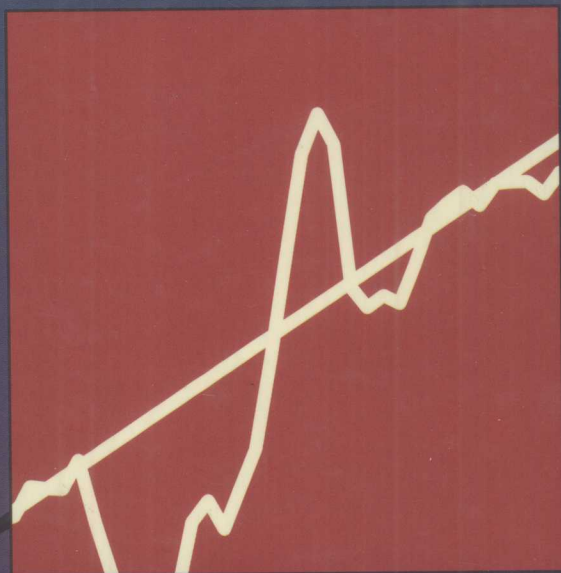


INTRODUCTION TO ECONOMIC GROWTH



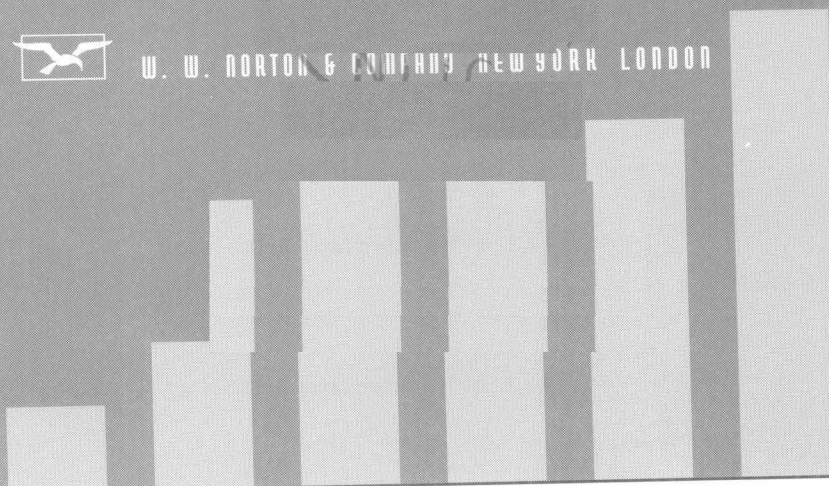
CHARLES I. JONES

INTRODUCTION TO
Economic Growth

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PREFACE

The importance of economic growth is difficult to overstate. The more than tenfold increase in income in the United States over the last century is the result of economic growth. So is the fact that incomes in the United States and Western Europe are at least thirty times greater than incomes in much of sub-Saharan Africa.

Our understanding of economic growth has improved enormously in the last fifteen years. Since the mid-1980s, growth has been one of the most active fields of research in economics. Yet while the advances in research now play a very prominent role in academic discourse and graduate education, they have not filtered through to the undergraduate level. A large part of the reason for this neglect is that these advances have been discussed primarily in academic journals. The result is a collection of fascinating but highly technical publications replete with mathematics, the modern language of economics.

This book translates these contributions into a more accessible language. The fundamental insights of old and new growth theory are explained with an emphasis on economics instead of math. No mathematics beyond the first-semester calculus taught at most colleges and universities is required. Moreover, the bulk of the required mathematics is introduced with the Solow model in Chapter 2; the analysis in subsequent chapters merely uses the same tools over and over again.¹

¹Two key simplifications enhance the accessibility of the material covered in this book. First, the models are presented without dynamic optimization. Second, the data analysis is conducted without econometrics.

This book should prove useful in undergraduate courses on economic growth, as well as in courses on macroeconomics, advanced macroeconomics, and economic development. Graduate students may find it valuable as a companion to the more advanced treatments available in the original journal articles and elsewhere. Finally, I hope that my colleagues will discover new insights in a place or two; I have certainly learned a tremendous amount in the process of preparing the manuscript.

I am deeply grateful to Robert Barro, Susanto Basu, Sunny Jones, Michael Kremer, Paul Romer, Xavier Sala-i-Martin, Bobby Sinclair, Terry Tao, John Williams, and Alwyn Young for their encouragement and for comments on earlier drafts. I also owe thanks to the National Science Foundation for a CAREER grant (SBR-9510916) that encouraged me to teach economic growth in my undergraduate courses.

Charles I. Jones
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Summer 1997

INTRODUCTION TO

Economic Growth

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INTRODUCTION: THE FACTS OF ECONOMIC GROWTH

“The errors which arise from the absence of facts are far more numerous and more durable than those which result from unsound reasoning respecting true data.”

— CHARLES BABBAGE, quoted in Rosenberg (1994), p. 27.

“It is quite wrong to try founding a theory on observable magnitudes alone. . . . It is the theory which decides what we can observe.”

— ALBERT EINSTEIN, quoted in Heisenberg (1971), p. 63.

Speaking at the annual meeting of the American Economic Association in 1989, the renowned economic historian David S. Landes chose as the title of his address the fundamental question of economic growth and development: “Why Are We So Rich and They So Poor?”¹ This age-old question has preoccupied economists for centuries. The question so fascinated the classical economists that it was stamped on the cover of Adam Smith’s famous treatise *An Inquiry into the Nature and Causes of the Wealth of Nations*. And it was the mistaken forecast of Thomas Malthus in the early nineteenth century concerning the future prospects for economic growth that earned the discipline its most recognized epithet, the “dismal science.”

¹See Landes (1990).

The modern examination of this question by macroeconomists dates to the 1950s and the publication of two famous papers by Robert Solow of the Massachusetts Institute of Technology. Solow's theories helped to clarify the role of the accumulation of physical capital and emphasized the importance of technological progress as the ultimate driving force behind sustained economic growth. During the 1960s and to a lesser extent the 1970s, work on economic growth flourished.² For methodological reasons, however, important aspects of the theoretical exploration of technological change were postponed.³

In the early 1980s, work at the University of Chicago by Paul Romer and Robert Lucas re-ignited the interest of macroeconomists in economic growth, emphasizing the economics of "ideas" and of human capital. Taking advantage of new developments in the theory of imperfect competition, Romer introduced the economics of technology to macroeconomists. Following these theoretical advances, empirical work by a number of economists, such as Robert Barro of Harvard University, emerged to quantify and test the theories of growth. Both theoretical and empirical work has continued with enormous professional interest in the 1990s.

The purpose of this book is to explain and explore the modern theories of economic growth. This exploration is an exciting journey, in which we encounter several ideas that have already earned Nobel Prizes and several more with Nobel potential. The book attempts to make this cutting-edge research accessible to readers with only basic training in economics and calculus.⁴

The approach of this book is similar to the approach scientists take in studying astronomy and cosmology. Like economists, astronomers are unable to perform the controlled experiments that are the hallmark of chemistry and physics. Astronomy proceeds instead through an interplay between observation and theory. There is observation: planets,

²A far from exhaustive list of contributors includes Moses Abramovitz, Kenneth Arrow, David Cass, Tjalling Koopmans, Simon Kuznets, Richard Nelson, William Nordhaus, Edmund Phelps, Karl Shell, Eytan Sheshinski, Trevor Swan, Hirofumi Uzawa, and Carl von Weizsacker.

³Romer (1994) provides a nice discussion of this point and of the history of research on economic growth.

⁴The reader with advanced training is referred also to the excellent presentation in Barro and Sala-i-Martin (1995).

stars, and galaxies are laid out across the universe in a particular way. Galaxies are moving apart, and the universe appears to be sparsely populated with occasional “lumps” of matter. And there is theory: the theory of the Big Bang, for example, provides a coherent explanation for these observations.

This same interplay between observation and theory is used to organize this book. This first chapter will outline the broad empirical regularities associated with growth and development. How rich are the rich countries, how poor are the poor? How fast do rich and poor countries grow? The remainder of the book consists of theories to explain these observations. In the limited pages we have before us, we will not spend much time on the experiences of individual countries, although these experiences are very important. Instead, the goal is to provide a general economic framework to help us understand the process of growth and development.

A critical difference between astronomy and economics, of course, is that the economic “universe” can potentially be re-created by economic policy. Unlike the watchmaker who builds a watch and then leaves it to run forever, economic policy makers constantly shape the course of growth and development. A prerequisite to better policies is a better understanding of economic growth.

1.1 THE DATA OF GROWTH AND DEVELOPMENT

The world consists of economies of all shapes and sizes. There are very rich countries, and there are very poor countries. Some economies are growing rapidly, and some are not growing at all. Finally, a large number of economies — most, in fact — lie between these extremes. In thinking about economic growth and development, it is helpful to begin by considering the extreme cases: the rich, the poor, and the countries that are moving rapidly in between. The remainder of this chapter lays out the empirical evidence — the “facts” — associated with these categories. The key questions of growth and development then almost naturally ask themselves.

Table 1.1 displays some basic data on growth and development for seventeen countries. We will focus our discussion of the data on measures of per capita income instead of reporting data such as life

TABLE 1.1 STATISTICS ON GROWTH AND DEVELOPMENT

	GDP per capita, 1990	GDP per worker, 1990	Labor force participation rate, 1990	Average annual growth rate, 1960-90	Years to double
"Rich" countries					
U.S.A.	\$18,073	\$36,810	0.49	1.4	51
West Germany	14,331	29,488	0.49	2.5	28
Japan	14,317	22,602	0.63	5.0	14
France	13,896	30,340	0.46	2.7	26
U.K.	13,223	26,767	0.49	2.0	35
"Poor" countries					
China	1,324	2,189	0.60	2.4	29
India	1,262	3,230	0.39	2.0	35
Zimbabwe	1,181	2,435	0.49	0.2	281
Uganda	554	1,142	0.49	-0.2	-281
"Growth miracles"					
Hong Kong	14,854	22,835	0.65	5.7	12
Singapore	11,698	24,344	0.48	5.3	13
Taiwan	8,067	18,418	0.44	5.7	12
South Korea	6,665	16,003	0.42	6.0	12
"Growth disasters"					
Venezuela	6,070	17,469	0.35	-0.5	-136
Madagascar	675	1,561	0.43	-1.3	-52
Mali	530	1,105	0.48	-1.0	-70
Chad	400	1,151	0.35	-1.7	-42

SOURCE: Penn World Tables Mark 5.6, an update of Summers and Heston (1991), and author's calculations.

Notes: The GDP data are in 1985 dollars. The growth rate is the average annual change in the log of GDP per worker. A negative number in the "Years to double" column indicates "years to halve."

expectancy, infant mortality, or other measures of quality of life. The main reason for this focus is that the theories we develop in subsequent chapters will be couched in terms of per capita income. Furthermore,

per capita income is a useful “summary statistic” of the level of economic development in the sense that it is highly correlated with other measures of quality of life.⁵

We will interpret Table 1.1 in the context of some “facts,” beginning with the first:⁶

FACT # 1 There is enormous variation in per capita income across economies. The poorest countries have per capita incomes that are less than 5 percent of per capita incomes in the richest countries.

The first section of Table 1.1 reports real per capita gross domestic product (GDP) in 1990, together with some other data, for the United States and several other “rich” countries. The United States was the richest country in the world in 1990, with a per capita GDP of \$18,073 (in 1985 dollars), and it was the richest by a substantial amount—countries such as Japan and West Germany trailed around the \$14,300 mark.

These numbers may at first seem slightly surprising. One often reads in newspapers that the United States has fallen behind countries like Japan or Germany in terms of per capita income. Such newspaper accounts can be misleading, however, because market exchange rates are typically used in the comparison. U.S. GDP is measured in dollars, while Japanese GDP is measured in yen. How do we convert the Japanese yen to dollars in order to make a comparison? One way is to use prevailing exchange rates. For example, in January 1997, the yen-dollar exchange rate was around 120 yen per dollar. However, exchange rates can be extremely volatile. Just a little over one year earlier, the rate was only 100 yen per dollar. Which of these exchange rates is “right”? Obviously, it matters a great deal which one we use: at 100 yen per dollar, Japan will seem 20 percent richer than at 120 yen per dollar.

⁵See, for example, the World Bank’s *World Development Report, 1991* (New York: Oxford University Press, 1991).

⁶Many of these facts have been discussed elsewhere. See especially Lucas (1988) and Romer (1989).

Instead of relying on prevailing exchange rates to make international comparisons of GDP, economists attempt to measure the actual value of a currency in terms of its ability to purchase similar products. The resulting conversion factor is sometimes called a purchasing power parity-adjusted exchange rate. For example, the *Economist* magazine produces a yearly report of purchasing power parity (PPP) exchange rates based on the price of a McDonald's Big Mac hamburger. If a Big Mac costs 2 dollars in the United States and 300 yen in Japan, then the PPP exchange rate based on the Big Mac is 150 yen per dollar. By extending this method to a number of different goods, economists construct a PPP exchange rate that can be applied to GDP. Such calculations suggest that 150 yen per dollar is a much better number than the prevailing exchange rates of 100 or 120 yen per dollar.⁷

The second column of Table 1.1 reports a related measure, real GDP per worker in 1990. The difference between the two columns lies in the denominator: the first column divides total GDP by a country's entire population, while the second column divides GDP by only the labor force. The third column reports the 1990 labor force participation rate — the ratio of the labor force to the population — to show the relationship between the first two columns. Notice that while Japan and West Germany had similar per capita GDP in 1990, they had very different GDP per worker. The labor force participation rate is much higher in Japan than in the other industrialized countries.

Which column should we use in comparing levels of development? The answer depends on what question is being asked. Perhaps per capita GDP is a more general measure of welfare in that it tells us how much output per person is available to be consumed, invested, or put to some other use. On the other hand, GDP per worker tells us more about the productivity of the labor force. In this sense, the first statistic can be thought of as a welfare measure, while the second is a productivity measure. This seems to be a reasonable way to interpret these measures, but one can also make the case for using GDP per worker as a welfare measure. Persons not officially counted as being in the labor force may be engaged in "home production" or may work in the underground economy. Neither of these activities is included in GDP, and in this case measured output divided by measured labor input may prove more

⁷*Economist*, April 19, 1995, p. 74.

accurate for making welfare comparisons. In this book, we will often use the phrase “per capita income” as a generic welfare measure, even when speaking of GDP per worker, if the context is clear. Whatever measure we use, though, Table 1.1 tells us one of the first key things about economic development: the more “effort” an economy puts into producing output, the more output there is to go around. “Effort” in this context corresponds to the labor force participation rate.

The second section of Table 1.1 documents the relative and even absolute poverty of some of the world’s poorest economies. India and Zimbabwe had per capita GDPs around \$1,000 in 1990, little more than 5 percent of per capita GDP in the United States. A number of economies in sub-Saharan Africa are even poorer: per capita income in the United States is more than 40 times higher than income in Ethiopia.

To place these numbers in perspective, consider some other statistics. The typical worker in Ethiopia or Uganda must work a month and a half to earn what the typical worker in the United States earns in a day. Life expectancy in Ethiopia is only two-thirds that in the United States, and infant mortality is more than 20 times higher. Approximately 40 percent of GDP is spent on food in Ethiopia, compared to about 7 percent in the United States.

What fraction of the world’s population lives with this kind of poverty? Figure 1.1 answers this question by plotting the distribution of the world’s population in terms of GDP per worker. In 1988, nearly half of the world’s population lived in countries with less than 10 percent of U.S. GDP per worker. The bulk of this population lives in only two countries: China, with more than one-fifth of the world’s population, had a GDP per worker of less than one-fifteenth of that of the United States; India, with one-sixth of the world’s population, had a GDP per worker less than one-tenth that of the United States. Together, these two countries account for nearly 40 percent of the world’s population. In contrast, the 39 countries that make up sub-Saharan Africa constitute less than 10 percent of the world’s population.

Figure 1.2 shows how this distribution has changed since 1960. Overall, the distribution has equalized as the share of the world’s population living in countries with GDP per worker less than 30 percent of U.S. GDP has fallen, largely shifting into the 40 percent and 50 percent categories. Of the poorest countries, both China and India have seen substantial growth in GDP per worker, even relative to the United