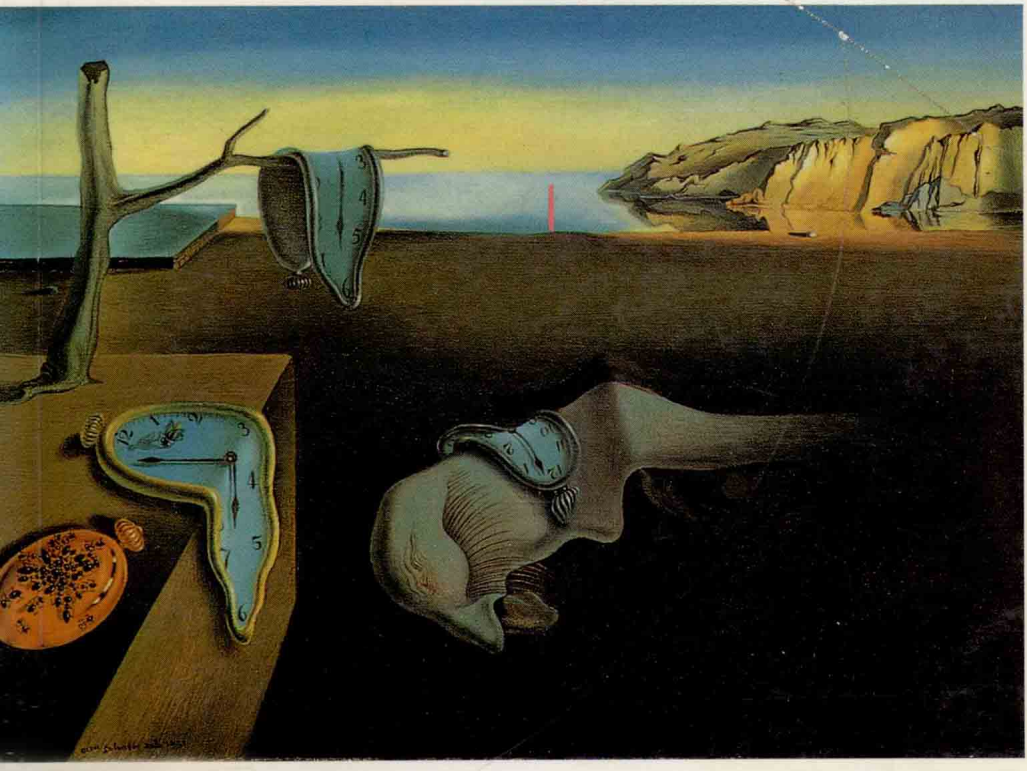
ROBERT J. BARRO
XAVIER SALA-I-MARTIN

ECONOMIC GROWTH



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ECONOMIC GROWTH

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To My First Grandchild
—Robert J. Barro

A la Gubi i a la Schuxeta
—Xavier Sala-i-Martin

FOREWORD

The field of economic growth has reawakened. When I began studying economics almost two decades ago, the field of economic growth was dormant. The courses I took in macroeconomics included at most a brief section on long-run economic growth. And even that was at the end of the course. It was part of the material that the professor, always running behind schedule, never had time to cover in class.

Today, economic growth is central to the study of macroeconomics. Economists have come to understand that long-run growth is as important—perhaps even more important—than short-run fluctuations. The newspaper is filled with accounts of monthly changes in industrial production and retail sales. But these short-run changes have a relatively minor impact on economic well-being. Why GPD rose or fell a few percent over the last three months can be an intriguing question. Even more significant, however, is why the United States is so much richer than Nigeria or why growth in U.S. incomes over the past quarter-century has been slower than growth over the previous quarter-century.

Scholars choose the topics they study, however, based on more than the topics' importance. To a large extent, they choose topics based on their ability to say something novel. It is for this reason that the field of economic growth became dormant and then reawoke. Work on economic growth stopped in the 1960s because economists had nothing new to say. Twenty years later, a small group of economists began to explore alternative ways of explaining the large differences in income we observe across countries and over time. The new growth theory has highlighted ideas that played only a small role in the growth theory inherited from the past. Increasing returns, human capital, research and development, learning-by-doing, and externalities are now central to discussions of economic growth. At the same time, new data on economic growth have become available for a large sample of countries. These data have allowed the new research to include a healthy interplay between theory and empirics.

When the editors at McGraw-Hill asked me to help them assemble a series of advanced textbooks in economics, I had no doubt that a book on economic growth

should be high on the agenda. Much had been learned and reported in academic journals. But no book was available to explain systematically all this material to the student. This book, the first in the McGraw-Hill series, fills that void. Moreover, this synthesis is presented by two of the most important scholars in this exploding field.

Economic growth comes largely from the accumulation of knowledge. This knowledge passes from one generation to the next in the form of textbooks. So, in a sense, this wonderful book by Robert Barro and Xavier Sala-i-Martin is not just about economic growth. It is itself part of the process of economic growth.

N. Gregory Mankiw
Harvard University
July 1994

PREFACE

> Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, *what,* exactly? If not, what is it about the "nature of India" that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else. (Lucas [1988])

Economists have, in some sense, always known that growth is important. Yet at the core of the discipline, the study of economic growth languished after the late 1960s. Then, after a lapse of nearly two decades, this research became vigorous again in the mid-1980s. The impending tenth anniversary of this revival is a good time to assess the recent investigations and to place them in the context of earlier work. This unified approach brings out the contributions of the old and new research and also reveals areas in which knowledge is lacking. We attempt in some cases to fill the holes and in other cases to point out profitable directions for future work.

The research of the mid-1980s began with models of the determination of long-run growth, an area that is now called endogenous growth theory. Other recent research extended the older, neoclassical growth model, especially to bring out further the empirical implications of the theory. This book combines new results with expositions of the main research that appeared from the 1950s through the 1990s. The discussion stresses the empirical implications of the theories and the relation of these hypotheses to data and evidence. This combination of theory and empirical work is the most exciting aspect of the ongoing resurgence of work on economic growth.

The introduction motivates the study, brings out some key empirical regularities in the growth process, and provides a brief history of modern growth theory. Chapters 1–3 deal with the neoclassical growth model, from Solow–Swan in the 1950s, to Cass–Koopmans (and recollections of Ramsey) in the 1960s, to recent extensions. Chapters 4 and 5 cover the versions of endogenous growth theory that rely on forms of constant returns to reproducible factors. Chapters 6–8 explore recent models of technological change and R&D, including expansions in the variety and quality of products and the diffusion of knowledge. Chapter 9 allows for an

endogenous determination of labor supply and population, including models of migration, fertility, and labor/leisure choice. Chapter 10 details the nature and availability of applicable data, and Chapters 11 and 12 discuss some empirical findings.

The material is written as a text at the level of first-year graduate students in economics. It is especially suitable for courses in macroeconomics, economic growth, and economic development. The authors developed and used the manuscript in second-year elective courses on economic growth and have used parts of the material in first-year, core graduate courses in macroeconomics. Other professors have already successfully used the manuscript for classes in macroeconomics, growth, and development.

Most of the chapters include problems that guide the students from routine exercises through suggestive extensions of the models. The level of mathematics includes differential equations and dynamic optimization, topics that are discussed in the mathematical appendix at the end of the book. For undergraduates who are comfortable with this level of mathematics, the book would work well for an advanced, elective course.

The lively pace of theoretical and empirical research on growth means that this version of the book will not remain up to date for many years. We therefore plan to revise as needed to maintain currency with developments in the field. Suggestions from readers—including notices of omissions of important contributions—would be appreciated. We have benefited in the preparation of this first edition from comments on the text or on related papers of ours by Philippe Aghion, Minna S. Andersen, Gary Becker, Olivier Blanchard, Juan Braun, Paul Cashin, Daniel Cohen, Michelle Connolly, Oded Galor, Zvi Griliches, Gene Grossman, Elhanan Helpman, Dale Jorgenson, Ken Judd, Jinill Kim, Michael Kremer, Phil Lane, Norman Loayza, Greg Mankiw, Casey Mulligan, Kevin M. Murphy, Pietro Peretto, Torsten Persson, Jordan Rappaport, Sergio Rebelo, Paul Romer, Michael Sarel, Etsuro Shioji, Chris Sims, B. Anna Sjögren, Nancy Stokey, Robert Tamura, Merritt Tilney, Aaron Tornell, Jaume Ventura, and Alwyn Young.

Robert J. Barro
Xavier Sala-i-Martin

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INTRODUCTION

I.1 THE IMPORTANCE OF GROWTH

The real per capita gross domestic product (GDP) in the United States grew by a factor of 8.1 from $2244 in 1870 to $18,258 in 1990, all measured in 1985 dollars. The increase in real per capita GDP corresponds to a growth rate of 1.75 percent per year. This performance gave the United States the highest level of real per capita GDP in the world in 1990 (with the possible exception of the United Arab Emirates, an oil producer with a small population).[1]

To appreciate the consequences of apparently small differentials in growth rates when compounded over long periods of time, we can calculate where the United States would have been in 1990 if it had grown since 1870 at 0.75 percent per year, one percentage point per year below its actual rate. A growth rate of 0.75 percent per year is close to the rate experienced in the long run—from 1900 to 1987—by India (0.64 percent per year), Pakistan (0.88 percent per year), and the Philippines (0.86 percent per year). If the United States had begun in 1870 at a real per capita GDP of $2244 and had then grown at a rate of 0.75 percent per year over the next 120 years, then its real per capita GDP in 1990 would have been $5519, only 2.5 times the value in 1870 and 30 percent of the actual value in 1990 of $18,258. Then, instead of ranking first in the world in 1990, the United States would have ranked 37th out of 127 countries with data. To put it another way, if the growth rate had been lower by just 1 percentage point per year, then the U.S. real per capita GDP in 1990 would have been close to that in Mexico and Hungary and would have been about $1000 less than that in Portugal and Greece.

[1]The long-term data on GDP are in Tables 10.2 and 10.3 of Chapter 10. The cross-country information for recent years is in Table 10.1. See Chapter 10 for sources and definitions.