The S/H v.5 growth rates are calculated from the data in Summers and Heston (1991). The World Bk. growth rates are based on the World Bank data files, as provided by Ross Levine.

Table 5: Regressions for Growth Rate of Real Per Capita GDP, part 1

	(1)	(2)	(3)	(4)	(5)	(6)
Est. method	SUR	3SLS	3SLS (inst. for revolution)	3SLS low income	3SLS high income	3SLS
log(GDP)	-.0264 (.0030)	-.0255 (.0035)	-.0229 (.0038)	-.0239 (.0078)	-.0255 (.0052)	-.0254 (.0035)
Male second. school	.0134 (.0041)	.0138 (.0042)	.0150 (.0042)	.0234 (.0104)	.0089 (.0048)	.0136 (.0043)
Female second. school	-.0084 (.0045)	-.0092 (.0047)	-.0109 (.0047)	-.0270 (.0217)	-.0047 (.0050)	-.0061 (.0050)
log(life exp.)	.0727 (.0132)	.0801 (.0139)	.0733 (.0150)	.0850 (.0242)	.0049 (.0268)	.0806 (.0139)
I/Y	.120 (.020)	.077 (.027)	.084 (.030)	.071 (.051)	.137 (.038)	.076 (.029)
G/Y	-.170 (.026)	-.155 (.034)	-.151 (.035)	-.148 (.052)	-.086 (.050)	-.157 (.035)
log(1+black-mkt. prem.)	-.0279 (.0048)	-.0304 (.0094)	-.0245 (.0090)	-.0181 (.0091)	-.0786 (.0188)	-.0311 (.0094)
revolutions	-.0171 (.0082)	-.0178 (.0089)	-.0158 (.0113)	-.0199 (.0159)	-.0188 (.0120)	-.0164 (.0090)
Male higher school						.000 (.021)
Female higher school						-.021 (.024)
R^2 (no. obs.)	.57 (85) .58 (95)	.56 (85) .56 (95)	.47 (68) .57 (94)	.56 (41) .53 (48)	.56 (44) .58 (47)	.56 (85) .57 (95)
serial corr.	.00	.01	.00	.01	.03	.01

Table 5: Regressions for Growth Rate of Real Per Capita GDP, part 2

Est. method	3SLS (7)	3SLS (8)	3SLS (9)	3SLS (10)	3SLS (11)	3SLS (12)
log(GDP)	-.0247 (.0035)	-.0252 (.0036)	-.0258 (.0036)	-.0257 (.0035)	-.0258 (.0036)	-.0253 (.0034)
Male second. school	.0199 (.0048)	.0133 (.0043)	.0135 (.0042)	.0139 (.0042)	.0119 (.0043)	.0112 (.0042)
Female second. school	-.0162 (.0054)	-.0080 (.0050)	-.0102 (.0048)	-.0095 (.0047)	-.0094 (.0048)	-.0072 (.0047)
log(life exp.)	.0903 (.0148)	.0829 (.0157)	.0701 (.0157)	.0781 (.0148)	.0666 (.0160)	.0643 (.0148)
I/Y	.073 (.027)	.079 (.028)	.063 (.028)	.075 (.027)	.052 (.029)	.082 (.026)
G/Y	-.145 (.033)	-.157 (.034)	-.160 (.034)	-.160 (.034)	-.151 (.035)	-.155 (.033)
log(1+black-mkt. prem.)	-.0276 (.0091)	-.0310 (.0094)	-.0303 (.0097)	-.0306 (.0095)	-.0280 (.0098)	-.0332 (.0091)
revolutions	-.0187 (.0087)	-.0187 (.0090)	-.0168 (.0090)	-.0178 (.0089)	-.0164 (.0092)	-.0132 (.0087)
Growth of male second. school	.289 (.121)					
Growth of fem. second. school	-.453 (.193)					
Male secondary enrollment		.0072 (.0117)				
Female secondary enrollment		-.0119 (.0162)				
log(FERT)			-.0088 (.0064)		-.0238 (.0118)	
Growth rate of population				-.090 (.200)	.57 (.38)	
Change in pop. share under 15						-.185 (.075)
R^2 (no. obs.)	.58 (85) .57 (95)	.56 (85) .56 (93)	.54 (84) .57 (95)	.56 (85) .56 (95)	.53 (84) .57 (95)	.59 (85) .56 (95)
serial corr.	.01	.00	.02	.01	.03	.01

Table 5: Regressions for Growth Rate of Real Per Capita GDP, part 3

Est. method	3SLS (13)	3SLS (14)	3SLS (15)	3SLS (16)	3SLS (17)	3SLS (18)
log(GDP)	-.0250 (.0035)	-.0278 (.0051)	-.0268 (.0035)	-.0253 (.0035)	-.0257 (.0035)	-.0260 (.0038)
Male second. school	.0157 (.0040)	.0113 (.0048)	.0119 (.0044)	.0136 (.0042)	.0139 (.0042)	.0090 (.0044)
Female second. school	-.0100 (.0045)	-.0088 (.0054)	-.0057 (.0050)	-.0089 (.0047)	-.0094 (.0047)	-.0052 (.0047)
log(life exp.)	.0685 (.0145)	.1102 (.0217)	.0791 (.0142)	.0798 (.0139)	.0803 (.0140)	.0712 (.0148)
I/Y	.076 (.026)	.054 (.043)	.085 (.026)	.077 (.027)	.078 (.028)	.078 (.028)
G/Y	-.176 (.033)	-.167 (.048)	-.149 (.033)	-.158 (.034)	-.155 (.034)	-.131 (.037)
log(1+black-mkt. prem.)	-.0324 (.0098)	-.0224 (.0174)	-.0326 (.0091)	-.0260 (.0099)	-.0315 (.0094)	-.0332 (.0087)
revolutions	-.0190 (.0082)	-.0182 (.0157)	-.0136 (.0089)	-.0159 (.0090)	-.0182 (.0092)	-.0163 (.0087)
Tariff rate	-.048 (.076)					
Growth rate of terms of trade		.061 (.072)				
Political freedom			-.0070 (.0026)			
Civil liberties			.0077 (.0030)			
wardum				-.0036 (.0033)		
wartime					.004 (.015)	
Sub-Saharan Africa						-.0116 (.0051)
Latin America						-.0087 (.0037)
East Asia						.0040 (.0057)
R^2 (no. obs.)	.57 (72) .64 (80)	.49 (40) .56 (54)	.59 (84) .56 (94)	.55 (85) .57 (95)	.56 (85) .56 (48)	.57 (85) .60 (95)
serial corr.	.00	.00	.01	.01	.01	.01

Table 6: Sources of Growth for Groups of Countries

Group	Period	Convergence effect (net)	I/Y	G/Y	Black-mkt premium	Revolution	Fitted growth	Actual growth
14 Sub-Saharan	1965-75	-.002	-.006	-.011	-.002	-.003	-.023	-.028
African	1975-85	.006	-.006	-.010	-.009	-.003	-.022	-.039
slow growers	1985-95	.017	-.007	-.011	-.007	-.003	-.010	--
5 Latin-	1965-75	-.009	.000	.002	-.003	-.001	-.011	-.019
American	1975-85	-.004	-.003	-.008	-.010	-.001	-.025	-.041
slow growers	1985-95	.002	-.003	-.011	-.016	-.001	-.029	--
4 Sub-Saharan-	1965-75	.022	-.004	-.006	.000	.002	.014	.032
African	1975-85	.010	.000	-.008	.001	.002	.004	.016
fast growers	1985-95	.004	.001	-.008	.003	.002	.001	--
3 Latin-	1965-75	.004	.002	.002	.000	.000	.010	.026
American	1975-85	-.005	.002	.002	.001	.000	.000	.012
fast growers	1985-95	-.007	.002	.003	.000	.000	-.002	--
8 East-Asian	1965-75	.016	.002	.006	.003	.001	.028	.031
fast growers	1975-85	.008	.006	.010	.006	.001	.030	.042
	1985-95	-.001	.006	.010	.007	.001	.023	--
6 OECD	1965-75	.005	.008	.001	.004	.001	.020	.016
fast growers	1975-85	.005	.005	.001	.005	.001	.017	.025
	1985-95	-.005	.005	.001	.007	.001	.008	--

Note: The groups of countries refer to those shown in Tables 3 and 4. Each entry shows the average contribution of the indicated variable to the fitted growth rate of real per capita GDP (expressed relative to the sample mean). The contributions are averages for the designated group of countries and time period. The net convergence effect is the combined impact from the initial values of log(GDP), male and female secondary school attainment, and log(life expectancy). The fitted growth rate is the sum of the contributions shown separately. The actual growth rate refers to the average deviation from the sample mean for the indicated group of countries and time period.

Table 7: Regressions for Fertility, Infant Mortality, and Life Expectancy

dep. var.	log(FERT) (1)	log(FERT) (2)	log(FERT) (3)	MORT (4)	MORT (5)	MORT (6)
method	SUR panel 1965, 1985	SUR cross-sect. 1985	SUR first-diff. 1985-1965	SUR panel 1965, 1985	SUR cross-sect. 1985	SUR first-diff. 1985-1965
log(GDP)	.69 [.00] (.25)	1.12 [.00] (.33)	.38 [.05] (.32)	-.038 [.00] (.022)	-.019 [.00] (.030)	-.047 [.25] (.028)
log(GDP) squared	-.053 (.017)	-.080 (.022)	-.032 (.021)	.0016 (.0015)	.0001 (.0020)	.0031 (.0018)
Female schooling	-.119 [.01] (.040)	-.152 [.03] (.054)	-.105 [.11] (.051)	-.0044 [.00] (.0034)	-.0094 [.12] (.0052)	-.0023 [.84] (.0041)
Female school sq.	.0121 (.0040)	.0146 (.0053)	.0082 (.0048)	-.00020 (.00034)	.00055 (.00052)	.00012 (.00042)
Male schooling	.155 [.00] (.044)	.140 [.14] (.068)	.126 [.04] (.051)	-.0211 [.00] (.0037)	-.0113 [.16] (.0068)	-.0131 [.01] (.0042)
Male school sq.	-.0145 (.0042)	-.0127 (.0061)	-.0117 (.0047)	.00161 (.00034)	.00066 (.00060)	.00113 (.00040)
log(LIFE)	14.5 [.05] (5.9)	11.7 [.08] (11.2)	17.3 [.04] (6.9)			
log(LIFE) squared	-1.88 (0.76)	-1.61 (1.41)	-2.15 (0.88)			
MORT	7.2 [.02] (2.5)	6.3 [.35] (4.2)	5.4 [.16] (3.0)			
MORT squared	-25.7 (10.7)	-30.1 (19.9)	-15.9 (12.1)			
means of dep. var.	1.60 1.30	1.30	-0.35	0.088 0.060	0.060	-0.034
R^2 (no. obs.)	.81 (81) .89 (89)	.90 (89)	.63 (81)	.78 (84) .85 (92)	.86 (92)	.50 (84)
serial correl.	.30	.26		.51	.00	
test for equal coeffs.		p=0.24			p=0.00	

Table 7, continued

dep. variable	log(LIFE) (7)	log(LIFE) (8)	log(LIFE) (9)
method	SUR panel 1965, 1985	SUR cross-sect. 1985	first-diff. 1985-1965
log(GDP)	.261 [.00] (.073)	.238 [.00] (.099)	.263 [.02] (.092)
log(GDP) squared	-.0129 (.0048)	-.0096 (.0066)	-.0172 (.0060)
Female schooling	.018 [.00] (.011)	.032 [.05] (.017)	.018 [.39] (.013)
Female school squared	.0004 (.0011)	-.0014 (.0017)	-.0017 (.0014)
Male schooling	.065 [.00] (.012)	.032 [.38] (.022)	.033 [.06] (.014)
Male school squared	-.0050 (.0011)	-.0025 (.0020)	-.0024 (.0013)
means of dep. var.	4.03 4.14	4.14	1.30
R^2 (no. obs.)	.82 (84) .88 (91)	.89 (91)	.90 (89)
serial correl.	.53	.00	
test for equal coeffs.		p=0.00	

Notes to Table 7: Standard errors are in parentheses. Numbers in brackets show p-value for joint significance of the linear variable and its squared value. Columns 1, 4, and 7 use SUR estimation of system of two equations, with the dependent variable observed for 1965 and 1985. The coefficients, aside from constants that are not shown, are constrained to be the same for both equations. Columns 2,3; 5,6; 9,10 use SUR estimation of a system with the level of the variable in 1985 and the difference between 1985 and 1965 used as the dependent variables. The coefficients (including constants that are not shown) are allowed to differ across the two equations. FERT is the total fertility rate, MORT is the infant mortality rate, and LIFE is the life expectancy at birth. log(GDP) is the log of real per capita GDP. Female schooling is the average years of attainment for adult females. Male schooling is the average years of attainment for adult males. The R^2 values apply to each of the periods. Serial correl. is the first-order residual serial correlation coefficient implied by the estimated residual correlation matrix. The test for equal coefficients refers to a likelihood-ratio test of the hypothesis that the coefficients are the same in the cross-sectional and first-difference specifications. The p-value for the rejection of the hypothesis is shown.

Table 8: Regressions for Primary School Enrollment Ratios

dep. var.	female primary (1)	female primary (2)	female primary (3)	male primary (4)	male primary (5)	male primary (6)
method	SUR panel 1965, 1985	SUR cross-sect. 1985	SUR first-diff. 1985-1965	SUR panel 1965, 1985	SUR cross-sect. 1985	SUR first-diff. 1985-1965
log(GDP)	.57 [.00] (.17)	.45 [.05] (.19)	.53 [.12] (.26)	.63 [.00] (.15)	.51 [.01] (.18)	.80 [.00] (.24)
log(GDP) squared	-.035 (.011)	-.029 (.013)	-.034 (.017)	-.039 (.010)	-.032 (.012)	-.052 (.016)
Female schooling	.058 [.08] (.027)	.093 [.01] (.032)	-.010 [.35] (.039)	-.027 [.48] (.025)	-.043 [.33] (.030)	-.037 [.43] (.035)
Female school sq.	-.0035 (.0027)	-.0050 (.0033)	-.0028 (.0040)	.0032 (.0025)	.0049 (.0031)	.0011 (.0036)
Male schooling	.119 [.00] (.030)	.101 [.07] (.042)	.089 [.05] (.039)	.101 [.00] (.027)	.149 [.00] (.039)	.034 [.59] (.036)
Male school sq.	-.0080 (.0028)	-.0077 (.0037)	-.0055 (.0038)	-.0076 (.0026)	-.0111 (.0035)	-.0034 (.0034)
means of dep. var.	0.77 0.86	0.86	0.131	0.86 0.93	0.93	0.087
R^2 (no. obs.)	.76 (86) .73 (91)	.72 (91)	.42 (83)	.59 (86) .44 (91)	.86 (92)	.26 (83)
serial correl.	.12	.21		.11	.18	
test for equal coeffs.		p=0.04			p=0.06	

Notes: The dependent variable for columns 1-3 is the gross primary enrollment ratio for females. That in columns 4-6 is the gross primary enrollment ratio for males. See the notes to Table 7 for additional information.

Table 9: Regressions for Secondary School Enrollment Ratios

dep. var.	female secondary (1)	female secondary (2)	female secondary (3)	male secondary (4)	male secondary (5)	male secondary (6)
method	SUR panel 1965, 1985	SUR cross-sect. 1985	first-diff. 1985-1965	SUR panel 1965, 1985	SUR cross-sect. 1985	first-diff. 1985-1965
log(GDP)	.121 (.016)	.124 (.017)	.105 (.031)	.118 (.020)	.116 (.022)	.057 (.036)
Female schooling	.039 (.011)	.036 (.013)	.052 (.021)	-.011 (.014)	-.029 (.016)	.011 (.024)
Male schooling	.018 (.012)	.020 (.014)	.014 (.017)	.057 (.014)	.077 (.018)	.013 (.020)
means of dep. var.	0.26 0.51	0.51	0.28	0.35 0.54	0.54	0.22
R^2 (no. obs.)	.80 (86) .89 (87)	.89 (87)	.31 (80)	.63 (86) .81 (87)	.81 (87)	.07 (80)
serial correl.	.02	.38		.17	.16	
test for equal coeffs.		p=0.99			p=0.12	

Notes: The dependent variable for columns 1-3 is the gross secondary enrollment ratio for females. That in columns 4-6 is the gross secondary enrollment ratio for males. See the notes to Table 7 for additional information.

Table 10: Regressions for Higher School Enrollment Ratios

dep. var.	female higher (1)	female higher (2)	female higher (3)	male higher (4)	male higher (5)	male higher (6)
method	SUR panel 1965, 1985	SUR cross-sect. 1985	first-diff. 1985-1965	SUR panel 1965, 1985	SUR cross-sect. 1985	first-diff. 1985-1965
log(GDP)	.0101 (.0083)	.0068 (.0093)	.0215 (.0132)	.0247 (.0093)	.0224 (.0108)	.0217 (.0137)
Female schooling	.0138 (.0060)	.0110 (.0071)	.0138 (.0085)	.0107 (.0066)	.0001 (.0081)	.0219 (.0089)
Male schooling	.0036 (.0058)	.0080 (.0076)	.0044 (.0074)	.0108 (.0063)	.0241 (.0087)	.0041 (.0076)
means of dep. var.	0.040 0.129	0.129	0.099	0.077 0.162	0.162	0.093
R^2 (no. obs.)	.52 (86) .39 (91)	.54 (91)	.10 (83)	.63 (86) .62 (91)	.64 (91)	.17 (83)
serial correl.	.42	.75		.28	.54	
test for equal coeffs.		p=0.95			p=0.53	

Notes: The dependent variable for columns 1-3 is the gross higher enrollment ratio for females. That in columns 4-6 is the gross higher enrollment ratio for males. See the notes to Table 7 for additional information.

Appendix Table: List of Countries Included in Growth-Rate Regressions

1. Algeria
3. Benin
4. Botswana
7. Cameroon
9. Central Afr. Rep.

12. Congo
13. Egypt*
16. Gambia*
17. Ghana
21. Kenya

22. Lesotho
23. Liberia
25. Malawi
26. Mali
28. Mauritius*

31. Niger
33. Rwanda
34. Senegal
36. Sierra Leone*
38. South Africa

39. Sudan
40. Swaziland*
41. Tanzania
42. Togo
43. Tunisia

44. Uganda
45. Zaire
46. Zambia
47. Zimbabwe
49. Barbados*

50. Canada
51. Costa Rica
53. Dominican Republic
54. El Salvador
56. Guatemala

57. Haiti
58. Honduras
59. Jamaica
60. Mexico
61. Nicaragua

62. Panama
65. Trinidad & Tobago*
66. United States
67. Argentina
68. Bolivia

69. Brazil
70. Chile
71. Colombia
72. Ecuador
73. Guyana*

74. Paraguay
75. Peru
77. Uruguay
78. Venezuela
81. Bangladesh

84. Hong Kong
85. India
86. Indonesia
87. Iran
88. Iraq

89. Israel
90. Japan
91. Jordan
92. Korea
94. Malaysia

95. Nepal
97. Pakistan
98. Philippines
100. Singapore
101. Sri Lanka

102. Syria
103. Taiwan
104. Thailand
106. Yemen (N. Arab)*
107. Austria

108. Belgium
109. Cyprus*
110. Denmark
111. Finland
112. France

113. Germany
114. Greece
117. Ireland
118. Italy
120. Malta

121. Netherlands
122. Norway
124. Portugal
125. Spain
126. Sweden

127. Switzerland
128. Turkey
129. United Kingdom
131. Australia
133. New Zealand

Note: The countries indicated are included in the growth-rate regressions. Those marked with an asterisk are included for 1975-85 but not for 1965-75. The numbers shown are those in the Barro-Lee panel data set (to be distributed at a future date).