

UNIVERSIDAD FRANCISCO MARROQUIN

WORLD ECONOMIC GROWTH, 1980-1999:
A GROWTH-REGRESSION APPROACH

A DISSERTATION SUBMITTED TO THE
SCHOOL OF ECONOMICS
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

by

JULIO H. COLE

Guatemala, September 2003

To Gina, my wife
For her love and understanding

“Nothing in the history of science is ever simple.”

— Steven Weinberg, *Dreams of a Final Theory* (1992), p. 171.

“Life is complicated, but not uninteresting.”

— Jerzy Neyman, quoted by Constance Reid, *Neyman* (1997), p. 3.

“Although rigorous axiomatic theories cannot be called useless, they do not generally make any great contributions to important scientific advances simply because they ignore intuition, which alone can reveal previously unknown facts.”

— Louis de Broglie, *New Perspectives in Physics* (1962), p. 205.

TABLE OF CONTENTS

List of Tables	6
List of Illustrations	7
INTRODUCTION	8
Chapter	
I. THEORETICAL AND EMPIRICAL BACKGROUND	
<i>World Economic Growth, 1980-99: A Descriptive Summary</i>	10
<i>The Solow Growth Model</i>	15
<i>Convergence in Theory and Practice</i>	19
<i>Conditional Convergence: An Empirical Framework for Growth Analysis</i>	26
II. EXTENSIONS OF THE BASIC MODEL	
<i>Introduction</i>	32
<i>Price Distortions and Economic Growth</i>	32
<i>Geography and Economic Growth</i>	36
<i>Which Dependent Variable? Alternative Measures of Economic Growth</i> ..	39
III. RESULTS AND INTERPRETATION	
<i>Introduction</i>	45
<i>Basic Model</i>	46
<i>Economic Freedom in a Neo-Classical Growth Model</i>	47
<i>Geography in a Neo-Classical Growth Model</i>	48
<i>What Does it All Mean?</i>	49
<i>Growth Rate of "Private" GDP</i>	59
<i>Conclusions</i>	59

APPENDIXES

A — Components of Economic Freedom of the World Index	68
B — Data Sources and Definitions	71
C — Statistical Tables	73
REFERENCES	86

LIST OF TABLES

Table

1. World Economic Growth: Summary Statistics, 1960-80 and 1980-99 (average annual rates of growth, real per capita GDP)	11
2. Economic Freedom, per capita Income, and Economic Growth	35
3. GDP per capita and Geographic Variables, 1950, 1990 and 1995	39
4. Determinants of Economic Growth, 1980-99: Regression Results	64
5. Rate of Growth of Private GDP, 1980-99: Further Regression Results	66

LIST OF ILLUSTRATIONS

Figure

1. Growth Rates, 1960-80 vs. 1980-99	12
2. Frequency Distribution of Growth Rates, 106 Countries, 1980-99	14
3. Economic Growth in 106 Countries, 1980-99 (average annual rate of growth, real per capita GDP)	14
4. Growth Rate vs. Initial Income in 106 Countries, 1980-99	21
5. Absolute Convergence in 18 OECD Countries, 1980-99	24
6. Regional Convergence in 32 Mexican States, 1940-95	25
7. GDP per capita by Latitude, 1995	38
8. Government Consumption (% of GDP), world average, 1960-99	41
9. Government Consumption (% of GDP), 146 countries, 1999	42
10. Frequency Distribution of Growth Rates, Private GDP (Total GDP minus Government Consumption) per capita, 1980-99	44
11. Growth Rates of Total and Private GDP per capita, 97 countries, 1980-99	44
12. Investment rate vs. EFW index, 92 countries, 1980-99	56
13. World Fertility Rates, 1960 and 1999	61
14. Barro-Lee Educational Attainment Measure, 92 countries, 1995 (years of schooling per adult aged 15 and over)	62

INTRODUCTION

The purpose of this study is to explain the statistical variation in economic growth rates in a broad cross-section of countries, over the period 1980-99. This problem will be addressed within the framework of the so-called “growth-regression” approach, which seeks to explain this variation by relating economic growth to a list of potential explanatory variables. Though this approach is essentially empirical, it is not “merely” empirical, since the resulting list of explanatory variables must be not only statistically significant, but also meaningful in terms of some theoretical framework. A large number of studies published since the early 1990’s have been based on the so-called “neo-classical theory of economic growth,” and we will follow this approach as a first approximation. These results will then be complemented by evaluating the incremental explanatory power of several additional variables not usually contemplated in the conventional neo-classical approach.

The empirical analysis will be detailed in Chapters II and III. As a preliminary to this analysis, however, and in order to get a better “feel” for the problem, Chapter I will provide a brief descriptive summary of the economic growth experienced by the countries in our sample over the last two decades of the 20th century. (To provide some perspective, this experience will be compared to the growth experienced over 1960-80 for the same sample of countries.) Also, this chapter will provide a review of the relevant theoretical and empirical literature, especially as it has developed over the last decade or so.

Many people have helped me in this undertaking, and I should begin my list of acknowledgements by thanking my thesis advisor, Dr. Robert Higgs, for many helpful comments and suggestions. Thanks are also due to Lucía Olivero, for valuable research assistance, and Professors James Gwartney and Robert Lawson, for critical comments and help in providing some of the datasets. Preliminary presentations of work-in-progress were very useful, and I am grateful to my fellow doctoral students and the faculty members of

the “Colegio Doctoral” at Universidad Francisco Marroquín for their comments and criticisms, especially Dr. Hugo Maul. I also need to thank the students in my “Econometrics” and “Economic Growth” courses at this School of Economics during the 2001 and 2002 sessions, my captive (but not passive) audiences at the earliest stages of this project. Finally, a word of thanks to Prof. Robert Barro, who visited the UFM campus in August 1999 to impart a short course on economic growth, which is the “how” and “when” I started to study and think systematically about this topic.

J. H. C.

Guatemala, June 2003

Chapter 1

THEORETICAL AND EMPIRICAL BACKGROUND

“In theory, there’s no difference between theory and practice. In practice, there is.”

— Yogi Berra (attributed)

World Economic Growth, 1980-99: A Descriptive Summary

The particular measure of economic growth that will be used in this study is the annual rate of growth in real Gross Domestic Product (GDP) per capita. Since GDP is a measure of a country’s production of final goods and services, an increase in this measure, relative to the country’s population, is often interpreted as an improvement in the average level of economic welfare. To be sure, it is often a crude measure, and there are many conceptual difficulties in the definition and interpretation of national accounts data, to say nothing of the practical problems involved in actual measurement (especially in less developed countries). Nonetheless, existing GDP data are often the best measure available for cross-country comparisons, so this has in practice become the standard referent in studies in this field. National accounts data assembled according to internationally comparable standards are available for most major countries in the world (though for most developing countries comprehensive data are available only from about 1960).

Table 1 provides summary statistics for the average annual rate of growth of real per capita GDP in the 106 countries which constitute our basic sample, over the period 1980-99.¹ For comparison, summary statistics for 1960-80 are also shown (data are not available for all countries for 1960-80, hence the smaller sample for that period).

A comparison of the two periods shows that world economic growth appears to have slowed down. The mean rate of growth in per capita GDP was about 1.07 % per annum during 1980-99, quite a bit lower than the mean rate of 2.64 % for 1960-80. (Though these

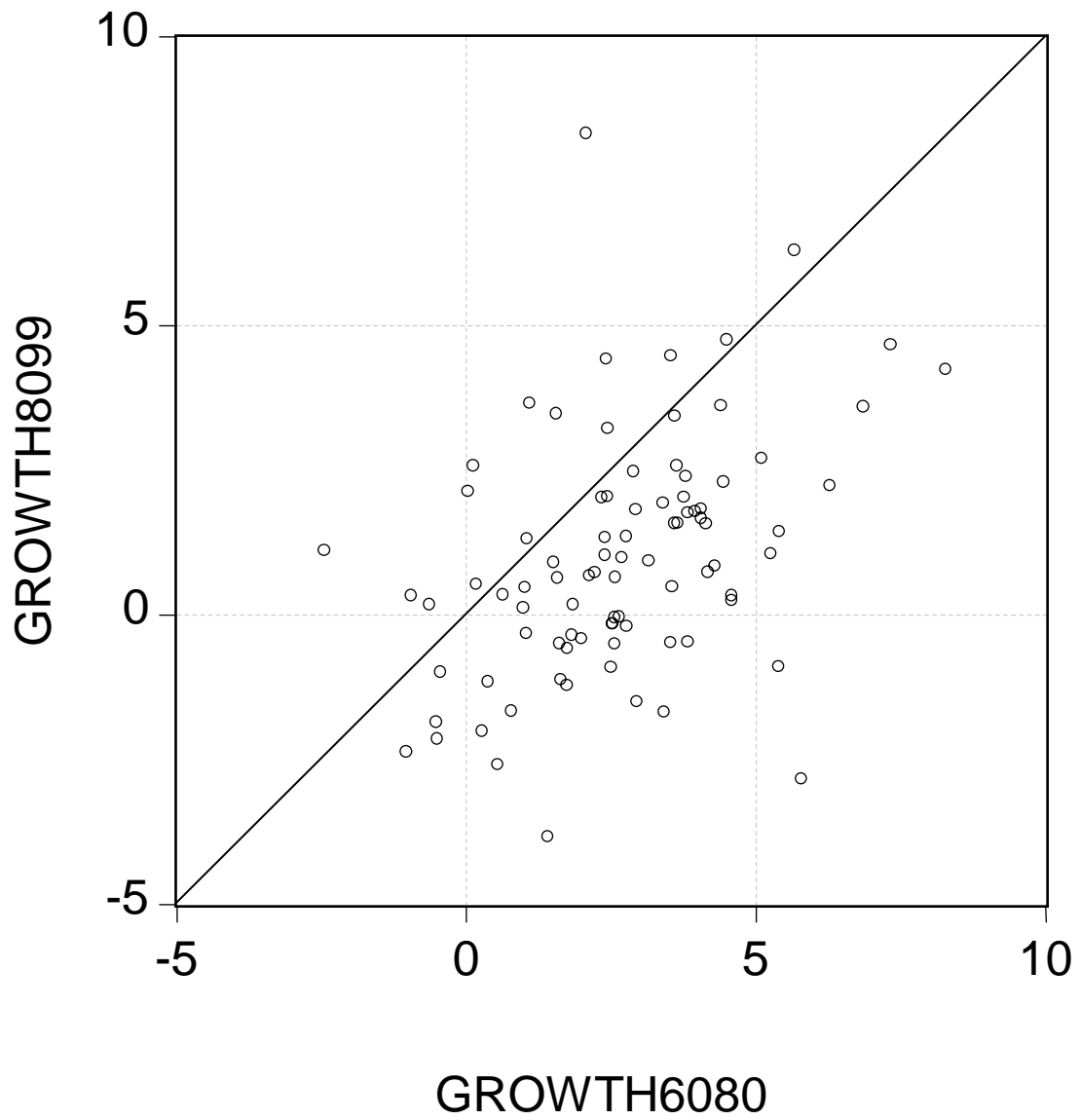
¹A more detailed description of the basic sample is provided in Appendix B.

Table 1 — World Economic Growth: Summary Statistics, 1960-80 and 1980-99 (average annual rates of growth, real per capita GDP).		
	1960-80	1980-99
Mean	2.644	1.069
Median	2.539	0.897
Maximum	8.254	8.346
Minimum	-2.469	-3.812
Std. Deviation	1.960	2.039
Studentized Range	5.469	5.962
N	88	106

means correspond to different sample sizes, the same conclusions obtain from a comparison of median growth rates, which are much less sensitive to changes in sample size.) Another way to appreciate this trend is to look at pair-wise comparisons of countries for which data are available for both periods. This is done in Figure 1, a scatter diagram which plots, for each country, the growth rate for 1960-80 vs. the corresponding growth rate for 1980-99. Notice that most points fall below the 45 degree diagonal, which means that for most countries the growth rate for 1980-99 was lower than for 1960-80. To be sure, this is not invariably the case, and some countries actually had higher growth during 1980-99 than during 1960-80. This is the case, however, in only 15 countries (about 17 % of the 88 countries for which data are available in both periods). Nonetheless, though few in number, the very existence of these “mavericks”—countries that “buck the trend”—serves to illustrate the essential diversity of growth experiences in the different countries that constitute the world economy.

Indeed, the most interesting aspect of the data summarized in Table 1 is not the mean values for the samples, but the *variability* of average growth rates across countries: for 1980-99, these range from a high of 8.34 % per annum (recall that this is the average annual growth rate for that particular country over practically two decades, a remarkable performance), to a low of -3.81 % per annum (an equally remarkable achievement, in its

Figure 1 — Growth Rates, 1960-80 vs. 1980-99.



own way), with a standard deviation of about 2.04.²

The nature of this variation is represented graphically in Figure 2, which shows a frequency distribution of the growth rates for the 1980-99 sample, and in Figure 3, which arrays the 106 countries in descending order according to their growth rates, providing a particularly good visual representation of the wide variation in growth experience over the sample period. Though most countries are located in the middle-range of the chart, with more or less “average” rates of economic growth, the ones that are particularly interesting for purposes of this study are those located at the two extremes of the chart range. On one end are what we might call the “fast-growers”: 31 countries had rates of growth in excess of 2 % per annum (of which 19 had rates in excess of 3 % per annum). On the other end are countries that have not improved at all in this period, but have actually fallen behind: 35 countries (one third of the sample) had *negative* rates of growth in per capita GDP during the sample period. What accounts for this dismal performance?

More generally, what accounts for the observed cross-country variation in economic growth rates? Are there systematic factors at work that explain why some countries are located at the high end of the chart, while others are located at the opposite end? If so, what are those factors, and how do they interact? These are the problems that the theory of economic growth seeks to address.

²The variability of growth rates for the 1960-80 sample period is essentially the same as for 1980-99: average annual growth rates ranged from -2.47 to 8.25 % per annum, with a standard deviation of 1.96. The slightly lower standard deviation during 1960-80 is partly due to the fact that in this period the annual growth rates were averaged over 20 years instead of 19 (for a given variance of annual growth rates, this factor alone would reduce the variance of average annual growth rates by 5 % ($19/20 = 0.95$) and the standard deviation by about 2.5 %). The studentized range statistics indicate that both samples are consistent with a normal distribution—upper and lower critical values for a 5 %, two-tailed test are about 6.01 and 4.11 for $N = 88$, and about 6.14 and 4.24 for $N = 106$ (Pearson and Stephens, 1964, Table 3, p. 486).

Figure 2 — Frequency Distribution of Growth Rates, 106 Countries, 1980-99.

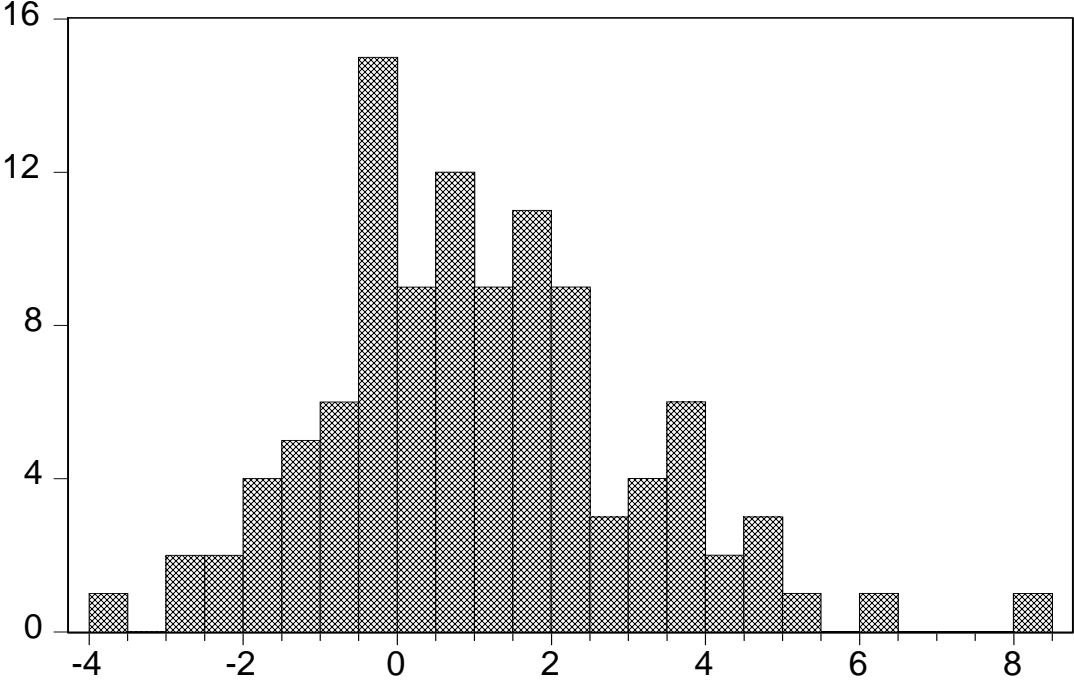
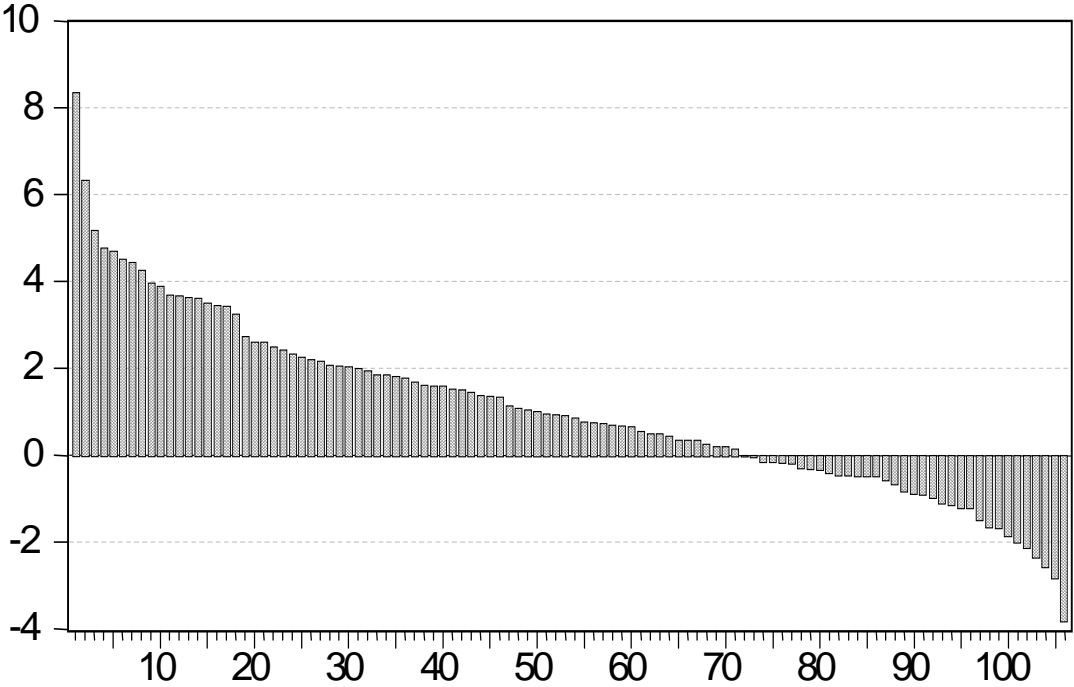


Figure 3 — Economic Growth in 106 Countries, 1980-99 (average annual rate of growth, real per capita GDP).



The Solow Growth Model

The 1990's witnessed a remarkable revival of research activity in the field of economic growth, much of it inspired by two seminal papers by Barro (1991) and Mankiw, Romer and Weil (1992). This new crop of growth studies is characterized by a theory-fact complementarity that was quite lacking in earlier work. Indeed, though much of the earlier work on growth *theory* had achieved a high degree of formal rigor, it was quite divorced from any pretense of real-world relevance. The authors of an exhaustive review and appraisal of the theoretical growth literature as of the early 1960's³ made a point of stressing the very low relevance/rigor ratio in much of the work surveyed:

... for a model to be directly useful for the understanding of reality it should be able to ... yield testable, non-trivial "predictions." Thus, it is well established that there have been substantial differences between countries and between periods in rates of growth. It would be difficult to claim that any of the models we have discussed goes far towards explaining these differences or predicting what will happen to them in the future it may reasonably be argued that most model-builders have not been trying to do this anyway While not disparaging the insights that have been gained, we feel that in these areas the point of diminishing returns may have been reached. Nothing is easier than to ring the changes on more and more complicated models, without bringing in any really new ideas and without bringing the theory any nearer to casting light on the causes of the wealth of nations. The problems posed may well have intellectual fascination. But it is essentially a frivolous occupation to take a chain with links of very uneven strength and devote one's energies to strengthening and polishing the links that are already relatively strong (pp. 889-90).

Interestingly enough, both the older, overly theoretical work which Hahn and Matthews complained about and the more empirically-based work of recent vintage owe much of their inspiration to the neo-classical framework pioneered by Solow (1956), which is based on constant returns to scale and diminishing returns to capital, plus an additional set of highly simplified and stylized assumptions.⁴ In fact, these assumptions are so stringent that, on a first reading, the model seems too artificial to have any direct relevance for real economies. Nonetheless, it does provide some important insights, and serves to highlight

³Hahn and Matthews (1964)—over a hundred pages of text, buttressed by a 12 page bibliography!

⁴This is often referred to as the Solow-Swan model, since Swan (1956) independently developed a similar model leading to essentially the same conclusions.

the manner in which several key variables interact in the growth process. Thus, it serves as a guide for empirical analysis, and should be interpreted as such.⁵

Solow's model postulates a single commodity ($Y =$ "output" or GDP), produced according to an aggregate production function involving two factors of production, "capital" (K) and "labor" (L). The labor force is assumed to grow exogenously at a constant rate n (which in the long-run can be approximated by the population growth rate⁶). No specific form is postulated for the production function (though the Cobb-Douglas form is often invoked as a good first approximation⁷). To allow for technical progress, output is assumed to be a function of "effective labor":

$$Y = f(K, L') = f(K, A(t)L)$$

where $L' = A(t)L$ is the amount of effective labor, and $A(t)$, an index of the state of technology at time t , is a scale factor relating the existing labor force (L) to its equivalent amount of effective labor (L') at any given time. An increase in productivity due to improved technology, represented here as an increase in $A(t)$, is equivalent to an increase in the "effective" labor force since, with a given amount of capital, the same amount of output can be produced with less amounts of actual labor. (Alternatively, with the same amounts of K and L , more output can be produced.) Thus, this type of technical progress is known as "labor-augmenting" or "Harrod-neutral" technical change.⁸ Higher productivity due to

⁵In other words, whatever mathematical properties the model postulates should be recognized for what they are: simplifying abstractions that facilitate the analysis, but not actual descriptions of the real world. The purely mathematical niceties of the resulting models should not be taken too literally.

⁶Of course, to assume that $n =$ population growth rate implies a stable proportion between the labor force and total population, which in turn presupposes two things: (1) the age distribution of the population does not change through time, and (2) rates of labor force participation do not change either.

⁷Cobb and Douglas (1928). For a general discussion of this and other production functions see Walters (1968).

⁸Harrod-neutrality is often contrasted with an alternative representation, known as Hicks-neutrality:

$$Y = A(t)f(K,L)$$

It is not obvious which of these two concepts is the better description of technical progress

labor-augmenting technical change is also assumed to be exogenous, $A(t)$ increasing at a constant rate g . Thus, effective labor will grow at the rate $n+g$. Define $y = Y/L$ (output per unit of labor), $k = K/L$ (capital per unit of labor), $y' = Y/L'$ (output per unit of effective labor), and $k' = K/L'$ (capital per unit of effective labor). As mentioned above, the model assumes decreasing marginal productivities for both capital and labor, and constant returns to scale (e.g., if both capital and labor inputs are doubled, output doubles).⁹ Given constant returns to scale, output per unit of effective labor can be expressed as:

$$y' = Y/L' = f(K/L') = f(k')$$

In addition, the model assumes long-run macroeconomic equilibrium, in the sense that Savings (S) = Investment (I), with a constant propensity to save (invest):

$$S = I = sY$$

(or even whether technical progress should be treated as “neutral” at all). However, it can easily be shown that for the Cobb-Douglas form, they are mathematically equivalent, and amount to the same thing (in fact, it is the *only* production function with this property—see Hahn and Matthews [1964], pp. 825-30 for a general discussion, and Jones [1965] for a graphical presentation). Theoretically, the Solow growth model must assume Harrod-neutrality since, according to a result originally due to Uzawa (1961), it is the only form of technical progress consistent with a steady state solution—see Hahn and Matthews (1964), pp. 828-31, and Burmeister and Dobell (1970), pp. 77-80. For our purposes this is quite convenient, since one main advantage of Harrod-neutrality is that it is analytically more tractable.

⁹More generally, constant returns to scale implies that the production function is homogeneous of degree 1:

$$f(\lambda K, \lambda L') = \lambda f(K, L')$$

A third set of assumptions, the so-called “Inada conditions” (Inada, 1963), are also required:

$$\lim_{K \rightarrow \infty} MP_K = \lim_{L' \rightarrow \infty} MP_{L'} = 0$$

$$\lim_{K \rightarrow 0} MP_K = \lim_{L' \rightarrow 0} MP_{L'} = \infty$$

where MP_K and $MP_{L'}$ represent the marginal products of K and L' , respectively. Though, as Sala-i-Martin (1990a) puts it, they are often “swept under the rug” (p. 20n), these conditions are also necessary to ensure a steady state solution, and hence have mathematical significance, nonsensical as they may seem if interpreted literally. The Cobb-Douglas form satisfies all three sets of assumptions.

where s , the marginal propensity to save, is a constant fraction of current income (output). Assuming also a constant rate of depreciation (δ) of the current capital stock, the growth of the capital stock will be given by the rate of net investment:

$$\Delta K = I - \delta K = sY - \delta K$$

The rate of growth of the capital stock will then be given by:

$$\frac{\Delta K}{K} = \frac{sY - \delta K}{K} = \frac{sY}{K} - \delta$$

Capital per unit of effective labor will then grow at the rate:

$$\frac{\Delta k'}{k'} = \frac{\Delta K}{K} - \frac{\Delta L'}{L'} = \frac{sY}{K} - (n + g + \delta) = s \left[\frac{Y/L'}{K/L'} \right] - (n + g + \delta) = s \left[\frac{f(k')}{k'} \right] - (n + g + \delta)$$

This rate of growth will be positive as long as $s \left[\frac{f(k')}{k'} \right] > (n + g + \delta)$. However, since $f(k')$ increases less rapidly than k' (due to the diminishing returns property of the production function), the left hand side of the inequality will fall as k' rises, and the rate of growth of k' will eventually fall to 0. At that point, k' will stabilize at its “steady state” value. Since k' no longer grows, $y' = f(k')$ will also cease to grow. At that point, the economy is said to have reached its “steady state.”¹⁰

¹⁰In the steady state, both y' and k' are constants, but this does not mean that there is no growth in per capita incomes. What really matters for welfare is not output per effective worker, but output per worker. If productivity due to technical progress increases at rate g , then $y = Y/L$ will have to increase at the same rate to keep y' constant. Therefore, in the Solow model, the rate of growth in per capita incomes is determined by the rate of technical progress once the economy has reached the steady state. An interesting implication of this analysis is that a country’s long-term growth rate does not depend on its savings rate:

... it turned out to be an implication of diminishing returns that the equilibrium rate of growth is not only not proportional to the saving (investment) rate, but is independent of the saving (investment) rate. A developing economy that succeeds in permanently increasing its saving (investment) rate will have a higher level of output than if it had not done so, and must therefore grow faster for a while. But it will not achieve a permanently higher rate of growth of output. More precisely: the permanent rate of growth of output per unit of labor input is independent of the saving (investment) rate and depends entirely on the rate of technological progress in the broadest sense (Solow, 1988, pp. 308-09).

Notice that, since $\frac{f(k')}{k'}$ is a decreasing function of k' , *the rate of growth* of k' (and hence y') will be higher, the farther the economy is from its steady state.

Convergence in Theory and Practice

An important implication of the Solow growth model is that economies should eventually converge to their “steady-state” levels of income. At any given time, some countries will be closer to the steady-state than others, but lagging countries should eventually “catch up.” Of course, the steady-state is not observable, but if a tendency toward “convergence” does in fact exist it would show up, empirically, as a negative correlation between a country’s rate of growth over a given period and its initial level of real income. That is, low-income countries would tend to have higher growth rates than high-income countries. (Otherwise, the predicted convergence would never be achieved, and we would instead observe “divergence” in income levels.)

This is a strong prediction, though at first it could not be tested empirically on the basis of existing national accounts data, since these are expressed in each country’s domestic currency units. Rates of growth are of course dimensionless, and hence can be compared across countries, but to test the convergence hypothesis growth rates need to be related to levels of initial income, which is only possible if these are all expressed in terms of the same currency units. Converting domestic currency GDP figures to a common unit (say, u.s. dollars) via foreign exchange rates is not a workable solution, since the resulting dollar-denominated GDP figures are still not strictly comparable in terms of real income because a “dollar” is not worth the same, in terms of real purchasing power, in different countries. What was required, then, was a set of internationally comparable real income figures, adjusted for the “purchasing power parity” of the dollar in different countries. Ideally, this would be a better measure of comparative economic welfare than simple currency conversions via exchange rates as determined in foreign exchange transactions.

This problem motivated a very large-scale research project (centered at the University of Pennsylvania but involving many other institutions and agencies over several decades) focused on the calculation of appropriate PPP-conversion factors and the compilation of comprehensive sets of internationally comparable GDP accounts. This major investment in

empirical data-gathering paid off by the mid-1980's, and nowadays international income comparisons using "PPP-adjusted" GDP data are regarded as quite routine.¹¹

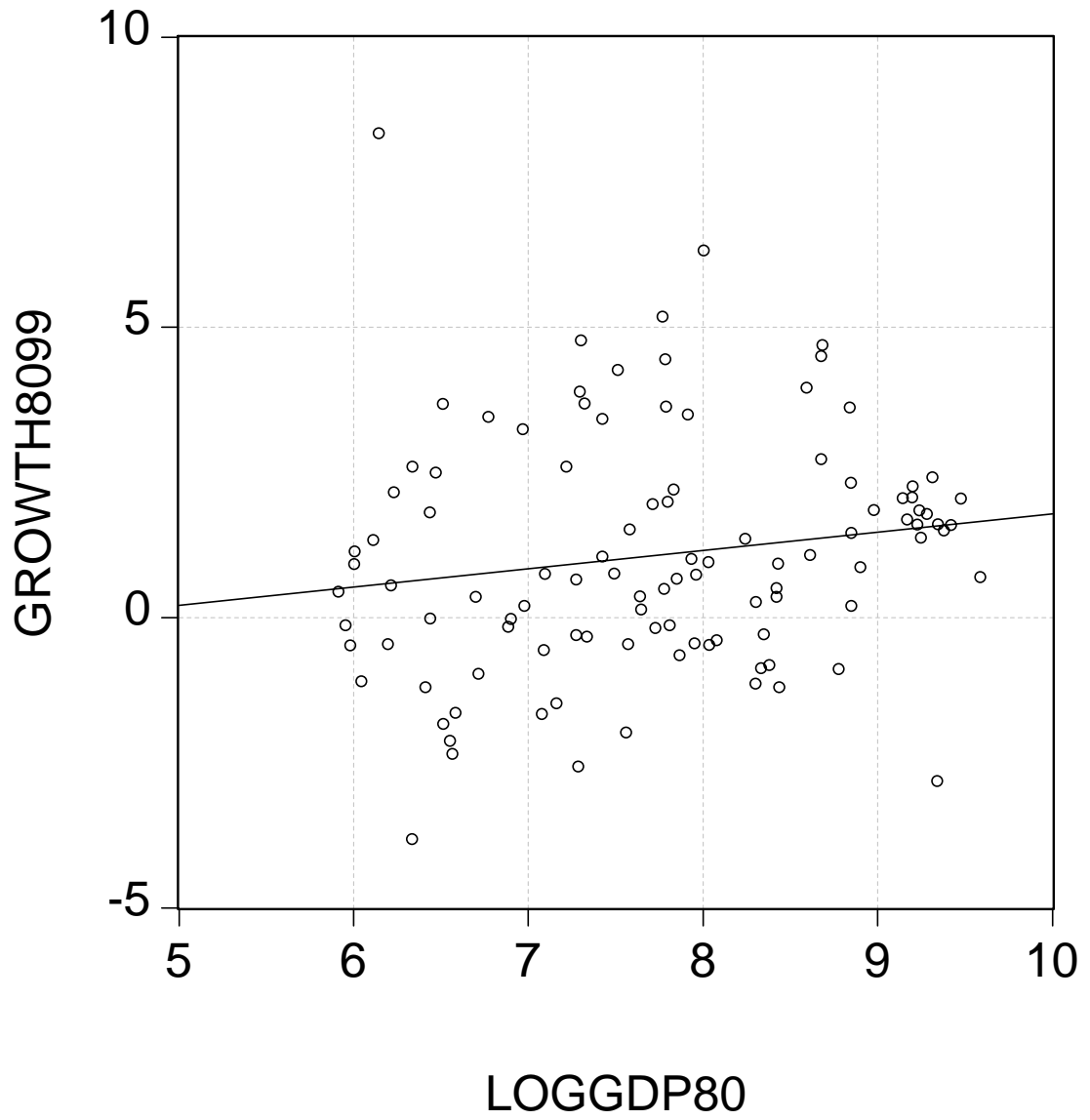
As it turned out, the first empirical tests of the convergence hypothesis using PPP-adjusted GDP figures did find evidence of long-run convergence for a small group of industrialized countries, but failed to show any tendency for absolute convergence in a broader cross-section of countries (Baumol, 1986, p. 1080). This lack of absolute convergence has been confirmed by many other studies (Barro, 1991, p. 408; Mankiw, Romer and Weil, 1992, p. 427; Sala-i-Martin, 1996, p. 1023), and is also evident in our own data for the 1980-99 sample period (see Figure 4). If anything, there appears to be a very small *positive* correlation between growth rates and initial income levels, indicating a slight tendency for rich countries to grow *faster* than poor ones.

Initially, this led some theorists to question the very basis for the convergence prediction, i.e., the neo-classical model itself. Since the major driving force leading to convergence in the Solow model is the assumption of decreasing returns to physical capital, rejection of this assumption spawned an entirely new class of "endogenous growth" models based on the contrary assumption of constant returns to capital.¹² These models have interesting theoretical features, though it is not clear that they have really advanced our understanding of economic growth in real-world economies. In fact, wholesale rejection of the neo-classical theory may have been premature and unwarranted, since its validity does not depend upon absolute convergence of income levels (or lack thereof). What "endogenous growth" enthusiasts failed to appreciate is that, though the neo-classical model predicts convergence to a steady state, different economies are not necessarily all converging to the *same* steady state. As Sala-i-Martin (1996) pointed out:

¹¹The standard reference on PPP-adjusted income comparisons is Summers and Heston (1991). This dataset, updated on a regular basis, has been readily incorporated into the modern economist's standard "toolkit." However, though it is a major achievement in applied economic research, the history of the efforts involved in its development remains one of the great "unsung stories" of modern-day economics. For work-in-progress reports at an earlier stage of the International Comparison Project see Kravis (1984, 1986). Ruggles (1967) provides a good review of what might today be described as the "pre-history" of international comparisons of incomes and purchasing power.

¹²For instance, Rebelo (1991) and Romer (1986, 1987, 1990). For a useful survey and discussion of the theoretical properties of endogenous growth models, see Sala-i-Martin (1990b).

Figure 4 — Growth Rate vs. Initial Income in 106 Countries, 1980-99.



The argument that the neoclassical model predicts that initially poor countries will grow faster than initially rich ones relies heavily on the key assumption that *the only difference across countries lies in their initial levels of capital*. In the real world, however, economies may differ in other things such as their levels of technology, ..., their propensities to save, or their population growth rates. If different economies have different technological and behavioural parameters, then they will have different steady states and the ... argument (developed by the early theorists of endogenous growth) will be flawed (p. 1027).

In other words, the convergence prediction of the neo-classical model is actually a *ceteris paribus* prediction: over any given period, an economy with lower initial income will have a higher growth rate than one with higher initial income, *if the two economies are converging to the same steady state*. Thus, what the neo-classical growth predicts is not absolute convergence, but rather what has been labeled “conditional” convergence (Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992; Barro, 1994). As Sala-i-Martin puts it:

What the model says is that, as the capital stock of the growing economy increases, its growth rate will decline and go to zero as the economy reaches its steady state. Hence, the prediction of the neoclassical model is that the growth rate of an economy will be positively related to the distance that separates it from its own steady state with common steady states, initially poorer economies will be unambiguously farther away from their steady state. In other words, the conditional convergence and the absolute convergence hypotheses coincide, *only if all the economies have the same steady state* (ibid., italics added).

Thus, we would not expect to observe convergence in a broad cross-section of the entire world economy, since these countries differ in too many relevant respects. The world economy as a whole is simply too heterogeneous. On the other hand, the model does predict convergence of incomes in countries which are sufficiently similar. (In the language of the neo-classical model, economies are “sufficiently” similar if they can be expected to have more or less the same steady states). In fact, there is a considerable amount of empirical evidence that confirms this prediction. As noted above, Baumol found evidence of long-run convergence in industrialized countries. This finding was criticized on grounds of “selection bias”: by working with a sample of countries that are *currently* industrialized, countries that did *not* converge (i.e., are currently still poor) were excluded from the

sample, so for the selected countries convergence was virtually guaranteed.¹³ However, even though it is probably partly due to selection bias, the observed degree of convergence in this particular group of countries cannot be entirely written off as a statistical artifact. If that were the case, then we would observe convergence over the very long-run period surveyed by Baumol (1870-1979)—this would be the convergence induced by sample selection—but not over shorter, more recent periods. Dowrick and Nguyen (1989), however, found quite strong evidence of convergence in OECD countries over 1950-85 (see also Williamson [1991], p. 58, and Mankiw, Romer and Weil [1992], p. 425). Our own data confirm this for the 18 OECD countries in our 1980-99 sample (Figure 5).¹⁴

Somewhat stronger evidence for absolute convergence was found by examining the comparative performance of different *regions* within the same country. Studies of regional convergence *within* a given country would not be affected by the selection bias critique. Evidence from such studies (surveyed by Sala-i-Martin, 1996) points to long-run regional convergence in U.S. states (1880-1990), Japanese prefectures (1930-90), and in 90 regions within five European countries (1950-90). More recently, Esquivel (1999) reported evidence of convergence of per capita incomes in Mexican states (1940-95)—see Figure 6.

¹³“... when properly interpreted, Baumol’s finding is less informative than one might think. For Baumol’s regression uses an *ex post* sample of countries that are now rich and have successfully developed Those nations that have not converged are excluded from his sample because of their resulting present relative poverty. Convergence is thus all but guaranteed in Baumol’s regression ” (de Long, 1988, pp. 1138-39). Baumol accepted this criticism: “By using readily accessible data that dealt only with countries that afterward turned out to be successful I loaded the dice toward an appearance of convergence” (Baumol and Wolff, 1988, p. 1155). This type of pitfall can easily lead to similarly misleading conclusions in other contexts: A study of the growth of industrial companies based exclusively on a sample of the currently largest corporations (say, the Fortune 500) will always conclude that small companies tend to grow faster than larger ones, since the ones that started out as smaller companies had to grow faster in order to get selected in the sample. However, since it is a biased sample from the universe of small companies (only the successful ones were selected), it tells us nothing about small companies in general: it does not imply, for instance, that there is a general tendency for small companies to grow faster than larger ones, and much less can it be taken as “evidence” of a tendency towards “convergence in company size.”

¹⁴Turkey and Mexico were excluded since, though technically OECD members (Turkey as an original member and Mexico since 1994), for our purposes they are not sufficiently “similar” to other industrialized OECD countries, and are more properly regarded as less developed economies.

Figure 5 — Absolute Convergence in 18 OECD Countries, 1980-99.

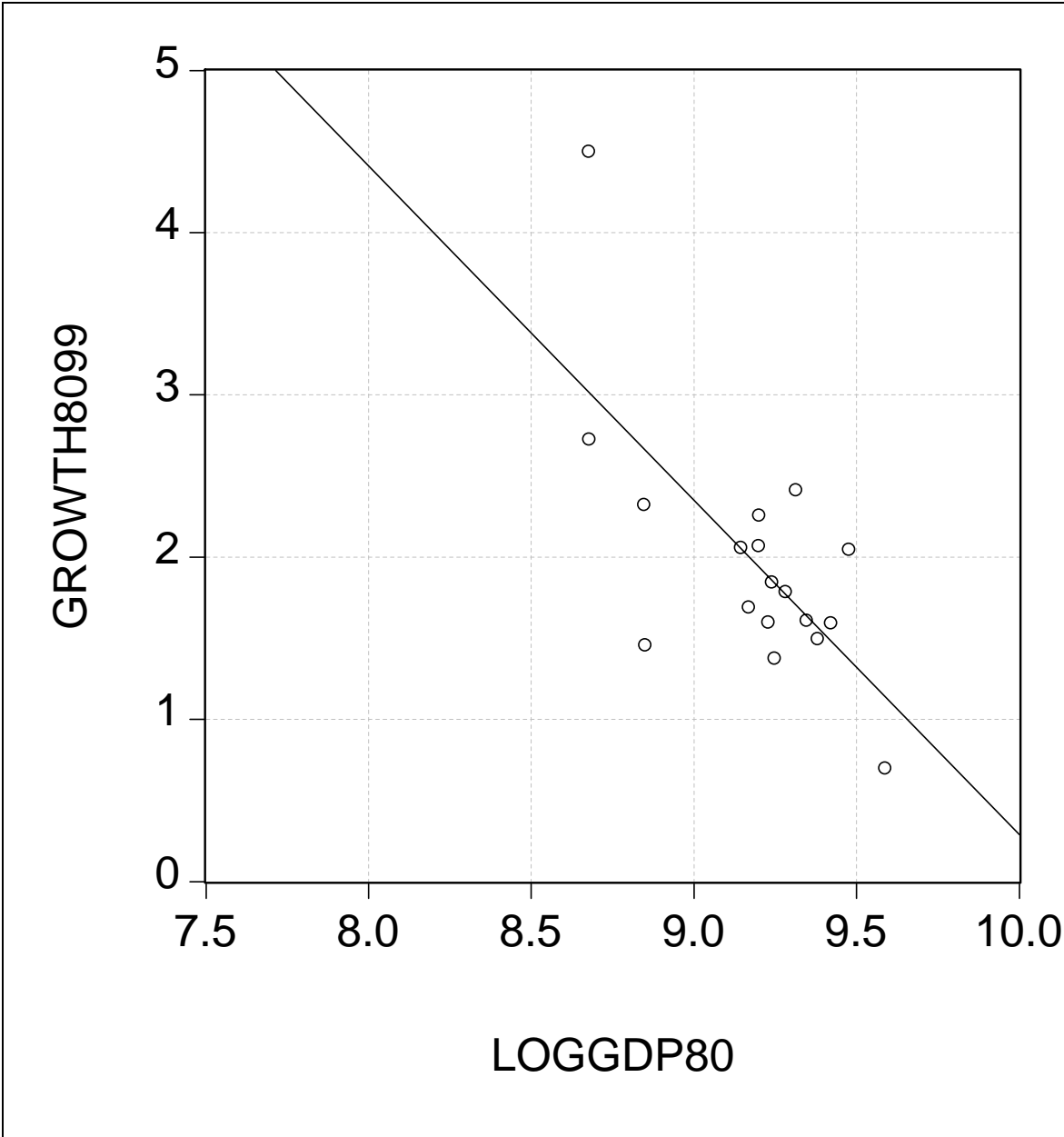
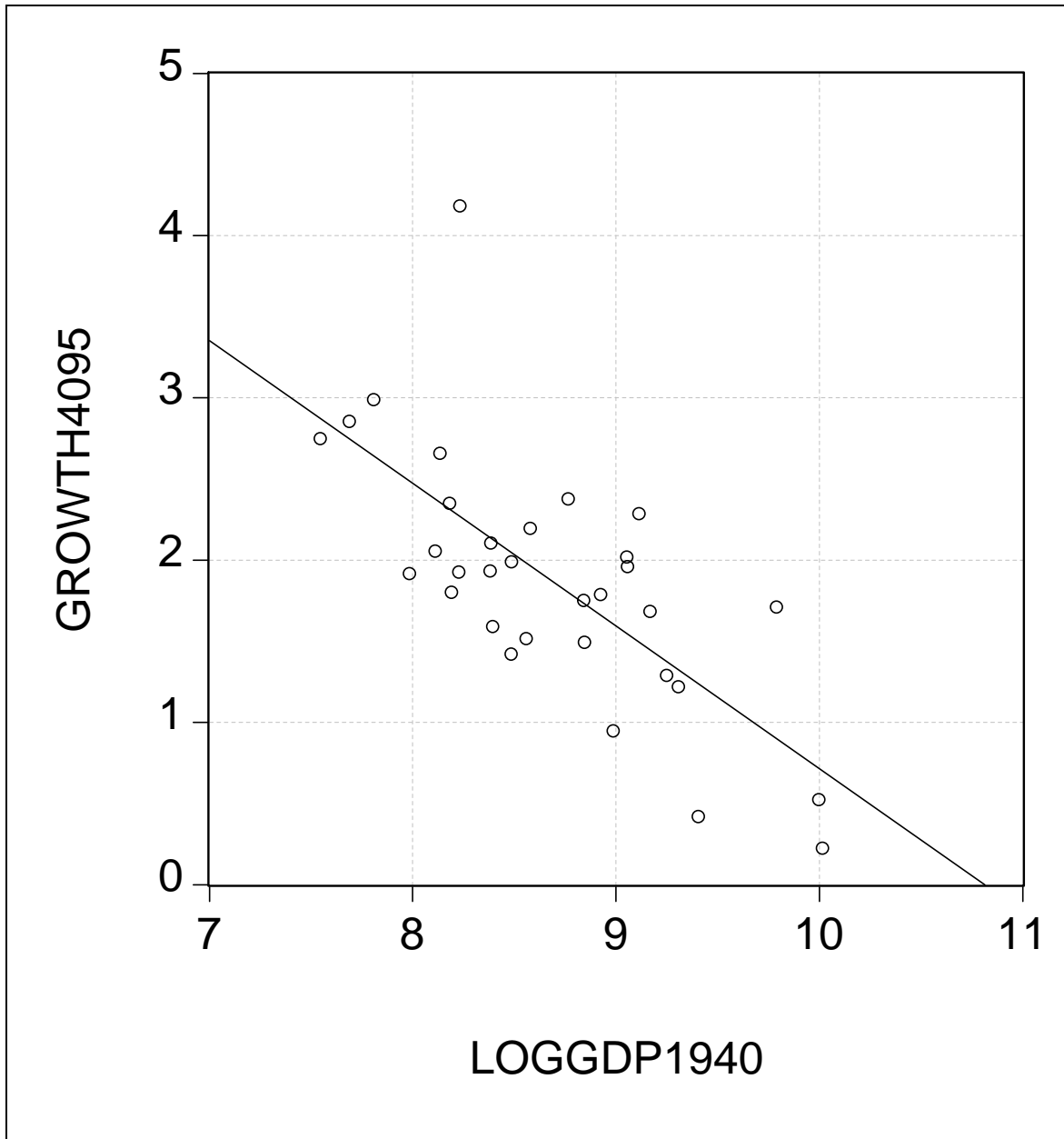


Figure 6 — Regional Convergence in 32 Mexican States, 1940-95.



Source: Computed from data reported in Esquivel (1999), Table A1, p. 759.

Conditional Convergence — An Empirical Framework for Growth Analysis

To recapitulate, the Solow growth model predicts absolute convergence of income levels when the economies being compared can be assumed to have the same steady state. When this assumption is more or less plausible (OECD countries, regions within the same country) the data do in fact confirm the convergence hypothesis. On the other hand, when the assumption of a common steady state is not plausible, the model predicts “conditional convergence”: each economy converges to its own steady state, which will differ across countries according to the values of each country’s “fundamentals” (to borrow a term often used by financial analysts). We should still observe a negative correlation between a country’s growth rate and its level of initial per capita GDP, though this is now a *ceteris paribus* prediction: the negative relationship should arise when other factors are held constant, but if these other factors are *not* constant then the negative relationship should be tested within a multiple regression framework, controlling for the variation in other relevant variables. Evidence for conditional convergence, in this sense, has been provided by the large number of “growth-regressions” that have swamped the field of growth studies.¹⁵ Several early empirical growth studies found that inclusion of initial income in a growth-regression results in a negative coefficient for this variable—for instance, Grier and Tullock (1989), Landau (1986)—which is consistent with conditional convergence. A more formal theoretical framework, based explicitly on the Solow model, was provided in an important paper by Mankiw, Romer and Weil (1992), who decided to “take Robert Solow seriously” (p. 407) by working out the steady state solution for a Cobb-Douglas production function:

$$Y = f(K, L) = K^\alpha (L)^{1-\alpha}$$

¹⁵Indeed, this is one way to look at the basic motivation for the growth-regression framework: an attempt to control for “other factors,” in order to test for the conditional convergence effect as predicted by the Solow growth model. To be sure, most analysts are interested in much more than mere testing of a model’s predictions, so an alternative way of looking at the problem is perhaps more meaningful: the Solow model is important for empirical growth studies, because it suggests that any attempt to explain the statistical variation of growth rates in a broad cross-section of countries within a multiple regression framework must include initial income in the list of regressors, in order to allow for the convergence effect (which predicts that the estimated coefficient for this variable will be negative). If the Solow model is valid, then any empirical growth-regression that fails to allow for conditional convergence will be biased due to an “omitted variables” effect.

or, in terms of $y' = Y/L'$,

$$(1) \quad y' = f(k') = (k')^\alpha$$

From the Solow equation, we know that in the steady state:

$$\frac{\Delta k'}{k'} = s \left[\frac{f(k')}{k'} \right] - (n + g + \delta) = s \left[\frac{(k')^\alpha}{k'} \right] - (n + g + \delta) = 0$$

or, alternatively,

$$s(k')^\alpha = (n + g + \delta)k'$$

Solving for k' and substituting in (1) yields the steady state value for y' :

$$y' = \left[\frac{Y}{A(t)L} \right] = \left[\frac{s}{n + g + \delta} \right]^{\frac{\alpha}{1-\alpha}}$$

In terms of output per worker ($y = Y/L$),

$$(2) \quad y^* = \left[\frac{Y}{L} \right]^* = A(t) \left[\frac{s}{n + g + \delta} \right]^{\frac{\alpha}{1-\alpha}}$$

Thus, in the steady state, the level of per capita output (i.e., the standard of living) is positively related to the savings rate (s), and negatively related to the population growth rate (n). Moreover, since by assumption α and δ are fixed parameters, while n , g and s are exogenously determined, it follows that in the steady state per capita income will only increase with $A(t)$, so in the long run the rate of growth equals the rate of technical progress (g).

To test this “textbook Solow model,” Mankiw, Romer and Weil (MRW) derived regression equations for levels and growth rates of per capita income (actually, GDP per worker). From (2), taking logs,

$$\log\left(\frac{Y}{L}\right) = \log(A) + \left(\frac{\alpha}{1-\alpha}\right)\log(s) - \left(\frac{\alpha}{1-\alpha}\right)\log(n + g + \delta)$$

This was estimated by a least-squares regression, with data for 1960-85 and based on the (then) most recent version of the Summers-Heston PPP-adjusted GDP tables. For the level regressions the variables were: Y/L = GDP in 1985 divided by working-age population, n = annual rate of growth of the working-age population (defined as 15 to 64), s = average share of investment in GDP, while $g+\delta$ was assumed to equal $0.02 + 0.03 = 0.05$. The results suggested that variations in the two key variables identified by the Solow model (the investment rate and population growth) explain almost 60 % of the cross-country variation in Y/L . The estimated coefficients, however, were deemed too large, and the authors conjectured that this might be due to an omitted variable effect: the basic Solow model neglects human capital. They then postulated and estimated an “augmented Solow model” that includes the effect of initial human capital endowments.¹⁶ Addition of this variable increased the explanatory power of the regression to almost 80 %.¹⁷

¹⁶The definition of human capital used restricts the concept to investment in education (ignoring investments in health, for instance). Even this is hard to measure—not all costs of education are considered (for instance, forgone earnings while in school), and not all education spending is intended to yield human capital (much of humanities and religious education are actually a form of consumption). The empirical measure of human capital accumulation used by the authors is rather complicated: the percentage of working-age population that is in secondary school (UNESCO data on fraction of the 12 to 17 population enrolled in secondary school, multiplied by fraction of working-age population that is of school age 15-19).

¹⁷It seems today quite obvious that investments in education and other forms of human capital should have a significant impact on both the level of per capita income and its rate of growth, and in a sense there is really nothing new about this, since economists have had a clear and well-defined concept of human capital at least since the time of Adam Smith: referring to “... the acquired and useful abilities of all the inhabitants or members of the society,” he went on to say that “The acquisition of such talents, by the maintenance of the acquirer during his education, study or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person. Those talents, as they make a part of his fortune, so do they likewise of that of the society to which he belongs. The improved dexterity of a workman may be considered in the same light as a machine or instrument of trade which facilitates and abridges labour, and which, though it costs a certain expense, repays that expense with a profit” (Smith, 1937 [1776], pp. 265-66)—see also Schultz (1992). However, it took a surprisingly long time for this concept to get incorporated in formal growth models. In the extensive survey article by Hahn and Matthews (1964), for instance, there is no mention of human capital at all (and only a passing reference to “education”). Most probably, this simply reflected a general lack of interest among the profession at large: formal work on human capital did not really begin until the early 1960’s (for a review, see Schultz, 1968). It deserves to be mentioned, however, that one

For the rate of growth of per capita income, recall that from the Solow equation, the rate of growth of k' (and hence, the rate of growth of y') falls as the economy approaches its steady state. Conversely, rates of growth will be higher, the farther the economy is from its steady state. If so, then for any given period, we would expect a country's growth rate to be proportional to the difference between its initial income and its steady state income:

$$\frac{\Delta y}{y} = \lambda[\log(y^*) - \log(y)] = \lambda \log(y^*) - \lambda \log(y)$$

where λ is a measure of the “speed of convergence.” Thus, in the Solow model the growth rate of per capita income will vary positively with the determinants of steady-state income, and inversely with the level of initial income. To test this implication, MRW regressed the log-difference of GDP per working-age person (1985 compared to 1960), against the log of 1960 GDP per working-age person, and the three explanatory variables included in the level regressions. The full regression (i.e., including the human capital measure) explains 46 % of variation in GDP growth, and the results exhibit conditional convergence (the coefficient on initial income is negative, and statistically significant).

Another important paper in the growth-regression literature, Barro (1991), is also based on the Solow model, but in a somewhat less formal manner than MRW. Barro's research strategy, which has been highly influential (so much so that these are often referred to as “Barro regressions”), can be described as a search for the best set of “other” variables (in addition to the convergence effect) that jointly explain the variation in growth rates. This search is guided by theory, but the criteria for inclusion of any given variable are essentially empirical. One major difference is that Barro invariably uses the growth rate of per capita income as the dependent variable (rather than income per worker, as per a strict construction of the Solow model). Another difference is that Barro uses female fertility (average number of children per woman over her lifetime) as the measure of population

important strand of empirical growth analysis—the so-called “growth accounting” framework pioneered by Denison (1962)—took investments in education seriously from the very beginning. For surveys of international evidence on the “returns to investment in education” and the contribution of education to economic growth, see Psacharopoulos (1984, 1994).

growth, instead of the rate of growth in the labor force. Presumably, these choices are dictated by empirical considerations.

In his 1991 paper, Barro studied a sample of 98 countries for 1960-85 (the same period studied by MRW), using the Summers-Heston dataset and other sources. The growth rate of GDP per capita is regressed on the *level* (not the log) of GDP per capita in 1960 and other explanatory variables. Barro includes two human capital variables: school-enrollment rates at the secondary and primary level in 1960. Other variables include government spending as proportion of GDP (but excluding spending on education and defense), averaged over 1970-85, two measures of political instability—number of coups per year, and number of political assassinations (per million people) per year—and a measure of price distortions. Barro too finds evidence of conditional convergence, in that “... given the human-capital variables, subsequent growth is substantially negatively related to the initial level of per capita GDP. Thus, in this modified sense, the data support the convergence hypothesis of neoclassical growth models. A poor country tends to grow faster than a rich country, but only for a given quantity of human capital; that is, only if the poor country’s human capital exceeds the amount that typically accompanies the low level of per capita income” (p. 409). Given that initial GDP is measured in thousands of 1980 dollars, the estimated coefficient on this variable implies that a \$1,000 increase in per capita GDP reduces the annual growth rate of per capita income by 0.75 percentage points.

Later studies by Barro and associates (Barro, 1994; Barro and Lee, 1994; Barro, 1996, 1997, 2001) maintain the basic framework, but exhibit quite a lot of experimentation with the minor details. All of these studies share what we might call the “canonical” explanatory variables of the augmented Solow model:

- initial income,
- the investment/GDP ratio,
- a measure of population growth (as noted, Barro invariably uses the fertility rate),
- a measure of human capital.

The treatment of these variables varies somewhat across studies. Thus in the 1991 paper initial income was measured in level form, though in all later studies it is measured in log form. Sometimes a squared term in initial income is included (to allow for possible curvature in the relationship), sometimes not. The human capital measure is largely based

on schooling, though sometimes life expectancy is added as well, to capture other dimensions of human capital. Schooling data are usually disaggregated into male and female components, and often distinguish primary and secondary education levels. Though the 1991 paper used primary and secondary enrollment rates, later studies are based on a much more refined measure of educational attainment: average years of schooling attained by the adult population.¹⁸ Overall, the results of these several studies are consistent with the predictions of the (augmented) Solow model: (1) initial income has a negative coefficient, confirming the convergence hypothesis; (2) a higher investment rate has a positive effect on growth rates¹⁹; (3) higher fertility (population growth) has a negative effect on growth rates; (4) higher levels of human capital (especially male schooling) have a positive effect on growth rates.

Where these studies mostly differ is in the “other” variables that are introduced in order to increase the explanatory power of the regressions. As noted above, the initial 1991 paper included government spending as a share of GDP, measures of political instability, and a measure of price distortions. Later studies have included black market exchange rate premiums, import tariffs, inflation rates, terms of trade effects, rule-of-law and democracy indices, interaction effects between the different variables, and different sorts of dummy variables to capture geographic and/or wartime effects (not all of these variables are used in every study²⁰). It is interesting to note that many of these other variables are measures of distortions in the price system, which can be expected to affect incomes/output through their effects on efficiency in the allocation of resources. This issue will be explored further in the following chapter.

¹⁸For a detailed description of the methodology used to measure this variable see Barro and Lee (2001).

¹⁹This does not contradict the conclusion regarding independence of growth rate and investment rate in the steady state (Note 10), since the convergence effect is also operative: higher investment rates increase the growth rate, but as income levels rise the growth rate declines due to the convergence effect. In the Solow model the steady-state growth rate is determined by the rate of technical progress.

²⁰Indeed, as one reviewer has remarked, once what we have called the “canonical” variables are accounted for, in the Barro methodology “what [else] to include becomes a pretty open question” (Tabarrok, 1999, p. 479).

Chapter 2

EXTENSIONS OF THE BASIC MODEL

“It is a capital mistake to theorize before you have all the evidence. It biases the judgment.”

— Sherlock Holmes, *A Study in Scarlet*

Introduction

In the previous chapter we reviewed the theoretical and empirical work leading up to the “augmented Solow growth model,” in order to provide a framework for an empirical analysis of growth rates in our 1980-99 sample period. As we will see in Chapter 3, as a first approximation this basic model performs rather well, in the sense that a large share of the cross-country variation in growth rates can be explained by the variables stressed in that model. However, we will also see that a significant share of the observed variation in growth rates remains unexplained, so there is room for other explanatory variables. Therefore, prior to a full-scale analysis of the data, we will devote this chapter to extensions of the analytical framework, by considering several sets of variables not usually contemplated in the conventional neo-classical growth model, and by considering alternative definitions for the basic dependent variable.

Price Distortions and Economic Growth

In his pioneering 1991 paper and in subsequent studies, Barro introduced, in addition to what we have called the “canonical variables” of the augmented Solow model, a series of supplementary variables designed to increase the explanatory power of the estimated growth-regressions. As we noted in the previous chapter, many of these variables actually measure different sorts of distortions in the price system resulting from misguided government policies, which can be expected to affect output growth through their effects on

efficiency in resource allocation. This is of course nothing new, and it would not be much of an exaggeration to say that most applied work in microeconomics and international trade theory over the past couple of centuries has been largely devoted to the analysis of inefficiencies resulting from policy-induced price distortions. A large number of studies have also dealt with macro-level effects of different types of distortions on overall economic growth. For instance, it is well-known that inflation has a negative effect on growth.¹ Other studies have focused on protective tariff regimes and other types of restrictions on international trade.² The growth-effects of distortionary tax systems have also been studied.³

Though all of these separate studies have provided useful insights, one disadvantage is that they tend to focus on a single issue. It often happens in practice, however, that the effects of any given distortion are often confounded with other effects: policy-induced

¹Though an exhaustive list of references would require a separate bibliography, the following papers by researchers affiliated with the IMF provide a good survey of recent research on the inflation-growth issue: Sarel (1996), Ghosh and Phillips (1998), Khan and Senhadji (2001).

²The negative effect of restrictions on free trade has been a major theme of economics at least since the time of Adam Smith, and again, an exhaustive bibliography would be otiose. However, it does seem useful to point out that rapid export-led economic growth since about 1960 in several East Asian countries (especially South Korea and Taiwan) has been attributed, in part, to the relative absence of trade-related and exchange rate distortions in those countries, as compared to most other developing countries—see, for instance, Tsiang (1984), Krueger (1985), and the series of papers in the volume edited by Lau (1990).

³See, for instance, Marsden (1986). It is not altogether clear that high tax rates, *per se*, will necessarily have an effect on the *rate of growth* of income (as opposed to *income levels*): “The effects which follow a reduction in marginal tax rates (on work) are such that a man would be induced to put in more effort and more hours to adjust for the fact that he now gets a larger slice of his marginal output. But this is a *once-and-for-all adjustment*. The level of output would increase; but there would be no persistent effect producing a higher rate of growth in succeeding years. True, there would be a higher rate of growth of output as people adjusted to the lower taxes. But people would not continue to increase their effort and hours of work in response to that one tax cut. Hence that increase would be only transitory, and the rate of growth would fall back to its old underlying value. Our conclusions, then, are that high marginal taxes do not explain low growth rates, and that, except for a transitory effort, lowering marginal tax rates will not induce an increase in the rate of growth of output”—Christ and Walters (1981), p. 76. In a recent study of OECD countries, however, Padovano and Galli (2001) argue that high marginal tax rates do in fact have a negative impact on economic growth.

distortions rarely occur in a vacuum, and the effects of different types of distortions are almost surely mutually reinforcing. In any case, they tend to be highly correlated—countries with bad policies tend to be consistently bad along many policy dimensions—so it is hard to sort out their separate effects. This has led to attempts to combine different types of distortions into an index of the overall level of distortions in an economy. One early study along these lines is that by Agarwala (1983), who studied 31 developing countries and ranked them according to an aggregate “distortion index,” defined as a composite of several different indicators: levels of effective tariff protection; distortions in exchange rates, interest rates and wages; underpricing of agriculture (vis-à-vis manufacturing); inflation; and underpricing of basic public utilities (mainly electricity generation). When the distortion rankings were used to compare the sample of countries in terms of their rates of economic growth over 1970-80, it was found that countries with low distortion levels tended to have higher economic growth, whereas high-distortion countries tended to have lower growth.

Though Agarwala’s study is highly suggestive, pointing as it does to a major factor that is largely neglected in formal theories of economic growth, its major drawback is the relatively small sample of countries surveyed. A project sponsored by the Fraser Institute is much broader in scope, both in terms of number of countries and the list of relevant variables. Since 1986, a group of researchers associated with that institute have focused on the definition and measurement of an internationally comparable index of “economic freedom,” a concept that encompasses policy-induced distortions in the price system, but also attempts to measure the general degree of government intervention in the economy (Easton and Walker, 1992; Gwartney, Block and Lawson, 1996). This work has resulted in the development of a numerical index which, in its most recent version (Gwartney *et al.*, 2002), ranks 123 countries in terms of their degree of economic freedom, as measured by a composite of 38 indicators grouped in five major categories (size of government, legal structure, monetary and banking policy, international trade, and regulation).⁴ One important finding is that the resulting economic freedom index is highly correlated with both the level and the rate of growth of real per capita GDP (see Table 2).

⁴A listing and description of the components of the “Economic Freedom of the World” index is provided in Appendix A. For methodological details, data sources, etc., see Gwartney *et al.* (2002), Chapter 1.

Table 2 — Economic Freedom, per capita Income, and Economic Growth.

Countries Ranked by EFW Index	GDP per capita 2000 PPP (us\$)	Growth rate (%), per capita GDP, 1990-2000
Bottom quintile	\$2,556	-0.85
4 th quintile	\$4,365	1.44
3 rd quintile	\$6,235	1.13
2 nd quintile	\$12,390	1.57
Top quintile	\$23,450	2.56

Source: Gwartney *et al.* (2002), p. 20, Exhibits 5 and 8.

These comparisons, though striking, nonetheless suffer from two limitations: (1) they are simple, two-variable correlations, and (2) they are average results for groupings of countries. Thus, analyzing the results for countries grouped in quintiles essentially averages out much of the actual dispersion in the data, while ignoring the effect of other explanatory variables might bias the results due to an “omitted variables” effect. What we really want to do, therefore, is evaluate the incremental explanatory power of the EFW index in the context of a more general model of economic growth.⁵

At first glance, the results in Table 2 seem to contradict at least some aspects of neo-classical growth models, since the high-EFW countries are not only richer than low-EFW ones, but also grow faster, contrary to the “convergence” predictions of the standard Solow growth model. However, these two effects are not necessarily mutually exclusive—in principle *both* effects can hold—since, as we pointed out earlier, the convergence effect is actually a *ceteris paribus* prediction. What the neo-classical model predicts is that, *other things equal*, countries with higher initial income will have slower growth, and vice-versa. Therefore, a direct test of the existence of both effects would be to regress the growth rate of real per capita GDP against (1) the log of initial-year PPP-adjusted per capita GDP, (2) the EFW index, and (3) a set of additional explanatory variables, as suggested by some prior theoretical framework. The convergence effect predicts that the first variable should have a negative coefficient, and the interpretation of the regression in *ceteris paribus* terms

⁵For previous studies along these lines based on earlier versions of the EFW index, see Easton and Walker (1997) and Dawson (1998).

is straightforward: (1) if two countries have the same level of economic freedom, as measured by the EFW index, the country with the higher initial income will tend to have a lower growth rate due to the convergence effect; (2) on the other hand, if two countries start out with the same income level, the country with more economic freedom will tend to grow faster.

Geography and Economic Growth

A series of recent studies directed by Jeffrey Sachs have focused on the relationship between geography and economic development (Gallup, Sachs and Mellinger, 1999; Sachs, 2000). The motivation for these studies is based on two empirical observations:

- (1) Countries located in tropical regions of the world tend to be poor, whereas countries in temperate zones tend to be wealthier—a comparison of GDP per capita in countries grouped according to geographic latitude illustrates this tendency quite graphically (Figure 7).
- (2) Countries with easy access to maritime transportation tend to be wealthier than landlocked countries. (These two tendencies are mutually reinforcing: landlocked *and* tropical countries are in double jeopardy, and tend to be the poorest of all.)

Regarding the first of these tendencies, one might well ask why absolute distance from the equator should be, in itself, an explanatory variable for economic development. Sachs conjectures that part of the explanation could be due to climatic and ecological factors, which relate to geography *per se*, though it might also be partly due to distance from the main centers of the world market, which are in fact located in temperate zones of the northern hemisphere. (This latter factor would constitute a disadvantage, for instance, for temperate countries located in the southern hemisphere.) Therefore, Sachs makes a distinction between factors related to geographic location (distance from the equator), and factors related to transportation costs (access to maritime transportation and distance from the main world markets).

The effect of climate-related and ecological factors shows up in two main areas: (1) food production, and (2) health. Agricultural productivity, especially in cereals production, is noticeably higher in temperate zones. This is due to several related factors: the fact that

tropical soils are fragile and more easily eroded, the negative effect of high temperatures on photosynthetic potential and use of water resources, and the higher prevalence of insects and parasites in tropical ecosystems, affecting both farming and animal husbandry. The tropics are also notoriously disease-ridden, which is partly due to lower agricultural productivity (through its effect on nutrition levels), and partly due to the greater prevalence of infectious diseases in these areas (itself in large measure a consequence of the greater prevalence of insects). Many bacterial diseases are a direct result of the high temperatures and humid conditions that characterize tropical regions. Poor health, in turn, has a direct impact on labor productivity (and hence on income levels).

Though these studies consider a very large number of different variables, we will concentrate here on the three main geographic variables used in Gallup, Sachs and Mellinger (1999):

TROPICAR = proportion of a country's territory located in the geographic tropics,⁶

POP100KM = proportion of the country's population living within 100 kilometers of the sea coast,

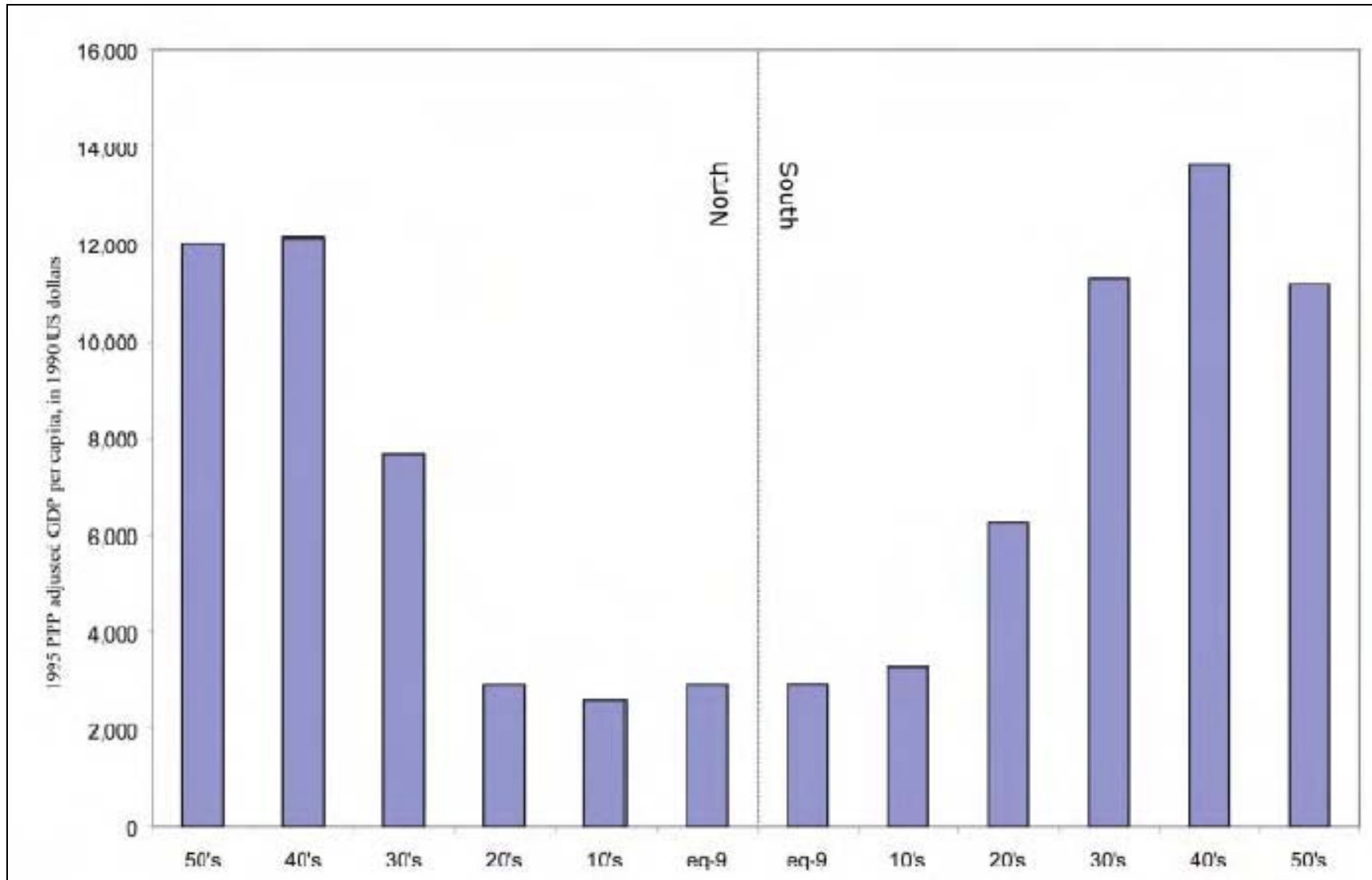
LOGDIST = log of minimum distance of the country to one of three core areas of the world economy (defined as New York, Rotterdam or Tokyo).

From the regressions reported in Table 3, it appears that these three variables statistically explain a large share of the cross-country variation in real income *levels* in 1950, 1990 and 1995. Income per capita is a positive function of POP100KM, and a negative function of TROPICAR and LOGDIST. In addition, note that the effect of these variables has increased through time, implying a geographic effect on *rates of growth* as well.⁷ As the authors put it: "The implication is that being tropical, landlocked, and distant was already bad in 1950, and that it adversely affected growth between 1950 and 1995" (p. 146). Thus, there is a strong *prima facie* case for a geographic effect on economic growth,

⁶Tropical regions are defined as areas located between 23.5 degrees of latitude North (Tropic of Cancer) and 23.5 degrees of latitude South (Tropic of Capricorn).

⁷For instance, in 1950 the "penalty" coefficient for TROPICAR was -0.69 , implying that, other things equal, per capita income in tropical countries was on average 50 % lower than in non-tropical countries ($e^{-0.69} = 0.50$). By 1995 the "penalty" had risen to -0.99 (for an average income equivalent to 37 % of that in non-tropical countries). The same trend holds for the other two variables.

Figure 7 — GDP per capita by Latitude, 1995.



Source: Sachs (2000), Figure 2, p. 36.

Table 3 — GDP per capita and Geographic Variables, 1950, 1990 and 1995.

	Dependent Variable: PPP-adjusted GDP per capita (natural log)		
	1950	1990	1995
Constant	9.07 (13.58)	11.19 (16.26)	10.98 (14.10)
TROPICAR	-0.69 (4.13)	-0.99 (5.78)	-0.99 (5.10)
POP100KM	0.71 (4.02)	1.00 (5.43)	1.09 (5.27)
LOGDIST	-0.22 (2.56)	-0.39 (4.39)	-0.34 (3.41)
R ²	0.38	0.58	0.50
N	129	129	129

Note: Numbers in parentheses are t-ratios (absolute value) for the estimated coefficients.

Source: Gallup, Sachs and Mellinger (1999), Table 2, p. 146.

though we still need to evaluate the incremental explanatory power of these variables in the context of a more general growth model.

Which Dependent Variable? — Alternative Measures of Economic Growth

The previous sections of this chapter have extended the basic framework for growth analysis, by considering two sets of potential explanatory variables that are not usually contemplated in the conventional neo-classical model. Another direction in which the analytical framework can be extended is by considering alternative definitions for the dependent variable. Up to this point we have been following standard practice in this field, which takes the rate of growth of GDP per capita (sometimes per worker) as the relevant empirical measure of what the theoretical models seek to explain. However, there might be some reasons for questioning this assumed correspondence.

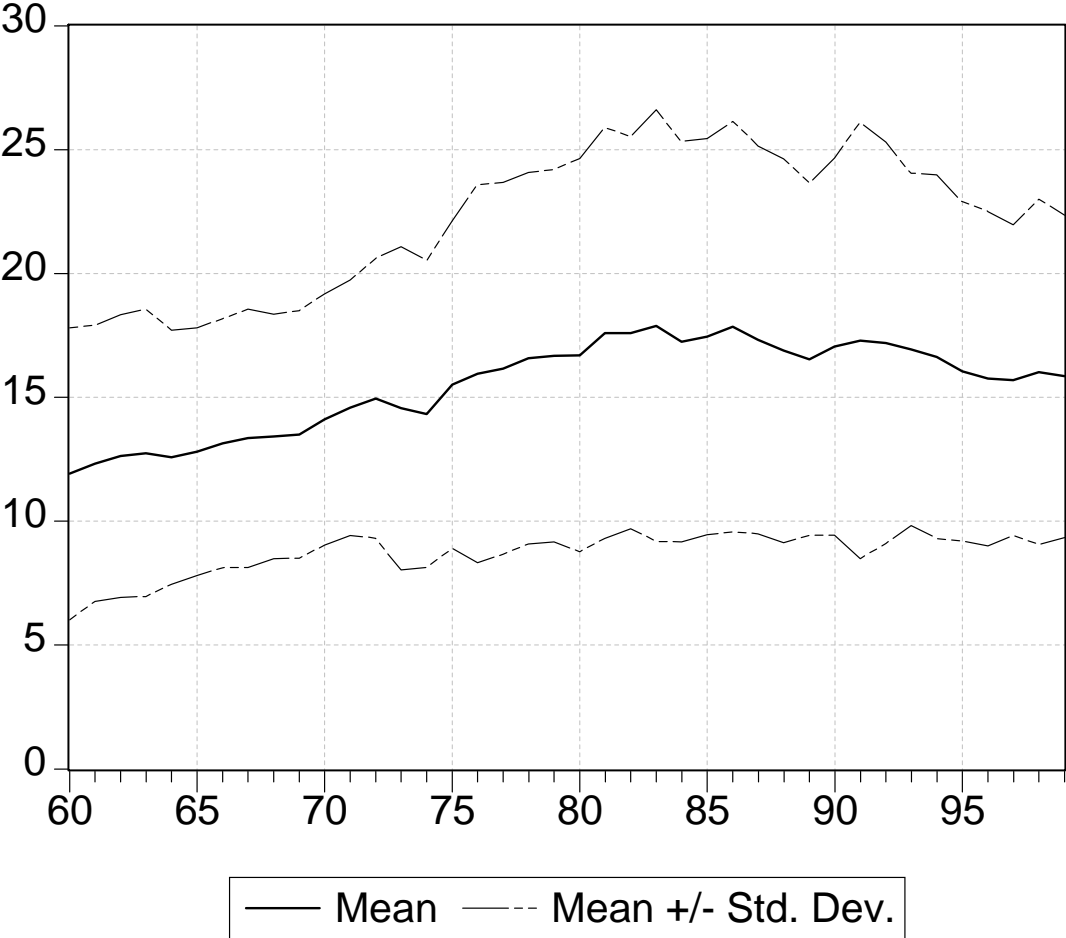
One source of ambiguity has do with the treatment of government expenditures in the conventional national accounts framework. In principle, the reason for including government spending in GDP is because part of a country's total output of final goods and services (which is what GDP purports to measure) consists of goods and services produced by the government. Most of what the government produces is not bought and sold on the market, which poses a practical measurement problem, since the value of government output must be expressed in money terms if it is to be included in the national accounts. The conventional solution is to value government output "at cost," which in practice assumes that the value of government's contribution to the economy in any given period equals the amount of resources that it consumes in order to provide its services (i.e., the amount of money which government spends on goods and services over that given period).⁸ This working assumption can only be valid, however, if there is no waste at all in the production of government services—i.e., if every single resource that government consumes is employed efficiently in the production of government "output." The counter-factual nature of this assumption should be apparent to any impartial observer.

It is quite possible, therefore, that conventional GDP measures seriously overstate real output, to the extent that in every country at least some part of what counts as the public sector's "contribution" to total output is really just a measure of the value of the resources that are wasted by government. The extent to which this is so probably varies greatly from one country to another, introducing yet another complicating factor in international comparisons. This would not matter much if government's share were a small proportion of actual GDP, or if it were more or less stable. In many countries, however, the government component has become quite large in recent decades, and it varies a great deal across countries and within countries over time (see Figures 8 and 9).⁹

⁸One of the earliest theoretical challenges to this conventional approach is that of Kuznets (1951).

⁹This of course is not a new phenomenon, and has been going on for quite some time—see, for instance, Nutter (1978) and Peltzman (1980) on trends in OECD countries as of the mid-1970's. Regarding the data summarized in Figure 8, data availability varies for different years, so the averages are not always based on the same sample sizes. The \pm one standard deviation lines cover roughly two-thirds of the countries in each year (though only approximately, since the empirical distributions are not exactly bell-shaped—see Figure 9). It is also perhaps worthwhile to point out that these data refer to government's contribution

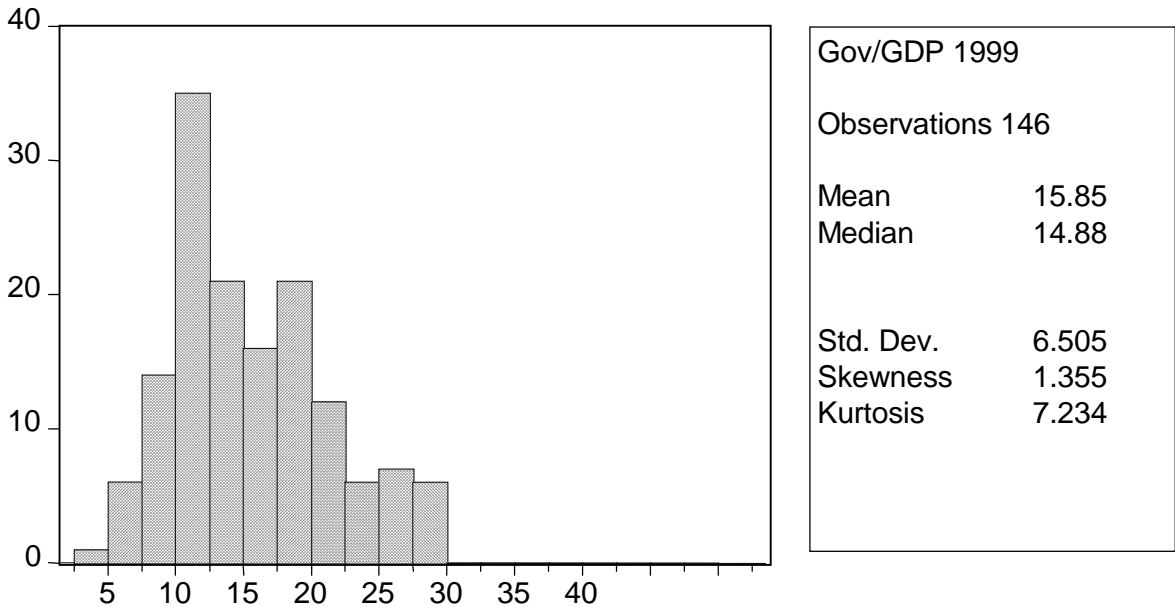
Figure 8 — Government Consumption (% of GDP), world average, 1960-99.



Source: Computed from data reported in *World Development Indicators 2001* (World Bank, CD-ROM version).

to “current” output (i.e., what is referred to as “government consumption”), and thus do not include government “investment” spending, which in the standard national accounting framework is lumped together with private investment to form a single category for “Gross Fixed Capital Formation.” Also, note that the sum of these two components (government consumption plus government investment) equals “government spending on final goods and services,” which should not be confused with “total government spending,” since the latter also includes transfer payments (interest payments on the public debt, welfare and unemployment benefits, etc.) that are not included in current GDP. Therefore, the figures on government consumption should not be regarded as a measure of government’s “command over resources,” which in every country is actually much greater than what is implied by the “G” component in conventional GDP statistics.

Figure 9 — Government Consumption (% of GDP), 146 countries, 1999.



Source: *World Development Indicators 2001* (World Bank, CD-ROM version).

Since standard GDP figures suffer greatly from inclusion of government spending as a national accounting category, we would like to know to what extent this might affect any of the conclusions derived from an empirical analysis based on conventional measures. Therefore, as a rough sensitivity check on the results obtained for the growth rate of per capita GDP, we will replicate the empirical analysis using an alternative measure of economic growth, which we will describe as “private-sector GDP,” defined as conventional GDP minus government consumption of final goods and services. Figure 10 shows a frequency distribution and summary statistics for the average annual rate of growth of “private GDP” per capita, for the 97 countries for which data are available over the 1980-99 sample period. Figure 11 compares the rate of growth of this variable with that of conventional GDP per capita, for each of the 97 countries. It seems pretty clear from this initial comparison that the results of an empirical growth analysis should not be much affected by whether government is excluded or not from the basic GDP figures. The growth rates for private GDP are quite similar to those for total GDP, both in terms of average

values and in range of variability (the standard deviation of the growth rates for private GDP is slightly higher than for total GDP), and they are both highly correlated across countries (Figure 11). Nonetheless, as a check on the robustness of the conclusions, we will be interested in performing the empirical analysis on both sets of measures.

Figure 10 — Frequency Distribution of Growth Rates, Private GDP (Total GDP minus Government Consumption) per capita, 1980-99.

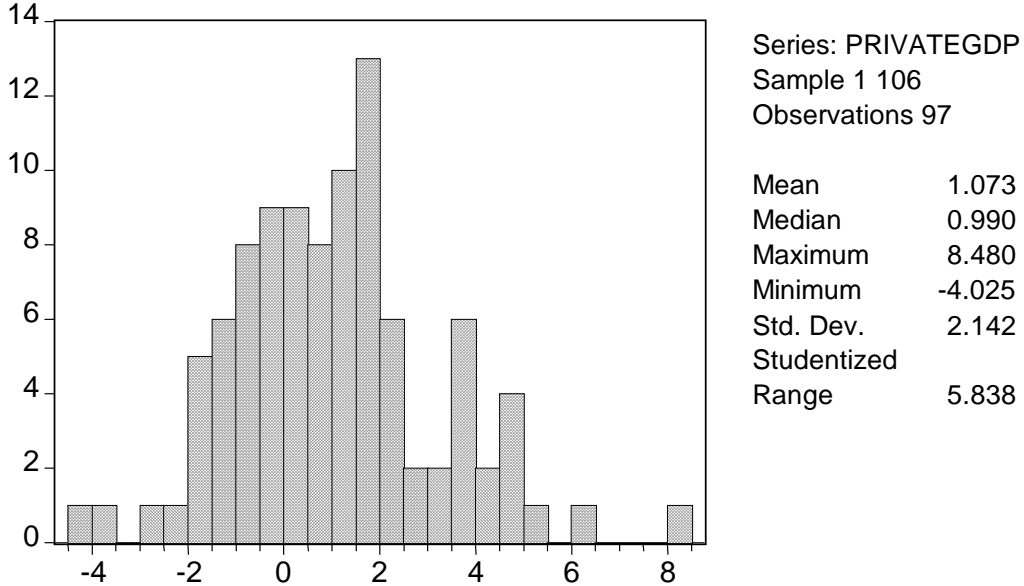
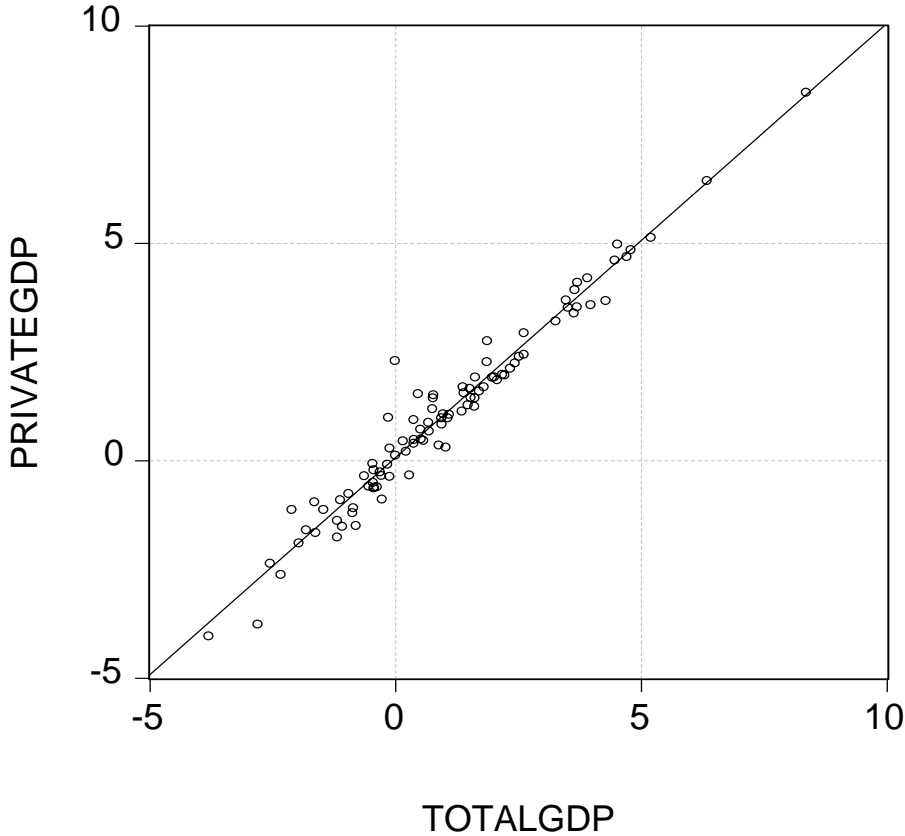


Figure 11 — Growth Rates of Total and Private GDP per capita, 97 countries, 1980-99.



Chapter 3

RESULTS AND INTERPRETATION¹

“In concluding this brief survey ... , I should like to stress the danger that always threatens theorists: the temptation to consider our current knowledge as final. Almost instinctively our intellect tends to make apparently complete syntheses based on knowledge which is, and, no doubt, will always remain, fragmentary. Such syntheses are often extremely valuable in guiding scientific research, but we must always be careful not to attribute to them a permanency which they lack.”

— Louis de Broglie (1962)

Introduction

Our purpose in the first two chapters was to provide a framework for empirical growth analysis. We must now see how far this framework will take us in explaining the observed variation in growth rates over our 1980-99 sample period. As a first approximation, we will estimate a growth-regression based on the neo-classical growth model (Mankiw, Romer and Weil, 1992; Knight, Loayza and Villanueva, 1993). Models following this approach include what we have described as the “canonical” variables of the augmented Solow model: initial income (convergence effect), the investment/GDP ratio, a measure of population growth, and a measure of human capital. The results for this model will then serve as a basis for evaluating the incremental explanatory power of the additional sets of variables discussed in Chapter 2. The final section of this chapter will discuss the implications of the empirical results.

¹Some of the results reported in this chapter were published previously in Cole (2003).

Basic Model

Regressions based on the neo-classical model are reported in Table 4 (Regressions 1 to 3). The first regression uses the following variables:²

LOGGDP80 = log of PPP-adjusted per capita GDP in 1980,

INV = investment share in GDP, average for 1980-99,

FERTIL = total fertility rate, average for 1980-99, used as the measure of population growth,³

DSCH15 = change in “average years of schooling for the population aged 15 and over,” 1980-95 (as measured by Barro and Lee, 2001), used as the human capital variable.

This basic model performs rather well: these four variables statistically explain practically 59 % of the cross-country variation in economic growth over 1980-99, and all of the variables are significant and have the expected signs. Regression 2 disaggregates DSCH15 into its male (DMALESCH15) and female (DFEMSCH15) components, and the results suggest that, at least in this sample period, it is the male component of the schooling variable that really counts in terms of economic growth.⁴ Dropping DFEMSCH15 (Regression 3) yields results for the other variables that are essentially identical to those in Regression 1.

As a first approximation, therefore, the basic neo-classical model seems to work well, in the sense that a large share (almost 60 %) of the cross-country variation in growth rates can be statistically explained by the variables stressed in that model. On the other hand, these results also imply that a significant share of the observed variation in growth rates remains unexplained, so there is room for other explanatory variables.

²All of the regressions in this study were estimated by ordinary least squares. Data sources and definitions of the basic variables are detailed in Appendix B.

³Use of the fertility rate as the measure of population growth gives a better fit in the regressions, and its coefficient is also easier to interpret. However, none of the substantive conclusions are altered by using the population growth rate instead.

⁴This confirms findings of other researchers (for instance, Barro, 2001), and may be due to the fact that in most countries men still account for the larger share of the labor-force. Even with current low female labor-participation rates, however, this result does not imply that female education has no effect at all on economic growth, since, as we will see later on, there is an important indirect effect due to the impact of female education on fertility levels.

Economic Freedom in a Neo-Classical Growth Model

Regression 4 shows the results of adding the average EFW index for each country (measured as the average of the values for 1980, 1985, 1990 and 1995). Though we lose 5 observations due to missing values, the results are still quite strong. The coefficient for EFW is positive and significant, and the explanatory power of the regression increases to 68.5 %. The coefficients for the other variables are significant and quite similar to the previous results. The estimated coefficient for EFW implies that, other things equal, countries with higher levels of economic freedom can be expected to have higher rates of economic growth than countries with lower levels of economic freedom.

Regression 5 adds DEFW = change in the EFW index from 1980 to 1995. This too has a positive and significant coefficient, and increases the explanatory power to 72.6 %. This suggests that the growth-effect of economic freedom depends not only on the absolute *level* of the EFW index during any given period, but also on the direction (and magnitude) of the *change* in the index over that period.⁵

Overall, these results suggest that the EFW index adds significantly to the explanatory power of the neo-classical growth model.⁶

⁵This result, however, should be interpreted with caution. The coefficient for DEFW is only marginally significant in Regression 6, which shows the result of adding that variable in isolation (i.e., without EFW). This would seem to indicate that the effect of a *change* in the level of economic freedom cannot be adequately estimated unless the *level* effect is controlled for as well.

⁶Easton and Walker (1997), working with *levels* of income, and Dawson (1998), working with rates of growth, applied an earlier version of the EFW index to extend the results of Mankiw, Romer and Weil (1992). Both studies confirmed that addition of an economic freedom measure increases the explanatory power of the neo-classical model. Since there is no unique way of allocating the total explained variation in a multiple regression between different subsets of regressors, one could just as easily say that the neo-classical variables add significantly to the explanatory power of the freedom index. However, since we are taking the neo-classical model as our starting point, the statement in terms of the incremental explanatory power of the EFW index seems more natural. Another way of testing this incremental explanatory power is to regress the residuals from Regression 3 against EFW and DEFW. This auxiliary regression yields the following results (t-values in parentheses):

$$\begin{array}{l} \text{RESID3} = -2.416 + 0.392 \text{ EFW} + 0.301 \text{ DEFW} \qquad \text{adj } R^2 = 0.147 \quad N = 85 \\ \qquad \qquad \qquad (-3.839) (3.621) \qquad \qquad (2.355) \qquad \qquad \text{White test} = 5.33 (p = 0.377) \end{array}$$

Geography in a Neo-Classical Growth Model

Chapter 2 (Table 3) reported some regression results obtained by Gallup, Sachs and Mellinger (1999) which suggest that a large share of the cross-country variation in income *levels* can be statistically explained in terms of three basic geographic variables:

TROPICAR = proportion of a country's territory located in the geographic tropics,

POP100KM = proportion of the country's population living within 100 kilometers of the sea coast,

LOGDIST = log of minimum distance of the country to one of three core areas of the world economy (defined as New York, Rotterdam or Tokyo).

Moreover, the effect of these variables appears to have increased through time, implying a geographic effect on rates of growth as well. To test if this effect is present in the 1980-99 data, we estimate Regression 7, which relates the growth rate of per capita GDP to these three variables. The explanatory power of this regression is quite low (18.6 %), so obviously these variables by themselves do not explain much of the variation in growth rates, though the results do seem to indicate the existence of some sort of geographic effect on growth rates: the distance variable is not significant, but both TROPICAR and POP100KM are significant and have the expected signs. What remains to be seen is whether these variables have incremental explanatory power in the context of a more general model. Specifically, does adding a geographic dimension increase the explanatory power of the neo-classical growth model?

To test this, we estimate Regression 8, which adds the three geographic variables to Regression 3. These results do not support the hypothesis of a geographic effect on growth. None of the geographic variables are significant, so it would appear that, Regression 7

Both EFW and DEFW are positive and significant, confirming that these variables do indeed have explanatory power, even after adjusting for the neo-classical variables. Note that this is a quite strong test for the economic freedom variables, since a "step-wise" regression of this sort is likely to underestimate the contribution of the added variables (as compared to their coefficients when they are included as regressors in a multiple regression for the original dependent variable)—see Goldberger (1968), pp. 31, 37, 131.

notwithstanding, these variables do not in fact provide much relevant information beyond that already contained in the neo-classical variables.⁷

Before concluding that geography has no place at all in a growth-regression, however, we still need to explore one more option: Do the geographic variables have incremental explanatory power in the context of a neo-classical model that controls for economic freedom? What would be the effect, in other words, of adding the three geographic variables to Regression 5? The results of this exercise (Regression 9) are rather surprising: POP100KM and LOGDIST are still non-significant, but TROPICAR now appears to have a significantly negative effect on economic growth. Thus, there does seem to be some basis for the view that geography has an effect on economic growth, though perhaps not as strong as some initial studies seemed to imply.

What Does it All Mean?

Regression 10 summarizes the end-result of this statistical exercise: a neo-classical model, augmented by the economic freedom variables and one geographic variable (TROPICAR), statistically explains roughly 78 % of the observed variation in the reduced sample, which is quite impressive, given the nature of the dependent variable.⁸ What are we to make of all this? As G. Warren Nutter once wrote (in a different setting): “Somewhere in these generalizations and the mass of figures behind them lie lessons of history. The trick is to find them” (Nutter, 1959, p. 173).

For starters, the results clearly vindicate the neo-classical growth model: the variables we have used to measure the “canonical” neo-classical variables are all significant, and their signs are consistent with that model’s predictions. Though not unexpected, given what we know from prior work in this field, the results are nonetheless “not uninteresting,” since,

⁷One possibility is that the results in Regression 7 are merely a “proxy” effect, i.e., that the geographic variables are simply proxying for the effect of some of the neo-classical variables. (An obvious candidate is the fertility rate.) In that case, once the “true” underlying variable is included in the regression the proxies provide little additional information, so their coefficients become non-significant.

⁸Due to missing observations for some of the variables in some countries, the sample sizes vary for different regressions, which means that they are not always strictly comparable in terms of R^2 . Nonetheless, the samples seem large enough warrant generalizations, even though none of the regressions are based on all of the 106 countries in our basic sample.

though some neo-classical predictions seem quite obvious and common-sensical, others are much less so. The results for investment, for instance, conform to common intuition, even in the absence of a formal theoretical model, since it seems pretty obvious that countries that save/invest a large share of GDP should grow faster than countries that save/invest little. Likewise, we don't need a formal growth model to know that countries that invest heavily in human capital can expect to grow faster than countries that do not. On the other hand, the neo-classical predictions regarding "convergence" and the effects of demographic growth, though strong implications of the model, are much less intuitively obvious, so the fact that they do actually show up in the data serves to strengthen our confidence in the model as a representation of the fundamental processes involved in economic growth.⁹

The results also suggest, however, that the neo-classical model is not the whole story, and that there is scope for extension in this basic model in at least two directions: (1) allowing for cross-country differences in the degree of economic freedom, and (2) allowing for the effect of geography. None of these factors is considered explicitly in formal neo-classical growth models, though both were found to have incremental explanatory power vis-à-vis the neo-classical variables.

Regarding the estimated regression coefficients:

(1) LOGGDP80 — The negative value for this coefficient confirms the "conditional convergence" prediction of the Solow growth model: other things equal, a country's economic growth rate will tend to decline as its income level rises. A one point increase in LOGGDP80 is associated, on average, with a decline of about 2 percentage points in the annual growth rate of per capita GDP. (This effect is not as large as may seem at first glance: the mean value for LOGGDP80 in the 106-country sample is 7.7209, corresponding to about \$2,255 in 1980 dollars. At this level, a one point increase in LOGGDP80 would correspond to a per capita GDP of \$6,124—i.e., an increase of over 170 %. The decline in growth rates due to the convergence effect is actually quite slow.)

⁹In this regard, it is interesting to note that, statistically, these two effects are in fact the strongest elements in the relationship: their t-values are larger than those of any other of the variables in Regression 10. Therefore, the negative effect of these two variables would show up in any regression based on a subset of this particular list of variables, since we know from a theorem due to Leamer (1975) that dropping any regressor from a multiple regression can never reverse the sign of a non-deleted regressor if the latter's (absolute) t-value is larger than that of the deleted regressor.

(2) INV — The value for this coefficient implies that, on average, a one point increase in the investment/GDP ratio can be expected to increase the annual growth rate of per capita GDP by about 0.09 percentage points. Thus, if two countries are identical in every relevant respect, except that one country invests 20 % of its GDP whereas the other invests only 10 %, the difference in their annual growth rates will be, on average, about 0.9 percentage points.¹⁰

(3) FERTIL — This coefficient has a negative value, confirming the neo-classical prediction regarding population growth. The fertility rate is measured in terms of children per woman, and the value of the coefficient implies that, other things equal, a unit increase (one additional child) in the average fertility rate will decrease a country's annual growth rate by about 0.9 percentage points. Quite apart from its implications in terms of the Solow growth model, this is a matter of considerable empirical interest, since the debate over the economic consequences of population growth is by no means settled.¹¹ To be sure, this does not necessarily imply an endorsement of neo-Malthusian alarmism, since an overall worldwide *decline* in fertility levels has been noticeable for quite some time (Maudlin, 1981; Coale, 1983; Robey, Rutstein and Morris, 1993; Lutz, Sanderson and Scherbov, 2001). A continuation of this trend, given our empirical results, would actually provide some grounds for optimism regarding growth prospects in less developed countries. In any case, our results clearly support the view that high fertility levels are, other things equal, a negative factor in terms of per capita income growth. In the Solow model, this negative effect arises from the fact that, for a given investment rate, higher population growth implies a lower steady state capital-labor ratio. Our results confirm this theoretical prediction, but it should be pointed out that our empirical estimate probably picks up at least three other fertility-related effects that are not explicitly developed in formal growth models:

- a) A factor that is often ignored in income comparisons between developed and underdeveloped countries is that younger workers tend to be less productive than older

¹⁰One is tempted to interpret this as an estimate of the average incremental rate of return on physical capital (about 9 % per annum). This temptation should be resisted. As Barro and Lee (1994) note, "some assumptions about depreciation are required for this calculation" (p. 278).

¹¹Kelley (1988) provides a good survey of the voluminous literature on these issues.

ones (since they have less on-the-job experience), so average levels of productivity are affected by changes in the age-structure of the population. High-fertility countries have high birth rates, which implies that they tend to have “young” populations, and hence, lower average productivity than countries with lower birth rates. For explorations of some of these issues see Sarel (1995) and Crenshaw, Ameen and Christenson (1997). Moreover, although fertility rates have been declining in low-income countries, the age-structure problem will probably persist for some time to come, because the large proportion of young people in the population creates a certain demographic “momentum”: when the ever more numerous younger cohorts attain reproductive age, they begin having children, and even if their average fertility is lower than that of the previous generation, the birth rate will remain high simply because there are now more women of reproductive age. (In other words, though each woman has less children than before, there are many more women having children, so the total number of births may be much larger than before.) Eventually, of course, fertility reductions will reduce the birth rate, and this will result in an “older” population, but the process is very slow. Gwatkin and Braudel (1982) provide a good non-technical explanation of this phenomenon.¹²

- b) An interesting “two-way causation” between fertility and human capital arises from the fact that children in smaller families tend to have, on average, more years of schooling. This is partly an income-effect (higher income families tend to have less children), but not entirely, since the family-size effect on schooling levels shows up even after controlling for income.¹³ Thus, declining fertility can be expected to boost per capita income growth through its effects on human capital.

¹²Changes in the age-structure have many other sociological consequences, but most of them need not concern us. At least one age-related social pathology, however, is probably relevant: in every country most crimes are committed by males aged 15 to 25—see Wilson and Herrnstein (1985) and the vast social science literature cited therein—so a large proportion of young men in the population is bad news anywhere. Economists hardly ever address this issue, but clearly it has tremendous economic implications.

¹³See Blake (1989) for a review of evidence for the United States, and Knodel, Havanon and Sittitrai (1990) for a discussion of evidence from Thailand, a country that has experienced extremely rapid fertility declines in recent decades.

- c) A third effect has to do with the relationship between family size (i.e., fertility) and child health. Infant mortality rates tend to be lower in smaller families—see, for instance, Reves (1985)—so declining fertility can also be expected to increase productivity by increasing the “return” on resources invested in childbearing. (It seems rather crass to stress the purely economic benefits of lower infant mortality, since this is of course a worthy objective in its own right. The fact remains, however, that resources consumed by children that die young are essentially wasted from an economic point of view.)
- (4) DMALESCH15 — Recall from Regression 2 that the female component of the schooling variable turned out to be non-significant, which is why all successive regressions have employed the male component only.¹⁴ We have used the *change* in average years of schooling, rather than the level of schooling, since this is what seems to correspond to an investment concept for human capital. (Notice that in the case of physical capital, what actually affects economic growth in the Solow model is not the *stock* of physical capital, but the rate of *investment*, which is the *change* in the capital stock. Higher *stocks* of capital, both physical and human, will of course be associated with higher income *levels*, but not necessarily with higher growth rates.) The value for this coefficient implies that each one-year increase in the level of adult schooling over the sample period has been associated, on average, with an increase of about 0.3 percentage points in the annual growth rate of per capita GDP.
- (5) EFW and DEFW — The coefficient on EFW measures the level effect of cross-country differences in the EFW index, and its estimated value implies that, other things equal, countries with greater economic freedom will have higher growth rates: each one point difference in the EFW index is associated, on average, with a difference of about 0.8 percentage points in the annual growth rate of per capita GDP. Moreover, it matters whether economic freedom is increasing or decreasing through time: the coefficient on

¹⁴In Note 4 we pointed out that this does not imply that female schooling has no impact at all on economic growth. In fact, there is an indirect positive impact, since it is well known that female schooling has a significant effect on fertility levels—see, for instance, Jain (1981) for a general discussion, Singh and Casterline (1985) for a review of international evidence as of the early 1980’s, and Hirschman and Guest (1990) and Ainsworth, Beegle and Nyamete (1996) for surveys of recent evidence for Southeast Asian and Sub-Saharan African countries, respectively.

DEFW implies that each one point *increase* in the EFW index over the sample period has been associated, on average, with an increase of about 0.5 percentage points in the growth rate of per capita GDP.¹⁵ The mechanism involved is probably quite complex, since the EFW index is a composite of several different indicators. Many of these elements amount to measures of price distortions in the economy, so it is possible that one main line of causation runs through the effects of economic freedom on the overall level of efficiency in resource allocation. However, it is also possible that the EFW index affects growth indirectly through effects on some other explanatory variable. It certainly seems plausible to assume, for instance, that greater economic freedom provides more incentives and a better “investment climate.” Therefore, it is theoretically interesting to determine whether the main growth-effect of economic freedom is through a direct “efficiency effect” on overall productivity, or through an indirect “incentive effect” on investment. (Of course, these effects are not contradictory in any way, and they might both be present.) The issue is also important empirically, since if the main effect is through the investment rate, this would pose an estimation problem for the regressions in Table 4—in fact, it would not make much sense to include *both* INV and EFW as regressors in that case. Dawson (1998) has outlined some of the statistical implications of this issue for empirical growth analysis:

First, if institutions are the primary factor driving cross-country differences in investment, it is redundant to include both investment and an institutional measure as regressors in a cross-country [growth-regression]. One should, however, observe a strong relationship between institutions [i.e., the EFW index] and investment in this case, and the relationship between institutions and growth should strengthen, in a statistical sense, if investment is omitted as a conditioning variable. Second, if factors other than institutions also contribute to cross-country variation in investment or if the effect of institutions operates partially outside the investment channel, the inclusion of an institutions variable should attenuate the size and significance of the estimated coefficient on investment to the extent that the investment channel is operative. Elimination of investment as a conditioning variable would not be appropriate in this case, however, as important information

¹⁵In this regression, the change effect is *additional* to the level effect. The reason for incorporating these two effects separately is to allow for a temporal dynamic in the effects of changes in the degree of economic freedom: two countries might have the same *average* EFW index over some period, even though it is increasing in one country and decreasing in the other one. If so, one would expect the first country to have a better growth performance, and the empirical results confirm this intuition. Of course, the change effect is a temporary, one-time affair, which will last as long as the country’s EFW index continues to increase (which presumably must reach some limit), whereas the level effect is permanent.

would presumably be lost if institutions influence growth primarily through an effect on total factor productivity, measures of both investment and institutions should be statistically significant In summary, if institutions operate predominantly through the investment channel, measures of freedom will have little or no explanatory power if the saving rate is already included as an explanatory variable in cross-country regressions. If institutions work primarily through a direct effect on factor productivity, however, including a measure of freedom in a growth regression can be expected to add explanatory power. If institutions work through both channels simultaneously, the inclusion of an institutions variable as a regressor should add explanatory power and reduce the estimated size and significance of investment's impact on growth (pp. 605-06).

By these criteria, our evidence clearly supports the hypothesis of a “productivity effect” (EFW and DEFW are significant in every regression), but does not seem to favor the “investment channel” as a main line of influence, since the coefficients for INV are pretty much the same in Regression 3 as in Regressions 5 and 10. Moreover, there does not seem to be any strong positive relationship between the investment rate and economic freedom in the 1980-99 sample period.¹⁶ Therefore, it seems likely that the “efficiency effect” is the main causal link between the EFW index and economic growth.¹⁷ Some further light on this issue is provided by Regression 11, which replaces INV with an interaction term between INV and EFW (INV*EFW). In this regression, the effect of changes in the investment rate is now conditional on the value of EFW: each one point increase in the EFW index increases the impact of a one point increase in INV by about 0.016 percentage points. Thus,

¹⁶See Figure 12. The weak relationship shows up even if INV is regressed on *both* EFW and DEFW:

$$\text{INV} = 10.79 + 1.647 \text{ EFW} + 1.246 \text{ DEFW}$$

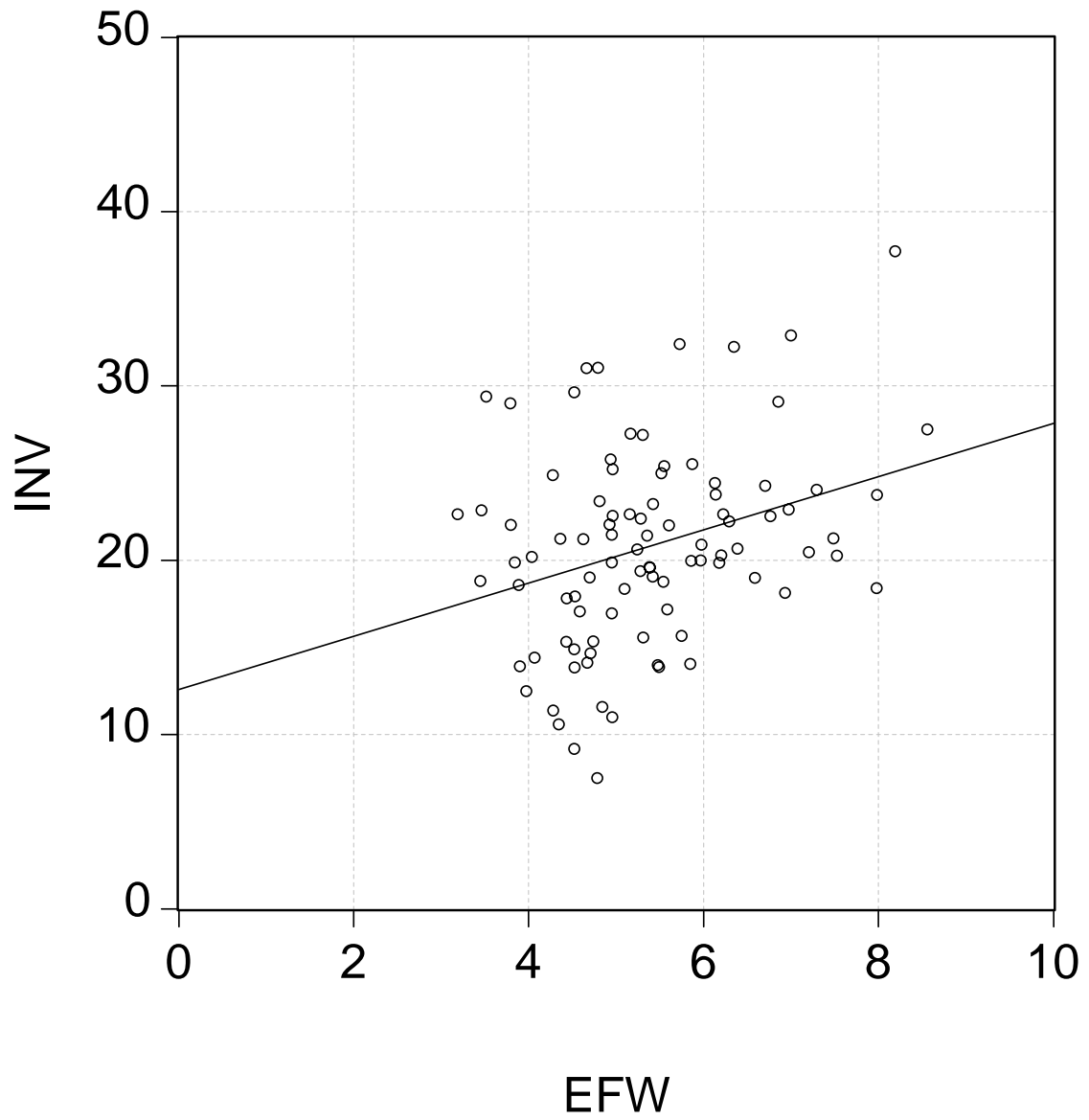
$$(3.868) \quad (3.371) \quad (2.129)$$

$$\text{adj } R^2 = 0.120 \quad N = 92 \quad \text{White test} = 6.422 \quad (p = 0.267)$$

Though the estimated coefficients are both positive and significant, the explanatory power of this regression is quite low.

¹⁷It should be mentioned that Dawson concludes from his own sample period (1975-90) that both effects are operative. There is some degree of overlap between our sample and his, but the methodologies are slightly different, as well as the list of variables (he uses labor force growth instead of fertility as the demographic variable, and does not consider geographic variables), so the different conclusion is probably a cumulation of several factors. Further research should eventually clarify this issue.

Figure 12 — Investment rate vs. EFW index, 92 countries, 1980-99.



other things equal, if the investment rates in two countries differ by 10 points (say, 10 and 20 % of GDP), on average their annual growth rates would differ by about 1.6 percentage points if EFW = 10 (very high economic freedom), but only by about 0.16 percentage points if EFW = 1 (very low economic freedom). Notice that EFW has an independent effect of its own in Regression 11, which implies that not all of its effect occurs through effects on investment productivity.¹⁸ The coefficients for the other variables are quite similar to those in Regression 10, and the explanatory power is practically the same in both regressions, so there is not much reason for preferring one over the other on purely statistical grounds, though Regression 11 seems theoretically more appealing since it allows for changes in the productivity of investment as a function of economic freedom. It certainly makes sense to assume that any given level of investment will have a higher growth impact in countries with greater degrees of economic freedom.¹⁹ The “productivity of investment” effect might even explain the low correlation between the investment rate and the level of economic freedom. There is no theoretically compelling reason to assume that higher investment productivity will necessarily lead to higher rates of investment. It might happen in some countries, but other countries might prefer to enjoy the benefits of economic freedom by actually investing less, and consuming more, since any given growth objective could be achieved with less investment, the higher the degree of economic freedom. Presumably, this will depend on the prevailing rates of time preference, which probably differ greatly across countries. This situation is analogous to the role of income and substitution effects in analyzing the effects on labor supply of an increase in wage rates: some countries might prefer to invest less if the productivity of investment rises, just as some people might actually work less when wages rise if preference for leisure is very

¹⁸The coefficient for EFW in Regression 11 is lower than in Regression 10, but these coefficients cannot be compared directly because in Regression 11 the effect of a unit change in EFW is conditional on INV, and now equals $0.424 + 0.0157 \cdot \text{INV}$. The mean value for INV is 21.1 % of GDP for the 80 countries in the sample for Regressions 10 and 11 (for the 106 country sample it is 21.5 %). For this value of INV, the effect of a unit change in EFW would be 0.755, which is actually quite close to the estimated coefficient for EFW in Regression 10.

¹⁹This issue is also explored, using a slightly different methodology, in a forthcoming paper by Gwartney, Holcombe and Lawson (2003).

high. Only the less free countries actually *need* to invest more to have economic growth.²⁰

(6) TROPICAR — The coefficient on this variable confirms the presence of a geographic effect on growth rates during the sample period. Tropical countries do seem to have a disadvantage, even controlling for other relevant variables, and the reasons for this effect are probably due to the factors stressed in the recent literature on this issue (Gallup, Sachs and Mellinger, 1999; Sachs, 2000). The estimated coefficient implies that, other things equal, a tropical country will have a lower growth rate than a non-tropical country, the penalty for “tropicality” amounting to an average difference of about 1 percentage point in the annual growth rate of per capita GDP.

²⁰Perhaps the most extreme case in this regard is that of the former Soviet Union, which had one of the highest investment rates in the world, but very low productivity to show for it. On the characteristics of Soviet economic growth see Schroeder (1985), Ofer (1987) and Ericson (1990). In interpreting historical trends in the Soviet economy, an important caveat should be borne in mind: we nowadays measure a country’s wealth by its “Gross Domestic Product,” but we tend to forget that this does not consist exclusively of consumption goods, so a high GDP growth rate does not necessarily imply an improvement in the provision of consumer goods, which is ultimately what matters for consumer welfare. The Soviet economy, for instance, had high rates of “economic growth” for several decades, but in practice the greater share of increased production consisted of capital goods, which were reinvested in the productive process, with very little improvement in living standards. Worse still, the high investment rate did not result in major productivity increases, so to sustain the same rate of economic growth the Soviet economy required much higher investment rates than would have been required in more efficient economies. What is not altogether clear, however, is whether we should interpret as “economic growth” an increase in the production of goods that are devoted exclusively to the maintenance of the productive system itself (losing sight of the fact that, ultimately, the *raison d’ être* of the productive system is the provision of consumer goods). Western economists had long been aware of this problem—see, for instance, Nutter (1959, 1968) and Powell (1968). In any case, there is no reason why investment should be valued for its own sake, and there is nothing intrinsically valuable about a high investment rate *per se*. What ultimately matters for consumer welfare is the level of consumption, and though investment is important for economic growth, both investment and growth are desirable only to the extent that they enable higher levels of consumption. This seems obvious (and almost trivial), but every so often economists need to be reminded: “Consumption is the sole end and purpose of all production; and the interest of the producer ought to be attended to, only so far as it may be necessary for promoting that of the consumer. The maxim is so perfectly self-evident, that it would be absurd to attempt to prove it. But in the mercantile system, the interest of the consumer is almost constantly sacrificed to that of the producer; and it seems to consider production, and not consumption, as the ultimate end and object of all industry and commerce” (Smith, 1937 [1776], p. 625)—see also Cannan (1926).

Growth Rate of “Private” GDP

In Table 5, the preceding analysis was replicated using the rate of growth of “private GDP” (as defined in Chapter 2) as the dependent variable. The sample sizes are slightly smaller in the regressions for private GDP, due to missing observations for some countries, but the results are essentially the same, which would tend to indicate that the conclusions are not very sensitive to the particular definition of economic growth that is used. The only major difference is that the coefficient on DMALESCH15 is only marginally significant in Regressions 10 and 11, and the R^2 's for all regressions tend to be smaller. Thus, correcting for the government component in GDP appears to introduce some additional element of “noise” in the relationship. Since none of the substantive conclusions are altered, and in most cases even the individual coefficient estimates are quite similar to those in the corresponding regressions in Table 4, this seems to confirm the essential robustness of the previous results.

Conclusions

This study has drawn on a large body of previous theoretical and empirical work, in order to provide a framework for the analysis of growth rates in a broad cross-section of the world economy during the last two decades of the 20th century. We should now recapitulate our main findings and summarize the conclusions that derive from them:

- 1) Conditional convergence, as predicted by the Solow model, is present in the 1980-99 data, and seems to be a fundamental aspect of the underlying growth process. Other things equal, a country's growth rate will tend to decline as its per capita income rises, though the actual rate of decline is quite slow. Nonetheless, this factor must be taken into account in any empirical growth analysis.
- 2) High population growth, as measured by the fertility rate, has a negative effect on economic growth. The worldwide trend over the past few decades has been in the direction of declining fertility levels (see Figure 13), but they still remain quite high in many less developed countries. A continuation of this trend would provide some

grounds for optimism regarding the prospects for growth in low-income countries.²¹

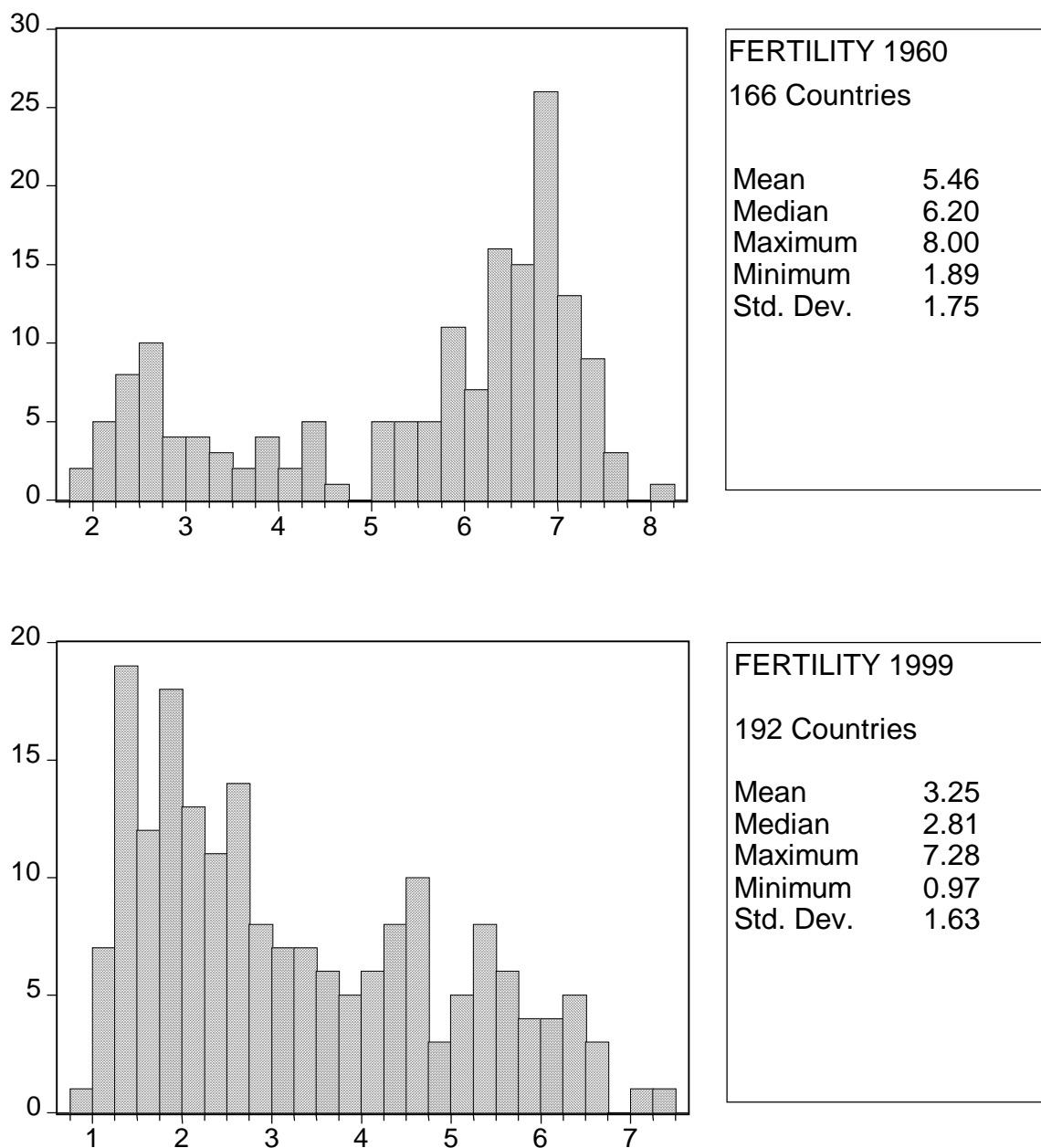
Countries that maintain persistently high population growth, however, will be at a disadvantage in terms of per capita income growth.

- 3) Investment in physical capital is important, and countries that save/invest a large share of GDP will grow faster than countries that save/invest little.
- 4) Human capital is also important for economic growth, and here too there is much scope for improvement. In 1995 the average level of the Barro-Lee educational attainment measure (“average years of schooling for the population aged 15 or over”) was about 6 years per adult, with a median value of 5.82 years (Figure 14). In other words, in half of the countries surveyed in Figure 14, the average adult has not completed primary education. Major improvements in this area can be expected to boost per capita income growth in less developed countries in the foreseeable future, and should remain a priority for development policy planners.²²

²¹Not, however, in the case of high-income countries, where the fertility decline may have already gone too far: in most developed countries it is now far below “replacement level” fertility (estimated at about 2.1 children per woman), and many experts are concerned about the future economic consequences of an impending “demographic implosion” in those countries—see, for instance, Eberstadt (1997) and Bongaarts (1998).

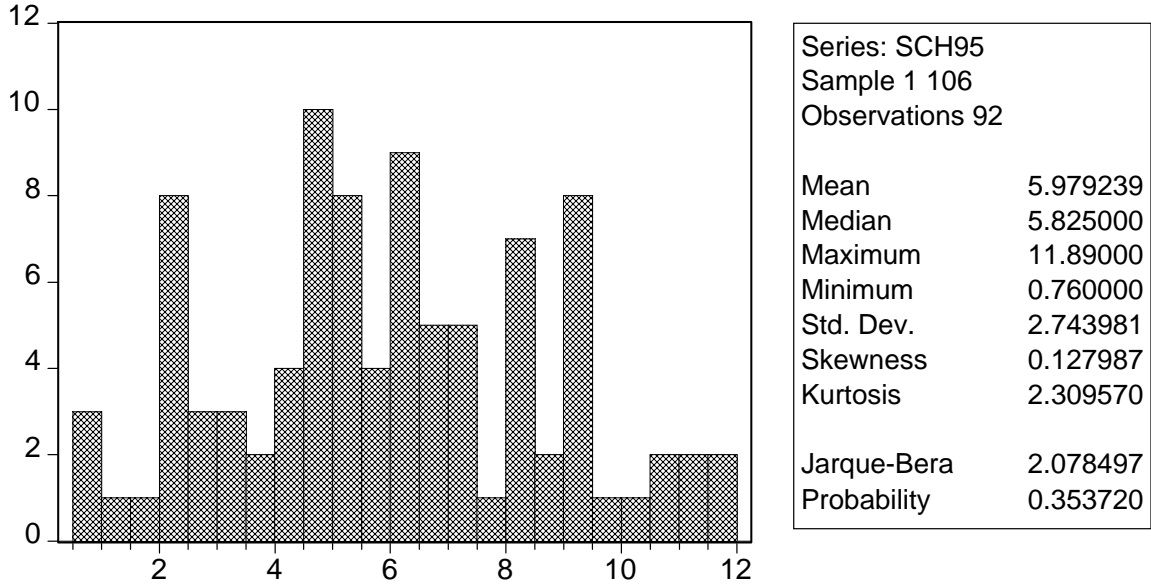
²²An important factor that should be borne in mind, however, is that the cost/benefit ratio is not the same for resources invested in different levels of education: the social return on investments in primary education is higher than for secondary education, and much higher than for post-secondary education (Psacharopoulos, 1982, 1994). Apparently, this results from the inter-action of two factors: (1) an enormous productivity differential between illiterates and primary-school graduates, and (2) the relatively low cost of primary schooling, compared to secondary and higher education. The productivity advantage of literacy is especially obvious in urban contexts, but the result is evident in rural settings as well (see Lockheed, Jamison and Lau [1980] for a survey of 18 studies of the impact of farmer education on agricultural productivity, and Griliches [1968] for a general discussion of the determinants of agricultural productivity and, *inter alia*, the role of education in improving the “quality” of farm labor). Therefore, in low-income countries where large segments of the population have no access to any education at all, much greater improvements in average educational attainment levels can be achieved, at lower cost, by concentrating on ensuring access to primary education for broader segments of the population, than by providing even greater educational resources for the few people that already have access to primary education.

Figure 13 — World Fertility Rates, 1960 and 1999.



Source: *World Development Indicators 2001* (World Bank, CD-ROM version).

Figure 14 — Barro-Lee Educational Attainment Measure, 92 countries, 1995 (years of schooling per adult aged 15 and over).



5) Perhaps the most important conclusions of this study relate to the role of economic freedom. Higher degrees of economic freedom, as measured by the EFW index, are associated with higher rates of economic growth. The main channel of influence appears to be through a direct “productivity effect,” since many of the components of the EFW index amount to measures of price distortions, which can be expected to affect economic growth through their effects on efficiency in the allocation of resources. An indirect “incentive effect” via the investment rate may also be present, but the evidence is less clear on this point (though there does appear to be a strong positive relationship between economic freedom and the *productivity* of investment).²³

²³It should be noted that the “productivity/incentives” distinction is proposed as a rough classification of the possible causal mechanisms through which economic freedom influences growth, and not as an air-tight taxonomy. Thus, greater economic freedom might produce many effects that influence economic growth that are not mediated through the investment rate, but can just as easily be described as “incentive” effects: greater work effort, greater (and better) levels of entrepreneurship, investments in human capital, etc. These factors will affect overall productivity, but are certainly incentive-related, so they could be classified under either rubric. Firms that operate in a more competitive environment will be “quicker on their feet,” and hence more *productive*, but only because

- 6) Geography is a factor that should be taken into account in explaining cross-country variations in growth rates, since tropical countries are at a disadvantage in terms of economic growth. This pessimistic conclusion, however, should be tempered by a healthy dose of pragmatism: geographic location is an unalterable fact, and there is nothing that can be done about it, though much can be done in terms of the other determinants of economic growth. The penalty for “tropicality” can be overcome, for instance, by promoting policies that increase the level of economic freedom. In tropical countries, therefore, the case for economic freedom is even stronger than in non-tropical countries.²⁴

Finally, though these variables explain a large share of the observed cross-country variation in growth rates, a significant portion of this variation (over 20 %) remains unexplained. Some part of this, no doubt, is due to measurement error, and country-specific factors also play some role. No *general* explanatory model can ever hope to explain 100 % of the observed variation over any given period, though there are probably many other systematic factors at work which need to be explored. There is still plenty of scope for further research in this field.

they have an *incentive* to do so. The “productivity/incentives” schema is merely an artificial analytical construct, designed mainly to distinguish between effects of economic freedom that operate through the investment rate and effects that do not.

²⁴In this regard, it seems worthwhile to point out that some of the most rapidly growing economies of the past half century are located in the tropics: Singapore and Malaysia almost precisely on the equator, and Taiwan and Hong Kong on the Tropic of Cancer. (I am indebted to Prof. Robert Higgs for this observation.)

Table 4 – Determinants of Economic Growth, 1980-99: Regression Results.

Dependent Variable: Average annual rate of growth (%), real per capita GDP, 1980-99.

Regression Number: [1] [2] [3] [4] [5] [6]

Explanatory variables: [numbers in parentheses are t-values of the estimated coefficients]

Constant	14.604 [5.559]	14.436 [5.517]	14.498 [5.585]	12.945 [4.720]	11.669 [4.996]	13.611 [5.039]
LOGGDP80	-1.433 [-5.831]	-1.422 [-5.813]	-1.429 [-5.892]	-1.729 [-6.015]	-1.752 [-8.007]	-1.423 [-5.779]
INV	0.076 [3.035]	0.083 [3.271]	0.081 [3.309]	0.091 [2.898]	0.084 [3.288]	0.104 [3.492]
FERTIL	-1.203 [-7.859]	-1.204 [-7.905]	-1.205 [-7.957]	-1.093 [-6.971]	-1.002 [-7.251]	-1.152 [-7.261]
DSCH15	0.531 [2.868]					
DMALESCH15		0.590 [2.324]	0.527 [3.193]	0.551 [2.963]	0.521 [3.649]	0.469 [2.812]
DFEMSCH15		-0.090 [-0.328]				
EFW				0.599 [3.479]	0.761 [5.490]	
DEFW					0.461 [3.616]	0.236 [1.668]
Adjusted R-squared	0.587	0.591	0.596	0.685	0.726	0.626
N	90	90	90	85	85	85
White test (chi-square)	5.030	29.622	9.317	35.940	38.830	17.550
d.f. for White test	14	20	14	20	27	20
prob-value	0.985	0.076	0.810	0.016	0.066	0.617

Note: Since regression 4 shows signs of heteroskedasticity, t-values were estimated using the White (1980) correction.

Table 4 (cont.)

Dependent Variable: Average annual rate of growth (%), real per capita GDP, 1980-99.

Regression Number: [7] [8] [9] [10] [11]

Explanatory variables:

Constant	-0.124 [-0.062]	17.202 [5.195]	12.748 [4.550]	13.675 [6.170]	15.877 [7.923]
LOGGDP80		-1.670 [-6.449]	-1.970 [-9.056]	-1.988 [-9.459]	-1.991 [-9.492]
INV		0.072 [2.879]	0.088 [3.551]	0.089 [3.659]	
INV*EFW					0.0157 [3.679]
FERTIL		-1.229 [-7.564]	-0.913 [6.524]	-0.926 [-6.951]	-0.937 [-7.122]
DSCH15					
DMALESCH15		0.427 [2.472]	0.317 [2.198]	0.337 [2.438]	0.332 [2.399]
DFEMSCH15					
EFW			0.811 [5.826]	0.797 [5.915]	0.424 [2.339]
DEFW			0.495 [3.957]	0.513 [4.277]	0.513 [4.280]
TROPICAR	-1.754 [-3.549]	-0.647 [-1.513]	-1.219 [-3.351]	-1.098 [-3.695]	-1.196 [-4.006]
POP100KM	1.718 [3.143]	0.285 [0.620]	0.140 [0.368]		
LOGDIST	0.152 [0.604]	-0.028 [-0.147]	0.091 [0.552]		

Adjusted R-squared	0.186	0.631	0.773	0.778	0.779
N	96	84	80	80	80
White test (chi-square)	5.025	37.828	66.422	44.942	42.987
d.f. for White test	9	35	54	35	35
prob-value	0.832	0.341	0.119	0.121	0.166

Table 5 – Rate of Growth of Private GDP, 1980-99: Further Regression Results.

Dependent Variable: Annual rate of growth (%), private GDP per capita, 1980-99.

Regression Number: [1] [2] [3] [4] [5] [6]

Explanatory variables: [numbers in parentheses are t-values of the estimated coefficients]

Constant	13.911 [4.683]	13.424 [4.521]	13.730 [4.717]	12.325 [3.996]	11.084 [4.197]	13.570 [4.558]
LOGGDP80	-1.469 [-5.262]	-1.432 [-5.143]	-1.461 [-5.354]	-1.710 [-4.887]	-1.740 [-7.035]	-1.474 [-5.317]
INV	0.107 [3.296]	0.120 [3.587]	0.113 [3.622]	0.102 [2.987]	0.091 [3.210]	0.109 [3.377]
FERTIL	-1.092 [-6.433]	-1.080 [-6.403]	-1.090 [6.521]	-1.018 [-5.921]	-0.924 [-6.035]	-1.086 [-6.320]
DSCH15	0.482 [2.199]					
DMALESCH15		0.602 [2.211]	0.487 [2.591]	0.488 [2.319]	0.470 [2.883]	0.479 [2.562]
DFEMSCH15		-0.183 [-0.585]				
EFW				0.617 [3.021]	0.780 [4.927]	
DEFW					0.516 [3.643]	0.319 [2.048]
Adjusted R-squared	0.553	0.559	0.562	0.639	0.691	0.592
N	83	83	83	79	79	79
White test (chi-square)	3.091	23.564	7.588	35.990	39.102	15.728
d.f. for White test	14	20	14	20	27	20
prob-value	0.999	0.262	0.909	0.015	0.062	0.733

Note: Since regression 4 shows signs of heteroskedasticity, t-values were estimated using the White (1980) correction.

Table 5 (cont.)

Dependent Variable: Annual rate of growth (%), private GDP per capita, 1980-99.

Regression Number: [7] [8] [9] [10] [11]

Explanatory variables:

Constant	-0.641 [-0.240]	15.568 [3.963]	11.932 [3.524]	12.784 [5.039]	15.096 [6.575]
LOGGDP80		-1.689 [-5.786]	-1.945 [-7.754]	-1.944 [-8.111]	-1.941 [-8.125]
INV		0.110 [3.405]	0.092 [3.281]	0.094 [3.406]	
INV*EFW					0.0170 [3.483]
FERTIL		-1.040 [-5.769]	-0.798 [-5.071]	-0.829 [-5.491]	-0.839 [-5.637]
DSCH15					
DMALESCH15		0.332 [1.673]	0.241 [1.445]	0.265 [1.635]	0.260 [1.608]
DFEMSCH15					
EFW			0.848 [5.226]	0.845 [5.346]	0.434 [2.054]
DEFW			0.545 [3.876]	0.573 [4.231]	0.572 [4.233]
TROPICAR	-1.718 [-2.955]	-1.004 [-2.071]	-1.404 [-3.377]	-1.210 [-3.570]	-1.314 [-3.875]
POP100KM	1.965 [3.136]	0.671 [1.296]	0.377 [0.843]		
LOGDIST	0.206 [0.609]	0.028 [0.109]	0.092 [0.413]		

Adjusted R-squared	0.165	0.604	0.738	0.743	0.745
N	88	77	74	74	74
White test (chi-square)	5.309	34.028	69.156	48.900	47.789
d.f. for White test	9	35	54	35	35
prob-value	0.807	0.515	0.080	0.059	0.073

APPENDIX A

COMPONENTS OF “ECONOMIC FREEDOM OF THE WORLD” INDEX

1. Size of Government: Expenditures, Taxes, and Enterprises
 - A. General government consumption spending as a percentage of total consumption
 - B. Transfers and subsidies as a percentage of GDP
 - C. Government enterprises and investment as a percentage of GDP
 - D. Top marginal tax rate (and income threshold to which it applies)
2. Legal Structure and Security of Property Rights
 - A. Judicial independence: The judiciary is independent and not subject to interference by the government or parties in dispute (GCR)
 - B. Impartial courts: A trusted legal framework exists for private businesses to challenge the legality of government actions or regulation (GCR)
 - C. Protection of intellectual property
 - D. Military interference in rule of law and political process (ICRG)
 - E. Integrity of the legal system (ICRG)
3. Access to Sound Money
 - A. Average annual growth of the money supply in the last five years minus average annual growth of real GDP in the last ten years
 - B. Standard inflation variability in the last five years
 - C. Recent inflation rate
 - D. Freedom to own foreign currency bank accounts domestically and abroad
4. Freedom to Exchange with Foreigners
 - A. Taxes on international trade
 - i. Revenue from taxes on international trade as a percentage of exports plus imports
 - ii. Mean tariff rate
 - iii. Standard deviation of tariff rates
 - B. Regulatory trade barriers
 - i. Hidden import barriers: No barriers other than published tariffs and quotas (GCR)
 - ii. Costs of importing: The combined effect of import tariffs, license fees, bank fees, and the time required for administrative red-tape

raises costs of importing equipment by (10 = 10 % or less; 0 = more than 50 %) (GCR)

- C. Actual size of trade sector compared to expect size.
 - D. Difference between official exchange rate and black market rate
 - E. International capital market controls
 - i. Access of citizens to foreign capital markets and foreign access to domestic capital markets (GCR)
 - ii. Restrictions on the freedom of citizens to engage in capital market exchange with foreigners—index of capital controls among 13 IMF categories
5. Regulation of Credit, Labor, and Business
- A. Credit Market Regulations
 - i. Ownership of banks: Percentage of deposits held in privately owned banks
 - ii. Competition: Domestic banks face competition from foreign banks (GCR)
 - iii. Extension of credit: Percentage of credit extended to private sector
 - iv. Avoidance of interest rate controls and regulations that lead to negative real interest rates
 - v. Interest rate controls: Interest rates on bank deposits and/or loans are freely determined by the market (GCR)
 - B. Labor Market Regulations
 - i. Impact of minimum wage: The minimum wage, set by law, has little impact on wages because it is too low or not obeyed (GCR)
 - ii. Hiring and firing practices: Hiring and firing practices of companies are determined by private contract (GCR)
 - iii. Share of labor force whose wages are set by centralized collective bargaining
 - iv. Unemployment benefits: The unemployment benefits system preserves the incentive to work (GCR)
 - v. Use of conscripts to obtain military personnel
 - C. Business Regulations
 - i. Price controls: Extent to which business are free to set their own prices
 - ii. Administrative conditions and new businesses: Administrative procedures are an important obstacle to starting a new business (GCR)

- iii. Time with government bureaucracy: Senior management spends a substantial amount of time dealing with government bureaucracy (GCR)
- iv. Starting a new business: Starting a new business is generally easy (GCR)
- v. Irregular payments: Irregular, additional payments connected with import and export permits, business licenses, exchange controls, tax assessments, police protection, or loan applications are very rare (GCR)

GCR = *Global Competitiveness Report* (World Economic Forum), ICRG = *International Country Risk Guide* (PRS Group)

Source: Gwartney, *et al.* (2002), pp. 8-9.

APPENDIX B — DATA DEFINITIONS AND SOURCES

(Basic data for this study are contained on an Excel spreadsheet, available upon request to: jhcole@ufm.edu.gt.)

(a) Sources

- 1) Economic and population variables: *World Development Indicators*, 2001 (CD-ROM version). This source reports data for 207 countries, though coverage for some of them is rather limited. For this study, the basic sample is restricted to countries for which figures are available on real GDP per capita for the years 1980 and 1999 (thus allowing calculation of a rate of growth of real per capita GDP over that sample period). This sample is reduced further to 106 countries for which full data are available on variables required for Regression 1 and/or Regression 7.
- 2) Geographic variables: Gallup, Sachs and Mellinger (1999), dataset downloaded from <http://www2.cid.harvard.edu/ciddata/geodata.csv>.
- 3) Educational Attainment: Barro and Lee (2001), dataset downloaded from <http://www2.cid.harvard.edu/ciddata/barrolee/Appendix.xls>.
- 4) Economic Freedom of the World Index: James Gwartney and Robert Lawson, “Chain-linked Adjusted Summary Index,” Madrid Meeting of Economic Freedom Network (Oct 2002). Dataset provided by Prof. Lawson.

(b) Data Definitions

For each country, an effort has been made to obtain figures for as many of the following variables as possible:

GDP1980 = PPP-adjusted GDP per capita, in international dollars, 1980.

GROWTH6080 = average annual growth rate of real GDP per capita, 1960-80.

GROWTH8099 = average annual growth rate of real GDP per capita, 1980-99. This is the dependent variable for the regressions reported in Table 4.

GOV = Government Consumption (% of GDP), 1980 and 1999.

PRIVATE GDP = average annual growth rate of “private” real GDP per capita, 1980-99 (as defined in Chapter 3). This is the dependent variable for the regressions reported in Table 5.

INV = Investment/GDP ratio (Gross Fixed Capital Formation as % of GDP), average for 1980-99.

FERTIL = Total fertility rate (births per woman), average for 1980-99.

[An effort has been made to compute these averages using all annual values over the full sample period. However, for some countries there are missing data in some years. In every case, the average has been computed using all available annual data over the sample period.]

POPGROWTH = average annual population growth rate, 1980-99, based on total population figures for 1980 and 1999.

TROPICAR = proportion (0 to 1) of the country's territory located in the geographic tropics (defined as areas located between 23.5 degrees of latitude North and 23.5 degrees of latitude South).

POP100KM = proportion (0 to 1) of the country's population living within 100 kilometers of the sea coast.

AIRDIST = minimum Great-Circle (air) distance, in kilometers, from the country to one of three core areas of the world economy (defined as New York, Rotterdam or Tokyo).

SCH15 = Average years of schooling for the total population aged 15 and over, 1980 and 1995.

FEMSCH15 = Average years of schooling for the female population aged 15 and over, 1980 and 1995.

MALESCH15 = Average years of schooling for the male population aged 15 and over, 1980 and 1995.¹

EFW [year] = Economic Freedom of the World Index, a number ranging from 1 (low freedom) to 10 (high freedom). Chain-linked adjusted summary index, for the years 1980, 1985, 1990, 1995 and 2000.

¹Figures on male schooling for 1980 and 1995 were derived from data on total and female schooling using the formula $MALESCH = 2 * SCH - FEMSCH$.

APPENDIX C — STATISTICAL TABLES

Table C-1.	Economic Variables	74
Table C-2.	Population and Geographic Variables	77
Table C-3.	Educational Attainment	80
Table C-4.	Economic Freedom of the World Index	83

Table C-1. Economic Variables.

Country Code	Country Name	GDP1980	GROWTH		GOV		PRIVATE GDP	INV
			60-80	80-99	1980	1999		
DZA	Algeria	3220	1.97	-0.39	13.78	17.01	-0.59	29.0
ARG	Argentina	6956	1.83	0.20	..	12.89	..	19.0
AUS	Australia	9877	2.42	2.07	19.16	..	..	24.0
AUT	Austria	10717	3.80	1.79	18.43	19.74	1.70	22.5
BGD	Bangladesh	565	0.10	2.60	1.90	4.59	2.45	18.6
BRB	Barbados	7336	4.28	0.87	14.92	22.66	0.36	17.2
BEL	Belgium	11442	3.63	1.61	25.70	21.20	1.93	20.5
BEN	Benin	500	0.16	0.56	8.64	10.10	0.47	15.4
BOL	Bolivia	1443	1.02	-0.30	14.00	14.58	-0.34	15.3
BWA	Botswana	1828	8.25	4.26	19.61	27.66	3.69	25.5
BRA	Brazil	4031	4.57	0.27	9.20	18.85	-0.32	20.2
BFA	Burkina Faso	451	1.03	1.34	10.42	13.58	1.15	21.4
BDI	Burundi	421	1.61	-1.09	9.22	16.07	-1.50	13.9
CMR	Cameroon	1197	1.73	-0.56	9.70	10.03	-0.58	18.8
CAN	Canada	11827	..	1.50	21.55	19.02	1.67	20.3
CAF	Central African Rep.	824	-0.46	-0.96	15.14	11.54	-0.75	10.6
TCD	Chad	405	-2.47	1.14	..	8.03	..	7.5
CHL	Chile	2730	1.53	3.50	12.45	11.83	3.54	20.3
CHN	China	465	2.05	8.35	14.59	12.56	8.48	31.1
COL	Colombia	2786	2.66	1.01	10.07	21.09	0.32	17.9
COG	Congo, Rep.	395	2.54	-0.48	17.59	10.75	-0.06	31.0
CRI	Costa Rica	3794	2.37	1.36	18.22	12.78	1.70	20.0
CIV	Cote d'Ivoire	1288	2.92	-1.48	16.86	10.92	-1.12	14.0
CYP	Cyprus	5393	..	3.96	13.67	19.30	3.59	25.0
DMA	Dominica	1512	..	3.69	27.29	21.50	4.11	30.7
DOM	Dominican Republic	2234	3.38	1.95	7.60	8.17	1.92	22.1
ECU	Ecuador	1938	3.50	-0.45	14.51	10.36	-0.20	19.4
EGY	Egypt	1362	3.61	2.60	15.67	10.06	2.95	23.4
SLV	El Salvador	2384	0.99	0.49	13.99	9.99	0.73	14.7
FJI	Fiji	2564	2.55	0.67	15.93	15.65	0.69	15.7
FIN	Finland	9349	3.74	2.06	18.65	21.48	1.87	22.9
FRA	France	10163	3.57	1.60	21.50	23.67	1.45	20.7
GAB	Gabon	4151	5.37	-0.87	13.23	16.58	-1.08	29.6
GMB	Gambia	976	..	-0.16	31.21	14.26	1.01	19.5
GHA	Ghana	1071	-0.66	0.20	11.16	10.85	0.22	13.9
GRC	Greece	6966	5.38	1.46	12.11	14.90	1.29	22.0
GTM	Guatemala	2268	2.75	-0.17	7.96	6.24	-0.08	13.9
GNB	Guinea-Bissau	369	..	0.45	27.64	11.08	1.55	28.8
GUY	Guyana	2091	0.97	0.14	24.20	19.45	0.46	29.4
HTI	Haiti	1458	0.52	-2.56	10.08	6.37	-2.36	11.0
HND	Honduras	1532	1.80	-0.33	12.67	11.45	-0.25	20.6
HKG	Hong Kong, China	6896	6.84	3.62	6.15	9.84	3.40	27.5
HUN	Hungary	5501	5.23	1.08	10.29	10.41	1.07	22.6
ISL	Iceland	12327	4.12	1.60	16.46	21.65	1.25	19.8
IND	India	672	1.07	3.68	9.86	12.00	3.55	21.5

Table C-1 (cont.)

Country Code	Country Name	GDP1980	GROWTH		GOV		PRIVATE GDP	INV
			60-80	80-99	1980	1999		
IDN	Indonesia	871	3.58	3.46	10.52	6.49	3.70	25.4
IRN	Iran	2862	..	0.74	20.80	13.55	1.20	19.9
IRL	Ireland	5855	3.51	4.50	21.17	13.95	4.99	18.1
ISR	Israel	7919	4.03	1.86	40.05	29.04	2.76	21.2
ITA	Italy	9572	4.04	1.69	16.77	18.11	1.61	20.9
JAM	Jamaica	2077	0.61	0.36	20.24	18.19	0.50	25.8
JPN	Japan	9885	6.26	2.26	9.81	..	..	29.1
JOR	Jordan	2602	..	-0.65	28.82	24.60	-0.34	27.2
KEN	Kenya	625	2.62	-0.01	19.80	17.50	0.14	15.6
KOR	Korea, Rep.	2988	5.65	6.33	11.95	10.09	6.45	32.4
LVA	Latvia	4359	..	-0.81	7.89	19.02	-1.48	23.4
LSO	Lesotho	624	3.93	1.82	21.79	..	..	48.2
MDG	Madagascar	674	-0.54	-1.83	12.11	7.85	-1.58	11.4
MWI	Malawi	385	2.51	-0.13	19.29	12.38	0.30	14.9
MYS	Malaysia	2412	4.38	3.63	15.99	11.14	3.94	32.9
MLI	Mali	490	..	-0.45	9.83	12.60	-0.62	19.9
MRT	Mauritania	991	2.54	-0.02	45.30	15.18	2.31	21.6
MUS	Mauritius	2400	2.40	4.45	14.07	11.30	4.62	24.4
MEX	Mexico	4532	3.53	0.51	10.04	10.01	0.51	19.6
MAR	Morocco	1672	2.38	1.05	18.34	19.32	0.99	22.6
MOZ	Mozambique	404	..	0.92	12.15	11.05	0.99	13.9
NAM	Namibia	4217	..	-0.28	17.41	26.31	-0.88	19.6
NPL	Nepal	507	0.01	2.16	6.70	9.60	1.99	18.4
NLD	Netherlands	10277	2.91	1.85	29.13	23.15	2.28	21.3
NIC	Nicaragua	1918	..	-1.98	19.73	18.23	-1.89	22.6
NER	Niger	709	-1.05	-2.34	10.38	14.92	-2.61	11.6
NGA	Nigeria	607	1.72	-1.20	12.09	14.86	-1.37	18.8
NOR	Norway	11071	3.77	2.42	18.72	21.17	2.25	24.3
PAK	Pakistan	646	2.86	2.50	10.04	11.52	2.41	17.0
PAN	Panama	3069	3.13	0.96	17.60	15.56	1.09	20.0
PNG	Papua New Guinea	1206	2.20	0.76	24.07	13.39	1.46	22.2
PRY	Paraguay	2838	3.81	-0.44	6.02	8.84	-0.60	23.2
PER	Peru	3089	1.59	-0.47	10.52	10.89	-0.49	22.0
PHL	Philippines	2459	2.50	-0.13	9.07	12.95	-0.36	22.4
PRT	Portugal	5866	5.08	2.73	14.17	..	..	23.8
ROM	Romania	4612	..	-1.20	5.04	14.65	-1.75	24.9
RWA	Rwanda	722	0.76	-1.64	12.49	12.66	-1.65	14.4
SAU	Saudi Arabia	11371	5.76	-2.81	15.74	29.89	-3.75	21.5
SEN	Senegal	811	-0.97	0.36	20.30	10.93	0.95	14.1
SLE	Sierra Leone	563	1.38	-3.81	7.66	11.46	-4.02	9.2
SGP	Singapore	5894	7.31	4.70	9.75	9.70	4.70	37.7
ZAF	South Africa	6474	2.48	-0.88	14.29	19.23	-1.19	19.6
ESP	Spain	6939	4.42	2.33	14.11	17.11	2.14	22.6
LKA	Sri Lanka	1062	2.42	3.25	8.55	8.99	3.22	25.2
KNA	St. Kitts and Nevis	2364	..	5.18	20.90	21.50	5.14	43.7

Table C-1 (cont.)

Country Code	Country Name	GDP1980	GROWTH		GOV		PRIVATE GDP	INV
			60-80	80-99	1980	1999		
LCA	St. Lucia	1672	..	3.43	17.54	..	..	26.0
VCT	St. Vincent/Grenadines	1470	..	3.89	22.98	18.41	4.21	28.1
SWZ	Swaziland	1957	..	1.52	19.07	19.98	1.46	24.4
SWE	Sweden	10365	2.75	1.38	29.58	27.02	1.57	19.0
CHE	Switzerland	14553	2.11	0.70	12.48	..	..	23.8
SYR	Syria	1792	4.15	0.76	23.15	11.37	1.52	22.9
THA	Thailand	1482	4.48	4.78	12.29	11.04	4.86	32.2
TGO	Togo	1183	3.40	-1.66	22.37	10.91	-0.94	17.1
TTO	Trinidad and Tobago	4540	4.56	0.36	12.06	11.26	0.40	21.4
TUN	Tunisia	2431	..	2.00	14.47	15.51	1.93	27.3
TUR	Turkey	2519	..	2.21	11.55	15.21	1.98	21.2
USA	United States	13023	2.31	2.05	16.92	..	..	18.4
URY	Uruguay	4576	1.49	0.93	12.45	13.83	0.85	14.1
VEN	Venezuela	4023	0.35	-1.13	11.79	7.60	-0.89	19.1
ZMB	Zambia	700	-0.52	-2.12	25.51	9.59	-1.12	12.5
ZWE	Zimbabwe	1441	1.55	0.66	18.51	14.91	0.89	17.8

Table C-2. Population and Geographic Variables.

Country Code	Country Name	POPGROWTH	FERTIL	POP100KM	AIRDIST	TROPICAR
DZA	Algeria	2.52	4.80	0.704	1675	0.162
ARG	Argentina	1.40	2.90	0.189	8570	0.027
AUS	Australia	1.35	1.86	0.835	7800	0.386
AUT	Austria	0.36	1.47	0.006	840	0.000
BGD	Bangladesh	2.06	4.23	0.370	4900	0.403
BRB	Barbados	0.36	1.80	...	...	...
BEL	Belgium	0.20	1.58	0.714	190	0.000
BEN	Benin	3.04	6.47	0.492	5040	1.000
BOL	Bolivia	2.23	4.73	0.000	6500	1.000
BWA	Botswana	3.00	5.13	0.000	8760	0.703
BRA	Brazil	1.71	2.86	0.341	7700	0.931
BFA	Burkina Faso	2.43	7.07	0.000	4480	1.000
BDI	Burundi	2.56	6.63	0.000	6600	1.000
CMR	Cameroon	2.82	5.83	0.152	5470	1.000
CAN	Canada	1.14	1.68	0.133	540	0.000
CAF	Central African Rep.	2.26	5.37	0.000	5450	1.000
TCD	Chad	2.74	6.88	0.000	4550	1.000
CHL	Chile	1.58	2.52	0.527	8290	0.163
CHN	China	1.30	2.26	0.191	2100	0.031
COL	Colombia	2.01	3.18	0.272	4030	1.000
COG	Congo, Rep.	2.87	6.21	0.183	6330	1.000
CRI	Costa Rica	2.41	3.17	1.000	3575	1.000
CIV	Cote d'Ivoire	3.43	6.25	0.372	5260	1.000
CYP	Cyprus	1.16	2.29	...	...	...
DMA	Dominica	-0.03	2.61	...	...	...
DOM	Dominican Republic	2.07	3.41	1.000	2420	1.000
ECU	Ecuador	2.36	3.90	0.601	4580	1.000
EGY	Egypt	2.27	4.11	0.483	3250	0.166
SLV	El Salvador	1.56	3.93	1.000	3350	1.000
FJI	Fiji	1.24	3.21	...	...	...
FIN	Finland	0.41	1.73	0.636	1640	0.000
FRA	France	0.44	1.78	0.329	440	0.000
GAB	Gabon	2.99	4.95	0.469	5790	1.000
GMB	Gambia	3.58	6.04	0.624	4660	1.000
GHA	Ghana	2.99	5.52	0.433	5190	1.000
GRC	Greece	0.47	1.58	0.968	2130	0.000
GTM	Guatemala	2.59	5.48	0.733	3300	1.000
GNB	Guinea-Bissau	2.12	5.87	0.812	4780	1.000
GUY	Guyana	0.63	2.73	...	...	...
HTI	Haiti	2.00	5.10	1.000	2500	1.000
HND	Honduras	3.05	5.17	0.706	3220	1.000
HKG	Hong Kong, China	1.53	1.32	1.000	2940	1.000
HUN	Hungary	-0.32	1.70	0.000	1160	0.000
ISL	Iceland	1.04	2.16			
IND	India	1.98	3.95	0.225	5860	0.512

Table C-2 (cont.)

Country Code	Country Name	POPGROWTH	FERTIL	POP100KM	AIRDIST	TROPICAR
IDN	Indonesia	1.77	3.21	0.961	5800	1.000
IRN	Iran	2.54	4.75	0.064	4100	0.000
IRL	Ireland	0.52	2.30	0.929	800	0.000
ISR	Israel	2.42	2.96	0.988	3300	0.000
ITA	Italy	0.11	1.35	0.746	1270	0.000
JAM	Jamaica	1.04	3.04	1.000	2560	1.000
JPN	Japan	0.42	1.59	0.974	140	0.000
JOR	Jordan	4.17	5.30	0.219	3390	0.000
KEN	Kenya	3.05	5.96	0.063	6650	1.000
KOR	Korea, Rep.	1.09	1.90	0.958	1150	0.000
LVA	Latvia	-0.24	1.70	0.486	1430	0.000
LSO	Lesotho	2.38	5.06	0.000	9320	0.000
MDG	Madagascar	2.82	6.18	0.471	8940	0.877
MWI	Malawi	2.97	7.01	0.000	7870	1.000
MYS	Malaysia	2.67	3.72	0.905	5380	1.000
MLI	Mali	2.52	6.85	0.000	4500	0.959
MRT	Mauritania	2.75	5.87	0.149	4180	0.823
MUS	Mauritius	1.03	2.26	1.000	9590	1.000
MEX	Mexico	1.90	3.39	0.297	3360	0.466
MAR	Morocco	2.00	4.01	0.631	2175	0.000
MOZ	Mozambique	1.90	6.06	0.404	9080	0.903
NAM	Namibia	2.68	5.36	0.047	8400	0.656
NPL	Nepal	2.55	5.21	0.000	5160	0.000
NLD	Netherlands	0.58	1.56	0.835	140	0.000
NIC	Nicaragua	2.78	4.85	0.752	3440	1.000
NER	Niger	3.38	7.41	0.000	4460	1.000
NGA	Nigeria	2.96	6.02	0.243	4770	1.000
NOR	Norway	0.46	1.80	0.881	1000	0.000
PAK	Pakistan	2.60	5.84	0.086	5950	0.000
PAN	Panama	1.94	3.05	1.000	3590	1.000
PNG	Papua New Guinea	2.24	5.26	0.691	4500	1.000
PRY	Paraguay	2.90	4.63	0.000	7580	0.561
PER	Peru	2.00	3.73	0.556	5940	1.000
PHL	Philippines	2.29	4.16	1.000	3010	1.000
PRT	Portugal	0.12	1.65	0.869	1750	0.000
ROM	Romania	0.06	1.86	0.046	1820	0.000
RWA	Rwanda	2.54	6.96	0.000	6460	1.000
SAU	Saudi Arabia	4.12	6.50	0.271	4700	0.480
SEN	Senegal	2.76	6.17	0.613	4757	1.000
SLE	Sierra Leone	2.26	6.35	0.568	5080	1.000
SGP	Singapore	2.63	1.68	1.000	5300	1.000
ZAF	South Africa	2.25	3.51	0.367	8930	0.038
ESP	Spain	0.28	1.49	0.633	1420	0.000
LKA	Sri Lanka	1.34	2.64	0.987	6850	1.000
KNA	St. Kitts and Nevis	-0.43	2.69	...	...	...

Table C-2 (cont.)

Country Code	Country Name	POPGROWTH	FERTIL	POP100KM	AIRDIST	TROPICAR
LCA	St. Lucia	1.53	3.11	...	...	...
VCT	St. Vincent/Grenadines	0.81	2.59	...	...	...
SWZ	Swaziland	3.16	5.34	...	...	...
SWE	Sweden	0.34	1.79	0.704	1200	0.000
CHE	Switzerland	0.64	1.53	0.000	600	0.000
SYR	Syria	3.16	5.56	0.279	3290	0.000
THA	Thailand	1.35	2.44	0.393	4620	1.000
TGO	Togo	2.98	6.26	0.417	5120	1.000
TTO	Trinidad and Tobago	0.94	2.45	1.000	3600	1.000
TUN	Tunisia	2.09	3.33	0.822	1740	0.000
TUR	Turkey	1.97	3.15	0.539	2520	0.000
USA	United States	1.07	1.95	0.379	140	0.002
URY	Uruguay	0.68	2.51	0.725	8560	0.000
VEN	Venezuela	2.41	3.47	0.691	3530	1.000
ZMB	Zambia	2.90	6.26	0.000	7820	1.000
ZWE	Zimbabwe	2.83	4.92	0.000	8190	1.000

Table C-3. Educational Attainment.

Country Code	Country Name	SCH15		FEMSCH15		MALESCH15	
		1980	1995	1980	1995	1980	1995
DZA	Algeria	2.68	4.83	1.77	3.94	3.59	5.72
ARG	Argentina	7.03	8.46	7.10	8.52	6.96	8.40
AUS	Australia	10.29	10.67	9.92	10.40	10.66	10.94
AUT	Austria	7.34	8.05	6.39	7.22	8.29	8.88
BGD	Bangladesh	1.90	2.41	1.03	1.63	2.77	3.19
BRB	Barbados	6.77	8.34	6.81	8.29	6.73	8.39
BEL	Belgium	8.24	9.10	7.95	8.79	8.53	9.41
BEN	Benin	1.09	2.14	0.63	1.19	1.55	3.09
BOL	Bolivia	4.62	5.31	3.80	4.79	5.44	5.83
BWA	Botswana	3.12	5.86	3.20	5.91	3.04	5.81
BRA	Brazil	3.11	4.45	3.06	4.19	3.16	4.71
BFA	Burkina Faso	...	...	...	...	...	...
BDI	Burundi	...	...	...	...	...	...
CMR	Cameroon	2.41	3.37	1.76	2.78	3.06	3.96
CAN	Canada	10.32	11.39	10.22	11.36	10.42	11.42
CAF	Central African Rep.	1.28	2.45	0.69	1.61	1.87	3.29
TCD	Chad	...	...	...	...	...	...
CHL	Chile	6.42	7.25	6.36	7.21	6.48	7.29
CHN	China	4.76	6.11	3.73	4.74	5.79	7.48
COL	Colombia	4.41	4.96	4.50	5.40	4.32	4.52
COG	Congo, Rep.	5.00	5.12	3.91	4.58	6.09	5.66
CRI	Costa Rica	5.19	5.77	5.18	5.77	5.20	5.77
CIV	Cote d'Ivoire	...	...	...	...	...	...
CYP	Cyprus	6.52	8.91	5.81	8.43	7.23	9.39
DMA	Dominica	4.88	...	5.07	...	4.69	...
DOM	Dominican Republic	3.75	4.66	3.57	4.69	3.93	4.63
ECU	Ecuador	6.11	6.14	5.86	6.13	6.36	6.15
EGY	Egypt	2.34	4.98	1.56	3.91	3.12	6.05
SLV	El Salvador	3.20	4.70	3.00	4.64	3.40	4.76
FJI	Fiji	6.81	8.08	6.43	7.74	7.19	8.42
FIN	Finland	7.16	9.65	7.11	9.50	7.21	9.80
FRA	France	6.69	7.42	6.66	7.18	6.72	7.66
GAB	Gabon	...	...	...	...	...	...
GMB	Gambia	0.89	1.95	0.52	1.32	1.26	2.58
GHA	Ghana	3.44	3.75	2.02	2.09	4.86	5.41
GRC	Greece	7.01	8.32	6.35	7.24	7.67	9.40
GTM	Guatemala	2.72	3.25	2.39	2.90	3.05	3.60
GNB	Guinea-Bissau	0.26	0.78	0.26	0.65	0.26	0.91
GUY	Guyana	5.20	6.00	5.15	6.10	5.25	5.90
HTI	Haiti	1.93	2.83	1.68	2.04	2.18	3.62
HND	Honduras	2.82	4.50	2.72	3.68	2.92	5.32
HKG	Hong Kong, China	7.95	9.28	6.98	8.68	8.92	9.88
HUN	Hungary	9.06	8.83	8.72	8.37	9.40	9.29
ISL	Iceland	7.37	8.48	7.15	8.26	7.59	8.70
IND	India	3.27	4.52	1.89	3.18	4.65	5.86

Table C-3 (cont.)

Country Code	Country Name	SCH15		FEMSCH15		MALESCH15	
		1980	1995	1980	1995	1980	1995
IDN	Indonesia	3.67	4.55	3.01	4.02	4.33	5.08
IRN	Iran	2.82	4.73	2.00	3.93	3.64	5.53
IRL	Ireland	7.46	9.08	7.53	9.12	7.39	9.04
ISR	Israel	9.41	9.45	9.00	9.28	9.82	9.62
ITA	Italy	5.89	6.85	5.43	6.48	6.35	7.22
JAM	Jamaica	4.07	5.02	4.32	5.39	3.82	4.65
JPN	Japan	8.51	9.23	8.16	8.86	8.86	9.60
JOR	Jordan	4.28	6.47	3.26	5.68	5.30	7.26
KEN	Kenya	3.44	4.01	2.49	3.42	4.39	4.60
KOR	Korea, Rep.	7.91	10.56	6.77	9.72	9.05	11.40
LVA	Latvia	...	9.45	...	9.29	...	9.61
LSO	Lesotho	3.84	4.06	4.31	4.62	3.37	3.50
MDG	Madagascar	...	...	...	...	...	...
MWI	Malawi	2.68	2.70	1.81	2.19	3.55	3.21
MYS	Malaysia	5.09	6.49	3.81	5.79	6.37	7.19
MLI	Mali	0.54	0.76	0.31	0.47	0.77	1.05
MRT	Mauritania	...	2.42	...	1.85	...	2.99
MUS	Mauritius	5.23	5.79	4.50	5.28	5.96	6.30
MEX	Mexico	4.77	6.96	4.40	6.63	5.14	7.29
MAR	Morocco	...	...	...	...	...	...
MOZ	Mozambique	0.76	1.03	0.35	0.76	1.17	1.30
NAM	Namibia	...	...	...	...	...	...
NPL	Nepal	0.91	2.01	0.21	1.13	1.61	2.89
NLD	Netherlands	8.23	9.12	7.99	8.89	8.47	9.35
NIC	Nicaragua	3.23	4.09	3.09	4.13	3.37	4.05
NER	Niger	0.55	0.93	0.25	0.57	0.85	1.29
NGA	Nigeria	...	...	...	...	...	...
NOR	Norway	8.15	11.70	7.74	11.41	8.56	11.99
PAK	Pakistan	2.06	3.92	1.05	2.61	3.07	5.23
PAN	Panama	6.44	8.36	6.48	8.39	6.40	8.33
PNG	Papua New Guinea	1.68	2.58	1.22	2.14	2.14	3.02
PRY	Paraguay	5.08	6.10	4.87	5.97	5.29	6.23
PER	Peru	6.11	7.31	5.43	6.81	6.79	7.81
PHL	Philippines	6.51	7.88	6.46	8.00	6.56	7.76
PRT	Portugal	3.78	5.47	3.42	5.22	4.14	5.72
ROM	Romania	7.82	9.42	5.92	8.94	9.72	9.90
RWA	Rwanda	1.73	2.36	1.18	1.92	2.28	2.80
SAU	Saudi Arabia	...	...	...	...	...	...
SEN	Senegal	2.17	2.39	1.55	1.80	2.79	2.98
SLE	Sierra Leone	1.64	2.27	1.10	1.60	2.18	2.94
SGP	Singapore	5.50	6.72	4.86	6.27	6.14	7.17
ZAF	South Africa	3.79	6.03	4.47	6.13	3.11	5.93
ESP	Spain	5.98	6.83	5.47	6.68	6.49	6.98
LKA	Sri Lanka	5.59	6.45	5.14	6.13	6.04	6.77
KNA	St. Kitts and Nevis	8.09	...	8.13	...	8.05	...

Table C-3 (cont.)

Country Code	Country Name	SCH15		FEMSCH15		MALESCH15	
		1980	1995	1980	1995	1980	1995
LCA	St. Lucia	4.95	...	5.17	...	4.73	...
VCT	St. Vincent/Grenadines	5.47	...	5.69	...	5.25	...
SWZ	Swaziland	3.88	5.63	3.67	5.89	4.09	5.37
SWE	Sweden	9.71	11.23	9.45	11.25	9.97	11.21
CHE	Switzerland	10.37	10.31	9.93	9.76	10.81	10.86
SYR	Syria	3.65	5.48	2.37	4.38	4.93	6.58
THA	Thailand	4.43	6.08	4.04	5.68	4.82	6.48
TGO	Togo	2.33	3.15	1.25	1.94	3.41	4.36
TTO	Trinidad and Tobago	7.26	7.44	7.33	7.62	7.19	7.26
TUN	Tunisia	2.94	4.53	1.99	3.67	3.89	5.39
TUR	Turkey	3.41	5.12	2.29	4.10	4.53	6.14
USA	United States	11.86	11.89	11.82	11.85	11.90	11.93
URY	Uruguay	6.16	7.31	6.29	7.57	6.03	7.05
VEN	Venezuela	5.48	6.69	5.38	6.78	5.58	6.60
ZMB	Zambia	3.90	5.42	2.92	5.04	4.88	5.80
ZWE	Zimbabwe	2.13	5.19	1.72	4.55	2.54	5.83

Table C-4. Economic Freedom of the World Index.

Country Code	Country Name	EFW1980	EFW1985	EFW1990	EFW1995	EFW2000
DZA	Algeria	3.82	3.96	3.69	3.69	4.22
ARG	Argentina	4.09	3.69	4.59	6.41	7.19
AUS	Australia	6.95	7.22	7.23	7.77	7.98
AUT	Austria	6.67	6.54	6.83	7.00	7.42
BGD	Bangladesh	2.94	3.39	4.16	5.06	5.45
BRB	Barbados	5.35	5.73	5.64	5.62	5.55
BEL	Belgium	7.23	7.17	7.21	7.19	7.44
BEN	Benin	4.75	4.56	4.86	4.77	5.66
BOL	Bolivia	3.58	2.93	4.91	6.30	6.69
BWA	Botswana	5.66	5.73	5.82	6.28	6.96
BRA	Brazil	4.25	3.49	4.03	4.37	5.60
BFA	Burkina Faso	...	...	...	...	...
BDI	Burundi	4.13	4.69	4.91	4.38	5.14
CMR	Cameroon	5.52	5.79	5.73	5.13	5.42
CAN	Canada	7.40	7.39	7.53	7.77	8.10
CAF	Central African Rep.	4.18	3.95	4.60	4.64	4.87
TCD	Chad	4.55	4.80	4.87	4.92	5.32
CHL	Chile	5.22	5.74	6.52	7.31	7.49
CHN	China	4.43	5.01	4.61	5.12	5.40
COL	Colombia	4.01	4.45	4.37	5.30	5.53
COG	Congo, Rep.	4.63	4.50	4.75	4.77	4.92
CRI	Costa Rica	5.33	5.05	6.47	6.58	7.25
CIV	Cote d'Ivoire	5.14	5.72	5.42	5.62	5.98
CYP	Cyprus	4.91	5.24	5.74	6.18	6.14
DMA	Dominica	...	...	...	...	...
DOM	Dominican Republic	5.08	4.74	4.21	5.67	6.77
ECU	Ecuador	5.43	4.48	5.19	6.00	5.25
EGY	Egypt	4.14	4.79	4.50	5.81	6.66
SLV	El Salvador	3.73	3.88	4.30	6.91	7.20
FJI	Fiji	5.48	5.70	5.76	6.06	6.02
FIN	Finland	6.76	6.87	6.95	7.32	7.63
FRA	France	6.01	5.96	6.78	6.80	6.97
GAB	Gabon	3.81	4.53	4.91	4.82	5.27
GMB	Gambia	...	...	...	...	...
GHA	Ghana	2.44	2.84	4.90	5.41	5.62
GRC	Greece	5.45	5.06	5.68	6.22	6.82
GTM	Guatemala	5.50	4.61	5.23	6.62	6.34
GNB	Guinea-Bissau	...	2.75	3.30	3.79	4.10
GUY	Guyana	2.85	2.86	3.61	4.73	6.05
HTI	Haiti	4.70	5.12	5.03	4.98	6.31
HND	Honduras	5.09	4.68	5.25	5.93	6.30
HKG	Hong Kong, China	8.71	8.34	8.14	9.03	8.78
HUN	Hungary	4.61	4.84	4.88	6.28	6.56
ISL	Iceland	5.27	5.44	6.65	7.34	7.70
IND	India	4.91	4.62	4.67	5.59	6.11

Table C-4 (cont.)

Country Code	Country Name	EFW1980	EFW1985	EFW1990	EFW1995	EFW2000
IDN	Indonesia	4.50	5.48	5.82	6.39	5.95
IRN	Iran	3.13	3.58	4.30	4.35	5.08
IRL	Ireland	6.38	6.37	6.81	8.16	8.13
ISR	Israel	3.42	4.07	4.20	5.75	6.74
ITA	Italy	5.36	5.65	6.45	6.45	7.06
JAM	Jamaica	3.93	4.49	5.23	6.09	6.99
JPN	Japan	6.79	6.75	7.00	6.89	7.30
JOR	Jordan	4.63	5.29	5.08	6.21	7.20
KEN	Kenya	4.87	5.34	5.35	5.67	6.54
KOR	Korea, Rep.	5.34	5.37	5.80	6.39	6.97
LVA	Latvia	...	...	...	4.72	6.66
LSO	Lesotho	...	...	...	...	...
MDG	Madagascar	4.04	4.33	4.26	4.49	5.20
MWI	Malawi	4.34	4.68	4.85	4.22	4.50
MYS	Malaysia	6.79	6.81	7.07	7.33	6.66
MLI	Mali	4.99	4.71	4.88	5.22	5.65
MRT	Mauritania	...	...	...	...	...
MUS	Mauritius	5.01	6.29	6.00	7.21	7.31
MEX	Mexico	5.24	4.41	5.70	6.20	6.15
MAR	Morocco	4.13	4.85	4.90	5.97	5.92
MOZ	Mozambique	...	...	...	...	...
NAM	Namibia	...	...	4.92	6.10	6.27
NPL	Nepal	5.29	4.93	5.02	5.13	5.65
NLD	Netherlands	7.31	7.39	7.43	7.80	7.98
NIC	Nicaragua	3.33	1.68	2.79	4.95	6.45
NER	Niger	4.70	5.14	4.81	4.71	5.48
NGA	Nigeria	3.26	3.61	3.53	3.39	5.37
NOR	Norway	6.04	6.47	6.86	7.44	7.24
PAK	Pakistan	4.30	4.99	4.93	5.59	5.46
PAN	Panama	5.16	5.79	5.99	6.91	7.27
PNG	Papua New Guinea	6.02	6.35	6.47	6.32	5.89
PRY	Paraguay	5.26	4.79	5.33	6.30	6.31
PER	Peru	3.16	2.42	3.47	6.12	6.82
PHL	Philippines	4.53	4.51	4.99	7.09	7.07
PRT	Portugal	5.83	5.48	6.02	7.21	7.29
ROM	Romania	4.43	4.43	4.58	3.65	4.74
RWA	Rwanda	4.03	4.10	4.32	3.82	4.61
SAU	Saudi Arabia	...	...	...	...	...
SEN	Senegal	4.27	4.66	5.09	4.66	5.81
SLE	Sierra Leone	6.27	3.95	3.89	3.97	5.20
SGP	Singapore	7.77	7.97	8.26	8.76	8.57
ZAF	South Africa	5.34	4.95	4.99	6.23	6.73
ESP	Spain	5.83	5.93	6.15	6.98	7.31
LKA	Sri Lanka	4.61	4.83	4.58	5.82	6.07
KNA	St. Kitts and Nevis	...	...	...	...	...

Table C-4 (cont.)

Country Code	Country Name	EFW1980	EFW1985	EFW1990	EFW1995	EFW2000
LCA	St. Lucia	...	...	...	...	...
VCT	St. Vincent/Grenadines	...	...	...	...	...
SWZ	Swaziland	...	...	...	...	...
SWE	Sweden	5.96	6.51	6.68	7.19	7.36
CHE	Switzerland	8.05	8.05	7.84	7.99	8.21
SYR	Syria	3.13	3.03	3.38	4.30	4.96
THA	Thailand	5.89	5.90	6.51	7.08	6.64
TGO	Togo	3.70	5.00	4.80	4.84	5.03
TTO	Trinidad and Tobago	4.79	4.69	5.47	6.48	7.15
TUN	Tunisia	4.80	4.63	5.23	5.98	6.06
TUR	Turkey	3.57	4.68	4.59	5.66	5.73
USA	United States	7.85	7.86	7.91	8.30	8.53
URY	Uruguay	5.74	5.80	6.09	5.76	6.65
VEN	Venezuela	6.34	5.92	5.24	4.16	5.78
ZMB	Zambia	4.71	3.59	3.04	4.54	6.31
ZWE	Zimbabwe	3.94	4.02	4.40	5.37	4.79

REFERENCES

- Agarwala, Ramgopal. *Price Distortions and Growth in Developing Countries*. World Bank Staff Working Papers No. 575. Washington: World Bank, 1983.
- Ainsworth, Martha, Kathleen Beegle and Andrew Nyamete. "The Impact of Women's Schooling on Fertility and Contraceptive Use: A Study of Fourteen Sub-Saharan African Countries." *World Bank Economic Review*, 10 (Jan 1996): 85-122.
- Barro, Robert J. "Economic Growth in a Cross Section of Countries." *Quarterly Journal of Economics*, 106 (May 1991): 407-43.
- Barro, Robert J. *Economic Growth and Convergence*. Occasional Papers No. 46. San Francisco: International Center for Economic Growth, 1994.
- Barro, Robert J. "Democracy and Growth." *Journal of Economic Growth*, 1 (March 1996): 1-27.
- Barro, Robert J. *Determinants of Economic Growth*. Cambridge: MIT Press, 1997.
- Barro, Robert J. "Human Capital and Growth." *American Economic Review*, 91 (May 2001): 12-17.
- Barro, Robert J., and Jong-Wha Lee. "Losers and Winners in Economic Growth." *Annual Conference on Development Economics 1993*, pp. 267-97. Washington: World Bank, 1994.
- Barro, Robert J., and Jong-Wha Lee. "International Data on Educational Attainment: Updates and Implications." *Oxford Economic Papers*, 53 (July 2001): 541-63.
- Barro, Robert J., and Xavier Sala-i-Martin. "Convergence." *Journal of Political Economy*, 100 (April 1992): 223-51.
- Baumol, William J. "Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show." *American Economic Review*, 76 (Dec 1986): 1072-85.
- Baumol, William J., and Edward N. Wolff. "Productivity Growth, Convergence, and Welfare: Reply." *American Economic Review*, 78 (Dec 1988): 1155-59.
- Blake, Judith. "Number of Siblings and Educational Attainment." *Science*, 245 (1989): 32-36.
- Bongaarts, John. "Demographic Consequences of Declining Fertility." *Science*, 282 (1998): 419-20.

- Burmeister, Edwin, and A. Rodney Dobell. *Mathematical Theories of Economic Growth*. New York: Macmillan, 1970.
- Cannan, Edwin. "Adam Smith as an Economist." *Economica*, No. 17 (June 1926): 123-34.
- Christ, Carl F., and Alan A. Walters. "The Mythology of Tax Cuts." *Policy Review*, No. 16 (Spring 1981): 73-84.
- Coale, Ansley J. "Recent Trends in Fertility in Less Developed Countries." *Science*, 221 (1983): 828-32.
- Cobb, Charles W., and Paul H. Douglas. "A Theory of Production." *American Economic Review*, 18 (1928, Supplement): 139-65.
- Cole, Julio H. "The Contribution of Economic Freedom to World Economic Growth, 1980-99." *Cato Journal*, 23 (Fall 2003), forthcoming.
- Crenshaw, Edward M., Ansari Z. Ameen, and Matthew Christenson. "Population Dynamics and Economic Development: Age-Specific Population Growth Rates and Economic Growth in Developing Countries, 1965 to 1990." *American Sociological Review*, 62 (Dec 1997): 974-84.
- Dawson, John W. "Institutions, Investment and Growth: New Cross-Country and Panel Data Evidence." *Economic Inquiry*, 36 (Oct 1998): 603-19.
- de Long, J. Bradford. "Productivity Growth, Convergence, and Welfare: Comment." *American Economic Review*, 78 (Dec 1988): 1138-54.
- Denison, Edward F. *The Sources of Economic Growth in the United States*. Supplementary Paper No. 13. New York: Committee for Economic Development, 1962.
- Dowrick, Steve, and Duc-Tho Nguyen. "OECD Comparative Economic Growth 1950-85: Catch-up and Convergence." *American Economic Review*, 79 (Dec 1989): 1010-30.
- Easton, Stephen T., and Michael A. Walker, eds. *Rating Global Economic Freedom*. Vancouver: Fraser Institute, 1992.
- Easton, Stephen T., and Michael A. Walker. "Income, Growth, and Economic Freedom." *American Economic Review*, 87 (May 1997): 328-32.
- Eberstadt, Nicholas. "World Population Implosion?" *Public Interest*, 129 (Fall 1997): 3-22.
- Ericson, Richard E. *The Soviet Union, 1979-1990*. Country Studies No. 7. San Francisco: International Center for Economic Growth, 1990.
- Esquivel, Gerardo. "Convergencia Regional en México, 1940-1995." *El Trimestre Económico*, 66 (Oct-Dic 1999): 725-61.

- Gallup, John L., Jeffrey D. Sachs and Andrew D. Mellinger. "Geography and Economic Development." *Annual World Bank Conference on Development Economics 1998*, pp. 127-70. Washington: World Bank, 1999.
- Ghosh, Atish, and Steven Phillips. "Warning: Inflation May be Harmful to Your Growth." *IMF Staff Papers*, 45 (Dec 1998): 672-710.
- Goldberger, Arthur S. *Topics in Regression Analysis*. New York: Macmillan, 1968.
- Grier, Kevin B., and Gordon Tullock. "An Empirical Analysis of Cross-National Economic Growth, 1951-80." *Journal of Monetary Economics*, 24 (1989): 259-76.
- Griliches, Zvi. "Agriculture: Productivity and Technology." *International Encyclopedia of the Social Sciences* (1968), vol. 1, pp. 241-45.
- Gwartney, James D., W. E. Block and Robert A. Lawson. *Economic Freedom of the World: 1975-1995*. Vancouver: Fraser Institute, 1996.
- Gwartney, James D., et al. *Economic Freedom of the World—2002 Annual Report*. Vancouver: Fraser Institute, 2002.
- Gwartney, James D., Randall G. Holcombe and Robert A. Lawson. "Economic Freedom, Institutional Quality, and Cross-Country Differences in Income and Growth" (2003), unpublished manuscript.
- Gwatkin, D. R., and S. K. Braudel. "Life Expectancy and Population Growth in the Third World." *Scientific American*, 246 (May 1982): 33-41.
- Hahn, F. H., and R. C. O. Matthews. "The Theory of Economic Growth: A Survey." *Economic Journal*, 74 (Dec 1964): 779-902.
- Hirschman, Charles, and Philip Guest. "The Emerging Demographic Transitions of Southeast Asia." *Population and Development Review*, 16 (March 1990): 121-52.
- Inada, Ken-ichi. "On a Two-Sector Model of Economic Growth: Comments and a Generalisation." *Review of Economic Studies*, 30 (June 1963): 119-27.
- Jain, A. K. "The Effect of Female Education on Fertility: A Simple Explanation." *Demography*, 18 (Nov 1981): 577-95
- Jones, Ronald W. "Neutral Technological Change and the Isoquant Map." *American Economic Review*, 55 (Sept 1965): 848-55.
- Kelley, Allen C. "Economic Consequences of Population Change in the Third World." *Journal of Economic Literature*, 26 (Dec 1988): 1685-1728.

- Khan, M. S., and A. S. Senhadji. "Threshold Effects in the Relationship Between Inflation and Growth." *IMF Staff Papers*, 48 (2001): 1-21.
- Knight, Malcolm, Norman Loayza and Delano Villanueva. "Testing the Neoclassical Theory of Economic Growth." *IMF Staff Papers*, 40 (Sept 1993): 512-41.
- Knodel, John, Napaporn Havanon and Weraset Sittitrai. "Family Size and the Education of Children in the Context of Rapid Fertility Decline." *Population and Development Review*, 16 (March 1990): 31-62.
- Kravis, Irving B. "Comparative Studies of National Incomes and Prices." *Journal of Economic Literature*, 22 (March 1984): 1-39.
- Kravis, Irving B. "The Three Faces of the International Comparison Project." *World Bank Research Observer*, 1 (Jan 1986): 3-27.
- Krueger, Anne O. "Import Substitution versus Export Promotion." *Finance and Development*, 22 (June 1985): 20-23.
- Kuznets, Simon. "Government Product and National Income," in Erik Lundberg, ed., *Income and Wealth*, pp. 178-244. Cambridge: Bowes & Bowes, 1951.
- Landau, Daniel. "Government and Economic Growth in the Less Developed Countries: An Empirical Study for 1960-1980." *Economic Development and Cultural Change*, 35 (Oct 1986): 35-75.
- Lau, Lawrence J., ed. *Models of Development: A Comparative Study of Economic Growth in South Korea and Taiwan*. San Francisco: International Center for Economic Growth, 1990.
- Leamer, Edward E. "A Result on the Sign of Restricted Least-Squares Estimates." *Journal of Econometrics*, 3 (1975): 387-90.
- Lockheed, Marlaine E., Dean T. Jamison and Laurence J. Lau. "Farmer Education and Farm Efficiency: A Survey." *Economic Development and Cultural Change*, 29 (Oct 1980): 37-75.
- Lutz, Wolfgang, Warren Sanderson and Sergei Scherbov. "The End of World Population Growth." *Nature*, 412 (2001): 543-45.
- Mankiw, N. Gregory, David Romer and David N. Weil. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics*, 107 (May 1992): 407-37.
- Marsden, Keith. "Links Between Taxes and Economic Growth: Some Empirical Evidence." *Journal of Economic Growth*, 1 (1986): 3-16.

- Maudlin, W. Parker. "Patterns of Fertility Decline in Developing Countries, 1950-75," in Nick Eberstadt, ed., *Fertility Decline in the Less Developed Countries*, pp. 72-96. New York: Praeger, 1981.
- Nutter, G. Warren. "The Structure and Growth of Soviet Industry." *Journal of Law and Economics*, 2 (Oct 1959): 147-74.
- Nutter, G. Warren. "The Soviet Economy: Retrospect and Prospect," in M. M. Drachkovitch, ed., *Fifty Years of Communism in Russia*, pp. 75-98. University Park: Pennsylvania State University Press, 1968.
- Nutter, G. Warren. *Growth of Government in the West*. Washington: American Enterprise Institute, 1978.
- Ofer, Gur. "Soviet Economic Growth: 1928-1985." *Journal of Economic Literature*, 25 (Dic 1987): 1767-1833.
- Padovano, Fabio, and Emma Galli. "Tax Rates and Economic Growth in the OECD Countries (1950-1990)." *Economic Inquiry*, 39 (Jan 2001): 44-57.
- Pearson, E. S., and M. A. Stephens. "The Ratio of Range to Standard Deviation in the Same Normal Sample." *Biometrika*, 51 (1964): 484-87.
- Peltzman, Sam. "The Growth of Government." *Journal of Law and Economics*, 23 (Oct 1980): 209-87.
- Powell, R. P. "Economic Growth in the USSR." *Scientific American*, 219 (Dec 1968): 17-23.
- Psacharopoulos, George. "Education as an Investment." *Finance and Development*, 19 (Sept 1982): 39-42.
- Psacharopoulos, George. "The Contribution of Education to Economic Growth: International Comparisons," in John W. Kendrick, ed., *International Comparisons of Productivity and Causes of the Slowdown*, pp. 335-55. Cambridge, Mass.: Ballinger, 1984.
- Psacharopoulos, George. "Returns to Investment in Education: A Global Update." *World Development*, 22 (1994): 583-604.
- Rebelo, Sergio. "Long-Run Policy Analysis and Long-Run Growth." *Journal of Political Economy*, 99 (June 1991): 500-21.
- Reves, Randall. "Declining Fertility in England and Wales as a Major Cause of the Twentieth Century Decline in Mortality: The Role of Changing Family Size and Age Structure in Infectious Disease Mortality in Infancy." *American Journal of Epidemiology*, 122 (1985): 112-26.

- Robey, Bryant, Shea O. Rutstein and Leo Morris. "The Fertility Decline in Developing Countries." *Scientific American*, 269 (Dec 1993): 30-37.
- Romer, Paul M. "Increasing Returns and Long-Run Growth." *Journal of Political Economy*, 94 (Oct 1986): 1002-37.
- Romer, Paul M. "Growth Based on Increasing Returns Due to Specialization." *American Economic Review*, 77 (May 1987): 56-62.
- Romer, Paul M. "Endogenous Technological Change." *Journal of Political Economy*, 98 (Oct 1990): 71-102.
- Ruggles, Richard. "Price Indexes and International Price Comparisons," in William Fellner, et al., *Ten Economic Studies in the Tradition of Irving Fisher*, pp. 171-205. New York: John Wiley & Sons, 1967.
- Sachs, Jeffrey D. "Tropical Underdevelopment." CID Working Paper No. 57. Center for International Development, Harvard University (Dec 2000).
- Sala-i-Martin, Xavier. "Lecture Notes on Economic Growth (I): Introduction to the Literature and Neoclassical Models." Working Paper No. 3563, National Bureau of Economic Research (Dec 1990).
- Sala-i-Martin, Xavier. "Lecture Notes on Economic Growth (II): Five Prototype Models of Endogenous Growth." Working Paper No. 3564, National Bureau of Economic Research (Dec 1990).
- Sala-i-Martin, Xavier. "The Classical Approach to Convergence Analysis." *Economic Journal*, 106 (July 1996): 1019-36.
- Sarel, Michael. "Demographic Dynamics and the Empirics of Growth." *IMF Staff Papers*, 42 (June 1995): 398-410.
- Sarel, Michael. "Nonlinear Effects of Inflation on Economic Growth." *IMF Staff Papers*, 43 (March 1996): 199-215.
- Schroeder, Gertrude E. "The Soviet Economy." *Current History*, 84 (Oct 1985): 309-12, 340-42.
- Schultz, Theodore W. "Capital, Human." *International Encyclopedia of the Social Sciences* (1968), vol. 2, pp. 278-87.
- Schultz, Theodore W. "Adam Smith and Human Capital," in Michael Fry, ed., *Adam Smith's Legacy*, pp. 130-39. London: Routledge, 1992.

- Singh, Susheela, and John Casterline. "The Socio-Economic Determinants of Fertility," in John Cleland, John Hobcraft and Betzy Dinesen, eds., *Reproductive Change in Developing Countries*, pp. 199-222. Oxford: Oxford University Press, 1985.
- Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*, Edwin Cannan, ed. New York: Modern Library, 1937. [First edition: 1776.]
- Solow, Robert M. "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics*, 70 (Feb 1956): 65-94.
- Solow, Robert M. "Growth Theory and After" (Nobel Lecture). *American Economic Review*, 78 (June 1988): 307-17.
- Summers, Robert, and Alan Heston. "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988." *Quarterly Journal of Economics*, 106 (May 1991): 327-68.
- Swan, T. W. "Economic Growth and Capital Accumulation." *Economic Record*, 32 (Nov 1956): 334-61.
- Tabarrok, Alexander. "Review of *Determinants of Economic Growth*, by Robert J. Barro." *International Review of Economics and Finance*, 8 (1999): 479-81.
- Tsiang, S. C. "Taiwan's Economic Miracle: Lessons in Economic Development," in A. C. Harberger, ed., *World Economic Growth*, pp. 301-25. San Francisco: ICS Press, 1984.
- Uzawa, Hirofumi. "Neutral Inventions and the Stability of Growth Equilibrium." *Review of Economic Studies*, 28 (Feb 1961): 117-24.
- Walters, A. A. "Production and Cost Analysis." *International Encyclopedia of the Social Sciences* (1968), vol. 12, pp. 519-23.
- White, Halbert. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica*, 48 (May 1980): 817-38.
- Williamson, Jeffrey G. "Productivity and American Leadership: A Review Article." *Journal of Economic Literature*, 29 (March 1991): 51-68.
- Wilson, James Q., and Richard J. Herrnstein. *Crime and Human Nature*. New York: Simon & Schuster, 1985.