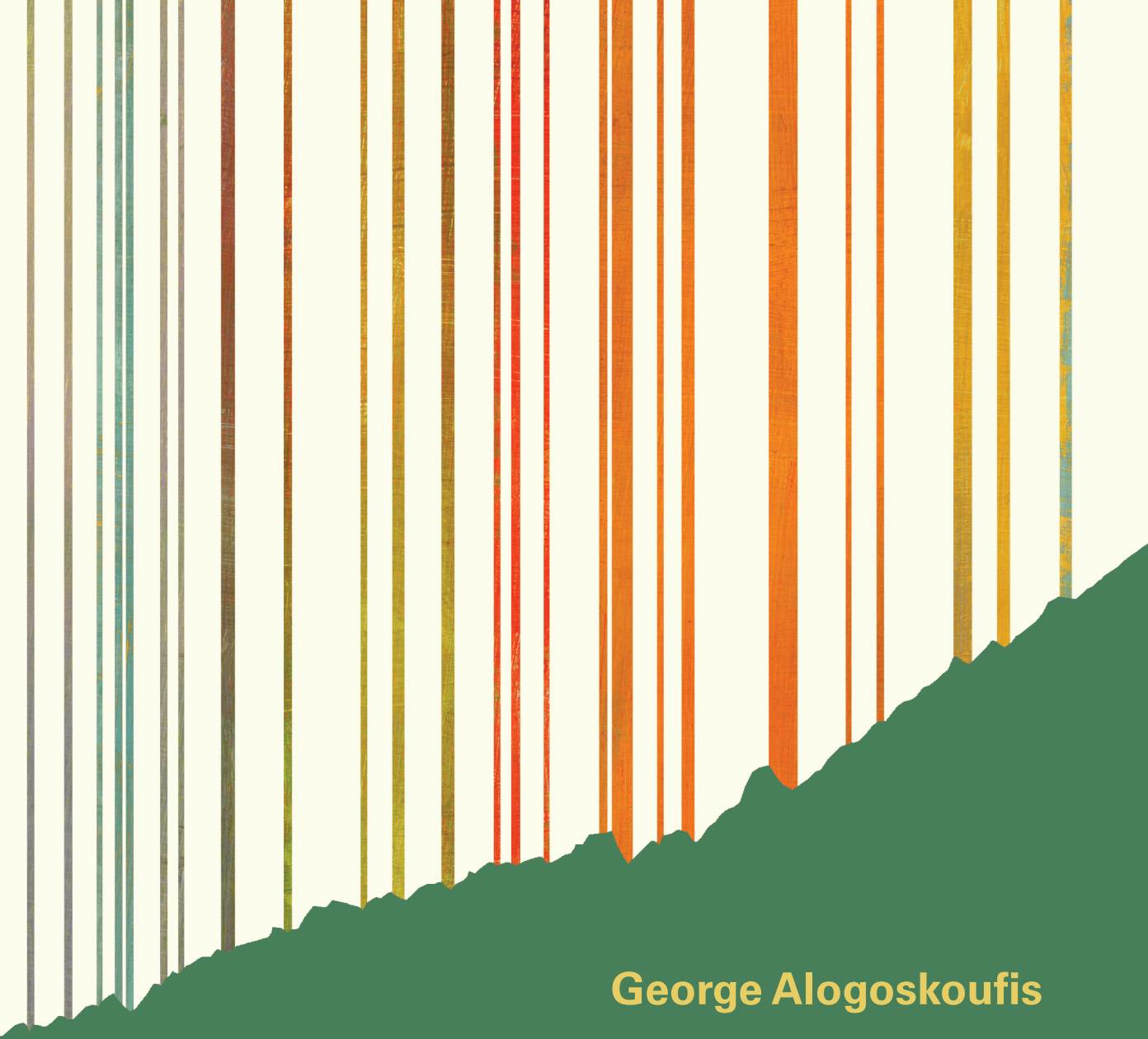

George Alogoskoufis

Dynamic Macroeconomics

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To Spyros, Athinais, and Danae

Contents

List of Figures and Table

Figures

Table

Preface

Macroeconomics deals with the structure, behavior and performance of economies in their entirety. It concentrates on aggregate variables, such as output and income (gross domestic product), unemployment rates, price indices, and inflation. It studies the structure and interrelations among economy-wide markets for output, labor, capital, and financial instruments and their implications for aggregate economic performance.

Macroeconomics mainly focuses on the determinants of long-run economic growth in living standards and the causes and implications of short-term fluctuations in economic aggregates.

This book is an advanced treatment of modern macroeconomics using a sequence of dynamic general equilibrium models, which are based on intertemporal optimization on the part of economic agents, such as households, firms, and the government. The book also analyzes and discusses the role of monetary and fiscal policy in the context of such dynamic models.

The intertemporal approach, based on the use of dynamic general equilibrium models, is currently the dominant approach to macroeconomics. This approach is adopted in this text. The book is addressed to advanced undergraduate as well as first-year graduate students of economics. It is also suitable for trained economists who wish to deepen and broaden their grasp of dynamic macroeconomics. It highlights the potential but also some limitations of the modern intertemporal approach.

Chapter 1 serves as an introduction and overview, providing a brief survey of the evolution of macroeconomics, as well as presenting the key facts about long-run economic growth and aggregate fluctuations. Accounting for these key facts is the main objective of the dynamic macroeconomic models that are analyzed in the rest of the book.

Chapter 2 introduces the main elements of the intertemporal approach to macroeconomics by means of two-period competitive general equilibrium models. Two-period models are the simplest possible intertemporal models. They help highlight both the strengths and the weaknesses of modern intertemporal macroeconomics without the need for advanced mathematical methods.

These two-period models are used to address issues such as savings and capital accumulation, intertemporal substitution in consumption and labor supply, the distinction between real and nominal variables, the classical dichotomy and the neutrality of money, monetary growth and inflation, Ricardian equivalence between debt and tax finance of public expenditure, and the effects of distortionary taxation. These are themes that recur again and again in macroeconomics. The two-period models of chapter 2 thus set the stage for the more advanced infinite-horizon dynamic and dynamic stochastic models that are the workhorses of modern theories of economic growth and aggregate fluctuations.

The remainder of the book is divided into 21 chapters, presenting models of economic growth, aggregate fluctuations, and monetary and fiscal policy.

The process of long-run economic growth is analyzed in chapters 3–8.

Chapter 3 introduces and discusses the basic neoclassical model of savings, investment, and economic growth. This model was developed by Solow [1956] and Swan [1956]. It is based on a neoclassical production function and an exogenous savings and investment rate. The model highlights the role of physical capital accumulation, technical progress, and population growth for the process of economic growth.

Chapter 4 presents and analyzes the model of the representative household. In this model, which was first put forward by Ramsey [1928] and later developed by Cass [1965] and Koopmans [1965], savings and investment are chosen optimally by a representative household with an infinite time horizon. The household is assumed to be able to borrow and lend freely in competitive capital markets.

Overlapping generations models of growth are presented in chapter 5. These are models in which different generations of households coexist. Younger households enter the economy with human capital as their only asset, because no intergenerational transfers of capital or financial assets take place. Overlapping generations models were first developed by Allais [1947], Samuelson [1958], and Diamond [1965], and later by Blanchard [1985] and Weil [1989].

Chapter 6 discusses models that highlight the intertemporal effects of fiscal policy, focusing on the effects of government consumption and the ways it is financed, such as through taxation and government debt.

Chapter 7 discusses models that focus on the intertemporal effects of the money supply and monetary growth. Monetary models help determine the evolution not only of real variables but also of nominal variables, expressed in money terms, such as the price level, nominal wages, inflation, and nominal interest rates.

More general growth models based on externalities, human capital accumulation, and endogenous technical change are discussed in chapter 8.

Chapters 9–12 introduce decision making under uncertainty in the context of dynamic stochastic models. These chapters highlight the role of expectations in macroeconomics. Chapter 9 introduces dynamic stochastic models under rational expectations, while chapters 10 and 11 focus on models of the microeconomic foundations of consumption under

uncertainty and investment and the cost of capital. Chapter 12 is an extended treatment of the role of money, alternative general equilibrium models with money, and the relation between the need for seigniorage and inflation.

Chapters 13–19 present and analyze alternative dynamic stochastic general equilibrium models of aggregate fluctuations. Such models are the basis of the new neoclassical synthesis, which is the dominant modern approach to the study of aggregate fluctuations.

Chapter 13 presents the stochastic growth model of aggregate fluctuations, and chapter 14 analyzes perfectly competitive models without capital. These are benchmark new classical models, based on competitive markets and perfectly flexible wages and prices.

Chapter 15 introduces and discusses the basic Keynesian model and the Phillips curve. Two new Keynesian dynamic stochastic models of aggregate fluctuations are then presented. Keynesian models assume distortions in the adjustment of wages and prices. Chapter 16 presents an imperfectly competitive model with staggered pricing; chapter 17 introduces an alternative new Keynesian model with periodic wage setting by labor market insiders. Chapter 18 focuses on labor market frictions and analyzes a matching model of the determination of the so-called natural rate of unemployment. Chapter 19 focuses on financial frictions and their macroeconomic implications.

Chapters 20 and 21 delve deeper into the roles of monetary and fiscal policy. The role and effectiveness of monetary policy is analyzed in chapter 20, whereas fiscal policy and the determination and implications of government debt are analyzed in chapter 21.

Chapter 22 focuses on dynamic stochastic models with bubbles, multiple macroeconomic equilibria, self-fulfilling prophecies, and sunspots. Such models allow for a different view of aggregate fluctuations than the standard dynamic stochastic general equilibrium models of the new neoclassical synthesis examined in chapters 13–19, which are usually based on a unique equilibrium.

Finally, chapter 23 discusses the current state of macroeconomics, highlighting the role of theoretical models and their interactions with empirical macroeonomics. It also discusses the impact of the financial crisis and the Great Recession of 2008–2009. The incorporation of labor market and financial frictions into dynamic stochastic general equilibrium models seems to be the main direction in which macroeconomics has been heading ever since.

Dynamic Macroeconomics is predominantly based on the intertemporal approach. The book presents and analyzes dynamic and dynamic stochastic general equilibrium models, in which households and firms (but also the government and the central bank) make their decisions taking full account of their intertemporal effects. The dynamic element of time, the element of uncertainty about stochastic shocks, and the techniques of intertemporal optimization permeate modern macroeconomics and are central to the analysis of the models in this book.

There are two exceptions to this rule about relying on models of intertemporal optimization. Chapter 3 contains an extensive discussion of the Solow model, which, from the perspective of the intertemporal approach, is an ad hoc general equilibrium model. In the

Solow model, the savings rate is assumed exogenous and is not derived from intertemporal optimization on the part of households. However, this model is pivotal for the theory of economic growth and provides the foundation for examining the implications of optimizing growth models, such as the representative household and overlapping generations model. The Solow model also provides the link to models with externalities, human capital accumulation, and endogenous growth. It is thus important that the Solow model and the role of savings and investment are fully analyzed and understood early on.

The second exception is chapter 15, which contains a full presentation and discussion of traditional Keynesian models, such as the Keynesian cross, the IS-LM model, the AD-AS model, and models of the Phillips curve. First sketched in the *General Theory* of Keynes [1936] and later developed by Hicks [1937], Modigliani [1944], Samuelson [1948], Hansen [1949], Patinkin [1956], and others, these models are the basis on which macroeconomics was originally developed as a separate subdiscipline of economics. They led to the original neoclassical synthesis and are the foundation of the new neoclassical synthesis and the distinction between the new classical and the new Keynesian approaches to intertemporal macroeconomics. It is thus crucial that the properties, the strengths, and the weaknesses of these traditional Keynesian models are fully understood.

Even though they belong to previous generations of macroeconomic models, the Solow model and the traditional Keynesian models serve as the basis through which the student of modern macroeconomics can appreciate the strengths, weaknesses, and policy implications of the intertemporal approach. Unlike the traditional approach to macroeconomics, the intertemporal approach is based on dynamic and dynamic stochastic models derived from explicit microeconomic foundations.

In the dynamic general equilibrium growth models that are discussed in this book, the optimal and mutually compatible decisions of households, firms, and the government (or central bank) help determine key macroeconomic aggregates. These aggregates include output and income, employment, consumption, investment, government expenditure and taxes, the stock of physical and human capital, the stock of government debt, the price level, real and nominal wages, real and nominal interest rates, and inflation. The performance of the economy depends on which distortions are present and how they are addressed by government policy.

In the models of aggregate fluctuations, such as the new classical, and the new Keynesian dynamic stochastic general equilibrium models presented here, fluctuations in aggregate real and nominal variables are the result of the individually optimal and mutually compatible reactions of households, firms, and the government and central bank to stochastic real or monetary disturbances.

Several elements differentiate this book from other advanced texts on macroeconomics. First, many of the concepts and the characteristics of intertemporal macroeconomics are introduced at an early stage (chapter 2) in the context of two-period intertemporal general equilibrium models, which can be analyzed with minimal mathematical superstructure. This

allows the student to gain a fundamental understanding of the issues at stake early on and relatively easily.

Second, the book focuses on a full analysis of a limited number of key intertemporal models. For example, in growth theory, the focus is on the representative household and overlapping generations models, variants of which are combined with different assumptions about technology, externalities from capital accumulation, human capital accumulation, and endogenous technical progress. In the theory of aggregate fluctuations, the focus is on essentially four models. They are the stochastic growth model and three short-run models of aggregate fluctuations: a new classical model without capital, an imperfectly competitive new Keynesian model with staggered pricing and an alternative new Keynesian model with periodic wage contracts. Such models form the basis of what has been termed the *new neoclassical synthesis* and are analyzed fully.

A third distinguishing element of the approach adopted in this book is that the models are stripped down to essentials, so that they can be fully solved and analyzed. Thus, most of the models used can be reduced to second-order dynamic systems whose solutions can be fully characterized, either algebraically or with the help of simple two-dimensional phase diagrams. This approach allows students to focus on the dynamic properties of the models and gain a deep understanding of the economics of these dynamic processes. A variety of exercises scattered throughout the text encourages students to try their hand at solving versions of the main dynamic models that define modern macroeconomics.

But because dynamic simulation techniques are an important element of modern dynamic macroeconomics and policy analysis (especially for higher-dimensional models), the dynamic models used in the book are also simulated numerically, and their impulse response functions are plotted and discussed. This is something intended to help students of this text gain a better grasp of the dynamic properties of the models themselves. In addition, such simulations allow for an assessment of the quantitative significance of the various effects highlighted in the theoretical models. They help determine which effects are quantitatively significant and which are not. Finally, the simulations demonstrate to students of this text how to set up and simulate dynamic and dynamic stochastic general equilibrium macroeconomic models, something that should familiarize them with the techniques and prepare them to analyze higher-dimensional, more complicated, and more realistic models.[1]

Modern macroeconomics is not based on a single generally accepted and all-encompassing model. For this reason, this book is eclectic. It treats macroeconomics as applied and policy-oriented general equilibrium analysis, based on various alternative, relatively simple aggregate dynamic or dynamic stochastic models. We examine a plurality of

1. The dynamic simulations of the various models are carried out through the use of the software platform Dynare (dynare.org), in conjunction with the programming language Matlab (mathworks.com). The Dynare programs used for carrying out the simulations are available through the dedicated website for the book (dynamic macroeconomics.com).

models, each of which is suitable for investigating specific issues and addressing specific questions, but may be unsuitable for other issues or questions. The book highlights both the potential strengths as well as the limitations of alternative models.[2]

However, some key unifying principles in the models are adopted. The most important of these principles is the assumption that economic agents base their decisions on intertemporal optimization of some well-defined objective function under appropriate constraints. Thus, for the most part, we examine dynamic general equilibrium models with explicit intertemporal microeconomic foundations. Where there are theoretical disagreements, alternative approaches are juxtaposed, their pros and cons are analyzed, and their compatibility with the empirical evidence is also briefly discussed.

Key facts about long-run economic growth and aggregate fluctuations are presented in chapter 1. Additional facts are also presented as we move to the particular models in the relevant chapters and they relate to the specific issues these models seek to explain. The discussion of these facts facilitates the process of evaluating the relevance and usefulness of the theoretical models in the rest of this book.

However, note that the rigorous and full empirical evaluation and testing of alternative theories and models is beyond the scope of this book. The present text, although concerned with models that account for the key stylized facts about macroeconomic phenomena, is a text on macroeconomic theory, not empirical or applied macroeconomics. Texts that focus on empirical macroeconomics and macroeconometrics could complement the present text for empirically inclined students and economists, and should indeed be consulted, as macroeconomics ultimately relies on the interactions between theory and evidence.[3]

The book assumes introductory knowledge of economic theory and mathematics for economists. The main mathematical techniques needed to analyze optimizing dynamic macroeconomic models are fully reviewed in the appendixes. These appendixes assume some basic prior knowledge of the material contained in mathematical textbooks for economists but are for the most part self-contained. They discuss some useful functional forms for the production and utility functions used in macroeconomics, derivatives and partial derivatives, optimization under constraints and the Lagrange method, linear algebra and the solution of linear models, solution methods for linear differential and difference equations, dynamic optimization techniques, and random variables and stochastic processes.

The book has emerged from my lectures over more than 30 years at Birkbeck College, University of London, and the Athens University of Economics and Business, both at

2. As noted by Keynes [1938], in a letter to Roy Harrod, "economics is a science of thinking in terms of models, joined to the art of choosing models which are relevant to the contemporary world." See Rodrik [2015] for a similarly eclectic approach to the role of models in economics in general, and the rules for setting up models and evaluating them.

3. Good examples of such texts are Favero [2001], Canova [2007], DeJong and Chetan [2011], and Herbst and Schorfheide [2015].

advanced undergraduate and postgraduate levels. The past 50 years have been a period of impressive progress for dynamic macroeconomics, which has transformed the discipline. The book traces this evolution and the current trends in macroeconomics, and is thus suitable for advanced undergraduates, professional economists, and graduate students in the first year of degrees leading to an MSc or a PhD in economics or related subjects, such as finance.

I thank a number of people who have contributed to this book, both directly and indirectly.

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I remain solely responsible for all remaining errors.

George Alogoskoufis
Fletcher School, Tufts University; and Athens University of Economics and Business