
JORDI GALÍ

Monetary Policy, Inflation, and the Business Cycle



An Introduction to the New Keynesian
Framework and Its Applications

SECOND EDITION

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Als meus pares

PREFACE

THE PRESENT monograph draws together some of the lecture notes for graduate-level courses on monetary economics that I have taught over the past fifteen years at different institutions, including Universitat Pompeu Fabra, the Barcelona Graduate School of Economics, the Massachusetts Institute of Technology (MIT), and the Swiss Beginner's Doctoral Program at Gerzensee. The book's main objective is to give the reader an introduction to the New Keynesian framework and some of its applications. That framework has emerged as the workhorse for the analysis of monetary policy and its implications for inflation, economic fluctuations, and welfare. It constitutes the backbone of the new generation of medium-scale models used at the Federal Reserve Board, the European Central Bank (ECB), and many other central banks. It has also provided the theoretical underpinnings to the inflation stability-oriented strategies adopted by the majority of central banks in the industrialized world.

A defining feature of the present book is the use of a single reference model throughout the chapters. That benchmark framework, which I refer to as the "basic New Keynesian model," is developed in chapter 3. It features monopolistic competition and staggered price setting in goods markets, coexisting with perfectly competitive labor markets. The "classical model" introduced in chapter 2, characterized by perfect competition in goods markets and flexible prices, can be viewed as a limiting case of the benchmark model, when both the degree of price stickiness and firms' market power vanish. The discussion of the empirical shortcomings of the classical monetary model provides the motivation for the development of the New Keynesian model, as discussed in the introductory chapter.

The implications for monetary policy of the basic New Keynesian model, including the desirability of inflation targeting, are analyzed in chapter 4. Each of the subsequent chapters then builds on the basic model, and analyzes an extension of that model along some specific dimension. Once the reader has grasped the contents of chapters 1 to 4, each of the subsequent chapters can be read independently, and in any order. Thus, chapter 5 introduces a policy tradeoff in the form of an exogenous cost-push shock, which serves as the basis for a discussion of the differences between the optimal policy with and without commitment. Chapters 6 and 7 extend the assumption of nominal

rigidities to the labor market and examine the policy implications of the coexistence of sticky wages and sticky prices. Chapter 8 develops a small open economy version of the basic New Keynesian model, introducing explicitly in the analysis a number of variables inherent to open economies, including trade flows, nominal and real exchange rates, and the terms of trade. In addition to some concluding comments, chapter 9 provides a brief description of several extensions of the basic model not covered in the present monograph, and a list of key references for each one.

Chapters 2 through 8 contain a final section with a brief summary and discussion of the related literature, including references to some of the key papers. Thus, references in the main text are kept to a minimum. The reader will also find at the end of most chapters a list of exercises related to the material covered therein.

The present second edition incorporates some new material to the contents of the book, in addition to providing an improved exposition of the old material and correcting some of the errors (none fatal, as far as I know) that passed it into the first edition and that have been uncovered by myself or others. The new material includes the analysis of the optimal policy under both discretion and commitment in the presence of a zero lower bound on the nominal interest rate, a constraint that was altogether ignored in the first edition, and whose relevance has come to the forefront of the policy debate (as well as the academic literature) in light of the economic and financial crisis of recent years and the associated responses of central banks. Moreover, a new chapter has been added (chapter 7), which introduces unemployment as an additional variable in the model, allowing for an analysis of its role in the design of monetary policy, following an approach that I originally proposed in my Zeuthen lectures. Throughout the book, consideration is made of exogenous shifts in the discount factor as a source of fluctuations, in addition to the technology and monetary policy shocks already allowed for in the first edition. Variations in the discount factor lead to changes in aggregate demand, without having any direct effect on labor supply and can thus be considered as a good stand-in for more general aggregate demand shocks.

The level of the book should make it suitable for use as a reference in a graduate course on monetary theory, possibly supplemented with readings covering some of the recent extensions not treated here. Chapters 1 through 5 could also prove useful as the basis for the “monetary block” of a first-year graduate macro sequence or even an advanced undergraduate course on monetary theory. Chapters 3 through 5 can also be used as the basis for a short course that serves as an introduction to the New Keynesian framework.

Much of the material contained in the present book overlaps with that found in two other (excellent) books on monetary theory published in recent years: Carl Walsh's *Monetary Theory and Policy* (MIT Press, 3rd ed.) and Michael Woodford's *Interest and Prices* (Princeton University Press). The focus of the present book on the New Keynesian model, with the use of a single underlying framework throughout the chapters, represents the main difference from Walsh's, with the latter providing in many respects a more comprehensive, textbook-like, coverage of the field of monetary theory, with a variety of models being used. On the other hand, the main difference from Woodford's comprehensive treatise lies in the more compact presentation of the basic New Keynesian model and its implications for monetary policy found here, which may facilitate its use as a textbook in an introductory graduate course. In addition, the present book contains an analysis of unemployment and of open economy extensions of the basic New Keynesian model, which are topics not covered in Woodford's book.

Many people have contributed to this book in important ways. First and foremost, I am in special debt with Rich Clarida, Mark Gertler, and Tommaso Monacelli, with whom I coauthored the original articles underlying much of the material found in this book, in particular that in chapters 5 and 8. I am also especially thankful to Olivier Blanchard who, as a teacher and thesis advisor at MIT, made me discover the fascination of modern macroeconomics. Working with him as a coauthor in recent years has helped me sharpen my understanding of many of the issues dealt with here. My interest in monetary theory was triggered by a course taught by Mike Woodford at MIT in the fall of 1988. His work in monetary economics (and in anything else) has always been a source of inspiration.

Many other colleagues have helped me improve the present monograph either with specific comments on earlier versions of the chapters or through discussions over the years on some of the topics covered here. A nonexhaustive list includes Kosuke Aoki, Larry Christiano, José de Gregorio, Andy Levin, David López-Salido, Albert Marcet, Dirk Niepelt, Louis Phaneuf, Stephanie Schmitt-Grohé, Lars Svensson, Lutz Weinke, and Iván Werning. I am also grateful to several anonymous reviewers for useful comments.

The two editions of the book have benefited from the help of excellent research assistants. Davide Debortoli, now already a well-established macroeconomist, was the main RA behind the first edition and came to my rescue again for the second edition when I ran into some technical hurdles. Mehregan Ameri, Lien Laureys, Cristina Manea, and Alain Schlaepfer have provided invaluable help with the second edition. Many others uncovered algebra mistakes or offered suggestions on different

chapters, including Suman Basu, Sevinc Cucurova, Jose Dorich, Andrew Li, Lorenzo Magnolfi, Elmar Mertens, and Juan Carlos Odar. Needless to say, I am solely responsible for any remaining errors.

I should also like to thank Princeton University Press and, in particular, Richard Baggaley, Sarah Caro, and Hannah Paul for their continuous support on this project.

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Monetary Policy, Inflation,
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Chapter 1

INTRODUCTION

OVER THE PAST TWO DECADES, monetary economics has been among the most fruitful research areas within macroeconomics. The efforts of many researchers to understand the relationship among monetary policy, inflation, and the business cycle have led to the development of a framework—the so called New Keynesian model—that is widely used for monetary policy analysis. The present monograph offers an overview of that framework and a discussion of its policy implications.

The need for a framework that can help us understand the links between monetary policy and the aggregate performance of an economy seems self-evident. On the one hand, and in their condition as consumers, workers, or investors, citizens of modern societies have good reason to care about developments in inflation, employment, and other economy-wide variables, for those developments affect to an important degree their opportunities to maintain or improve their standard of living. On the other hand, monetary policy has an important role in shaping those macroeconomic developments, both at the national and supranational levels. Changes in interest rates have an influence on the valuation of financial assets and their expected returns, as well as on the consumption and investment decisions of households and firms. Those decisions can in turn have consequences for GDP growth, employment, and inflation. It is thus not surprising that the interest rate decisions made by the Fed, the ECB, or other prominent central banks around the world are given so much attention, not only by market analysts and the financial press, but also by the general public. It would thus seem important to understand how those interest rate decisions end up affecting the various measures of an economy's performance, both nominal and real. A key goal of monetary theory is to provide us with an account of the mechanisms through which those effects arise, that is, the transmission mechanism of monetary policy.

Central banks do not change interest rates in an arbitrary or whimsical manner. Their decisions are meant to be purposeful, that is, they seek to attain certain objectives, while taking as given the constraints posed by the workings of a market economy, in which the vast majority of economic decisions are made in a decentralized manner by a large number of individuals and firms. Understanding what should be the

objectives of monetary policy and how the latter should be conducted in order to attain those objectives constitutes another important aim of modern monetary theory, in its normative dimension.

The following chapters present a framework that helps us understand both the transmission mechanism of monetary policy and the elements that come into play in the design of rules or guidelines for the conduct of monetary policy. The framework presented is, admittedly, highly stylized and should be viewed more as a pedagogical tool than a quantitative model that can be readily taken to the data. Nevertheless, and despite its simplicity, it contains the key elements (though not all the bells and whistles) found in the models being developed and used at central banks and other policy institutions.¹

The monetary framework that constitutes the focus of the present monograph has a core structure that corresponds to a Real Business Cycle (RBC) model, on which a number of “Keynesian features” are superimposed.² Each of those two influences is briefly described next, in order to provide some historical background to the framework developed in subsequent chapters.

1.1 BACKGROUND: REAL BUSINESS CYCLE THEORY AND CLASSICAL MONETARY MODELS

During the years following the seminal papers of Kydland and Prescott (1982) and Prescott (1986), Real Business Cycle (RBC) theory provided the main reference framework for the analysis of economic fluctuations, and became to a large extent the core of macroeconomics. The impact of the RBC revolution had both a methodological and a conceptual dimension.

From a *methodological* point of view, RBC theory established firmly the use of dynamic stochastic general equilibrium (DSGE) models as a central tool for macroeconomic analysis. Behavioral equations describing aggregate variables were thus replaced by first order conditions of intertemporal problems facing consumers and firms. Ad hoc assumptions on the formation of expectations gave way to rational expectations. In addition, RBC economists stressed the importance of the quantitative

¹ See, e.g., Bayoumi (2004), Christoffel, Coenen, and Warne (2008), Erceg, Guerrieri, and Gust (2006), Edge, Kiley, and Laforge (2007), Adolfson et al. (2007) for a description of some of the DSGE models used at the International Monetary Fund, the European Central Bank, and the Federal Reserve Board.

² That confluence of elements led some authors to label the new paradigm as the “new neoclassical synthesis.” See Goodfriend and King (1997).

aspects of modeling, as reflected in the central role given to the calibration, simulation, and evaluation of their models.

The most striking dimension of the RBC revolution was, however, conceptual. It rested on three basic claims:

- *The efficiency of business cycles.* Thus, the bulk of economic fluctuations observed in industrialized countries could be interpreted as an equilibrium outcome resulting from the economy's response to exogenous variations in real forces (most importantly, technology), in an environment characterized by perfect competition and frictionless markets. According to that view, cyclical fluctuations did not necessarily signal an inefficient allocation of resources (in fact, the fluctuations generated by the standard RBC model were fully optimal). That view had an important corollary: stabilization policies may not be necessary or desirable, and they could even be counterproductive. This was in contrast with the conventional interpretation, tracing back to Keynes (1936), of recessions as periods with an inefficiently low utilization of resources, which could be brought to an end by means of economic policies aimed at expanding aggregate demand.
- *The importance of technology shocks as a source of economic fluctuations.* That claim derived from the ability of the basic RBC model to generate "realistic" fluctuations in output and other macroeconomic variables, even when variations in total factor productivity—calibrated to match the properties of the Solow residual—are assumed to be the only exogenous driving force. Such an interpretation of economic fluctuations was in stark contrast with the traditional view of technological change as a source of long-term growth, unrelated to business cycles.
- *The limited role of monetary factors.* Most importantly, given the subject of the present monograph, RBC theory sought to explain economic fluctuations with *no reference to monetary factors*, even abstracting from the existence of a monetary sector.

Its strong influence among academic researchers notwithstanding, the RBC approach had a very limited impact (if any) on central banks and other policy institutions. The latter continued to rely on large-scale macroeconometric models despite the challenges to their usefulness for policy evaluation (Lucas (1976)) or the largely arbitrary identifying restrictions underlying the estimates of those models (Sims (1980)).

The attempts by Cooley and Hansen (1989) and others to introduce a monetary sector in an otherwise conventional RBC model, while sticking to the assumptions of perfect competition and fully flexible prices and wages, were not perceived as yielding a framework that was relevant

for policy analysis. As discussed in chapter 2, the resulting framework, which we refer to as the *classical* monetary model, generally predicts neutrality (or near neutrality) of monetary policy with respect to real variables. That finding is at odds with the widely held belief (certainly among central bankers) in the power of that policy to influence output and employment developments, at least in the short run. That belief is underpinned by a large body of empirical work, tracing back to the narrative evidence of Friedman and Schwartz (1963), up to the more recent work using time series techniques, as described in Christiano, Eichenbaum, and Evans (1999).³

In addition to the empirical challenges mentioned above, the normative implications of classical monetary models have also led many economists to call into question their relevance as a framework for policy evaluation. Thus, those models generally yield as a normative implication the optimality of the Friedman rule—a policy that requires that central banks keep the short-term nominal rate constant at a zero level—even though that policy seems to bear no connection whatsoever with the monetary policies pursued (and viewed as desirable) by the vast majority of central banks. Instead, the latter are characterized by (often large) adjustments of interest rates in response to deviations of inflation and indicators of economic activity from their target levels.⁴

The conflict between theoretical predictions and evidence, and between normative implications and policy practice, can be viewed as a symptom that some elements that are important in actual economies may be missing in classical monetary models. As discussed below, those shortcomings are the main motivation behind the introduction of some Keynesian assumptions, while maintaining the RBC apparatus as an underlying structure.

³ An additional challenge to RBC models has been posed by the recent empirical evidence on the effects of technology shocks. Some of that evidence suggests that technology shocks generate a negative short-run comovement between output and labor input measures, thus rejecting a prediction of the RBC model that is key to its ability to generate fluctuations that resemble actual business cycles (see, e.g., Galí (1999) and Basu, Fernald, and Kimball (2006)). Other evidence suggests that the contribution of technology shocks to the business cycle has been quantitatively small (see, e.g., Christiano, Eichenbaum, and Vigfusson (2003)), though investment-specific technology shocks may have played a more important role (Fisher (2006)). See Galí and Rabanal (2004) for a survey of the empirical evidence on the effects of technology shocks.

⁴ In the wake of the recent economic and financial crisis and the subsequent slow recovery, many central banks, including the Federal Reserve and the ECB, have brought down their policy rates to zero or near-zero levels. Few (if any) would interpret that policy as the result of a deliberate attempt to implement the Friedman rule. Rather, it should be viewed as an illustration of the zero lower bound on nominal interest rate becoming binding, in the face of central banks' attempt to provide further stimulus to the economy.

1.2 THE NEW KEYNESIAN MODEL: MAIN ELEMENTS AND FEATURES

Despite their different policy implications, there are important similarities between the RBC model and the New Keynesian monetary framework. The latter, whether in the simple versions presented below or in its more complex extensions, has at its core some version of the RBC model. This is reflected in the assumption of (i) an infinitely lived representative household, who seeks to maximize the utility from consumption and leisure, subject to an intertemporal budget constraint, and (ii) a large number of firms with access to an identical technology, subject to exogenous random shifts. Though endogenous capital accumulation, a key element of RBC theory, is absent in the basic versions of the New Keynesian model, it is easy to incorporate and is a common feature of medium-scale versions.⁵ Also, as in RBC theory, an equilibrium takes the form of a stochastic process for all the economy's endogenous variables, consistent with optimal intertemporal decisions by households and firms, given their objectives and constraints, and with the clearing of all markets.

The New Keynesian modeling approach, however, combines the DSGE structure characteristic of RBC models with assumptions that depart from those found in classical monetary models. Here is a list of some of the key elements and properties of the resulting models:⁶

- *Monopolistic competition.* Prices and/or wages are set by private economic agents in order to maximize their objectives, as opposed to being determined by an anonymous Walrasian auctioneer seeking to clear all markets.
- *Nominal rigidities.* Firms are subject to some constraints on the frequency with which they can adjust the prices of the goods they sell. Alternatively, they may face some costs of adjusting those prices. The same kind of friction applies to workers—or the unions that represent them—in the presence of sticky wages.
- *Short-run non-neutrality of monetary policy.* As a consequence of the presence of nominal rigidities, changes in short-term nominal interest rates (whether chosen directly by the central bank or induced by changes in the money supply) are not matched by one-for-one changes in expected inflation, thus leading to variations in real interest rates. The latter bring about changes in consumption and investment and, as a result, on output and employment, since

⁵ See, e.g., Smets and Wouters (2003, 2007).

⁶ See Galí and Gertler (2007) for an extended introduction to the New Keynesian model and a discussion of its main features.

firms find it optimal to adjust the quantity of goods supplied to the new level of demand. The same holds true for workers in the presence of sticky wages. In the long run, however, all prices and wages adjust, and the economy reverts back to its natural equilibrium, that is, the equilibrium that would prevail in the absence of nominal rigidities.

It is important to note that the three ingredients above were already central to the New Keynesian literature that emerged in the late 1970s and 1980s, and which developed in parallel with RBC theory. The models used in that literature, however, were often static or used reduced form equilibrium conditions that were not derived from explicit dynamic optimization problems facing firms and households. The emphasis of much of that work was instead on providing microfoundations, based on the presence of small menu costs, for the stickiness of prices and the resulting monetary non-neutralities.⁷ Other papers emphasized the persistent effects of monetary policy on output, and the role that staggered contracts played in generating that persistence.⁸ The novelty of the new generation of monetary models has been to embed those features in a fully specified DSGE framework, thus adopting the formal modeling approach that has been the hallmark of RBC theory.

Not surprisingly, important differences with respect to RBC models emerge in the new framework. First, the economy's response to shocks is generally inefficient. Second, the non-neutrality of monetary policy resulting from the presence of nominal rigidities makes room for welfare-enhancing interventions by the monetary authority, in order to minimize the existing distortions. Furthermore, those models are arguably suited for the analysis and comparison of alternative monetary regimes without being subject to the Lucas critique.⁹

1.2.1 Evidence of Nominal Rigidities and Monetary Policy Non-Neutrality

The presence of nominal rigidities and the implied real effects of monetary policy are two distinctive ingredients of New Keynesian models. It would be hard to justify the introductions of those features

⁷ See, e.g., Akerlof and Yellen (1985), Mankiw (1985), Blanchard and Kiyotaki (1987), and Ball and Romer (1990).

⁸ See, e.g., Fischer (1977) and Taylor (1980).

⁹ This will be the case at least to the extent that the economy is sufficiently stable so that the log-linearized equilibrium conditions remain a good approximation, and that some of the parameters that are taken as "structural" (including the degree of nominal rigidities) can be viewed as approximately constant.