Robert Barro: *Determinants of Economic Growth: A Cross-Country Empirical Study*, MIT Press, 1998, str. 12–35.

to the mean (the rate of convergence) and the variance of random shocks to height (or GDP). If the determinants of the long-run distribution do not change, then dispersion would tend to rise or fall depending on whether it happened to start below or above its long-run value. Moreover, if the underlying determinants stay constant for a long time, then the observed distribution for a large population would remain fixed (despite the presence of the convergence tendency).

Empirically, for 114 countries with data, the standard deviation of the log of real per capita GDP rose from 0.89 in 1960 to 1.14 in 1990. This observation of increased inequality does not reject the convergence implications of the neoclassical growth model, partly because the predicted convergence is only conditional and partly because the poor tending to grow faster than the rich is not the same as a declining trend in inequality.

Empirical Findings on Growth Across Countries

Table 1.1 shows results from regressions that use the general framework of equation 1.1. The regressions apply to a panel of roughly one hundred countries observed from 1960 to 1990.[3] The dependent variables are the growth rates of real per capita GDP over three periods: 1965–1975, 1975–1985, and 1985–1990.[4] (The first period begins in 1965 rather than 1960, so that the 1960 value of real per capita GDP can be used as an instrument.) Henceforth, the term GDP will be used as a shorthand to refer to real per capita GDP.

Table 1.1
Regressions for per capita growth rate

Independent variable	(1)	(2)
Log(GDP)	−.0254 (.0031)	−.0225 (.0032)
Male secondary and higher schooling	.0118 (.0025)	.0098 (.0025)
Log(life expectancy)	.0423 (.0137)	.0418 (.0139)
Log(GDP) ∗ male schooling	−.0062 (.0017)	−.0052 (.0017)
Log(fertility rate)	−.0161 (.0053)	−.0135 (.0053)
Government consumption ratio	−.136 (.026)	−.115 (.027)
Rule of law index	.0293 (.0054)	.0262 (.0055)
Terms of trade change	.137 (.030)	.127 (.030)
Democracy index	.090[a] (.027)	.094 (.027)
Democracy index squared	−.088 (.024)	−.091 (.024)
Inflation rate	−.043 (.008)	−.039 (.008)
Sub-Saharan Africa dummy		−.0042[b] (.0043)
Latin America dummy		−.0054 (.0032)
East Asia dummy		.0050 (.0041)
R^2	.58, .52, .42	.60, .52, .47
Number of observations	80, 87, 84	80, 87, 84

Table 1.1 (continued)

Notes: The system has three equations, where the dependent variables are the growth rate of real per capita GDP for 1965–1975, 1975–1985, and 1985–1990. The variables GDP (real per capita gross domestic product) and male schooling (years of attainment for the population aged twenty-five and over at the secondary and higher levels) refer to 1965, 1975, and 1985. Life expectancy at birth is for 1960–1964, 1970–1974, and 1980–1984. The variable log(GDP) ∗ male schooling is the product of log(GDP) (expressed as a deviation from the sample mean) and the male upper-level schooling variable (also expressed as a deviation from the sample mean). The rule of law index applies to the early 1980s (one observation for each country). The terms of trade variable is the growth rate over each period of the ratio of export to import prices. The inflation rate is the growth rate over each period of a consumer price index (or of the GDP deflator in a few cases). The other variables are measured as averages over each period. These variables are the log of the total fertility rate, the ratio of government consumption (exclusive of defense and education) to GDP, and the democracy index. Column 2 includes dummy variables for sub-Saharan Africa, Latin America, and East Asia. Individual constants (not shown) are also estimated for each period.

Estimation is by three-stage least-squares (with different instrumental variables used for each equation). The instruments include the five-year earlier value of log(GDP) (for example, for 1960 in the 1965–1975 equation); the actual values of the schooling, life expectancy, rule of law, and terms of trade variables; and, in column 2, the three area dummy variables. Additional instruments are earlier values of the other variables except the inflation rate. For example, the 1965–1975 equation uses the averages of the fertility rate and the government spending ratio for 1960–1964. Dummies for former colonies of Spain or Portugal and for former colonies of other countries aside from Britain and France are included as instruments. The instrument list also includes the cross product of the lagged value of log(GDP) (expressed as a deviation from the sample mean) with the male schooling variable (expressed as a deviation from the sample mean).

The estimation weights countries equally but allows for different error variances in each period and for correlation of these errors over time. The estimated correlation of the errors for column 1 is −0.13 between the 1965–1975 and 1975–1985 equations, 0.05 between the 1965–1975 and 1985–1990

Table 1.1 (continued)

(Notes, continued) equations, and 0.04 between the 1975–1985 and 1985–1990 equations. The pattern is similar for column 2. The estimates are virtually the same if the errors are assumed to be independent over the time periods. Standard errors of the coefficient estimates are shown in parentheses. The R^2 values and numbers of observations apply to each period individually.

[a] p value for joint significance of two democracy variables is 0.0006 in column 1 and 0.0004 in column 2.
[b] p value for joint significance of three dummy variables is 0.11.

Some previous analysis, such as Barro (1991), used a cross-sectional framework; that is, the growth rate and the explanatory variables were observed only once per country. The main reason to extend to a panel setup is to expand the sample information. Although the main evidence turns out to come from the cross-sectional (between-country) variation, the time-series (within-country) dimension provides some additional information. This information is greatest for variables that have varied a good deal over time within countries, such as the terms of trade and inflation.

The underlying theory relates to long-term growth, and the precise timing between growth and its determinants is not well specified at the high frequencies characteristic of business cycles. For example, relationships at the annual frequency would likely be dominated by mistiming and, hence, effectively by measurement error. In addition, many of the variables considered—such as fertility rates, life expectancy, and educational attainment—are not actually measured for many countries at periods finer than five or ten years. These considerations suggest a focus on the determination of growth rates over fairly long intervals. As a compromise with the quest for additional information, I settled on periods of five or ten years; specifically, growth rates were considered for 1965–1975 and 1975–1985 and for a final five-year period, 1985–1990. When the data through 1995 become available, the third period will be lengthened to 1985–1995.

The estimation uses an instrumental-variable technique, where some of the instruments are earlier values of the regressors. (The method is three-stage least squares, except that each equation contains a different set of instruments; see the notes to table 1.1 for details.) This approach may be satisfactory because the residuals from the growth rate equations are essentially uncorrelated across the periods. In any event, the regressions describe the relation between growth rates and prior values of the explanatory variables.

The regression shown in column 1 in table 1.1 includes explanatory variables that can be interpreted as initial values of state variables or as choice and environmental variables. The state variables include the initial level of GDP and measures of human capital in the forms of schooling and health. The GDP level reflects endowments of physical capital and natural resources (and also depends on effort and the unobserved level of technology). The choice and environmental variables are the fertility rate, government consumption spending, an index of the maintenance of the rule of law, the change in the terms of trade, an index of democracy (polit-

ical rights), and the inflation rate. The roles of democracy and inflation will be discussed in the subsequent chapters.

Initial Level of GDP

For given values of the other explanatory variables, the neoclassical model predicts a negative coefficient on initial GDP, which enters in the system in logarithmic form.[5] The coefficient on the log of initial GDP has the interpretation of a conditional rate of convergence. If the other explanatory variables are held constant, then the economy tends to approach its long-run position at the rate indicated by the magnitude of the coefficient.[6] The estimated coefficient of −0.025 (s.e. = 0.003) is highly significant and implies a conditional rate of convergence of 2.5 percent per year.[7] The rate of convergence is slow in the sense that it would take the economy twenty-seven years to get halfway toward the steady-state level of output and eighty-nine years to get 90 percent of the way. Similarly slow rates of convergence have been found for regional data, such as the U.S. states, Canadian provinces, Japanese prefectures, and regions of the main Western European countries (see Barro and Sala-i-Martin 1995, chap. 11).

Figure 1.2 shows the partial relation between growth and the starting level of GDP, as implied by the regression from column 1 of table 1.1. The horizontal axis plots log(GDP) for 1965, 1975, and 1985 for the observations in the regression sample. The vertical axis shows the corresponding growth rate of GDP after filtering out the parts explained by all

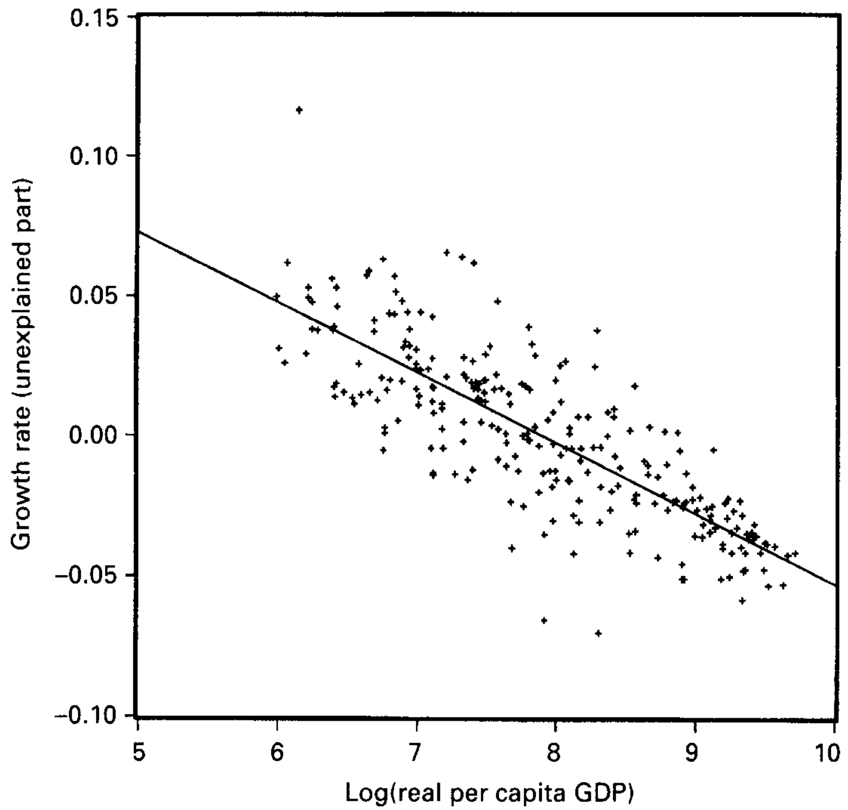

Figure 1.2
Growth rate versus level of GDP

explanatory variables other than log(GDP).[8] Thus, the negative slope shows the conditional convergence relation, that is, the effect of log(GDP) on the growth rate for given values of the other independent variables. In contrast to the lack of a simple correlation in figure 1.1, the conditional convergence relation in figure 1.2 is clearly defined in the graph. Also, the graph indicates that the relation is not driven by a few outliers and does not appear to be nonlinear.

Initial Level of Human Capital

Initial human capital appears in three variables in the system: average years of attainment for males aged twenty-five and over in secondary and higher schools at the start of each period, the log of life expectancy at birth at the start of each period (an indicator of health status),[9] and an interaction between the log of initial GDP and the years of male secondary and higher schooling. The data on years of schooling are updated and improved versions of the figures reported in Barro and Lee (1993).

The results show a significantly positive effect on growth from the years of schooling at the secondary and higher level for males aged twenty-five and over (0.0118 [0.0025]).[10] On impact, an extra year of male upper-level schooling is therefore estimated to raise the growth rate by a substantial 1.2 percentage points per year. (In 1990, the mean of the schooling variable was 1.9 years, with a standard deviation of 1.3 years.) The partial relation between the growth rate and the schooling variable—constructed analogously to the method described for log(GDP) in note 8—is shown in figure 1.3.

Male primary schooling (of persons aged twenty-five and over) has an insignificant effect if added to the system—the estimated coefficient is −0.0005 (0.0011)—whereas that on upper-level schooling remains similar to that found before (0.0119 [0.0025]). Thus, growth is predicted by male schooling at the upper levels but not at the primary level. Primary

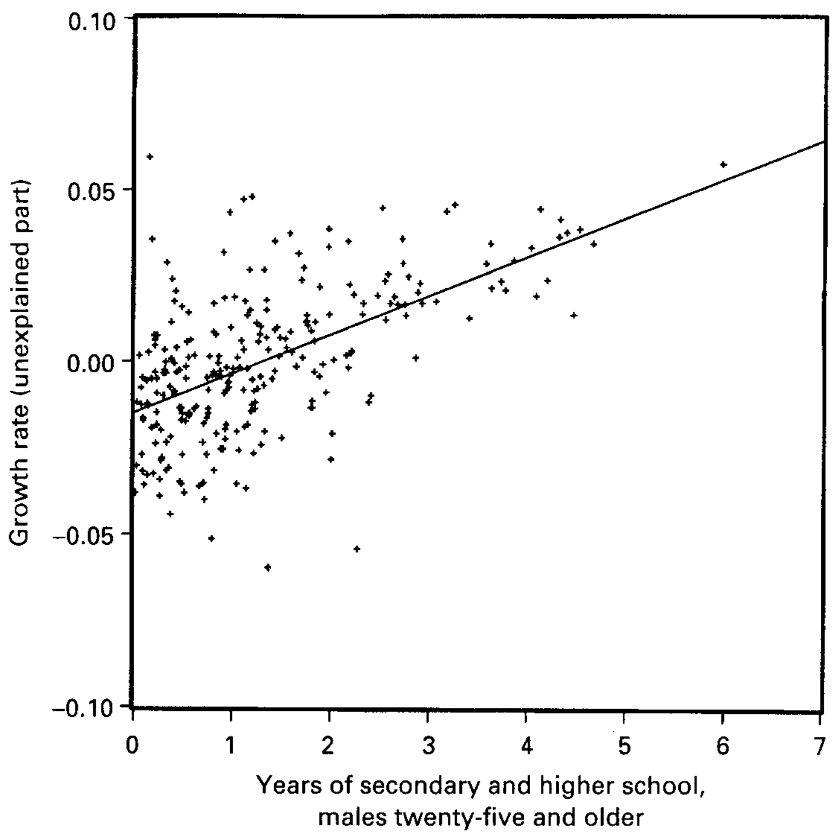

Figure 1.3
Growth rate versus male schooling

schooling, nevertheless, is indirectly growth enhancing because it is a prerequisite for training at the secondary and higher levels.

More surprising, female education at various levels is not significantly related to subsequent growth. For example, if years of schooling at the secondary and higher levels for females aged twenty-five and over is added to the system

shown in column 1 of table 1.1, then the estimated coefficient of this variable is −0.0023 (0.0046), whereas that for males remains significantly positive at 0.0132 (0.0036). For primary schooling of women aged twenty-five and over, the estimated coefficient is −0.0001 (0.0012), whereas that for men (twenty-five and over for secondary and higher schools) is 0.0118 (0.0025). Thus, these findings do not support the hypothesis that education of women is a key to economic growth.[11]

Some additional results indicate that female schooling is important for other indicators of economic development, such as fertility, infant mortality, and political freedom (see the next chapter). Specifically, female primary education has a strong negative relation with the fertility rate (see Schultz 1989, Behrman 1990, and Barro and Lee 1994). A reasonable inference from this relation is that female education would spur economic growth by lowering fertility, and this effect is not captured in the regressions shown in table 1.1 because the fertility rate is already held constant. If the fertility rate is omitted from the system, then the estimated coefficient on female primary schooling (the level of female schooling that affects fertility inversely) is 0.0012 (0.0012), which is positive but not significantly different from zero. Thus, there is only slight evidence that female education enhances economic growth through this indirect channel.

Returning to column 1 of table 1.1, the significantly negative estimated coefficient of the interaction term between male schooling and log(GDP), −0.0062 (0.0017), implies that more years of school raise the sensitivity of growth to the starting level of GDP. Starting from a position at the sample mean, an extra year of male upper-level schooling is estimated to raise the magnitude of the convergence coefficient from 0.026 to 0.032. This result supports theories that stress the positive effect of education on an economy's ability to absorb new technologies. The partial relation between the growth rate and the interaction variable appears in figure 1.4. (The points at the far right of the diagram are for the most developed countries, such as the United States, Canada, and Sweden, which have high values of GDP and schooling.)

The regression in column 1 of table 1.1 also reveals a significantly positive effect on growth from initial human capital in the form of health. The coefficient on the log of life expectancy is 0.042 (0.014). As an interpretation, it may be that life expectancy proxies not only for health status but more broadly for the quality of human capital. The partial relation between growth and life expectancy is shown in figure 1.5.

Fertility Rate

If the population is growing, then a portion of the economy's investment is used to provide capital for new workers rather than to raise capital per worker. For this reason, a higher rate of population growth has a negative effect on y^*, the steady-state level of output per effective worker in

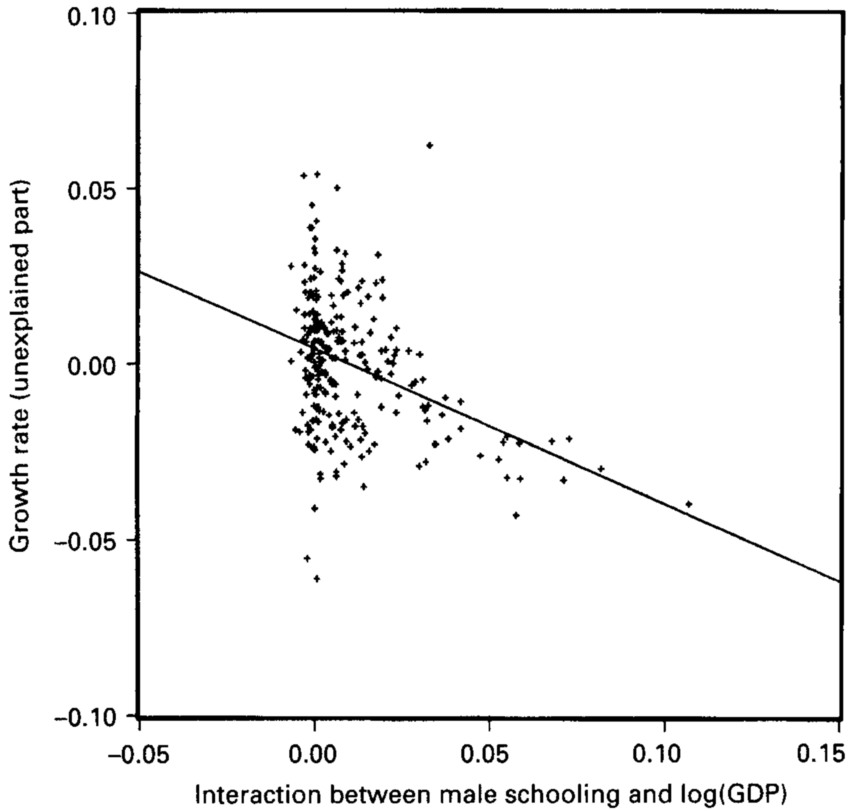

Figure 1.4
Growth rate versus interaction between schooling and level of GDP

the neoclassical growth model. A reinforcing effect is that a higher fertility rate means that increased resources must be devoted to child rearing rather than to production of goods (see Becker and Barro 1988). The regression in column 1 of table 1.1 shows a significantly negative coefficient, −0.016 (0.005), on the log of the total fertility rate. The partial relation between growth and fertility is in figure 1.6.

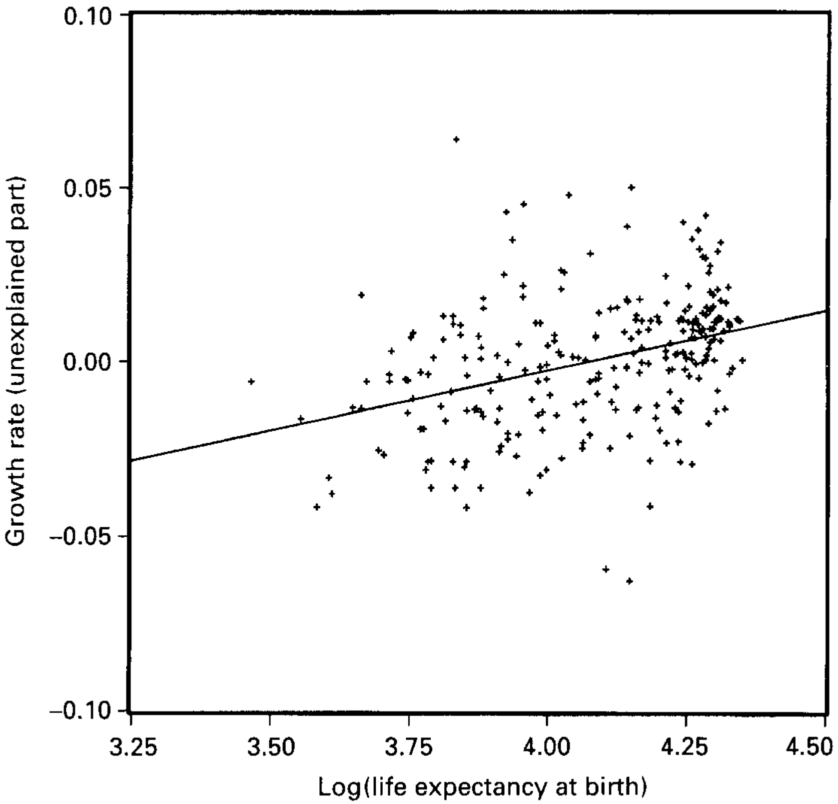

Figure 1.5
Growth rate versus life expectancy

Fertility decisions are surely endogenous; previous research has shown that fertility typically declines with measures of prosperity, especially female primary education (see Schultz 1989, Behrman 1990, and Barro and Lee 1994). The estimated coefficient of the fertility rate in the growth regression shows the response to higher fertility for given values of male schooling, life expectancy, GDP, and so on. Since the average of the fertility rate over the preceding five years

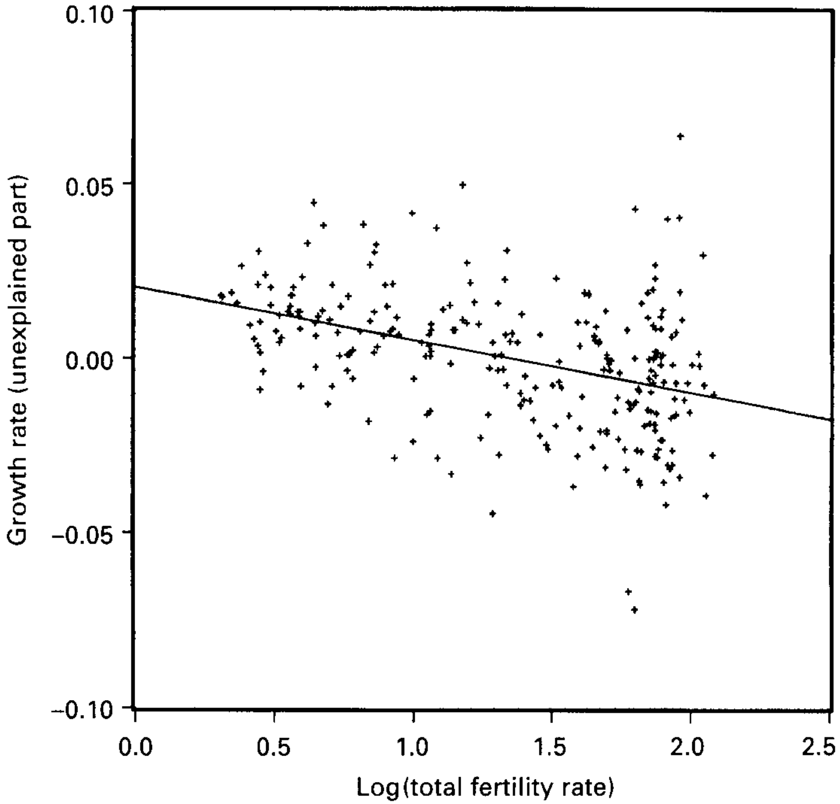

Figure 1.6
Growth rate versus fertility rate

is used as an instrument, the coefficient likely reflects the impact of fertility on growth, rather than vice versa. (In any event, the reverse effect would involve the level of GDP rather than its growth rate.) Thus, although population growth cannot be characterized as the most important element in economic progress, the results do suggest that an exogenous drop in birthrates would raise the growth rate of per capita output.

Government Consumption

The regression in column 1 of table 1.1 shows a significantly negative effect on growth from the ratio of government consumption (measured exclusive of spending on education and defense) to GDP. The estimated coefficient is −0.136 (0.026). (The period average of the ratio enters into the regression, and the average of the ratio over the previous five years is used as an instrument.) The particular measure of government spending is intended to approximate the outlays that do not improve productivity. Hence, the conclusion is that a greater volume of nonproductive government spending—and the associated taxation—reduces the growth rate for a given starting value of GDP. In this sense, big government is bad for growth. The partial relation between growth and the government consumption variable appears in figure 1.7.

The Rule of Law Index

Knack and Keefer (1995) discuss a variety of subjective country indexes prepared for fee-paying international investors and distributed as the *International Country Risk Guide*. (The various time series cover 1982 to 1995 and are available from Political Risk Services of Syracuse, New York.) The concepts covered include quality of the bureaucracy, political corruption, likelihood of government repudiation of contracts, risk of government expropriation, and overall maintenance of the rule of law. The general idea is

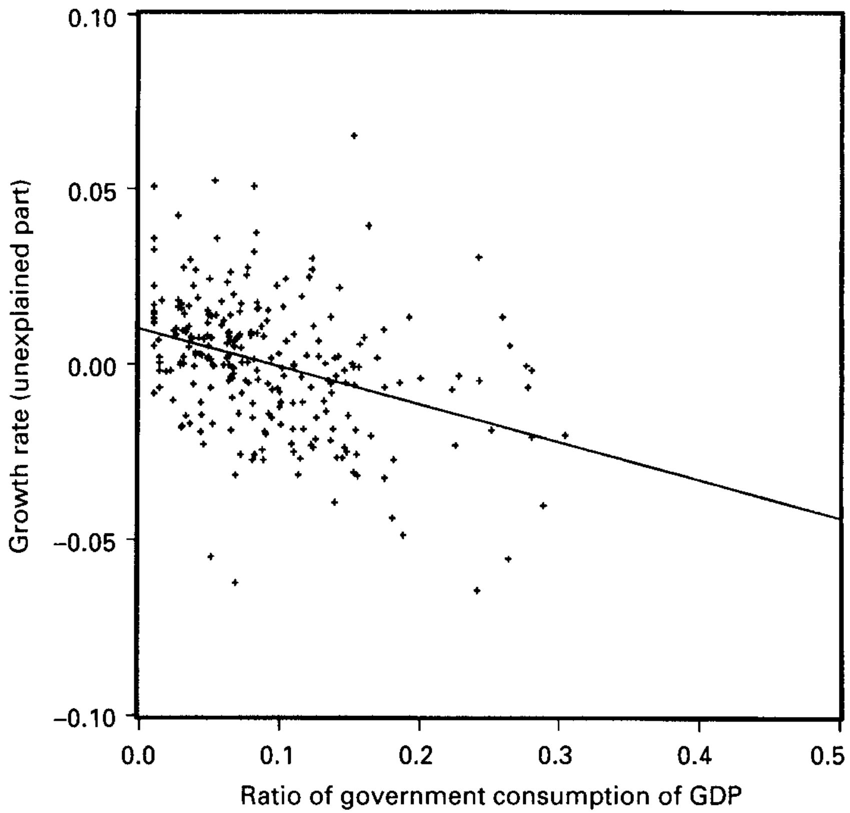

Figure 1.7
Growth rate versus government consumption ratio

to gauge the attractiveness of a country's investment climate by considering the effectiveness of law enforcement, the sanctity of contracts, and the state of other influences on the security of property rights. Although these data are subjective, they have the virtue of being prepared contemporaneously by local experts. Moreover, the willingness of customers to pay substantial fees for this information is perhaps some testament to their validity.

Among the various series available, the indicator for overall maintenance of the rule of law seemed a priori to be most relevant for investment and growth. This indicator was initially measured in seven categories on a 0 to 6 scale, with 6 the most favorable. The scale has been revised here to 0 to 1, with 0 indicating the worst maintenance of the rule of law and 1 the best.

The rule of law variable (observed, because of lack of earlier data, only once for each country in the early 1980s) was included in the regression system reported in column 1 of table 1.1 and has a significantly positive coefficient, 0.0293 (0.0054). (The other measures of investment risk, including political corruption and various indicators of political instability, are insignificant in these kinds of growth regressions if the rule of law index is also included.) The interpretation is that greater maintenance of the rule of law is favorable to growth. Specifically, an improvement by one rank in the underlying index (corresponding to a rise by 0.167 in the rule of law variable) is estimated to raise the growth rate on impact by 0.5 percentage point. The partial relation between growth and the rule of law index is in figure 1.8. (Note that only seven values for the index are observed.)

Terms of Trade

Changes in the terms of trade have often been stressed as important influences on developing countries, which typically specialize their exports in a few primary products. The

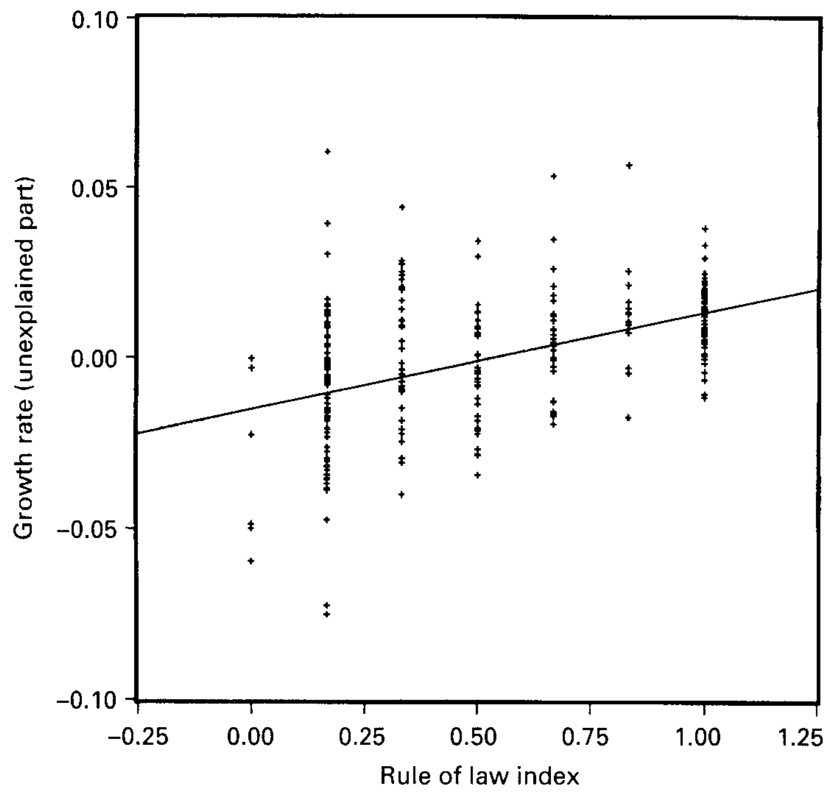

Figure 1.8
Growth rate versus rule of law index

effect of a change in the terms of trade, measured as the ratio of export to import prices, on GDP is, however, not mechanical. If the physical quantities of goods produced domestically do not change, then an improvement in the terms of trade raises real domestic income and probably consumption but would not affect real GDP. Movements in real GDP occur only if the shift in the terms of trade stimulates a change in domestic employment and output. For example, an oil-importing country might react to an increase in the relative price of oil by cutting back on its employment and production.

The result in column 1 of table 1.1 shows a significantly positive coefficient on the terms of trade: 0.14 (0.03). (The change in the terms of trade is regarded as exogenous to an individual country's growth rate and is therefore included as an instrument.) Thus, an improvement in the terms of trade apparently does stimulate an expansion of domestic output. The partial relation with growth appears in figure 1.9. Although the terms of trade variable is statistically significant, it turns out not to be the key element in the weak growth performance of many poor countries, such as those in sub-Saharan Africa.

Regional Variables

It has often been observed that recent rates of economic growth have been surprisingly low in sub-Saharan Africa and Latin America and surprisingly high in East Asia. For 1975–1985, the mean per capita growth rate for all 124 countries with data was 1.0 percent, compared with −0.3 percent in 43 sub-Saharan African countries, −0.1 percent in 24 Latin American countries, and 3.7 percent in 12 East Asian countries. For 1985–1990, the average growth rate was again 1.0 percent (for 129 places), compared with 0.1 percent in 40 sub-Saharan African countries, 0.4 percent in 29 Latin American countries, and 4.0 percent in 15 East Asian countries. An important question is whether these regions

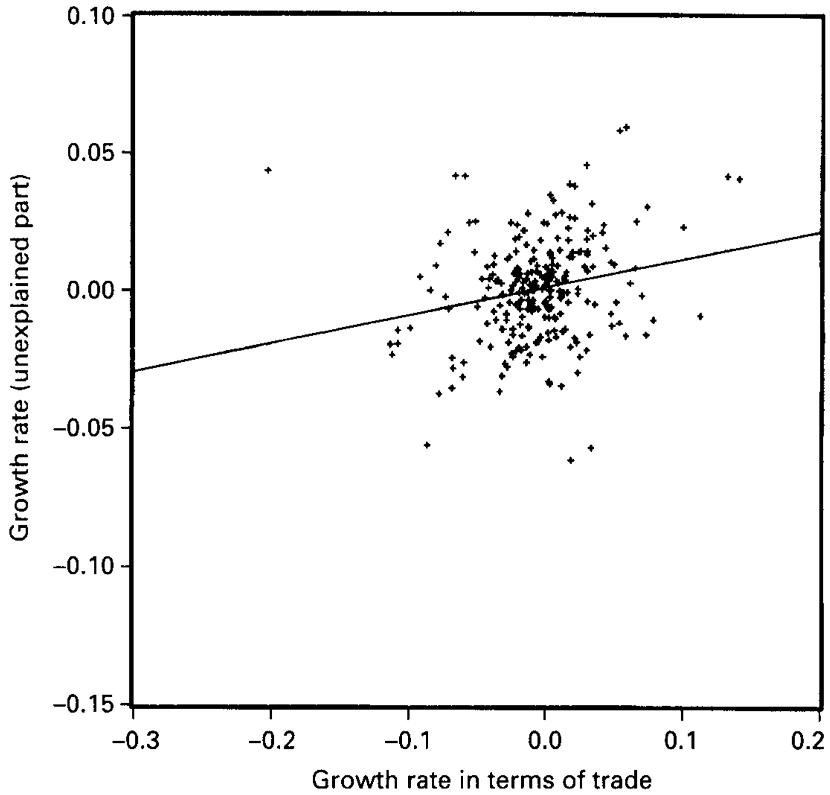

Figure 1.9
Growth rate versus change in terms of trade

continue to look like outliers once the explanatory variables considered in table 1.1 have been taken into account.

In some previous cross-country regression studies, such as Barro (1991), dummy variables for sub-Saharan Africa and Latin America were found to enter negatively and significantly into growth regressions. However, column 2 of table 1.1 shows that dummies for these two areas and also for East Asia are individually insignificant. (The *p* value for joint significance of the three dummy variables is 0.11.) Thus, the unusual growth experiences of these three regions are mostly accounted for by the explanatory variables.

The inclusion of the inflation rate is critical for eliminating the significance of the Latin America dummy (this interaction is discussed in the next chapter). The Latin America dummy also becomes significant if the fertility rate or the government consumption ratio is omitted. In the case of sub-Saharan Africa, the government consumption ratio is the only individual variable whose omission causes the dummy to become significant. For East Asia, the dummy is significant if male schooling, the rule of law indicator, or the democracy variables are deleted.

Investment Ratio

In the neoclassical growth model for a closed economy, the saving rate is exogenous and equal to the ratio of investment to output. A higher saving rate raises the steady-state level of output per effective worker and thereby raises the growth rate for a given starting value of GDP. Some empirical studies of cross-country growth have also reported an important positive role for the investment ratio (see, for example, DeLong and Summers 1991 and Mankiw, Romer, and Weil 1992).

Reverse causation is, however, likely to be important here. A positive coefficient on the contemporaneous investment ratio in a growth regression may reflect the positive relation between growth opportunities and investment rather than the positive effect of an exogenously higher investment ratio on the growth rate. This reverse effect is especially likely to apply for open economies. Even if cross-country differences in saving ratios are exogenous with respect to growth, the decision to invest domestically rather than abroad would reflect the domestic prospects for returns on investment, which would relate to the domestic opportunities for growth.

The system from column 1 of table 1.1 has been expanded to include the period-average investment ratio as an explanatory variable. If the instrument list includes the investment ratio over the previous five years but not the contemporaneous value, then the estimated coefficient on the investment variable is positive but not statistically significant: 0.027 (0.021). In contrast, the estimated coefficient is almost twice as high and statistically significant if the contemporaneous investment ratio is included as an instrument: 0.043 (0.018). These findings suggest that much of the positive estimated effect of the investment ratio on growth in typical cross-country regressions reflects the reverse relation between growth prospects and investment. Blömstrom, Lipsey, and Zejan (1993) reach similar conclusions in their study of investment and growth.

To interpret these results further, table 1.2 shows regression systems in which the dependent variables are the average ratios of investment to GDP for 1965–1974, 1975–1984, and 1985–1989. The independent variables (aside from the

Table 1.2
Regressions for investment ratio

Independent variable	(1)	(2)
Log(GDP)	−.010 (.011)	−.005 (.011)
Male secondary and higher schooling	−.0032 (.0088)	−.0064 (.0085)
Log(life expectancy)	.259 (.050)	.274 (.051)
Log(GDP) * male schooling	−.0004 (.0057)	.0009 (.0055)
Log(fertility rate)	−.0028 (.0192)	.0056 (.0186)
Government consumption ratio	−.264 (.089)	−.216 (.087)
Rule of law index	.092 (.023)	.074 (.024)
Terms of trade change	.074 (.068)	.070 (.064)
Democracy index	.148 (.069)	.168 (.070)
Democracy index squared	−.142 (.061)	−.153 (.062)
Inflation rate	−.053 (.022)	−.036 (.021)
Sub-Saharan Africa dummy		−.013[a] (.019)
Latin America dummy		−.038 (.014)
East Asia dummy		.010 (.017)
R^2	.59, .62, .61	.60, .65, .67
Number of observations	80, 87, 84	80, 87, 84

Table 1.2 (continued)

Notes: The systems correspond to those described in table 1.1, except that the dependent variables are now the average ratios of real investment (private plus public) to real GDP over the periods 1965–1974, 1975–1984, and 1985–1989. The correlation of the errors across the equations is substantial in the systems for investment. For example, for column 1, the correlation between the first and second periods is 0.53, that between the first and third periods is 0.35, and that between the second and third periods is 0.62.

[a] p value for joint significance of three dummy variables is 0.03.

investment ratio) are the same as those used in table 1.1. The key finding in column 1 of table 1.2 is that a number of the variables that are found to enhance the growth rate in table 1.1 also appear as stimulants to investment. In particular, the investment ratio is positively related to life expectancy (a proxy for the quality of human capital) and the rule of law index and negatively related to the government consumption ratio and the inflation rate. The investment ratio also follows the same sort of quadratic relation with democracy that showed up for the growth rate. The effects of democracy are explored in the next chapter.

A reasonable interpretation of the results is that some policy variables—such as better maintenance of the rule of law, lower government consumption, and price stability—encourage economic growth partly by stimulating investment. However, if investment is higher for given values of the policy instruments—perhaps because of variations in thriftiness across economies that lack perfect capital mobility—then the positive effect on growth is weak, as indicated by the estimated coefficient of 0.027 (0.021) on the investment ratio.