

METHODS OF MACROECONOMIC DYNAMICS SECOND EDITION

TURNOVSKY



METHODS OF MACROECONOMIC DYNAMICS

Second Edition

Stephen J. Turnovsky

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Preface to Second Edition

In the nearly five years since the completion of the manuscript to the first edition, macroeconomic dynamics continues to see important developments. Indeed, there is now a specialized journal, *Macroeconomic Dynamics*, published by Cambridge University Press, that is developing into one of the main research outlets in this important area of economics. Much of the new research is in the area of growth theory, and this is the component of the book where most of the changes have been introduced.

The book has been expanded by one chapter. This has been accomplished as follows. The material on rational expectations has been reduced, with the elimination of the previous Chapter 7, on the stability of deficit financing under rational expectations. While this had the merit of illustrating rational expectations solutions methods, the profession is now less interested in this aspect. The only other change in Part II is the reversal of the chapters on macroeconomic stabilization under rational expectations and saddlepoint behavior. These are now Chapters 6 and 7, respectively.

Part III, devoted to intertemporal optimization still contains 5 chapters. Chapter 12 is a new chapter on optimal monetary and fiscal policy. This combines new material with material that had appeared elsewhere in Part III. The chapter on growth theory, Chapter 13, has been moved, together with a new chapter, to Part IV, which is now a more comprehensive treatment of new growth models. Chapter 13 now deals with growth models in which the economy always lies on its balanced growth path. The discussion is both substantially revised and expanded to include two new issues: an analysis of growth and long-run government balance, and the introduction of endogenous labor supply. Chapter 14 introduces growth models characterized by transitional dynamics.

The continuous-time stochastic models are now discussed in Part V. This is relatively unchanged, although the final chapter has been expanded to deal with a wider range of issues, particularly those pertaining to exchange rate management. Other parts of the book remain relatively unchanged, although references have been pruned and updated.

As was the case for the first edition, some of the new work draws upon my own research. The first part of Chapter 13 is adapted from my paper "Optimal Tax, Debt, and Expenditure Policies in a Growing Economy," *Journal of Public Economics* 60 (1996), while the material on long-run government balance is drawn from my paper with Neil Bruce "Budget Balance, Welfare, and the Long-run Growth rate: 'Dynamic Scoring' of

the Long-run Government Budget,” *Journal of Money, Credit, and Banking* 31 (1999). The first part of Chapter 14 uses material from my paper “Public and Private Capital in an Endogenously Growing Economy,” *Macroeconomic Dynamics* 1 (1997). The discussion of the dynamics of nonscale models uses material from my forthcoming *Journal of Economic Dynamics and Control* paper “Transitional Dynamics in a Two-Sector Nonscale Growth Model,” coauthored with Theo Eicher.

Along with the friends and colleagues I thanked in the first edition, I would like to thank Neil Bruce and Theo Eicher for their permission to incorporate our joint material. I am grateful to the individuals who have provided feedback on the first edition. I would also like to thank Santanu Chatterjee for proofreading the manuscript and for preparing the index. Finally I want to express my appreciation to Terry Vaughn at MIT Press for encouraging this revision and to Melissa Vaughn for seeing it through the publication process.

Stephen J. Turnovsky
Seattle, WA, November 1998

Preface to First Edition

Macroeconomics has undergone radical changes over the past fifty years. It seems that every decade or so, just as it appears that some kind of consensus may be emerging, the paradigm changes. Prior to around the mid-1960s the *IS-LM* model was the standard workhorse of macroeconomics. But as economists became more adept at the methods of macrodynamics, the limitations of the static *IS-LM* framework became evident, and models stressing the dynamics associated with asset accumulation gained prominence. During this period macroeconomists also began to realize the importance of expectations—particularly inflationary expectations—which these asset accumulation models did not treat in an internally consistent way. Thus from the mid-1970s to the mid-1980s macroeconomics was preoccupied with the intrinsic forward-looking nature of expectations, and the assumption that expectations be rational became the critical focus of these models. However, the rational expectations models of the 1970s were linear and usually otherwise arbitrarily specified, and they in turn became the target of criticism. The need to provide macro models with firm microeconomic foundations (meaning derived from some form of intertemporal optimization) has become the dominant focus during the last decade. Many variants of such models exist, and while they continue to provide dominate current research in macroeconomics theory, they too receive their share of criticism. The usefulness of the representative agent framework has certainly come into question. Thus, as the above chronology suggests, we may expect to be in for a change, though the precise direction that it will take one can only conjecture.

In 1977, I published a book with Cambridge University Press entitled *Macroeconomic Analysis and Stabilization Policy*. This was completed just prior to the advent of the “rational expectations revolution” of the mid-1970s, but despite that, it was remarkably successful, particularly in Europe where the notion and methods of rational expectations were much slower to gain acceptance. For several years, the editors at CUP wanted me to revise the book by adding material on rational expectations, but it was evident to me that the rational expectations methodology represented a fundamental change in the methods of macrodynamic analysis and that a satisfactory treatment could not simply be introduced by means of a superficial revision. It would involve an entirely new book.

In the summer of 1986, I drafted several chapters discussing the methods of rational expectations. This formed the basis for what is Part II of

this book, though the material was set aside for several years. This coincided with the development of the intertemporal optimizing representative agent model, and I did not feel inclined to produce a book that might quickly become outdated. Meanwhile, I continued with my own research on the representative agent model.

Two events motivated me to put the material together and complete this book. The first was the visit of Terry Vaughn, the economics acquisition editor of MIT Press, to Seattle in the summer of 1992 when the University of Washington hosted the North American summer meetings of the Econometric Society. He showed great interest in the material I had previously prepared and encouraged me to pursue the project further, which I was initially reluctant to do. The other event was a chance meeting with a Japanese economist at a conference in Palm Cove, Australia, in August 1993; he recalled with obvious sincerity how he had pored over my 1977 Cambridge book, and how it had been the source of his background in macrodynamics. That brief remark convinced me that it was time to put this material together and finish the book.

Macroeconomics has never reached a consensus and probably never will. The subject is too diverse and the approaches too varied for that to become likely. My objective in this book is to emphasize the methods of analysis, in part from a historical perspective, but also in a way that will make them applicable and attractive to macroeconomists having a diverse range of interests and points of view. As I have already indicated, much of the earlier material has been around for some time. Part I is what is left of my 1977 book, which was written while I was at the Australian National University. Part II evolved from the graduate course I gave at the University of Illinois in the middle 1980s. Part III has formed the basis for part of the course on macrodynamics I have given at the University of Washington over the past several years.

As will be evident, much of the material is drawn from my own research efforts. It therefore represents a somewhat idiosyncratic approach to the subject, which may not be a bad thing. But in all cases, where the exposition has been drawn from previous material, it has been revised, adapted, updated, sometimes generalized, and modified in order to present a coherent unified approach to the subject. Chapter 2 is about what remains of my earlier book. The example in Section 6.1 is based on "Dynamic Macroeconomic Stability With or Without Equilibrium in Money and Labor Markets," *Economica* 48 (1981), coauthored with E.

Burmeister and R. Flood, with the Appendix to the chapter being a revised version of an unpublished Appendix to this paper. The example in Section 6.2 is adapted from a portion of “The Effects of Government Policy on the Term Structure of Interest Rates,” *Journal of Money, Credit, and Banking* 16 (1984), coauthored with M. H. Miller. The example in 6.3 is drawn from the first part of “The Stability of Exchange Rate Dynamics under Perfect Myopic Foresight,” *International Economic Review* 20 (1979,) coauthored with M. R. Gray. Chapter 7 uses material drawn from “Nonuniqueness and Instability under Rational Expectations: the Case of a Bond Financed Government Deficit,” in G. Gandolfo and F. Marzano (eds.), *Essays in Memory of Vittorio Guiffre* (Milano, 1987), coauthored with W. Scarth. The material on money-financed deficit was drawn from an expanded unpublished manuscript jointly written with Scarth. Some of the material in Chapter 8 was drawn from “Optimal Monetary Policy and Wage Indexation under Alternative Disturbances and Information Structures,” *Journal of Money, Credit, and Banking* 19 (1987).

Chapter 10 is drawn from “The Analysis of Macroeconomic Policies in Perfect Foresight Equilibrium,” *International Economic Review* 22 (1981), coauthored with W. A. Brock, and the first part of Chapter 11 uses material from “The Effects of Taxes and Dividend Policy on Capital Accumulation and Macroeconomic Behavior,” *Journal of Economic Dynamics and Control* 14 (1990). The basic model in Chapter 12 was first presented in “Fiscal Policy, Capital Accumulation, and Debt in an Open Economy,” *Oxford Economic Papers* 43 (1991), coauthored with P. Sen. Finally, the material in Part IV is in part adapted from joint work with E. Grinols. Specifically, Section 14.5 is a simplified version of material contained in an unpublished manuscript, while the open economy model of Chapter 15 is adapted from our joint paper “Exchange Rate Determination and Asset Prices in a Stochastic Small Open Economy,” *Journal of International Economics* 36 (1994).

I wish to reiterate, however, that because it is free of the constraints imposed by limitations of journal space, the exposition tends to be more leisurely, with more attention paid to ensuring that sufficient details and intuition are included, to make the discussion as comprehensible as possible. Also, in many cases, the analysis has been modified in substantive ways. The mastery of the methods of macrodynamics requires practice. Accordingly, a workbook containing problem sets has been prepared in

collaboration with Michael Hendrickson and is being published by MIT Press.

Much of my work has been conducted with colleagues and former students, and it is a pleasure to acknowledge their contribution, either as it appears directly in the joint work noted above, or indirectly, as it is discussed elsewhere in this volume. In this regard, I wish to express my gratitude to: Arthur Benavie, Marcelo Bianconi, Philip Brock, William Brock, Edwin Burmeister, Walter Fisher, Robert Flood, Malcolm Gray, Earl Grinols, Richard Marston, Marcus Miller, Thomas Nguyen, William Scarth, Partha Sen, and Peter Stemp. Helpful comments were made by graduate students in macroeconomics at the University of Illinois and the University of Washington who were exposed to parts of the material in draft form. Also, while in the process of revising the manuscript, I had the opportunity to present a series of lectures based on the latter part of the book to advanced students at the University of Paris I. This too provided helpful feedback. I would also like to thank Marian Bolan for her typing of Parts I and II of the manuscript, Michael Hendrickson and Tina Sun for proofreading, and to Christian Murray for preparing the index. I am grateful to Terry Vaughn, Melissa Vaughn, and Ann Sochi of the MIT Press for their efficient handling of this project and to the five anonymous reviewers for their thoughtful advice. Finally, the work underlying this book has occupied a large fraction of my working career, and I am grateful to my wife, Michelle, for her patience and support over a long period of time.

Stephen J. Turnovsky
Seattle, WA, May 1994

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1.1 The Evolution of Macrodynamics

The methods employed by economists to analyze macroeconomic systems and to address issues in macroeconomic policy have changed dramatically over the last fifty years or so. The beginnings of modern macroeconomic dynamics can be conveniently dated back to the famous models of business cycles introduced by Samuelson (1939) and Hicks (1950). This was followed by a period of intensive research on economic growth models during the 1950s and 1960s, and which was comprehensively reviewed by Burmeister and Dobell, (1970).

The analysis of dynamic macroeconomic systems that evolved from this literature was all *backward looking*. That is, the dynamics were assumed to evolve from some given initial state. This was certainly true, for example, of my own book (Turnovsky 1977), which emphasized what I called the *intrinsic dynamics* of the macroeconomic system. This term was used to describe the dynamics inherent in the process by which some groups in the economy create securities to finance their activities, while other groups absorb these securities in the course of saving and accumulating assets. These relationships necessarily impose a dynamic structure on the macroeconomic system, even if all the underlying behavioral relationships are static, because the accumulation of wealth affects consumption and the other components of aggregate demand. In terms of the simplest textbook model, the accumulation of wealth causes the *IS* and *LM* curves to shift over time. Expectations in this kind of analysis were also assumed to be generated by looking at the past, and hypotheses such as adaptive expectations (Nerlove 1958) were standard formulations at that time.

There are probably two main reasons for the backward-looking nature of the dynamics in this literature. First, the traditional theory of differential equations (or difference equations) that was being applied was largely borrowed from the applied physical sciences, in which the objects being studied can be viewed most naturally as evolving gradually from some given starting point. Initial positions and initial speeds in mechanics are usually what determine the arbitrary constants of integration that arise in the process of solving the differential equation describing their motion. A rocket is fired from the ground with some initial acceleration, and that determines its trajectory through time. But in addition, it is natural to think of certain economic variables—such as the capital stock that was in

fact the primary focus of economic growth theory—as changing gradually over time.

In the mid 1970s the methods of macroeconomic dynamics changed in a fundamental way with the impact of the theory of rational expectations, which had lain dormant for over a decade since Muth (1961) first introduced the concept in a different context. The key methodological innovation here was the observation that although certain economic variables were backward looking, others embodied expectations about the future and were therefore forward looking. The capital stock is a natural example of the former, whereas financial variables such as interest rates and the exchange rate are examples of the latter. This view fundamentally changed the way macroeconomic dynamics was carried out. Instead of starting from some given initial state, macrodynamics came to be determined by a combination of backward-looking dynamics and forward-looking dynamics, reflecting the fact that some economic variables are tied to the past, whereas others are looking to the future. This distinction was embodied into macrodynamics by the treatment of some variables as “jump variables” (meaning that they can respond instantaneously to new information), while other variables are “sluggish variables” (meaning that their evolution is constrained to continuous adjustments over time).

The rational expectations methodology was initially applied to linear models and in this form dominated macroeconomic dynamics for the decade between 1975 and 1985. One criticism leveled at this approach, however, was that whereas these models assumed rational behavior in the sense of expectations not being systematically wrong, the rest of the model in which the expectations were embedded was typically arbitrarily specified. Critics argued that a good macro model should be based on sound microeconomic foundations, and that involved deriving the behavioral relationships of the macro model from the intertemporal optimization of micro agents. This has led to the so-called representative agent model, which in the past decade has become the dominant macro paradigm. It too has its critics, however, and some of the arguments will be noted below.

Most of the literature employing the representative agent framework is deterministic. Stochastic intertemporal optimization is difficult and often very formal. One approach that many researchers have found to be fruitful is the method of continuous-time stochastic calculus. This approach has played a prominent role in the theory of finance, but has been little

used in macroeconomic dynamics. It suffers from the drawback that it is tractable only under restrictive conditions and for specific functional forms, but when it is tractable it offers tremendous insight and typically is much more transparent than the corresponding discrete time methods. Under the assumption that the underlying stochastic processes are Brownian motions, it naturally leads to an equilibrium in which the means and variances of the relevant variables are jointly determined. This has the advantage of being able to integrate issues in corporate finance, which are of relevance to macroeconomics, in a meaningful way. Issues such as the determinants of risk premia, the role of risk on key macroeconomic indicators of performance, such as growth and inflation, can now be addressed in a tractable and enlightening way.

1.2 Scope of the Book

The thrust of this book is to provide an overview of this evolution in the *methods* of macroeconomic dynamics as we have briefly outlined them. Setting out this kind of objective, immediately raises the question of balance. How much of the old approaches should one discuss, even though they may have been superseded? This is a question of judgment and, presumably, taste. There are good reasons for including material based on what some would view as obsolete models. For one thing, economic theory is somewhat like the clothing industry in that it is subject to fads and fashions. It is commonplace to see one particular topic be an area of intense research activity for some period of time, then fall out of fashion for a period, only to engage the attention of researchers again at some future time. Growth theory is a good example; after being so intensively studied during the period 1955–1970, it was all but dropped from the research agenda during the next fifteen years, while macroeconomists focused on issues pertaining to inflation and unemployment. Since the publication of Romer's (1986) paper, however, there has been a revival in the new growth theory and economic growth now seems to be attracting even more attention that it did around thirty years ago.

A second important reason for not discarding old techniques and models entirely is that by keeping a historical perspective, one gains a better understanding of the current models and methods of analysis. Related to this is the fact that some of the equilibrium properties of state-of-the-art