

Cukierman (1992), Chs. 8, 9

8 Overview of Models of Monetary Policy with Private Information

8.1 Introduction

This chapter reviews in an informal manner the different and sometimes subtle ways in which private information on the part of policymakers affects the economy and policy choices. The presence of private information fundamentally alters the effects of monetary policy on the economy. With perfect information its attempt to achieve real objectives such as employment or a balance-of-payments target only leads to an excessively high rate of inflation without having any effect on those variables (see chapters 3 and 5). But in the presence of private information the monetary authority can create inflationary surprises that have temporary effects on real variables such as employment and output. Hence stabilization policy becomes possible. In addition, since the public does not possess all the information used by policymakers and since this information is usually relevant for predicting future inflation rates, the public learns from past inflation about the possible future actions of policymakers.

Since policymakers are aware of this learning process, it affects their current choice of policy. This creates a link between periods. As a result the dynamic objective function of policymakers no longer decomposes into separate one-period problems as in section 3.4 of chapter 3. All the chapters in part II and all but the last chapter of part III plus chapter 18 deal with situations in which policymakers have an information advantage about something that affects their choice of monetary policy.

There are a number of factors that affect policy choices. These factors are at least temporarily known only by the monetary authority. Among them are the current relative importance given by policy to alternative and partially conflicting objectives, shifts in the extent of central bank's (CB) independence, and superior knowledge about some characteristics of the economy such as the demand for money or the natural level of economic activity. Changes in emphasis on alternative policy objectives could be due to changes in the intensity of political pressures emanating from various interest groups. In addition, even if the CB does not possess superior information about the economy, the forecasts it makes are not usually known by the public. Even if these forecasts are poor, they are still relevant for predicting future inflation for they affect the rate of monetary growth chosen by policymakers. The public also does not know with certainty whether policymakers are able to commit.

Existing models of monetary policy in the presence of private information are best characterized by a two-way classification: first, by whether the attribute about which there is private information is fixed or changing over time; second, by the nature of the variable or variables about which policymakers possess private information. Uncertainty about policymakers' ability to commit can be captured by postulating that there are two types of policymakers in the population. One type is able to commit, and the other is not. One of the two types is assumed to be in office for the duration of the analysis, but the public does not know, at least initially, which type is in office. The frameworks in Barro (1986) and Cukierman and Liviatan (1991) belong to this category. A model of this kind is presented in section 16.2 of chapter 16. When there are two possible (time-invariant) types that differ in their relative preference for economic stimulation versus price stability, and the public is uncertain about the identity of the type in office, we obtain the framework proposed by Vickers (1986). Section 16.3 discusses such a framework. As demonstrated by the discussion in section 16.4, policy choices and the behavior of the economy are qualitatively different, depending on whether private information is about the ability to commit or about the relative preference for stimulation versus price stability.

The main advantage of the models in chapter 16 is that they illustrate the effects of two different types of private information in relatively easily analyzable frameworks. But, due to a multitude of factors—such as changing political pressures, changes in the economy and changes in the effective degree of independence of the CB—policymaker types normally change over time.¹ Thus despite the fact that the public learns continually about the changing policymaker type, it never becomes fully informed about the identity of the type in office. The models that belong to this class are more realistic, though somewhat more complex, than those with fixed types in chapter 16. But what is lost in complexity is gained in realism. The added degree of realism makes models with changing types more suitable as frameworks for empirical work. Within this class there are two distinct categories of variables about which there is private information. In the first case the CB has private information about its own objectives, and in the second it has private forecasts about relevant economic variables. In some cases there is private information about both objectives and economic variables.

Chapters 9, 10, 14, and 18 deal with frameworks in which the CB has superior information about the changing objectives of policy. These changes may reflect changing pressures on the executive branch of government as well as changes in the degree of independence of the CB from the executive branch. Chapter 9 presents the minimal private information framework needed to evaluate the effects of changing objectives. The assumption made in that chapter is that two periods after it occurs, a change in objectives becomes public information. Being the first chapter on private information, this chapter is relatively detailed and explicit. It contains (in section 9.1) a discussion whose main objective is to support the view that private information is an important ingredient of actual monetary policy. This chapter is also the first full-fledged analysis of changing policy objectives under private information. It is therefore used as a benchmark for the more general analysis in some of the subsequent chapters. An extended information advantage in which a given change in objectives is never revealed with certainty is considered in chapter 10. Chapter 14 extends this framework to cases in which there are mandatory, but noisy, monetary announcements. To deal with private information about CB independence, the framework from chapter 10 is adapted to handle time variations in independence. This is done in chapter 18, which also analyzes the effect of differences in rates of time preference and in other objectives between the CB and the Treasury.

Chapter 15 explores a framework in which anticyclical monetary policy is possible because the CB has better information than the public about the permanence of real shocks to employment. Chapter 13 combines noisy private information about money demand with private information about the changing objectives of policymakers. Such a framework has been originally suggested by Canzoneri (1985). The basic inference problem faced by the public in this case is that when it observes an upward blip in the rate of inflation, the public is unsure about whether it is due to an error of forecast concerning money demand or to an increased concern for employment. Table 8.1 summarizes the two-way classification of chapters discussed above.

A policymaker's reputation is a prime determinant of the actions taken by him or her and by private individuals. There are two approaches to the modeling of credibility and reputation. One is based on the notion that the public learns from past inflation things about the nature of, or the information available to, policymakers, and this is relevant for predicting future

Table 8.1
Classification of chapters with private information

Type	Private information about	
	Objectives	Ability to commit
Fixed	16	16
Changing	9, 10, 11 (partially), 13, 14, 18	
		The economy
		13, 15

inflation. The other approach is based on the notion that the public utilizes its inflationary expectation strategically as a device for disciplining policymakers into maintaining low inflation. This approach is an application of trigger strategies from repeated games. These two approaches are compared and contrasted in chapter 11 in a mostly intuitive manner.

Trigger strategies require all individuals in the public to coordinate their expectations on a single strategy profile out of a large number of possible profiles in order to credibly deter policymakers from inflating at the discretionary rate. In reality there seldom is an institution that coordinates the expectations of different individuals. In the absence of such coordination, trigger strategies are not credible and do not therefore deter policymakers from inflating at the discretionary rate. By contrast, the learning approach parametrizes credibility in terms of the degree of cohesion between the actions or announcements of policymakers and the beliefs of the public. Like trigger strategies, learning acts as a deterrent to excessively high inflation. But this occurs as a by-product of the public's attempt to correctly forecast future inflation rather than because of strategic manipulation of expectations by individuals. Because of this and other reasons, which are discussed in chapter 11, this book uses the learning approach to conceptualize credibility and changes in credibility.

The following sections review intuitively the consequences of various types of private information. The materials reviewed are usually arranged in an increasing order of complexity and of realism. There also are sometimes different levels of complexity and of prerequisite materials within the groupings of topics in the following sections. Readers who have no previous familiarity with monetary policy games with private information are advised to follow the same order in reading the chapters and to study initially only the basic framework within each group of subjects. Other readers may follow the natural order of chapters or go directly to chapters

in which they are particularly interested. A good number of chapters can be read in separate modules. The following sections describe the breakdown of chapters into such modules and point out cases in which a chapter builds on one or more previous chapters.

8.2 Private Information about the Ability to Commit (Chapter 16, Sections 16.2 and 16.4)

This framework is designed to explore the consequences for policy and for wage contracts of uncertainty, on the part of the public, about policymakers' ability to commit. There are two possible policymaker types with the same objective function that gives a positive weight to employment and a negative weight to inflation. However, one type is able to commit while the other is not. We model this difference by assuming that prior to the formation of expectations the policymaker in office makes an announcement concerning the rate of inflation he or she will choose after contracts have been concluded. Since he or she incurs a cost for not fulfilling his or her promise, the dependable or "strong" policymaker always lives up to his or her announcement. The other type of policymaker, referred to as weak, does not incur such a cost. Hence, after nominal contracts have been concluded, he or she chooses the discretionary rate of inflation. Prior to concluding nominal contracts, the public does not know whether weak or strong types are in office but holds some prior view about the likelihood that either type is in office. Since weak policymakers have an incentive to mimic the announcement of strong policymakers, the public normally gives it some, but not full, credence. As a consequence both types of policymakers can affect expectations by making announcements.

Since announcements are believed only partially, the public's inflationary expectation is a weighted average between the equilibrium announcement and the higher discretionary rate. Hence, when a weak type is in office, unexpected inflation is positive. But when a strong type is in office, unexpected inflation is negative. This lowers employment and deters strong policymakers from delivering the zero rate of inflation that they would have produced if their identity had been known with certainty. The reason is that the potential presence of weak types, by raising expectations, makes it optimal for strong types to partially accommodate those expectations in order to avoid an excessively large reduction in employment.

Thus dependable policymakers partially accommodate inflationary expectations. But they do that by announcing and delivering more modest objectives for stabilization of inflation (in comparison to perfect information) rather than by attempting to surprise the public.

The upshot is that the presence of private information about the ability to commit induces even policymakers who can commit to partially accommodate inflationary expectations.

8.3 Private Information about the Relative Emphasis on Employment versus Price Stability with Fixed Types (Chapter 16, Sections 16.3 and 16.4)

Suppose that among the policymakers neither type is able to commit. Once in office both types are there for the duration of the game, and this is known by the public. The difference between the two types is that one (labeled weak) is more concerned about employment than about price stability in comparison to the other (the strong counterpart). Thus weakness and strength are conceived in terms of the policymakers' relative concern for price stability rather than in terms of their ability to commit.

Under discretion and perfect information the strong policymakers would have inflated at a lower rate than their weak counterparts. This is a direct consequence of the nature of equilibrium under perfect information in conjunction with the fact that the parameter A that measures the relative preference for employment is higher for the weak type (see equation 3.6). But the public is uncertain about the identity of the type in office.

The game considered consists of two periods. In the first the strong policymakers may want to inflate at a rate that is even lower than their full-information discretionary rate in order to separate themselves from their weak counterparts. The decision whether to do that involves weighting the benefits of lower inflationary expectations in the second period against the cost of a lower level of economic activity in the first. If in office the weak policymakers also want to keep inflationary expectations down. To achieve this, they try to behave, during the first period, in the same manner as their strong counterparts. Since the public is aware of these incentives, the strong policymakers, when in office, are forced to reduce the rate of inflation sufficiently to make it unprofitable for their weak counterparts to mimic them. If it pays the strong policymakers to engage in such

a course of action, equilibrium is separating and the public starts the second period with precise knowledge of the identity of the policymaker type in office. If it does not pay them to separate, the strong policymakers choose their (relatively low) discretionary rate in the first period and so do their weak counterparts. In this case the public's uncertainty is not resolved in the first period, and a pooling equilibrium emerges. Section 16.13 of chapter 16 focuses mostly on separating equilibria since for the class of models considered they are more likely to arise.

The nature of equilibrium differs fundamentally when the public is uncertain about the commitment ability of policymakers rather than about their relative concern for employment versus price stability. In the first case the strong policymakers partially compromise with the actions expected by the public from their weak counterparts. In the second case the strong policymakers, rather than compromising, inflate at a rate that is even lower than their full-information discretionary rate in order to signal their toughness. Thus, when "strength" is conceived in terms of commitment ability, a strong policymaker type inflates at a higher rate in the presence of private information. When "strength" concerns the relative concern for employment versus price stability, the opposite is true. The intuitive reasons for this basic difference are discussed in section 16.4 of chapter 16.

8.4 Changing Emphasis on Alternative Objectives—A Basic Framework (Chapters 9 and 10)

Although useful as a simplifying pedagogical device, the assumption that the emphasis of policy on alternative objectives is time invariant does not seem very realistic. In most countries CB policy is not totally divorced from the pressures and counterpressures exerted on and by the executive and legislative branches of government. Demands from monetary policy change continually due to shifting alliances, changes in personalities, changes in fiscal policy, changing evaluation by elected officials of the mood of the majority, and of the state of the economy. In countries whose central banks enjoy relatively little independence, these demands are transmitted directly to the CB who translates them into actual policy actions. But even in countries such as the United States where the CB enjoys a substantial degree of statutory independence, some of these

shifting demands from monetary policy are translated into actual changes in policy.

Many of the factors that shape the course of monetary policy are initially better known by policymakers within government than by the public at large. The public may have an idea about the type and direction of pressures exerted on policy but is usually not fully informed about the extent and the timing of the policy response. The public may be aware of the cyclical position of the economy but is normally not informed in real time about the forecasts of its future state by policymakers. Since policy is influenced by these forecasts, the public does not possess full knowledge of the information on which current monetary policy decisions are based. The public may learn about changes in the emphasis of policy or about policymakers' forecasts of various economic variables. But this learning process is usually gradual. In the interim monetary policy has real effects since surprises are created. By the time the public learns about factors that have shaped monetary policy in the recent past, new factors become relevant and new surprises are generated. As a result the public's learning process reduces but does not eliminate the public's uncertainty about the course of monetary policy.

A succinct case for this view of the policy process for the United States is made by Havrilesky (1990c) in the context of distributionally driven fiscal and monetary policies. He (p. 53) writes:

Voters may be forward looking, but they are imperfectly informed about future tax and financial regulatory environments. Therefore, when politicians make redistributive fiscal promises, voters cannot anticipate the timing, magnitude, or location of the subsequent sectoral impacts, nor can they anticipate the timing or magnitude of the related subsequent monetary surprises. Moreover, voters cannot easily filter credible signals for surprises from the often subtle, but continual barrage of political and private pressures on monetary policymakers. Informational asymmetry occurs basically because imperfect private information exists regarding policymakers' responses to these pressures.

Chapters 9, 10, 14, and 18 are all driven by the informational asymmetry regarding the response of the CB (or of the treasury in countries with subservient central banks). The simplest framework is that of chapter 9 in which the information advantage disappears by assumption two periods after an effective change in objectives occurs. Chapter 10 extends the same framework to the case in which new private information is fully assimilated by the public only asymptotically. The formulation in chapter 10 allows a

wider range of possible speeds of learning. The discussions in these two chapters thus represent two extreme cases as far as the diffusion of information is concerned. Many of the basic insights can be illustrated in the simpler framework of chapter 9. But the more general form because of its larger degree of flexibility is more appropriate as a framework for empirical work. It also serves as a benchmark for the analysis of the effect of mandatory, but noisy, monetary targets and of the degree of CB independence on expectations and policy choices. The effects of mandatory announcements are discussed in chapter 14 and those of the degree of CB independence in chapter 18.

The basic framework is laid down in chapter 9. The relative preference of policy for price stability versus high economic activity shifts stochastically, though in an autocorrelated manner through time. Those shifts are revealed to policymakers immediately and to the general public with a lag of two periods. In each period policymakers choose planned money growth so as to maximize the expected value of the discounted present value of their objectives. But because of imperfect control over the money supply, actual money growth and inflation can deviate from those that were planned by policymakers.² The larger the current preference for high employment, the larger is the rate of monetary expansion planned by policymakers. The public knows that policy objectives are serially correlated over time, so past inflation is relevant for predicting future inflation. As a consequence inflationary expectations rationally adjust up and down to past movements in inflation. But this adjustment is partial, since the public knows that part of the fluctuations in past inflation are due to control errors.

In choosing the current rate of monetary expansion, policymakers weigh the current employment benefits from surprise inflation against the costs of higher current inflation plus the cost of higher future inflationary expectations. This last cost arises because higher inflationary expectations reduce future employment or require a higher rate of inflation to maintain the same level of employment. Policymakers may not take these costs as seriously as they take current costs and benefits. But as long as they do not fully discount the future, the effect of current actions on future expectations moderates their tendency to stimulate current employment through monetary surprises.

Chapter 9 fully characterizes the equilibrium interaction between policymakers and the public as a rational expectations (or Nash) equilibrium in

which the public's process of expectation formation is mutually consistent with the decision rule of policymakers. More precisely equilibrium is characterized by the following conditions:

1. Given its perception of the way expectations are formed, policymakers choose the rate of inflation in each period so as to minimize the conditional expected present value of the combined costs of inflation and of deviations of actual from desired employment.
2. Given their perception of the policy rule followed by policymakers and the information available to them, individuals form their expectations (and conclude nominal contracts accordingly) so as to minimize the conditional mean forecast error in each period.
3. The public's perception of the policy rule postulated in condition 2 is identical to the policy rule that emerges as a solution to the problem in condition 1.
4. Policymakers' perception of the way expectations are formed postulated in condition 1 is identical to the expectations formation process that emerges as a solution to condition 2.

A basic difference between this equilibrium and the one obtained under perfect information is that both positive and negative monetary surprises are now possible, so monetary policy has real effects. Positive surprises occur when the relative concern for employment goes up, and negative surprises occur when it goes down. Credibility is naturally characterized by the difference between policymakers' current policy plans and the public's current perception of these plans. The chapter also investigates the effects of parameters such as the quality of control over the money supply and policymakers' rate of time preference on the distribution of inflation and on credibility.

The main additional contribution of chapter 10 is that it provides a substantially more flexible characterization of the informational advantage of the CB. This formulation leads to a learning process in which all past rates of inflation are relevant for predicting the future. Although more complex, this specification leaves more a priori freedom for empirical implementation. It is also better suited for the investigation of the effects of various parameters on the speed of learning and the determinants of credibility. Because of its wider generality chapter 10 rather than chapter 9 is used as a benchmark for the discussion in chapters 14 and 18, which are reviewed in the following section.

Before closing this section note that (as in Grossman 1990) the positive effect of inflationary surprises on policymakers' objectives need not arise only because of their stimulatory impact on employment. It could also reflect an underlying desire for larger seigniorage revenues, low real costs of servicing the public debt, or a balance-of-payments motive. Since all these motives affect the objectives of policymakers through unexpected inflation, as is the case with the employment motive, practically all the discussion of credibility, learning, and policy under asymmetric information extends naturally to cases in which these other motives operate instead of, or along with, the employment motive.

8.5 Mandatory Announcements and the Interaction of Private Information with Central Bank Independence (Chapters 14 and 18)

The discussion of chapters 14 and 18 is grouped together immediately after that of chapter 10 since both either rely on that chapter or extend it. During the 1970s and 1980s central banks in several developed countries introduced procedures that were designed to partially disclose their policy plans to the public. This was done by issuing monetary targets, official forecasts, or statements of intention. Announcements are (or have been) made in Germany, the United States, Japan, Britain, France, Canada, Switzerland, and Australia. These advance signals are imperfect, but not meaningless, indicators of planned policy actions. Their precision tends to vary across countries. The new (1989) Reserve Bank of New Zealand Act requires the governor of the bank to negotiate a monetary policy agreement with the minister of finance and to make it public. By contrast, under the previous law the governor could be directed to follow a particular policy without that directive being released publicly. The new law is therefore an institutional device that raises the precision of signals about monetary policy plans in comparison to its previous counterpart.

Chapter 14 explicitly recognizes the existence of advance signals about policy plans and analyzes the effects that their precision has on the policy process and on policy outcomes. The analysis takes the framework of chapter 10 as a point of departure. As in that chapter the public utilizes past rates of monetary expansion to forecast future rates. But in addition it has access to noisy signals issued by policymakers about their policy plans. The chapter characterizes policymakers' decision rules and the learning process of the public in the presence of imperfect, but not meaningless,

monetary signals and provides answers to such questions as: What determines the credibility of monetary targets, and what is their effect on the distribution of inflation and on monetary uncertainty? In particular the chapter demonstrates that monetary targets, even if imperfect, reduce the public's uncertainty and are likely to reduce the mean level of inflation. The substantial reduction of inflation in New Zealand following its new central bank law is consistent with the last implication. It is also supported by preliminary evidence from part IV which suggests that countries with monetary targets have, *ceteris paribus*, lower rates of inflation (column 1 of table 20.4).

Advance disclosure of monetary plans usually takes the form of monetary targets or statements of intention. But the discussion in chapter 14 may be viewed more generally as applying to any kind of signal issued by the central bank about its future monetary policy besides past money growth. With this wider interpretation in mind, the chapter implies that the lower the precision of monetary control, the more attention is paid to other signals of planned monetary growth such as public statements, rumors, and personalities. In such circumstances public appearances by high-ranking central bank officials receive wide press coverage. With very precise monetary control, on the other hand, past money growth is a good indicator for future plans and the pronouncements of central bank officials do not draw a lot of attention. Formally chapter 14 is an extension of the model in chapter 10 in which policymakers possess an extended information advantage about their own shifting priorities.

Chapter 18 provides a theoretical framework for the analysis and the subsequent empirical work on the effects of CB independence on the distribution of inflation and other characteristics of the policy process. The degree of CB independence obviously plays a meaningful role only in the presence of differences of emphasis on alternative policy objectives between the political authorities and the CB. The chapter focuses on two main differences. One relates to possible differences between the rate of time preference of political authorities and that of central banks. For various reasons central banks are normally more conservative and tend to take a longer view of the policy process. The other concerns the subjective trade-offs of the CB and of political authorities between price stability and other goals such as high employment, extraction of seigniorage revenues, and balance-of-payments objectives. The presumption is that at least on average, central banks are more conservative also in the sense that they

care relatively more than political authorities about price stability. The analysis is conducted within the framework of chapter 10 in which the public is not fully informed about the shifting objectives of the political authorities and in which there is no perfect control of inflation.

In most countries the degree of CB independence is determined by formal institutional characteristics such as the CB charter, which are often mitigated by more fluid and less permanent factors such as personalities and shifting views and alliances within the public sector inclusive of the CB. For example, in the United States, presidents have often tried to pack the Board of Governors of the Federal Reserve System with loyal appointees. Although acquiescence of board members to the shifting desires of administrations is by no means automatic, it does occur. But the degree of acquiescence may vary with professional and other characteristics of board members (Havrilesky 1991b provides interesting evidence). It also may vary with the state of the economy. Since such shifts often occur far from the public eye, there normally is a certain degree of uncertainty about the current level of CB independence. Policymakers within the CB or the Treasury have better information about the current degree of independence than the general public and may use it to further their objectives. Chapter 18 uses the framework of chapter 10 to analyze the effects of this type of uncertainty.

Several general conclusions emerge from the discussion in chapter 18. First a lower degree of CB independence is associated in all cases with more inflation variability as well as with more inflation uncertainty. The intuitive reason is that with less independence a larger fraction of the more volatile shifts in the objectives of the political authorities is injected into the conduct of monetary policy. Second, subject to some reasonable restrictions, a lower degree of CB independence is also associated with a higher mean level of inflation. Third, cross-country variations in CB independence and in the difference between the objectives of political authorities and of the CB tend to produce a positive cross-country correlation between the mean and the variance of inflation. This is a well-documented empirical regularity (Logue and Willet 1976). The hypothesis that it is due to cross-country variations in CB independence is tested in chapter 22. Finally, the lower the degree of CB independence, the lower will be the level of average credibility as measured by the variance of the deviation between actual policy actions and the public's perception of those actions. Since it mostly relies on propositions that are proved in chapter 10, chapter 18 is less technical than chapter 10.

8.6 Private Information about Money Demand and Changing Objectives (Chapter 13)

So far the discussion has abstracted, for simplicity, from shocks to money demand. When the monetary authority has to decide about the rate of monetary expansion prior to observing the current state of money demand, its control over the rate of inflation becomes imperfect even if it has perfect control over the money supply. To see why, note that the money market equilibrium condition implies that the price level is affected by factors on the side of money demand as well as by factors on the side of money supply. If the monetary authority has to choose the latter without perfect knowledge of the former, its control over the price level must in general be imperfect.

Central banks usually have a better feel for the state of money demand than the general public. The staff of the CB has access to indicators for money demand that are not available to the general public. In addition CB research departments are normally in a better position to evaluate the meaning of financial developments for the state of money demand. This does not mean that the CB can perfectly forecast the near-term level of money demand. But it does imply that it possesses private, but not totally accurate, information about the near-term level of money demand. A convenient way to model this information advantage is to assume that policymakers have access to private, but noisy information, on the near-term state of money demand. This way of modeling private information about money demand has been proposed by Canzoneri (1985).

Chapter 13 discusses the consequences of private information about both the changing emphasis of policy on surprise creation versus price stability and the state of money demand. A basic consequence of this conjunction of different types of private information is that past inflation becomes a noisy signal for future inflation even when the monetary authority has perfect control of the money supply. The reason is that actual inflation reflects both the deliberate decisions of policymakers as well as money demand forecast errors on their part. By observing both past money growth and price inflation, the public can deduce what has been the actual value of past shocks to money demand. But this still leaves it in the dark about how much of a given increase in monetary growth was due to a transitory overestimate of money demand by policymakers and how much to a persistent increase in their relative desire for positive monetary

surprises. Since only the latter is relevant for forecasting future inflation, the public tries to filter out persistent changes in the emphasis of policy on alternative objectives from forecast errors that were committed by policymakers.

As in chapter 9 policymakers are aware of the public's learning process and take it into consideration when making decisions about current monetary expansion. In particular, when maximizing the present discounted value of their objectives, policymakers take into consideration that an increase in current monetary expansion designed to raise surprise inflation will also raise future inflationary expectations, making it more costly in terms of price stability to achieve the same level of monetary surprise in the future. Factors that enter into this dynamic trade-off are policymakers' rate of time preference and the speed of learning, by the public, about changing policy objectives. This speed of learning, which is a prime determinant of credibility, depends in turn on more basic parameters such as the variability of money demand, the forecasting ability of the monetary authority, and its (politically or bureaucratically determined) rate of time preference.

Chapter 13 characterizes the simultaneous interaction between the choice of policy and the determination of the public's expectations and its choice of nominal contracts. The equilibrium concept is the same as that of chapter 9. It is a Nash (or a rational expectations) equilibrium in which policymakers maximize the expected present value of their objectives, taking the public's learning process as given, and the public picks its inflation forecast so as to minimize the mean square error of forecast. A more precise characterization of the equilibrium concept appears in section 8.4 above.

The chapter analyzes the determinants of reputation, credibility, and the speed of learning. In particular it stresses the effect of learning as a partial deterrent of attempts to push inflation up by policymakers. As a matter of fact the higher the speed of learning, the more potent is the deterring effect of learning.

One of the important aspects of monetary policy is its degree of activism. The framework of chapter 13 makes it possible to determine the degree of activism endogenously and to relate it to more fundamental parameters. The chapter shows that activism is more pronounced, the larger the short-run Phillips trade-off, the larger the (politically determined) rate of time preference of policymakers, and the poorer their ability to forecast changes in the demand for money.

The formal structure of chapter 13 is devised so that it maps into that of chapter 9. This mapping produces a substantial simplification in proofs and algebra, since many of the propositions in chapter 13 can be proved by relying on analogous propositions in chapter 9. This isomorphism between the two chapters is more than coincidental. First, both assume that policymakers possess only a minimal information advantage. At a deeper level the structural analogy between the two chapters reflects the fact that an essential ingredient of both models is policymakers' inability to perfectly control inflation in conjunction with common knowledge of this fact by the public. The reason for imperfect control is different in the two cases. In chapter 9 it is due to imperfect control of the money supply process, and in chapter 13 it is due to imperfect knowledge of the state of money demand. For simplicity of exposition these two types of imperfect control are analyzed separately. It is likely that both operate in reality. But this does not invalidate many of the conclusions in the two chapters, since a good number of them reinforce each other.

8.7 Private Forecasts about the State of the Economy and the Persistence of Inflation (Chapter 15)

An important base for making monetary policy decisions is the forecast by policymakers of the near-term cyclical position of employment and related real variables. Such forecasts require them to evaluate how much of the current deviation of employment from its desired level will persist into the future. Because of their judgmental and complex nature, such forecasts normally are the private information of policymakers. Chapter 15 explores the consequences of this information advantage for the persistence of inflation when the marginal political costs (to policymakers) of deviations from desired employment increase with the size of those deviations.

Policymakers may have some private information about the near-term natural level of employment. But, as is the case with all forecasters, they make errors particularly in forecasting the permanence of employment. Chapter 15 models this state of affairs by assuming that policymakers get information about current employment and its permanence with a small lead relative to the general public. Since the marginal political costs of low employment are increasing with unemployment, policymakers generally tend to inflate at higher rates (in order to create larger surprises) when the natural rate of unemployment is higher. But in doing that, they face an

important dynamic trade-off. Since they require larger inflation, larger surprises are not costless. If policymakers forecast that current unemployment, even if high, is lower than future unemployment, they are better off "saving" some of their ability to create surprises for the future. If, on the other hand, they believe that unemployment now is high in comparison to the future, they are better off using their surprise-creating ability already now.

The ability to create surprises rises and falls over time as a function of past rates of inflation. The mechanism responsible for this link is the public's learning process. Being aware of the persistence of natural employment and of government's decision rule, the public interprets recent high inflation as a sign that the former forecasts relatively high unemployment for the near future and that upcoming rates of inflation will therefore be higher. Because of this mechanism government's ability to create future monetary surprises diminishes with current inflation. The higher the current inflation, the higher will be the next period's inflationary expectations, and the costlier it is for government to create a given size inflationary surprise. Because of this effect policymakers try, given their information, to allocate larger surprises to periods with relatively large unemployment and to utilize periods with low natural unemployment to rebuild their credibility. This credibility is then partially used up when natural unemployment rises again.

Chapter 15 utilizes the dynamic interaction between policy and the public's expectations to explain how purely transitory shocks to natural employment contribute to the persistence of inflation. The basic idea is that a purely transitory upward blip in natural employment that leads through the current policy response to higher inflation is partly interpreted by the public as a persistent increase in natural unemployment. As a consequence individuals revise their expectations of near-term inflation upward and adjust nominal contracts accordingly. In the subsequent period policymakers are therefore faced with nominal contracts that are based on the assumption of a higher rate of inflation. Other things the same, these higher nominal settlements tend to reduce employment. Policymakers respond to this adverse effect on employment by inflating at a higher rate. Indeed, in the presence of private forecasts about the phase of the cycle, transitory blips to employment are transformed into a persistent inflationary process.

The analysis in chapter 15 implies that when monetary policy is discretionary, the time series properties of inflation are partially shaped by those

of natural employment. Furthermore it implies that the persistence of inflation should be larger under discretion than under rules. One way of testing this implication is to compare the persistence of inflation under fixed exchange rates with its persistence under flexible exchange rates. To the extent that fixed exchange rates function as partial commitment devices, we should expect inflation to be less persistent under fixed than under flexible exchange rates. Evidence presented in Alogoskoufis (1991) supports this implication. Another implication of the chapter is that inflation behaves countercyclically under discretion. This may explain a recent finding by Kydland and Prescott (1990) that the price level in the United States since World War II has been countercyclical.

8.8 Alternative Notions of Credibility and Reputation (Mostly Chapter 11)

In a world of perfect information and no commitments a policy announced today for some future period is either fully credible or not at all. It is fully credible if it is dynamically consistent and not at all credible if it is not dynamically consistent.

Under asymmetric information it is still the case that only dynamically consistent strategies are credible. However, due to the fact that the public is not fully informed about the objectives of policymakers, there may be a divergence between the rate of monetary expansion planned by the central bank and what the public believes about this rate. This divergence occurs because the public is not fully informed about the dynamically consistent or subgame perfect strategy of the central bank for the period. Hence under asymmetric information a natural measure of credibility is the absolute value of the divergence between planned and expected money growth in each period as well as on average. This conception of credibility is particularly appropriate for cases in which the emphasis of policy on alternative objectives changes over time.

Chapter 11 develops and characterizes this notion of credibility and compares it to notions of credibility that are based on trigger strategies. The basic idea underlying the application of such strategies to monetary policy games is that the public uses its inflationary expectation as a device to deter the central bank from producing the excessively high discretionary rate of inflation. The chapter compares and contrasts the learning and the

trigger strategy approaches to modeling reputation. It critically discusses the trigger strategy approach and comes strongly in favor of the first approach as more natural and realistic. The fact that private individuals invest resources in activities such as "Fed watching" supports the view that the learning approach is more realistic. Since the chapter is short and largely nontechnical, the reader is referred to it for further details.

What is an appropriate measure of credibility or reputation often depends on the nature of private information. For example, the (lack of) credibility of monetary targets (chapter 14) is naturally measured by the difference between the announced targets and the postannouncement expectation of the public. This is a measure of the average level of credibility. For some purposes it is useful to know by how much a unit change in announced targets changes inflationary expectations. This leads to the concept of a "marginal credibility of announced targets." Chapter 14 presents a formal definition and discusses the basic determinants of marginal credibility.

When, as is the case in chapter 16, the public does not know for sure whether policymakers in office are able to commit, the reputation of policymakers is naturally characterized by the probability assigned by the public to the event that the policymakers in office are able to commit.

8.9 Ambiguity in Monetary Policy (Chapter 12)

Central banks seem to value their private information. Existing evidence does not make it possible to determine whether this is a general feature of central bank policy or a particular characteristic of central banking in some developed countries. But existing evidence makes it clear that the Federal Reserve has an inclination for secrecy. Goodfriend (1986) reports a legal case in which the Federal Open Market Committee (FOMC) was sued under the Freedom of Information Act to make public immediately after each FOMC meeting the policy directives and minutes for the meeting. The Fed vigorously opposed this demand and went to great lengths to preserve its information advantage.

Chapter 12 presents two, not mutually exclusive, explanations for the preference for secrecy and ambiguity. One is based on the notion that a high degree of statutory independence for the central bank in conjunction with some ambiguity enables incumbent politicians to partially influence

monetary policy without taking the electoral risks associated with possible adverse effects of the policies they initiate.

The other explanation is based on the observation that since only unanticipated inflation affects real variables, ambiguity is needed to enable the monetary authority to influence real variables such as employment and output. In a world with a continually changing emphasis on alternative objectives (as in chapters 9, 10, 13, 14, and 15) there will be both positive and negative monetary surprises. Correspondingly output will sometimes be above its natural level and sometimes below it. On average, over long periods of time, output will be at the natural level since monetary policy is neutral in the long run. But this does not mean that the CB does not value the ability to create surprises. Such ability enables the bank to influence the timing of surprises. This may improve the long-run value of the bank's objectives by allowing it to create positive surprises when they are relatively highly valued and to leave the inevitable negative surprises for periods in which price stability is deemed relatively important. The preservation of this ability requires that the public's perception of the shifting objectives of policy not be totally accurate. This is achieved in turn by choosing money supply control procedures that are not necessarily as accurate as is technically feasible. Chapter 12 uses the analytical framework of chapter 9 to illustrate these ideas more precisely.

8.10 Concluding Reflections

The different models of monetary policy used to illustrate the many aspects of private information can obscure the fact that most of them share common principles. What is really crucial is that policymakers have private information about something. This may involve private information about the current balance of power between different constituencies or policy-making philosophies within government. It may involve the active promotion of particular interests by the central bank in conjunction with changes in its ability to achieve that aim because of changes in CB independence and other changing constraints. In such a case the "changing objectives" in part II and in some of the chapters in part III implicitly reflect changing constraints. The change in the constraints facing policymakers, due to changing economic conditions, can also be modeled explicitly, as is done in chapter 15. For instance, private information may concern a changing

evaluation by policymakers of the relative electoral costs of inflation and unemployment.

The common and crucial elements in all cases in which there are changing objectives, changing constraints, or changing forecasts can be summarized as follows.

1. Policymakers possess a certain amount of temporary private information about one or more shifting variables.
2. These variables have some persistence, and they influence current policy choices.
3. The public is not perfectly informed about the persistence of these variables, and current policy choices provide relevant, but noisy, information about their persistence and therefore about future inflation to the public.

These principles transcend the particular stochastic structures used to illustrate the many-faceted aspects of monetary policy under asymmetric information.

9 The Employment Motive in the Presence of a Minimal Information Advantage about Objectives

9.1 Introduction¹

In most countries the formation of monetary policy is at least partially influenced by political considerations. Even the Fed, which enjoys a high degree of formal independence, is not immune to pressures from the executive and legislative branches of government. There is an increasing body of evidence suggesting that monetary policy in the United States is partly responsive to the desires of the president, Congress, the financial community, and periodically some other less visible institutions or groups. The precise channels through which these responses are elicited are subtle and, at times, elude precise formulation because the president, Congress, and the Federal Reserve all have a common interest in preserving an image of the central bank as an independent, apolitical institution.

Weintraub (1978, p. 356) concludes, after summarizing the history of the postaccord monetary policy, that much of this policy "can be explained just by noting who the president was when the policy under review was in effect." In a study of presidential influence on monetary policy, Beck (1982) concludes that presidential political demands are somehow transmitted to the Fed. Beck notes that the transmission mechanism requires further study but that it seems clear that presidential preferences are an important determinant of Fed policymaking (Beck 1982, p. 443). Woolley (1984) holds a similar view. More precise studies reviewed in chapter 17 find that monetary policy in the United States partially depends on the party affiliation of the president.

Hetzel (1985) argues that current institutional arrangements allow members of Congress to pass on political pressures of various constituent groups to the Fed while avoiding association with the consequences that adversely affect the welfare of other groups. This explains Congress' consistent preference (noted by Woolley, 1984, ch. 7) for attempting to influence monetary policy through a variety of threats to limit the Fed's institutional autonomy rather than through an explicit mandate to guide monetary policy (Hetzel 1985, p. 7). Since the autonomy of the Fed depends on Congress, it must be at least somewhat sensitive to the wishes of Congress provided that the Fed values autonomy. This point of view also explains why, as noted by Beck (1990) and others, Congress has not, to date, attempted to discipline the Fed by exerting budgetary control. A related argument is made by Kane (1980, 1982). He argues that the Federal Reserve performs a scapegoat function for the president and Congress. In

return the Fed gets a fair degree of independence, which is necessary in order to credibly perform the scapegoat function. Both Congress and the presidency are institutions largely concerned with various redistributive considerations. As a consequence the Fed is, probably to a lesser degree, also sensitive to redistributive considerations (Havrilesky 1993).

Arthur Burns appears to share the view that the Fed is not a totally free agent. He believes that the Fed can work to achieve price stability only if the policy does not adversely affect production and employment and does not irritate Congress. In Burns' words, the role of the Fed is to continue "probing the limits of its freedom to undernourish . . . inflation" (Burns 1979, p. 16). Coming from a former chairman of the Federal Reserve, this statement is particularly revealing. It shows that as chairman of the board, Burns did not view himself as totally free to decide the course of monetary policy on his own. Instead, he viewed the Fed as partially responding to the wishes of other institutions and personalities within the government or, possibly, outside it. Clearly even within a country like the United States, in which the central bank has a high degree of statutory independence, monetary policy is not divorced from the general political process. This is a fortiori true in most other countries whose central banks do not enjoy as high a degree of legal independence as the Federal Reserve.²

Politicians and elected officials try to satisfy the conflicting demands of different constituencies. Some groups in society are more adversely affected by low employment than by inflation, and the reverse is true for other groups.³ These different groups exert conflicting pressures on elected officials. The formation of effective coalitions determined to change the course of monetary policy is subject to stochastic elements about which the concerned officials and the central bank have more timely information than the rest of the public. In terms of the model of chapter 3 this means that the parameter A (which measures the relative aversion of policymakers to employment below the desired level N^* and to inflation) is changing over time. Furthermore the central bank has a temporary information advantage about those changes. Such shifts in emphasis on relative policy objectives may occur almost continuously, though usually in small amounts. Large changes in policy objectives, such as the one that occurred in 1979 under the Volcker chairmanship, occur infrequently. But the probability of such changes is not zero. Since policy objectives usually change

by small amounts, there is a fair degree of persistence in the emphasis on various objectives. As a consequence past policy outcomes provide information about the likely state of future objectives and therefore about future inflation.

The view (held by many economists) that monetary policy in the United States does not reflect the optimizing decisions of an apolitical socially motivated monetary authority has recently been eloquently stated by Kane (1990, p. 289):

Contemporary economists characteristically think of themselves as specialists in positive economics: calculators *extraordinaire* of individual and institutional benefits and costs. To focus on economic problems *per se*, they determinedly strip away normative and political dimensions of policy problems. This predilection undermines the policy relevance of economic research whenever (as in monetary-policy framework decisions) normative and political aspects of the problem fail to be surgically separable issues.

This point of view also clarifies why, despite their evident advantages, many economically sound proposals for monetary reform have not been implemented. More important, it provides documentation for two basic presumptions. One is that the emphasis of policy on alternative objectives shifts continuously over time. The other is that the Fed possesses a temporary information advantage about those shifts. In Kane's (p. 290) words:

Virtually all reform proposals seek to impose stricter accountability on Fed officials for the monetary policy they choose to follow. If such proposals are to have a substantial chance for success, their sponsors must find a way to undo the political and bureaucratic incentives that make current arrangements so cozy both for incumbent politicians and for the Fed. The Fed minimizes its accountability to the electorate and to politicians in two ways: by accepting contradictory goals and by making discretionary use of a self-selected bevy of intermediate policy targets such as the federal funds rate, nonborrowed reserves, and various monetary growth rates. *The resulting vagueness in the institution's aims and methods lets Fed officials reverse their economic priorities suddenly in response to the ebb and flow of political pressure with minimal embarrassment. FOMC secrecy and the carefully crafted structural ambiguity of Fed decision-making permit Fed officials to fuzz over the important political compromises they effect between goals desired by different political constituencies and let those compromises be made with minimal short-term political stress for elected politicians.* Moreover, the large staff of professional economists whose research on policy issues is directed by the Fed serves the institution's leadership in two ways. *First, staff analysis helps Fed officials to maintain an informational advantage over the other players.* Second, by manipulating the size of

this staff and the activities for which they are rewarded and penalized, Fed officials help to shape the agenda of contemporary economic research on monetary policy. Unless Fed staff members are willing to risk career penalties, they are induced to devote their research to bureaucratically approved issues. Such issues focus on the control subsystem—topics such as the effects of using different arrays of intermediate targets or of moving from contemporary to lagged accounting for reserves and back again—rather than on the broader principal-agent conflicts comprised in the information and incentives subsystems of monetary policymaking. (*Italics added for the conception underlying the model of this chapter.*)

The existence of an information advantage on the part of the central bank fundamentally alters the nature of the interaction between policymakers and the public. Since policymakers know that current policy outcomes affect future inflationary expectations (which affect in turn their future ability to stimulate employment at any given rate of inflation), their current choice of policy becomes sensitive to reputational considerations even under discretion. The extent to which these considerations deter policymakers from inflating at the one-shot discretionary rate of chapter 3 depends on their degree of time preference and on the speed with which the public detects changes in their objectives. This chapter explores the implications of those new elements for policy outcomes and for expectations formation when the information advantage of the central bank is short lived. The next chapter explores similar issues when the information advantage is larger. In both cases the information advantage about the state of objectives at a particular moment dissipates with the passage of time. But this process is longer and more gradual in the second case. Even in the case of a short-lived information advantage, the public never fully catches up with the current state of objective, since by the time it learns precisely about past changes new changes occur.

Imperfect information is also crucial for understanding the existence of real effects of money on output. Despite the recent upsurge of the real business cycles view in which money growth responds passively to real variables,⁴ there are reasons to believe that fluctuations in monetary growth also contribute to real variability.⁵ The perfect information framework of chapter 3 does not provide an explanation for the effects of money on economic activity, since it implies that employment is always at the natural rate. By contrast, the asymmetric information framework in this chapter is consistent with some effects of money on output, particularly during periods of change in governmental objectives.

9.2 Shifting Objectives and the Structure of Information

Consider a policymaker whose objective is to maximize the expected value of⁶

$$-\sum_{i=0}^{\infty} \beta^i \left[x_i \phi(N^* - N_i) + \frac{\pi_i^2}{2} \right], \quad 0 \leq \beta \leq 1, \quad (9.1)$$

$$\phi(N^* - N_i) \equiv \begin{cases} N^* - N_i & \text{for } N^* - N_i \geq 0, \\ 0 & \text{otherwise,} \end{cases}$$

subject to a short-run Phillips relation as in equation (3.2) which is reproduced here as equation (9.2).

$$N - N_n = \alpha(\pi - \pi^e), \quad \alpha > 0. \quad (9.2)$$

As in chapter 3, N , N^* , and N_n are the actual, the desired, and the natural levels of employment; π and π^e are the actual and the expected rates of inflation; β is the politically determined discount factor of the policymaker; x_i measures the aversion of the policymaker to deviations of employment from N^* in comparison to his or her aversion to deviations from price stability.⁷ The employment-related term of the objective function implies that the costs of being away from desired employment N^* are positive and increasing in the difference $N^* - N_i$ as long as this difference is positive. But the policymaker does not incur any costs when employment is above the desired level. The short-run Phillips curve in equation (9.2) implies that in the absence of inflationary surprises $N^* - N = N^* - N_n$. Since the desired level of employment is larger than the natural level and inflationary surprises have a mean value of zero, the policymaker normally operates in a range in which $N^* - N > 0$. For simplicity, we will restrict the parameters so that all the realizations of $N^* - N$ occur in the nonnegative range with very high probability. The precise restriction is discussed in appendix C to this chapter. To capture the frequent shifts in relative emphasis on employment and price stability as well as their persistence, we specify x_i as a stochastic variable with the following characteristics:

$$x_i = A + p_i, \quad A > 0, \quad (9.3a)$$

$$p_i = \rho p_{i-1} + v_i, \quad 0 < \rho < 1, \quad (9.3b)$$

$$v_i \sim N(0, \sigma_v^2), \quad (9.3c)$$

where A is the mean, publicly known, value of x_i and p_i is the stochastic part of x_i . In period i the realization of A is known by the policymaker but not by the public. The policymaker is as ignorant as the public about future innovations v to his or her objectives. However, the policymaker knows the current value of x (or p) and thus can produce a more precise forecast of future x 's than the public. The persistence in the policymaker's objectives is captured by specifying p_i as a first-order Markoff process with a positive autoregressive coefficient as well as through the positive constant A . However, since A is known with certainty by the public while p_i is not, the persistence in these two components of x_i does not affect the equilibrium in identical manners.

The specification of v_i as a standard normal variate implies that there is a large probability that central bank's objectives will change by small amounts and a small (but nonzero) probability that they will change by a large amount. Minor readjustments in policy objectives occur continually but large changes, such as the one that led to Volcker's disinflation in 1979, are rare according to this specification. The recent literature on monetary policy games characterizes policymakers with different relative weights on employment and inflation as having different "types" (Backus and Driffill 1985a, 1985b and Vickers 1986). Here the type is determined by the realization of x_i . However, unlike in that literature, the number of types is not restricted to two and, more important, the type is changing over time. It is those continual changes that give policymakers a permanent information advantage despite the fact that the public continually updates its beliefs.

The public knows the stochastic structure of the political process which leads to changes in x_i . In other words, it knows σ_v^2 and ρ , and it utilizes this knowledge in conjunction with observations on past rates of monetary growth to forecast future inflation.⁸ This chapter focuses on the case in which the information advantage of the central bank about any particular x_i is extremely short-lived. In particular it is assumed that individuals obtain, through the media or other sources, a precise observation on p_{i-2} at the beginning of period i prior to the conclusion of nominal wage contracts for that period. (The underlying structure of contracts is identical to the one discussed in chapter 3. Details appear in section 3.6.) This still leaves them in the dark about p_{i-1} . Since p is serially correlated and since inflation in period $i - 1$ is, through the central bank's response, influenced by p_{i-1} individuals find it advantageous to use monetary growth in period $i - 1$ to sharpen their inflation forecast for period i .

An important consequence of this learning process is that current policy decisions affect next period's inflationary expectations. In particular, if the central bank raises the current rate of monetary expansion, this raises inflationary expectations in the subsequent period. Since (as shown in equation 9.1) the central bank is concerned about the future as well as about the present, it takes into consideration the adverse effect of its current action on next period's objectives. As a result the central bank is at least partly deterred from inflating at the rate it would have inflated at under complete information. Incomplete information about the shifting objectives of policymakers induces policymakers to inflate at a lower rate even under discretion.

Since $A > 0$, the probability that x_i will have a positive realization is larger than the probability it will have a negative realization. Only positive realizations of x_i are consistent with the notion that as long as $N_i < N^*$, policymakers prefer more to less employment given the rate of inflation. By making A sufficiently large in comparison to the variance of x_i , the probability of a negative x_i can be made as small as desired.⁹ This chapter maintains the simplification of chapter 3 by assuming that money growth impacts immediately on the rate of inflation.¹⁰ However, policymakers do not have perfect control over the rate of monetary growth and therefore over the rate of inflation. In particular, when the planned rate of monetary growth is m_i^p , the actual rate of monetary inflation is

$$m_i = m_i^p + \psi_i, \quad (9.4)$$

where ψ_i is a random monetary control error that is not known by government when it picks m_i^p . We assume that ψ_i is a standard normal variate with variance σ_ψ^2 and that it is distributed independently of the innovation v to policymakers' objectives.

9.3 Timing of Moves, Public's Beliefs, and the Equilibrium Concept

A "period" is defined by the length of the wage contract. The timing of moves within each period is as follows: First, nominal wage contracts are concluded based on the rate of inflation expected for the period. Then government chooses m_i^p , taking the wage contract and therefore those expectations as given. Then the control error for the period realizes and the rate of inflation for the period is determined by equation (9.4). How-

ever, since individuals learn from current inflation about changes in policymakers' objectives, they take into consideration the effect of their current choices on *future* expectations.

When committing to nominal contracts, individuals in the economy try to forecast as well as possible the rate of inflation for the period of the contract. This forecast depends on what they know about policymakers' objectives and behavior. Policymakers take the public's process of expectations formation as given and pick that part of monetary growth that they control so as to maximize the expected value of the objective function in equation (9.1). This gives rise to a discretionary decision rule in which the actual rate of inflation π depends on the current state of government's objectives and on the current realization of the control error ψ . Individuals know the structure of this decision rule but do not know the current state, p of policymakers' objectives. They utilize this information in an optimal manner to form a minimum variance estimate of the rate of inflation for the period. Thus government's decision rule depends on the process of expectations formation, and this process depends in turn on government's decision rule. In a (Nash) equilibrium the decision rule that emerges, given the process of expectations formation, should be identical to the decision rule individuals posit the government is using when choosing the form of their optimal predictor. This suggests that the process of expectations formation and government's decision rule are determined simultaneously. To find the explicit form of these two processes, we postulate that the public believes that government's decision rule is the following linear function of A and of p_i :¹¹

$$m_i^p = B_0 A + B p_i \quad \text{for all } i, \quad (9.5)$$

where B_0 and B are unknown combinations of parameters to be determined. To establish the consistency of those beliefs, it is necessary to show that given those beliefs, it is indeed optimal for government to behave according to the decision rule in equation (9.5). This is demonstrated in the following section. The remainder of this section derives the form of the optimal predictor of m_i , taking the public's belief in equation (9.5) as given. Readers who are not interested in the details of the derivation and its logic can go directly to the final result in equation (9.12).

The public does not observe m_i^p directly. Instead, it observes (using equations 9.5 in 9.4) the actual rate of monetary inflation

$$m_i = B_0 A + B p_i + \psi_i \quad (9.6)$$

up to and including the previous period. Due to the existence of a control error, m_i is a noisy indicator of m_i^p and p_i . From equation (9.6),

$$E[m_i | I_i] = B_0 A + B E[p_i | I_i], \quad (9.7)$$

where $E[m_i | I_i]$ is the expectation of m_i conditional on the information set I_i that includes past rates of monetary growth up to and including m_{i-1} and the value of p_{i-2} . Equation (9.3b) implies that

$$p_i = \rho^2 p_{i-2} + \rho v_{i-1} + v_i. \quad (9.8)$$

Since p_{i-2} is contained in the information set I_i ,

$$E[p_i | I_i] = \rho^2 p_{i-2} + \rho E[v_{i-1} | I_i] + E[v_i | I_i]. \quad (9.9)$$

Furthermore, since I_i does not contain any information about v_i , the last term on the right-hand side of equation (9.9) is equal to zero. Since I_i includes an observation on m_{i-1} which amounts to an observation on¹²

$$B v_{i-1} + \psi_{i-1} \equiv y_{i-1}, \quad (9.10)$$

the middle term in equation (9.9) can be rewritten

$$\rho E[v_{i-1} | y_{i-1}] = \rho \frac{\theta}{B} y_{i-1}, \quad (9.11a)$$

$$\theta \equiv \frac{B^2 \sigma_v^2}{B^2 \sigma_v^2 + \sigma_\psi^2}. \quad (9.11b)$$

Equation (9.11a) is the regression equation of v_{i-1} on y_{i-1} and θ/B is the slope coefficient in this regression.¹³ Substituting (9.11a) into (9.9) and inserting the resulting expression into (9.7), we obtain

$$E[m_i | I_i] = B_0 A + B \rho^2 p_{i-2} + \rho \theta y_{i-1}. \quad (9.7a)$$

The intuition underlying this predictor is simple. The public knows that actual inflation for the period is governed by equation (9.6). To forecast m_i , individuals have to forecast, on the basis of I_i , each of the components on the right-hand side of equation (9.6). Knowing the systematic parameters of the economy and of government's objectives, they can use $B_0 A$ as a forecast of itself, which is the first term on the right-hand side of (9.7a). The last two terms represent the forecast of $B p_i$.¹⁴ The first among those terms

represents that part of Bp_i that is forecastable on the basis of p_{i-2} . The second term represents the forecast of the part of Bp_i that is related to v_{i-1} —the innovation to government's objectives in period $i-1$. Individuals do not observe this innovation directly but observe y_{i-1} , which is a noisy indicator of that innovation. They therefore use y_{i-1} as a proxy for v_{i-1} but give it less than full weight ($\theta < 1$). Using (9.6), the optimal predictor in (9.7a) can be rewritten in terms of m_{i-1} as

$$E[m_i|I_i] = g(p_{i-2}) + \rho\theta m_{i-1}, \quad (9.12a)$$

$$g(p_{i-2}) \equiv (1 - \rho\theta)B_0A + \rho^2B(1 - \theta)p_{i-2}. \quad (9.12b)$$

Note that given B , a larger σ_ψ^2 implies through (9.11b) that θ is smaller and that the weight given to the last rate of inflation is smaller too. The intuition is that with a larger σ_ψ^2 the signal-to-noise ratio in m_{i-1} is smaller and the weight given to it therefore smaller.¹⁵

9.4 Derivation of the Policymakers' Decision Rule and Proof of the Rationality of Beliefs

Substituting equation (9.2) into (9.1), using the fact that $N^* - N_i \geq 0$ for all i and rearranging, we can formulate the policymakers' problem as a maximization of the expected value of

$$\sum_{i=0}^{\infty} \beta^i \left[\alpha(\pi_i - \pi_i^e) - (N^* - N_n) \right] x_i - \frac{\pi_i^2}{2}. \quad (9.1a)$$

The condition ensuring that $N^* - N_i \geq 0$ for all i is derived and discussed in appendix A to this chapter. Since, as in chapter 3, $\pi_i = m_i$ and individuals know this fact, so that $\pi_i^e = E[m_i|I_i]$, equation (9.1a) can be rewritten in terms of actual and expected rates of monetary expansion as

$$\sum_{i=0}^{\infty} \beta^i \left[(m_i - E[m_i|I_i])\alpha x_i - \frac{m_i^2}{2} - (N^* - N_n)x_i \right]. \quad (9.1b)$$

In each period policymakers choose the current planned rate of money growth and the contingent path of future rates so as to maximize the expected value of their objective function in (9.1b), taking the process of expectation formation in (9.12) as given. Using (9.12) and (9.4) in (9.1b), we express the policymakers' objective as

$$\max_{\{m_i^p, i=0, 1, \dots\}} E_{G_0} \sum_{i=0}^{\infty} \beta^i \left[\{m_i^p + \psi_i - g(p_{i-2}) - \rho\theta(m_{i-1}^p + \psi_{i-1})\} \alpha x_i - \frac{(m_i^p + \psi_i)^2}{2} \right], \quad (9.13)$$

where E_{G_0} stands for the expected value operator conditional on the policymakers' information set in period 0. This set includes the information set I_0 of the public in that period. In addition it includes precise knowledge of x_0 and therefore of p_0 which the public does not have. However, policymakers do not know ψ_i , $i \geq 0$, and x_i , $i \geq 1$, with certainty in period 0. Note that in going from equation (9.1b) to equation (9.13), the term $-\sum_{i=0}^{\infty} \beta^i (N^* - N_n)x_i$ has been dropped. The reason is that this term is not affected by planned monetary growth, which is the instrument at the disposal of policymakers. Hence maximization of the expected value of the expression in equation (9.1b) is equivalent to the problem in equation (9.13).

Since policymakers do not commit in advance to a given path of policy, the problem in equation (9.13) is solved anew in each period. Policymakers can be viewed as choosing the current value of m_0^p and a contingent plan for m_i^p , $i \geq 1$. Recognizing that in each future period policymakers face a problem that has the same structure as the period 0 problem, the stochastic Euler equations necessary for an internal maximum of this problem are¹⁶

$$\alpha(x_i - \beta\rho\theta E_{G_i}x_{i+1}) - m_i^p = \alpha[x_i - \beta\rho\theta(A + \rho p_i)] - m_i^p = 0, \quad i \geq 0. \quad (9.14)$$

Rearranging, we obtain

$$m_i^p = \alpha[(1 - \rho\beta\theta)A + (1 - \rho^2\beta\theta)p_i], \quad (9.15)$$

which confirms that the policymakers' decision rule has the form postulated in equation (9.5) with

$$B = \alpha[1 - \rho^2\beta\theta] = \alpha \left[1 - \rho^2\beta \frac{B^2\sigma_v^2}{B^2\sigma_v^2 + \sigma_\psi^2} \right] \equiv F(B), \quad (9.16a)$$

$$B_0 = \alpha[1 - \rho\beta\theta]. \quad (9.16b)$$

Equation (9.16a) implicitly determines B as a function of the basic parameters α , ρ , β , σ_v^2 , and σ_ψ^2 . Given those parameters, the solution for B turns

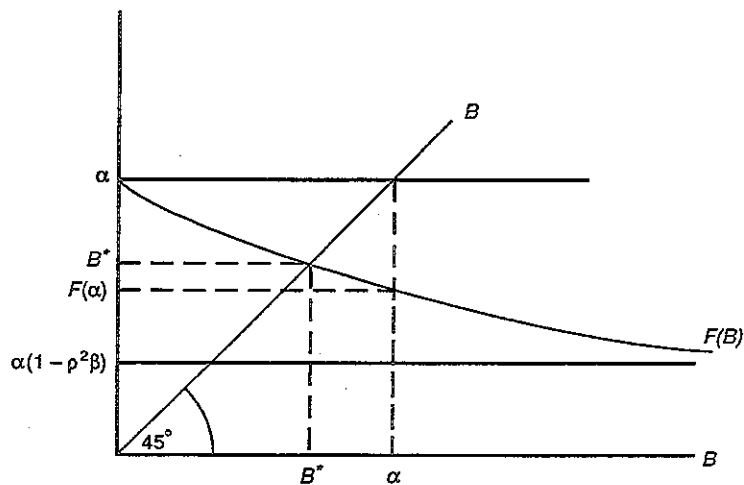


Figure 9.1
Determination of the equilibrium value of B

out to be unique. This can be seen by considering the right-hand side of (9.16a) as a function $F(B)$ of B and by noting that $F(0) = \alpha$ and that $F(B)$ is a monotonically decreasing function of B . The left-hand side of equation (9.16a) is a 45-degree straight line through the origin. The solution for B occurs at the intersection of those two lines. Since $F(B)$ is monotonically decreasing, the solution for B is unique and smaller than α . Figure 9.1 illustrates the argument. B^* in the figure designates the value of the solution.¹⁷ The equilibrium value of θ is determined by substituting B^* into (9.11b). Finally, the equilibrium value of B_0 is determined by substituting the equilibrium value of θ into (9.16b). This completes the solution of the model and the demonstration of the rationality of beliefs.

9.5 A Benchmark—The Policymakers' Strategy under Symmetric Information¹⁸

The behavior of policymakers under asymmetric information is fundamentally different from their behavior in the presence of symmetric information. To isolate the source of this difference and understand its effects, we first solve for the policymakers' decision strategy under symmetric information as a benchmark. In the context of the model of this chapter,

symmetric information means that in each period the public and the central bank possess the same information set. In particular at the beginning of each period, when wage contracts are concluded, the public already knows the realization of x and p for the period.¹⁹ Hence they can calculate precisely (as in chapter 3) the rate of inflation that will be picked up by policymakers after public expectations become embedded in nominal wage contracts.

An important implication of this information structure is that the current policy action does not affect the inflationary expectations of future periods, in particular those held in the subsequent period. Last period's monetary expansion is not used as an indicator for current central bank objectives because those objectives are fully known by the public in the current period. More formally, the partial derivative of $E[m_{i+1}^s | I_{i+1}^s]$ with respect to m_i^p is zero.²⁰ (By contrast, from equation 9.12a, this partial derivative is equal to $\rho\theta$ under asymmetric information.) As a consequence, with symmetric information, current policy actions do not affect future objectives, and the objective function in equation (9.1b) decomposes into a string of unrelated one-period problems whose typical form is

$$\max_{m_i^p} E_{G_i} \left[(m_i^p + \psi_i - E[m_i^s | I_i^s]) \alpha x_i - \frac{(m_i^p + \psi_i)^2}{2} \right], \quad i \geq 0. \quad (9.17)$$

As in the previous subsection the term $(N^* - N_n)x_i$ has been deleted because it does not depend on the instrument m_i^p . The first-order condition for this problem implies that

$$m_i^p = \alpha x_i = \alpha(A + p_i), \quad i \geq 0. \quad (9.18)$$

Combining (9.18) and (9.4), we obtain the actual rate of monetary inflation under symmetric information:

$$m_i^s = \alpha(A + p_i) + \psi_i. \quad (9.19)$$

Since the public knows x_i when it commits to nominal contracts,

$$E[m_i^s | I_i^s] = \alpha(A + p_i) \quad \text{for all } i. \quad (9.20)$$

As was the case in chapter 3, the public's forecast is not affected by current or past actions of policymakers. However, contrary to chapter 3, the public's forecast is not perfect because of the control error ψ . In particular

$$m_i^s - E[m_i^s | I_i^s] = \psi_i, \quad (9.21)$$

so the variance of the public's forecast error is equal to σ_ψ^2 . However, the central bank cannot utilize these surprises to improve its objectives since it is as ignorant of ψ_i (when it picks m_i^e) as the public.

9.6 Comparison of the Distributions of Inflation with and without Asymmetric Information

From (9.4) and (9.15) the rate of monetary expansion under asymmetric information is

$$m_i = \alpha[(1 - \rho\beta\theta)A + (1 - \rho^2\beta\theta)p_i] + \psi_i. \quad (9.22)$$

Comparison of (9.19) with (9.22) suggests that for the same realizations of the shocks p_i and ψ_i , the rate of monetary expansion is always lower with asymmetric information than with symmetric information. The intuitive reason is that under asymmetric information the central bank can lower next period's expected inflation by lowering current inflation, whereas this option does not exist with symmetric information. The fact that its current action affects future expectations checks the tendency of the central bank to inflate, making m_i^e smaller than m_i for all i . Essentially, by giving the central bank the ability to influence future expectations, asymmetric information makes it sensitive to reputational considerations. Such considerations are nonexistent under symmetric information because the central bank does not possess the ability to affect expectations in this case. The preceding discussion is summarized in the following proposition:

PROPOSITION 9.1 For the same realizations of governmental objectives and control error, monetary expansion under asymmetric information is never higher than under symmetric information and almost always strictly lower.

Thus the existence of asymmetric information and learning by the public attenuates the problem of dynamic inconsistency of monetary policy under discretion. However, except under extreme circumstances some of which are discussed below, it does not completely eliminate it.

We turn next to a discussion of the factors that determine the extent to which m_i is lower than m_i^e . Consider first the effect of the signal-to-noise ratio that operates on θ . It is shown in appendix B to this chapter that

$$\frac{d\theta}{d\sigma_\psi^2} < 0. \quad (9.23)$$

Hence, as the level of noise in the control of monetary inflation goes up, θ goes down and inflation under asymmetric information increases. At the limit when σ_ψ^2 tends to infinity, θ tends to zero, and the rate of monetary expansion in equation (9.22) tends toward its symmetric information counterpart. At the other extreme, when σ_ψ^2 tends to zero,

$$\lim_{\sigma_\psi^2 \rightarrow 0} m_i = \alpha[(1 - \rho\beta)A + (1 - \rho^2\beta)p_i] + \psi_i.$$

Note that if in addition $\rho = \beta = 1$, reputational considerations are sufficient to induce the central bank to plan a zero rate of inflation.

The intuition underlying the effect of σ_ψ^2 is that with a relatively large noise-to-signal ratio, individuals pay little attention to past inflation in forecasting the upcoming rate of inflation. As a result the effect of current inflation on future expectations is small, making the future cost to the central bank of current inflation small too. Hence the central bank inflates at a rate that is nearer to m_i^e .

It is shown in appendix C to this chapter that

$$\frac{dB}{d\beta} < 0, \quad \frac{dB_0}{d\beta} < 0, \quad (9.24)$$

so m_i is larger the lower the discount factor β . The less policymakers care about the future, the less meaningful are the future costs of higher expected inflation and the higher therefore their current choice of inflation. At the limit when $\beta = 0$, $m_i = m_i^e$ for all i .

We now turn to a comparison of the levels of monetary uncertainty inflicted on the public with and without asymmetric information. A natural measure of the level of monetary uncertainty is the variance of the forecast error of monetary inflation. From equation (9.21) this variance is simply σ_ψ^2 under symmetric information. Subtracting (9.7a) from (9.22), canceling terms, and calculating the variance of the resulting expression, we obtain the variance of the forecast error under asymmetric information:

$$[1 + (\rho\theta)^2]\sigma_\psi^2 + \alpha^2[1 - \rho^2\beta\theta]^2[1 + \rho^2(1 - \theta)^2]\sigma_v^2 \equiv V. \quad (9.25)$$

This expression is obviously larger than σ_ψ^2 . It follows, not too surprisingly, that the public is subjected to more inflation uncertainty in the presence of asymmetric information.

Variability and uncertainty are related but not identical concepts.²¹ From (9.19) and (9.22) the variances of inflation in the absence and in the presence of asymmetric information are, respectively,

$$\alpha^2 \sigma_p^2 + \sigma_\psi^2, \quad (9.26a)$$

$$\alpha^2 (1 - \rho^2 \beta \theta)^2 \sigma_p^2 + \sigma_\psi^2, \quad (9.26b)$$

where σ_p^2 is the variance of p . Comparison of those two variances leads to the following proposition:

PROPOSITION 9.2 The variability of inflation under symmetric information is never smaller than its variability under asymmetric information and is almost always strictly larger.

Thus despite the fact that inflation uncertainty is larger under asymmetric information, its variability is smaller in this case. The intuitive reason for this ranking of variabilities is related to the fact that under asymmetric information the central bank's response to changes in its objectives is smaller than under symmetric information. This is the case in turn because under asymmetric information the central bank possesses some control over the speed at which the public learns about its changing objectives. To exercise this control, the central bank's response to changes in objectives has to be weaker than in the symmetric information case. Otherwise, the information advantage is dissipated too quickly.

9.7 A Measure of Credibility under Asymmetric Information

In the presence of perfect information, as in chapter 3, a policy is either fully credible or not credible at all. Thus, as explained there, the socially optimal zero inflation policy is not credible under discretion, since it is dynamically inconsistent.

In the presence of asymmetric information credibility can be measured more continuously. The following definition provides an operational measure of this concept:

DEFINITION 9.1 Credibility is measured as minus the absolute value of the difference between the rate of monetary expansion planned by the central bank and the public's beliefs, at contracting time, about this rate. Formally, credibility in period i is written

$$C_i \equiv -|m_i^p - E[m_i^p | I_i]|. \quad (9.27)$$

When $e_i^p = m_i^p - E[m_i^p | I_i] = 0$, credibility is perfect and it decreases monotonically with the absolute value of e_i^p . The attitude of policymakers

toward credibility depends on the direction in which their objectives are changing. If, relative to the past, they become more concerned with price stability, their interest is that the public recognize that swiftly. The reason is that during such episodes e_i^p is typically negative, making employment even lower than the natural rate N_n . At high levels of credibility (large C_i 's) the reduction in employment is relatively small, making the output and employment cost of disinflation small. Hence high credibility is useful at such times, as was demonstrated by Volcker's disinflation at the beginning of the 1980s. On the other hand, when policymakers become more concerned with high employment, their interest is that the public be slow in recognizing that. During such periods e_i^p is typically positive, pushing employment above N_n toward the desired level of employment N^* . The lower credibility as measured by C_i , the larger is the temporary employment gains that are realized. This is probably the reason that public concern for lack of credibility is heard only during periods of disinflation. Clearly credibility has important real effects during periods of changes in the policymakers' objectives.

We turn now to a discussion of the determinants of credibility. Recognizing that $E[m_i^p | I_i] = E[m_i | I_i]$ and using (9.7a) and (9.15) in (9.27), we write

$$C_i = -|B[v_i + \rho(1 - \theta)v_{i-1}] - \rho\theta\psi_{i-1}| = -|e_i^p|. \quad (9.27a)$$

Credibility is lower when two neighboring innovations to governmental objectives have the same sign. The reason is that in period i the public is completely ignorant about v_i . It partly recognizes the realization of v_{i-1} through the observation of m_{i-1} but still misses $\rho(1 - \theta)v_{i-1}$ of the realization of v_{i-1} . Hence, if v_i and v_{i-1} have identical signs, the errors cumulate making C_i lower. Given that v_i and v_{i-1} have the same sign, credibility is lower the larger these innovations in absolute value. The more general conclusion from this example is that credibility is lower when there is a bunching of large and identically signed innovations to governmental objectives.²² The realizations of the control error ψ_{i-1} also affects credibility. Credibility is lower when the sign of ψ_{i-1} is opposite to that of $v_i + \rho(1 - \theta)v_{i-1}$. The reason is that this error is partly interpreted as an innovation to governmental objectives in period $i - 1$ and causes an error in the opposite direction. Hence, if ψ_{i-1} has a sign that is opposite to that of the linear combination of the v_i 's, it compounds the error caused by those innovations and reduces credibility even further.

The measure of credibility in equation (9.27) is period and therefore shock specific. To get a more general view of the effect of various parameters on the level of credibility, it is useful to look at some summary statistic of C_i that does not depend on particular shock realizations. Such a measure is the variance of e_i^p whose explicit form is (using equations 9.27a and 9.16a):

$$\alpha^2 [1 - \rho^2 \beta \theta]^2 [1 + \rho^2 (1 - \theta)^2] \sigma_v^2 + (\rho \theta)^2 \sigma_\psi^2 \equiv V^p. \quad (9.28)$$

This variance measures the average divergence between planned monetary growth and the public's beliefs about these plans. The larger it is, the lower will be the mean level of credibility in the economy. The following proposition summarizes the effect of various parameters on V^p .

PROPOSITION 9.3 The mean level of credibility, as measured by V^p , is lower the higher σ_ψ^2 , σ_v^2 , and α and the lower β .

Proof See appendix D to this chapter. \square

The intuition underlying proposition 9.3 is straightforward. Credibility is lower, the higher is the level of political uncertainty (the higher σ_v^2) and the worse is the precision in control of the money supply (the higher σ_ψ^2). Larger values of either σ_v^2 or of σ_ψ^2 increase the public's uncertainty and reduce average credibility. A larger value of the trade-off parameter α causes policymakers to be more activist in response to changes in their objectives. This increases the public's uncertainty and reduces credibility too. A corollary is that credibility is lower on average, the more sensitive the demand is for labor to the real wage rate. This follows from the discussion in section 3.6, which implies that α becomes larger as the sensitivity of the demand for labor increases with respect to the real wage rate. Finally, when policymakers care more about the future, their policies are less activist. They respond less strongly to changing political objectives. This reduces uncertainty and increases credibility. A low degree of time preference on the part of policymakers is conducive to higher credibility.

9.8 The Confusion between Persistent Changes in Objectives and Transitory Control Errors

In equilibrium the public optimally utilizes the information at its disposition to forecast the rate of inflation for the period of the contract. But, as

we saw, a residual margin of uncertainty remains. This uncertainty is due to several elements. First, at contracting time the public is ignorant about the realizations of the innovation to governmental objectives and of the control error during the period of the contract. This is simply uncertainty about the future. In addition the public does not know last period's innovation to governmental objectives which partly persists into the current one. It does observe last period's inflation which is a noisy indicator of this innovation. But a given value of m_{i-1} may be due to many different combinations of the persistent innovation v_{i-1} and of the transitory control error ψ_{i-1} . Although the information about v_{i-1} is filtered optimally, a residual level of uncertainty about it remains. The public normally confuses between transitory control errors and persistent changes in the objectives of policymakers. We will refer to this confusion as the "persistent-transitory confusion."²³ The filtering of v_{i-1} from m_{i-1} is based on the relative sizes of the average variabilities of v_{i-1} and of ψ_{i-1} . Hence, when only or mainly v_{i-1} is responsible for an increase in m_{i-1} , the public underpredicts it.

This underprediction enables government to utilize its information advantage in order to stimulate output. Similarly positive values of v_i are underpredicted. This too enables government to stimulate output. Since the marginal costs of inflation are increasing, government finds it optimal to spread the stimulus to employment made possible by its information advantage over more than one period. By doing so, government avoids the necessity to inflate at an excessive rate in any given period. This mechanism is responsible for the fact (discussed in section 9.6) that the discretionary rate of inflation is lower in the presence of asymmetric information.

Since we have assumed that p_{i-2} is already known in period i , the persistent-transitory confusion lasts only one period. More generally, when p_{i-2} is not revealed in period i , this confusion lasts longer and may take a long time to be completely resolved. A more general model in which this is the case is presented in chapter 10.

9.9 The Distribution of Monetary Growth under Asymmetric Information

We will characterize the distribution of money growth by the mean and the variance of m_i . From equation (9.22) mean inflation is

$$Em_i = B_0 A = \alpha [1 - \rho \beta \theta] A, \quad (9.29)$$

and the variance of inflation is given by equation (9.25). The following proposition summarizes the effects of various parameters on the mean and on the variance of monetary inflation:

PROPOSITION 9.4

1. Mean inflation is lower the larger σ_v^2 and β and the lower σ_ψ^2 .
2. The variance of inflation is lower the larger β and the lower σ_v^2 , σ_ψ^2 , and α .

Proof See appendix E to this chapter. \square

An intriguing implication of proposition 9.4 is that cross-country variability in the discount factor β and in the imprecision σ_ψ^2 of monetary control combine to produce a positive cross-sectional relationship between the mean and the variance of monetary inflation. A large body of empirical evidence (Okun 1971; Logue and Willet 1976; Jaffe and Kleiman 1977) suggests that the mean level and the variability of inflation are positively related across countries.²⁴

Note that when σ_ψ^2 tends to zero (so that the signal-to-noise ratio tends to one) and β and ρ tend to one, mean monetary inflation tends to zero even under discretion. With sufficient persistence, enough concern about the future, and sufficient quick learning by the public the excessive rate of inflation that arose under perfect information (chapter 3), disappears. When $\sigma_\psi^2 \rightarrow 0$ and $\theta \rightarrow 1$, the public practically has perfect information about last period's innovation to governmental objectives. In view of the fact that under perfect information there is an inflationary bias, it may seem strange that it disappears in this case. The reason for the difference is that in the first case the public knows government's objectives even before it observes last period's monetary expansion. By contrast, in the second case it obtains this information by observing monetary expansion. As a consequence the public expectation is independent of money growth in the first case but dependent on it in the second. This dependence is what deters policymakers from inflating for appropriate values of the parameters.

9.10 Concluding Remarks

Some of the recent literature has interpreted discretion as a situation in which policymakers always pick their one-shot preferred policy without

any concern for the future. The discussion of this chapter suggests that this is a narrow view of discretion. The presence of asymmetric information makes policymakers sensitive to the trade-offs between current and future objectives even under discretion. This reduces the inflationary bias of policy under discretion and almost eliminates it completely for some configurations of parameters.

Models of the Lucas (1972, 1973) variety in which money has real effects because of the confusion between aggregate monetary shocks and real relative shocks have been criticized on the ground that this confusion cannot have substantial real effects since figures on the money stock become publicly available fairly quickly. Note that this criticism does not apply to the surprise-generating mechanism of this chapter. Even when they have last period's rate of monetary growth in hand, the public is uncertain about the upcoming rate of inflation because government's objectives change over time. Information about past rates of monetary growth does not resolve the public's confusion between persistent changes in government's objectives and transitory control errors. Because we have assumed that p_{i-2} is perfectly known in period i , this confusion is short-lived. However, when past objectives are not perfectly revealed in a way other than through the observation of past rates of inflation, the confusion may last much longer. The next chapter develops a detailed example of such a case.

Appendix A: Derivation of a Condition for $N^* - N_i \geq 0$ and $x_i \geq 0$ for All i with High Probability

Part a

From (9.2),

$$N^* - N_i = N^* - N_n - \alpha(m_i - E[m_i|I_i]). \quad (9A.1)$$

Subtracting (9.12) from (9.22) and rearranging, we obtain

$$e_i \equiv m_i - E[m_i|I_i] = B[v_i + \rho(1 - \theta)v_{i-1}] + \psi_i - \rho\theta\psi_{i-1}. \quad (9A.2)$$

Substituting (9A.2) into (9A.1) and rearranging, we find that the condition $N^* - N_i \geq 0$ is equivalent to the condition

$$e_i = B[v_i + \rho(1 - \theta)v_{i-1}] + \psi_i - \rho\theta\psi_{i-1} \leq \frac{N^* - N_n}{\alpha} \equiv c. \quad (9A.3)$$

The expression on the left-hand side of (9A.3) is normally distributed. It has a zero expected value and a variance V whose explicit form is given in equation (9.25) in the text. Hence it is possible to use the standard normal distribution to make the probability that condition (9A.3) is violated as small as desired. For instance, when

$$3\sqrt{V} < c, \quad (9A.4)$$

this probability is 0.0013. Using (9.25) and the facts $\rho\theta < 1$, $\rho^2(1 - \theta) < 1$, and $B \leq \alpha$, a sufficient condition for the fulfillment of (9A.4) is

$$\sigma_v^2 + \alpha^2 \sigma_\psi^2 \leq \frac{(N^* - N_n)^2}{18\alpha^2}. \quad (9A.5)$$

This is a joint restriction on the divergence between the desired and the natural levels of employment, the sensitivity of the demand for labor with respect to the real wage (which determines α), and the variances σ_v^2 and σ_ψ^2 .

Part b

To make the probability that the condition $x \geq 0$ is violated no larger than 0.0013, A similarly has to be no smaller than $3\sigma_p^2$. From note 9 this condition is equivalent to

$$\sigma_v^2 \leq (1 - \rho^2) \frac{A^2}{9}. \quad (9A.6)$$

Combining (9A.5) and (9A.6), we obtain

$$\sigma_v^2 \leq \min \left[(1 - \rho^2) \frac{A^2}{9}, \frac{(N^* - N_n)^2}{18\alpha^2} - \frac{\sigma_\psi^2}{\alpha^2} \right]. \quad (9A.7)$$

Appendix B: Demonstration That θ Decreases When σ_ψ^2 Increases

From equation (9.16a) an increase in σ_ψ^2 raises the $F(B)$ curve in figure 9.1 and produces an intersection of $F(B)$ with the 45-degree line at a higher value of B . Hence B increases when σ_ψ^2 goes up. But

$$B = \alpha[1 - \rho^2\beta\theta],$$

which implies that θ decreases. Hence θ is a decreasing function of σ_ψ^2 .

Appendix C: Proof That B and B_0 Decrease in β

First, from figure 9.1 and equation (9.16a) an increase in β lowers the curve $F(B)$ and produces a lower equilibrium value of B . Second, since $B = \alpha[1 - \rho^2\beta\theta]$ and since B decreases when β goes up, $\beta\theta$ must increase when β goes up. It follows from (9.16a) that B_0 decreases too when β goes up.

Appendix D: Proof of Proposition 9.3

The conditional expected value in (9.12a) is the point estimate that minimizes the mean square forecast error of m_i given I_i . This mean square forecast error is given by V in equation (9.25). It follows that given the parameters α , β , ρ , σ_v^2 , and σ_ψ^2 , θ is a minimizer of V . Hence $\partial V/\partial\theta = 0$. Comparison of (9.25) with (9.28) suggests that $V^p = V - \sigma_\psi^2$. Hence θ is a minimizer of V^p as well, and $\partial V^p/\partial\theta = 0$. Let D be a dummy parameter such that $D = \sigma_\psi^2, \sigma_v^2, \alpha, \beta$. Then

$$\frac{dV^p}{dD} = \frac{\partial V^p}{\partial\theta} \frac{d\theta}{dD} + \frac{\partial V^p}{\partial D} = \frac{\partial V^p}{\partial D},$$

since $\partial V^p/\partial\theta = 0$. Hence

$$\frac{dV^p}{d\sigma_\psi^2} = (\rho\theta)^2 > 0,$$

$$\frac{dV^p}{d\sigma_v^2} = \alpha^2[1 - \rho^2\beta\theta]^2[1 + \rho^2(1 - \theta)^2] > 0,$$

$$\frac{dV^p}{d\alpha} = 2\alpha[1 - \rho^2\beta\theta]^2[1 + \rho^2(1 - \theta)^2]\sigma_v^2 > 0,$$

$$\frac{dV^p}{d\beta} = -2(\alpha\rho)^2\theta[1 - \rho^2\beta\theta][1 + \rho^2(1 - \theta)^2]\sigma_v^2 < 0.$$

The signs of the last three expressions are implied by the fact that $\rho^2\beta\theta < 1$. \square

Appendix E: Proof of Proposition 9.4

For part 1, an increase in σ_v^2 lowers the curve $F(B)$ in figure 9.1 and produces a lower value of B , which implies through equation (9.16a) that

θ is higher. A higher θ implies through equation (9.16b) that B_0 is lower. It follows from equation (9.29) that $dEm_i/d\sigma_v^2 < 0$. The result $dEm_i/d\beta < 0$ follows directly from equation (9.29) and the fact, proved in appendix C, that $dB_0/d\beta < 0$.

Finally, from appendix B, $d\theta/d\sigma_\psi^2 < 0$. It follows from equation (9.29) that $dEm_i/d\sigma_\psi^2 > 0$.

For part 2, from (9.25) and the fact that θ is a minimizer of V ,

$$\frac{dV}{d\sigma_\psi^2} = \frac{\partial V}{\partial \theta} \frac{d\theta}{d\sigma_\psi^2} + \frac{\partial V}{\partial \sigma_\psi^2} = 1 + (\rho\theta)^2 > 0.$$

The remaining results can be derived by noting that

$$\frac{dV}{dD} = \frac{dV^p}{dD}, \quad D = \sigma_v^2, \alpha, \beta,$$

and by using the expressions for dV^p/dD in the proof of proposition 9.3. \square

10 An Extended Information Advantage about Central Bank Objectives

10.1 Introduction

For simplicity and focus, the analysis in chapter 9 was conducted under the assumption that any current changes in objectives are revealed to the public with full precision after two periods. But in practice a certain degree of uncertainty about central bank objectives in a given period may remain for a longer time. The relative emphasis on alternative objectives in a given period is not a number that is ultimately published in some statistical bulletin. In some countries the deliberations of monetary policymakers are made public after a certain delay. For example, in the United States the minutes and directive of the Federal Open Market Committee (FOMC) to the New York trading desk are revealed to the public after six weeks. However, as stressed by Meltzer (1990) and others, the directive is usually framed in vague general terms without specific reference to precise rates of monetary growth. As time passes, the public may obtain additional pieces of information that make it possible to make more informed judgments about the policymakers' objectives in that period. But some judgmental process in which currently available information is used to draw inferences about the imperfectly known past (even when it is more distant than two periods away) is normally unavoidable.

This chapter makes an attempt to capture this more realistic information structure by considering a case in which the public never directly obtains information about the past relative emphasis of the central bank on employment and price stability. However, it continuously updates its beliefs about both current and past objectives as new figures about money growth or inflation are published over time. This formulation implies that there always remains, however small, a degree of uncertainty in the public's mind about the central bank objectives in past periods. Besides being more realistic, this formulation is more flexible than that of chapter 9. Depending on the values of the underlying parameters, it can accommodate various speeds of learning by the public about changes in the objectives of policymakers. This added flexibility is important to understand outcomes in periods during which policymakers' objectives undergo large changes that may be characterized as "regime change." During such periods the speed with which the public learns about changes in governmental objectives is an important determinant of the length of a recession following an increased concern for price stability or of the length of an expansion following an increased concern for employment.