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Jordi Galí: Monetary Policy, Inflation, and the Business Cycle

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Introduction

The present monograph seeks to provide the reader with an overview of modern monetary theory. Over the past decade, monetary economics has been among the most fruitful research areas within macroeconomics. The efforts of many researchers to understand the relationship between monetary policy, inflation, and the business cycle has led to the development of a framework—the so-called New Keynesian model—that is widely used for monetary policy analysis. The following chapters offer an introduction to that basic 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, 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 people's opportunities to maintain or improve their standard of living. On the other hand, monetary policy, as conducted by central banks, has an important role in shaping those macroeconomic developments, both at the national and supranational levels. Changes in interest rates have a direct effect 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 gross domestic product (GDP) growth, employment, and inflation. It is thus not surprising that the interest rate decisions made by the Federal Reserve system (Fed), the European Central Bank (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, i.e., 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, i.e., 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 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 medium-scale monetary models that are currently being developed by the research teams of many central banks.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 elements characteristic of Keynesian models are superimposed. That confluence of elements has led some authors to label the new paradigm as the New Neoclassical Synthesis.² The following sections describe briefly each of those two influences in turn, in order to provide some historical background to the framework developed in subsequent chapters.

1.1 Background: Real Business Cycle (RBC) Theory and Classical Monetary Models

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

From a methodological point of view, RBC theory firmly established 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 aspects of modelling, as reflected in the central role given to the calibration, simulation, and evaluation of their models.

¹ See, e.g., Bayoumi (2004) and Coenen, McAdam, and Straub (2006) for a description of the models under development at the International Monetary Fund and the European Central Bank, respectively. For descriptions of the Federal Reserve Board models, see Erceg, Guerrieri, and Gust (2006) and Edge, Kiley, and Laforte (2007).

² See Goodfriend and King (1997).

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

- *The efficiency of business cycles.* 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 that 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 important, 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 is referred 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 central banks to 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 in section 1.2, those shortcomings are the main motivation behind the introduction of some Keynesian assumptions, while maintaining the RBC apparatus as an underlying structure.

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 model.⁵ The latter, whether in the canonical form 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

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 An exception to that pattern is given by the Bank of Japan, which kept its policy rate at a zero level over the period 1999–2006. Few, however, would interpret that policy as the result of a deliberate attempt to implement the Friedman rule. Rather, it is generally viewed as a consequence of the zero lower bound on interest rates becoming binding, with the resulting inability of the central banks to stimulate the economy out of a deflationary trap.

⁵ See Galí and Gertler (2007) for an extended introduction to the New Keynesian model and a discussion of its main features.

infinitely-lived representative household that 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 canonical versions of the New Keynesian model, it is easy to incorporate and is a common feature of medium-scale versions.⁶ 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 modelling 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:

- *Monopolistic competition.* The prices of goods and inputs 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 (competitive) markets at once.
- *Nominal rigidities.* Firms are subject to some constraints on the frequency with which they can adjust the prices of the goods and services they sell. Alternatively, firms may face some costs of adjusting those prices. The same kind of friction applies to workers 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, because firms find it optimal to adjust the quantity of goods supplied to the new level of demand. In the long run, however, all prices and wages adjust, and the economy reverts back to its natural equilibrium.

It is important to note that the three aforementioned ingredients were already central to the New Keynesian literature that emerged in the late 1970s and 1980s, and which developed parallel to 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

⁶ See, e.g., Smets and Wouters (2003)

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 modelling 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 potentially 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 key ingredients of New Keynesian models. It would be hard to justify the use of a model with those distinctive features in the absence of evidence in support of their relevance. Next, some of that evidence is described briefly to provide the reader with relevant references.

1.2.1.1 Evidence of Nominal Rigidities

Most attempts to uncover evidence on the existence and importance of price rigidities have generally relied on the analysis of micro data, i.e., data on the prices of individual goods and services.¹⁰ In an early survey of that research, Taylor (1999) concludes that there is ample evidence of price rigidities, with the average frequency of price adjustment being about one year. In addition, he points to the very limited evidence of synchronization of price adjustments, thus providing some justification for the assumption of staggered price setting commonly found in the New Keynesian model. The study of Bils and Klenow (2004), based on the analysis of the average frequencies of price changes for 350 product categories underlying the U.S. consumer price index (CPI), called into question that conventional wisdom by uncovering a median duration of prices between 4 and

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 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.

¹⁰ See, e.g., Cecchetti (1986) and Kashyap (1995) for early works examining the patterns of prices of individual goods.

6 months. Nevertheless, more recent evidence by Nakamura and Steinsson (2006), using data on the individual prices underlying the U.S. CPI and excluding price changes associated with sales, has led to a reconsideration of the Bils–Klenow evidence, with an upward adjustment of the estimated median duration to a range between 8 and 11 months. Evidence for the euro area, discussed in Dhyne et al. (2006), points to a similar distribution of price durations to that uncovered by Nakamura and Steinsson for the United States.¹¹ It is worth mentioning that, in addition to evidence of substantial price rigidities, most studies find a large amount of heterogeneity in price durations across sectors/types of goods, with services being associated with the largest degree of price rigidities, and unprocessed food and energy with the smallest.

The literature also contains several studies based on micro data that provide analogous evidence of nominal rigidities for wages. Taylor (1999) surveys that literature and suggests an estimate of the average frequency of wage changes of about one year, the same frequency as for prices. A significant branch of the literature on wage rigidities has focused on the possible existence of asymmetries that make wage cuts very rare or unlikely. Bewley’s (1999) detailed study of firms’ wage policies based on interviews with managers finds ample evidence of downward nominal wage rigidities. More recently, the multicountry study of Dickens et al. (2007) uncovers evidence of significant downward nominal and real wage rigidities in most of the countries in their sample.

1.2.1.2 Evidence of Monetary Policy Non-neutralities

Monetary non-neutralities are, at least in theory, a natural consequence of the presence of nominal rigidities. As will be shown in chapter 3, if prices do not adjust in proportion to changes in the money supply (thus causing real balances to vary), or if expected inflation does not move one for one with the nominal interest rate when the latter is changed (thus leading to a change in the real interest rate), the central bank will generally be able to alter the level aggregate demand and, as a result, the equilibrium levels of output and employment. Is the evidence consistent with that prediction of models with nominal rigidities? And if so, are the effects of monetary policy interventions sufficiently important quantitatively to be relevant?

Unfortunately, identifying the effects of changes in monetary policy is not an easy task. The reason for this is well understood: An important part of the movements in whatever variable is taken as the instrument of monetary policy (e.g., the short term nominal rate) are likely to be endogenous, i.e., the result of a deliberate response of the monetary authority to developments in the economy.

¹¹ In addition to studies based on the analysis of micro data, some researchers have conducted surveys of firms’ pricing policies. See, e.g., Blinder et al. (1998) for the United States and Fabiani et al. (2005) for several countries in the euro area. The conclusions from the survey-based evidence tend to confirm the evidence of substantial price rigidities coming out of the micro-data analysis.

Thus, simple correlations of interest rates (or the money supply) on output or other real variables cannot be used as evidence of non-neutralities. The direction of causality could well go, fully or in part, from movements in the real variable (resulting from nonmonetary forces) to the monetary variable. Over the years, a large literature has developed seeking to answer such questions while avoiding the pitfalls of a simple analysis of comovements. The main challenge facing that literature lies in identifying changes in policy that could be interpreted as autonomous, i.e., not the result of the central bank's response to movements in other variables. While alternative approaches have been pursued in order to meet that challenge, much of the recent literature has relied on time series econometrics techniques and, in particular, on structural (or identified) vector autoregressions.

The evidence displayed in figure 1.1, taken from Christiano, Eichenbaum, and Evans (1999), is representative of the findings in the recent literature seeking to estimate the effects of exogenous monetary policy shocks.¹² In the empirical model underlying figure 1.1, monetary policy shocks are identified as the residual from an estimated policy rule followed by the Federal Reserve. That policy rule determines the level of the federal funds rate (taken to be the instrument of monetary policy), as a linear function of its own lagged values, current and lagged values of GDP, the GDP deflator, and an index of commodity prices, as well as the lagged values of some monetary aggregates. Under the assumption that neither GDP nor the two price indexes can respond contemporaneously to a monetary policy shock, the coefficients of the previous policy rule can be estimated consistently with ordinary least squares (OLS), and the fitted residual can be taken as an estimate of the exogenous monetary policy shock. The response over time of any variable of interest to that shock is then given by the estimated coefficients of a regression of the current value of that variable on the current and lagged values of the fitted residual from the first-stage regression.

Figure 1.1 shows the dynamic responses of the federal funds rate, (log) GDP, (log) GDP deflator, and the money supply (measured by M2) to an exogenous tightening of monetary policy. The solid line represents the estimated response, with the dashed lines capturing the corresponding 95 percent confidence interval. The scale on the horizontal axis measures the number of quarters after the initial shock. Note that the path of the funds rate itself, depicted in the top left graph, shows an initial increase of about 75 basis points, followed by a gradual return to its original level. In response to that tightening of policy, GDP declines with a characteristic hump-shaped pattern. It reaches a trough after five quarters at a level about 50 basis points below its original level, and then it slowly reverts back to its original level. That estimated response of GDP can be viewed as

¹² Other references include Sims (1992), Galí (1992), Bernanke and Mihov (1998), and Uhlig (2005). Peersman and Smets (2003) provide similar evidence for the euro area. An alternative approach to identification, based on a narrative analysis of contractionary policy episodes can be found in Romer and Romer (1989).

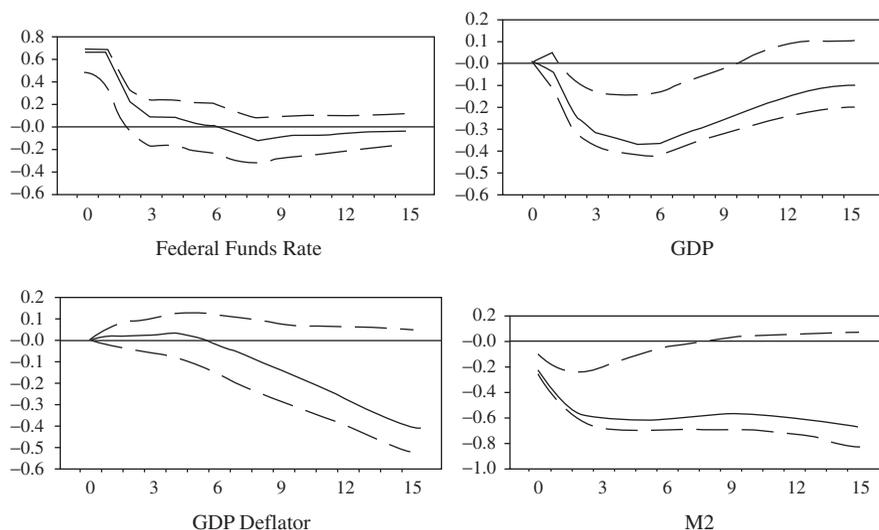


Figure 1.1 Estimated Dynamic Response to a Monetary Policy Shock

Source: Christiano, Eichenbaum, and Evans (1999).

evidence of sizable and persistent real effects of monetary policy shocks. On the other hand, the (log) GDP deflator displays a flat response for over a year, after which it declines. That estimated sluggish response of prices to the policy tightening is generally interpreted as evidence of substantial price rigidities.¹³ Finally, note that (log) M2 displays a persistent decline in the face of the rise in the federal funds rate, suggesting that the Fed needs to reduce the amount of money in circulation in order to bring about the increase in the nominal rate. The observed negative comovement between money supply and nominal interest rates is known as *liquidity effect*. As will be discussed in chapter 2, that liquidity effect appears at odds with the predictions of a classical monetary model.

Having discussed the empirical evidence in support of the key assumptions underlying the New Keynesian framework, this introductory chapter ends with a brief description of the organization of the remaining chapters.

1.3 Organization of the Book

The book is organized into eight chapters, including this introduction. Chapters 2 through 7 progressively develop a unified framework, with new elements being incorporated in each chapter. Throughout the book, the references in the main text are kept to a minimum, and a section is added to the end of each chapter with

¹³ Also, note that expected inflation hardly changes for several quarters and then declines. Combined with the path of the nominal rate, this implies a large and persistent increase in the real rate in response to the tightening of monetary policy, which provides another manifestation of the non-neutrality of monetary policy.

a discussion of the literature, including references to the key papers underlying the results presented in the chapter. In addition, each chapter contains a list of suggested exercises related to the material covered in the chapter.

Next, the content of each chapter is briefly described.

Chapter 2 introduces the assumptions on preferences and technology that will be used in most of the remaining chapters. The economy's equilibrium is determined and analyzed under the assumption of perfect competition in all markets and fully flexible prices and wages. Those assumptions define what is labeled as the *classical monetary economy*, which is characterized by neutrality of monetary policy and efficiency of the equilibrium allocation. In particular, the specification of monetary policy is shown to play a role only for the determination of nominal variables.

In the baseline model used in the first part of chapter 2, as in the rest of the book, money's role is limited to being the unit of account, i.e., the unit in terms of which prices of goods, labor services, and financial assets are quoted. Its potential role as a store of value (and hence as an asset in agents' portfolios), or as a medium of exchange, is ignored. As a result, there is generally no need to specify a money demand function, unless monetary policy itself is specified in terms of a monetary aggregate, in which case a simple log-linear money demand schedule is postulated. The second part of chapter 2, however, generates a motive to hold money by introducing real balances as an argument of the household's utility function, and examines its implications under the alternative assumptions of separability and nonseparability of real balances. In the latter case, in particular, the result of monetary policy neutrality is shown to break down, even in the absence of nominal rigidities. The resulting non-neutralities, however, are shown to be of limited interest empirically.

Chapter 3 introduces the basic New Keynesian model, by adding product differentiation, monopolistic competition, and staggered price setting to the framework developed in chapter 2. Labor markets are still assumed to be competitive. The solution is derived to the optimal price-setting problem of a firm in that environment with the resulting inflation dynamics. The log-linearization of the optimality conditions of households and firms, combined with some market clearing conditions, leads to the canonical representation of the model's equilibrium, which includes the New Keynesian Phillips curve, a dynamic IS equation and a description of monetary policy. Two variables play a central role in the equilibrium dynamic: the output gap and the natural rate of interest. The presence of sticky prices is shown to make monetary policy non-neutral. This is illustrated by analyzing the economy's response to two types of shocks: an exogenous monetary policy shock and a technology shock.

In chapter 4, the role of monetary policy in the basic New Keynesian model is discussed from a normative perspective. In particular, it is shown that, under some assumptions, it is optimal to pursue a policy that fully stabilizes the price

level (strict inflation targeting) and alternative ways in which that policy can be implemented are discussed (optimal interest rate rules). There follows a discussion of the likely practical difficulties in the implementation of the optimal policy, which motivates the introduction and analysis of simple monetary policy rules, i.e., rules that can be implemented with little or no knowledge of the economy's structure and/or realization of shocks. A welfare-based loss function that can be used for the evaluation and comparison of those rules is then derived and applied to two simple rules: a Taylor rule and a constant money growth rule.

A common criticism of the analysis of optimal monetary policy contained in chapter 4 is the absence of a conflict between inflation stabilization and output gap stabilization in the basic New Keynesian model. In chapter 5 that criticism is addressed by appending an exogenous additive shock to the New Keynesian Phillips curve, thus generating a meaningful policy tradeoff. In that context, and following the analysis in Clarida, Gali, and Gertler (1999), the optimal monetary policy under the alternative assumptions of discretion and commitment is discussed, emphasizing the key role played by the forward-looking nature of inflation as a source of the gains from commitment.

Chapter 6 extends the basic New Keynesian framework by introducing imperfect competition and staggered nominal wage setting in labor markets, in co-existence with staggered price setting and modelled in an analogous way, following the work of Erceg, Henderson, and Levin (2000). The presence of sticky nominal wages and the consequent variations in wage markups render a policy aimed at fully stabilizing price inflation as suboptimal. The reason is that fluctuations in wage inflation, in addition to variations in price inflation and the output gap, generate a resource misallocation and a consequent welfare loss. Thus, the optimal policy is one that seeks to strike the right balance between stabilization of those three variables. For a broad range of parameters, however, the optimal policy can be well approximated by a rule that stabilizes a weighted average of price and wage inflation, where the proper weights are a function of the relative stickiness of prices and wages.

Chapter 7 develops a small open economy version of the basic New Keynesian model. The analysis of the resulting model yields several results. First, the equilibrium conditions have a canonical representation analogous to that of the closed economy, including a New Keynesian Phillips curve, a dynamic IS equation, and an interest rate rule. In general, though, both the natural level of output and the natural real rate are a function of foreign, as well as domestic, shocks. Second, and under certain assumptions, the optimal policy consists in fully stabilizing domestic inflation while accommodating the changes in the exchange rate (and, as a result, in CPI inflation) necessary to bring about desirable changes in the relative price of domestic goods. Thus, in general, policies that seek to stabilize the nominal exchange rate, including the limiting case of an exchange rate peg, are likely to be suboptimal.

Finally, chapter 8 reviews some of the general lessons that can be drawn from the previous chapters. In doing so, the focus is on two key insights generated by the new framework, namely, the key role of expectations in shaping the effects of monetary policy, and the importance of the natural levels of output and the interest rate for the design of monetary policy. Chapter 8 ends by describing briefly some of the extensions of the basic New Keynesian model that have not been covered in the book, and by discussing some of the recent developments in the literature.

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