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The Design of Monetary Institutions

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THE DESIGN OF MONETARY INSTITUTIONS

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Proefschrift

ter verkrijging van de graad van doctor aan de Katholieke Universiteit Brabant, op gezag van de rector magnificus, prof. dr. L.F.W. de Klerk, in het openbaar te verdedigen ten overstaan van een door het college van decanen aangewezen commissie in de aula van de Universiteit op vrijdag 11 december 1998 om 16.15 uur

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Promotor: Prof. dr. S.C.W. Eijffinger

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1 Introduction

Monetary institutions differ considerably between the main industrial countries. Differences in preferences, labor market characteristics, political stability and the structure of the economy make that different countries have different needs. These different needs are also reflected in the design of monetary institutions or, more specifically, central banks. This book takes a political economy view on monetary policy making. Our starting point is that the central bank and rational agents in the private economy interact strategically. The central bank sets monetary policy (usually the rate of inflation) and the private agents rationally form expectations about the rate of inflation. The monetary policy maker has an information advantage about the state of the economy and in the last part of this book also about its own preferences. Using this simple game-theoretic framework, we analyze the effects of different institutional set-ups on macroeconomic policy outcomes.

In designing monetary institutions, countries have four fundamental questions to answer:

What is the position of the central bank vis-à-vis the government?

What is (are) the ultimate goal(s) of monetary policy?

What is (are) the intermediate target(s) of monetary policy?

What are the instruments of monetary policy?

In this book we will restrict ourselves to the first two questions.

The first question deals with the trade off between central bank independence and central bank accountability. The government, which is accountable to a democratically elected parliament, delegates monetary policy to an independent central bank. It is very important that the independent central bank, in turn, is (directly or indirectly) subject to democratic control and can be made accountable for its actions.

The second question deals with the trade off between price stability (credibility) and economic growth or employment (flexibility) in the short and long run. Most economists would agree that the only feasible objective for monetary policy in the long run is to achieve price stability. However, in the short run monetary policy can very well be used to accommodate stochastic supply shocks in order to stabilize the economy. This trade off between credibility and flexibility was first discussed by Rogoff (1985a) and still plays a central role in the discussion about central bank independence and conservativeness.

The third question deals with the choice of the intermediate target(s). In order to reach the ultimate goal of price stability, central banks can use several intermediate targets. The Deutsche Bundesbank has achieved great success by targeting a monetary aggregate, M3 (see, for instance, Issing, 1994). This approach has yielded several decades with a low and stable rate of inflation in Germany and will also be adopted by the European Central Bank. Other possible intermediate targets are the exchange rate (see Ungerer, 1990) as is done in the Netherlands or an inflation forecast as is done by the Bank of England (see Svensson, 1997b).

Finally, the fourth question deals with the choice of the instruments of the central bank. In order to reach the intermediate targets, central banks can use open market transactions, reserve requirements, official short term interest rates or combinations of these and other instruments (see Boonstra and Eijffinger, 1997).

The answers to these four questions ultimately determine the design of monetary institutions. In this book we will focus on two questions: the position of the central bank vis-à-vis the government and on the ultimate goals of monetary policy. We will address these issues mostly from a *positive* point of view, explaining why monetary institutions differ among countries and describing on which factors these differences depend. However, at some instances we will also take a *normative* approach. In these cases, we look at the optimal design of monetary institutions and give recommendations for improving the design of monetary institutions.

1.1 Structure of the Book

This book systematically investigates two of the four fundamental questions in six chapters. Table 1.1 gives an overview of the structure of the book. The six chapters that follow after the introduction cover five subjects that are related to the two questions that we want to address in this book.

Table 1.1 Structure of the book

	Ch. 2	Ch. 3	Ch. 4	Ch. 5	Ch. 6	Ch. 7
Credibility vs. Flexibility	x	x	x	x	x	x
Independence vs. Conservativeness	-	-	x	-	-	-
Preference Uncertainty	-	-	-	x	x	x
Goal vs. Instrument Independence	-	-	-	-	x	-
Independence vs. Accountability	-	-	-	-	-	x

The credibility vs. flexibility trade off is a key feature in all the models used in this book. This subject returns in all the chapters of the book and is related to the question about the ultimate goal(s) of monetary policy. The next issue, independence vs. conservativeness, is discussed in chapter 4. This issue is related to both the question of the ultimate goal(s) (conservativeness) and the question of the central bank's position vis-à-vis the government (independence). The preference uncertainty topic features in chapters 5, 6 and 7 and is also related to both questions. Uncertain central bank preferences influence the ultimate goal(s) of monetary policy, but are also related to the independence vs. accountability issue as is shown in chapter 7. The goal vs. instrument independence issue deals with the position of the central bank with respect to the government and is investigated in chapter 6. A central bank loses goal independence when it is subject to an inflation target à la Svensson (1997a) or a linear inflation contract, as proposed by Walsh (1995).

Chapter 7 deals with the independence vs. accountability topic and is also related to the question about the position of the central bank with respect to the government.

The first chapter after the introduction, chapter 2, investigates empirically the relationship between various measures of central bank independence on the one hand and macroeconomic performance on the other hand. Using a standard Rogoff (1985a) model we derive propositions on the variance of output, the variance of inflation and the level of inflation. These propositions are tested for nineteen industrial countries. This chapter deals with the fundamental questions about the position of the central bank and the ultimate goal of monetary policy. Does an independent central bank with a clear mandate for achieving price stability actually deliver a low and stable rate of inflation at the cost of a higher variance of output?

Chapter 3 extends the standard Rogoff model and applies it to an open economy. We investigate which factors determine whether a central bank focuses more on price stability or on the accommodation of supply shocks. The weight that the central bank attaches to stabilizing the inflation rate should depend on the country's economic and political characteristics.

The literature on central banking often fails to distinguish between central bank independence on the one hand and central bank conservativeness on the other. In chapter 4 we explicitly make this distinction. Central bank independence is related to the fundamental question of the position of the central bank. An independent central bank can set monetary policy without interference from the government. In the model we introduce central bank independence as the influence that the central bank has in setting monetary policy. Central bank conservativeness is related to the fundamental question of the ultimate goal of monetary policy and appears in the model as the weight that the central bank attaches to inflation stabilization relative to output stabilization.

The last three chapters deal with uncertainty about the central bank's preferences. In these chapters we do not explicitly introduce central bank independence (as was done in chapter 4) because doing this would complicate the discussion without yielding new insights.

Chapter 5 looks at the effect of uncertain central bank preferences on monetary policy and

macro economic outcomes. In particular, we investigate the effects of preference uncertainty on the level of inflation, the variance of inflation and the variance of output growth. In chapter 6 we introduce a linear inflation contract and an inflation target to a model with a central banker with uncertain preferences. In the standard models (without preference uncertainty) these two institutional arrangements turn out to be equivalent. We will show that this equivalence breaks down in the presence of preference uncertainty.
The last chapter, chapter 7 turns to the first fundamental question about the position of the central bank relative to the government. We introduce two features that are related to the accountability of a central bank: transparency and final responsibility. Then we analyze the effects of these two types of accountability on macroeconomic performance.

1.2 Detailed Overview

The success of the Deutsche Bundesbank in keeping the rate of inflation stable at a low level for several decades has caught the eye of both economic theorists and policymakers. Economic theory as developed by Rogoff (1985a), Neumann (1991) and Lohmann (1992) suggests that delegating monetary policy to an independent central bank yields a lower inflation rate. As pointed out by Kydland and Prescott (1977), politicians face a time-inconsistency problem when they try to implement their preferred policies and this leads to inferior policy outcomes. The time-inconsistency problem can be mitigated by delegating monetary policy to an independent central bank that is more conservative than the government in the sense that it cares more about inflation. However, the improved *credibility* that brings the lower rate of inflation comes at the cost of having less *flexibility*. Since the conservative central bank cares more about a low and stable rate of inflation, it will care less about stabilizing output shocks. This credibility/flexibility trade-off follows from the Rogoff (1985a) model. In chapter 2 we derive propositions about the level of inflation, the variability of inflation, the level of economic growth and the variability of economic growth. We confront these theoretical results with the data for twenty industrial countries. We also investigate how sensitive the empirical results are for the measure of

central bank independence and the sample period that is chosen. Therefore, we do a sensitivity analysis with four different measures for central bank independence and for both the whole sample period and two subperiods 1972-1982 and 1983-1992.
There are four important conclusions that follow from this chapter. First, our estimation results show an inverse relationship between central bank independence and the level of inflation that is also found by Alesina (1988, 1989) and Cukierman, Webb and Neyapti (1992). Including openness as an additional explanatory variable as suggested by Romer (1993) doesn't change our results. Secondly, like Alesina and Summers (1993), we find some empirical evidence that the more independent the central bank, the lower the variance of inflation. Thirdly, we do not find empirical support for the implication of the Rogoff (1985a) model that more central bank independence leads to a higher variance of real output growth. Finally, after controlling for other factors that influence economic growth as described by Barro (1991), De Long and Summers (1992) and Levine and Renelt (1992), we find no empirical relationship between central bank independence and the level of real output growth.

Chapter 3 deals with the determinants of central bank independence in an open economy. Empirical work on central bank independence [Alesina (1989), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), De Haan and Sturm (1992), Eijffinger and Schaling (1993a, 1996, 1998), Alesina and Summers (1993) and chapter 2 of this book] has focussed on the quantification of central bank independence and its relationship with macroeconomic outcomes. Broadly speaking, the conclusion is that the more independent the central bank, the lower the inflation rate, whilst the rate of output growth is unaffected.
However, this literature does not explain the observed differences in central bank independence. For instance, no explanation is offered for the high independence of the Bundesbank. It has often been pointed out that this fact may be explained by Germany's underlying aversion to inflation associated with its experience of hyperinflation in the 1920s.[1]

[1] See for instance Issing (1993) and Eijffinger and De Haan (1996).

In this chapter we extend the Rogoff (1985a) model to the open economy case and allow the exchange rate to deviate from purchasing power parity. Using a graphical method, we determine the optimal degree of conservativeness and express the boundaries of the interval containing the optimal degree of conservativeness in terms of the structural parameters of the model.

Furthermore, we derive propositions concerning the relation between economic and political factors and the optimal degree of central bank conservativeness. We show that optimal central bank conservativeness is higher, the higher the natural rate of unemployment, the greater the benefits of unanticipated inflation (the slope of the Phillips curve), the less inflation-averse society, the smaller the variance of productivity shocks, the smaller real exchange rate variability and the smaller the openness of the economy. These propositions are tested for nineteen industrial countries. We employ a *latent variables* approach (LISREL) in order to distinguish between actual and optimal monetary regimes.

Chapter 4 makes an explicit distinction between central bank independence and central bank conservativeness. Central bank independence is the extent to which the central bank can set monetary policy without interference of the government. Central bank conservativeness, on the other hand, is the central bank's preference for inflation stabilization relative to employment (or output) stabilization. It turns out that the product of independence and conservativeness (sometimes called *effective central bank independence*) is what really matters in monetary policy making.

In this chapter we try to explain the optimal degree of central bank *independence and conservativeness* by four economic and political determinants (the natural rate of unemployment, society's preferences for unemployment stabilization relative to inflation stabilization, the variance of productivity shocks and the benefits of unanticipated inflation) both theoretically and empirically. The empirical results are only given for the (twelve) member states of the European Union.

Chapter 5 investigates society's incentives to design monetary institutions that allow for central bank secrecy. We find that the main reason for central bank secrecy is its potentially beneficial effect on stabilization policy. Contrary to Cukierman and Meltzer (1986), we obtain this result even with a zero degree of persistence in the central bank's objectives. Unlike Lewis (1991), this result does not require the social planner's future preferences for policy objectives to change over time with changing economic circumstances.

More specifically, optimal central bank secrecy involves trading-off the harmful effects of uncertainty about monetary policy and the associated higher expected inflation, versus the potentially beneficial effects on the stabilization of output. The latter trade-off depends on the severity of society's time-consistency problem vis-à-vis its need for stabilization policy. The analysis predicts that if the credibility problem is large relative to the need for flexibility, optimal central bank institutions will be very open and transparent and vice versa. This reverses an earlier result by Garfinkel and Oh (1995).

Moreover it explains why high credibility institutions such as the Bundesbank and the future European Central Bank (ECB), *can afford* to be relatively closed, and why low credibility institutions such as the Reserve Bank of New Zealand and Banco d'España *need to* be very open and need to publish *e.g.* inflation and monetary policy reports of some kind, in addition to standard bank bulletins.

In chapter 6 we look at a conservative central banker with preference uncertainty in combination with a linear Walsh inflation performance contract and/or a Svensson inflation target. Walsh (1995) has shown that an optimal linear inflation contract can eliminate the inflationary bias without distorting stabilization policy. Thus the credibility-flexibility trade-off is eliminated and makes inflation targeting superior to Rogoff's conservative central banker. Moreover, Svensson (1997a) has shown that the linear contract can be mapped into an optimal *inflation target*. This means that these delegation arrangements are *equivalent*. They are both able to produce the pre-commitment outcome.

However, both Walsh (1995) and Svensson (1997a) on the one hand and Rogoff (1985a) on the other assume *symmetric information* in the principal-agent relationship. More specific, they assume that both the political principal and the private sector know the central banker's preferences.

Herrendorf and Lockwood (1997) and - most recently - Beetsma and Jensen (1997) abandoned this assumption. Herrendorf and Lockwood (1997) demonstrated that if a monopolistic trade union has more information about productivity shocks than the principal, maximum social welfare can be achieved by having a conservative central banker with perverse preferences *on top* of the contract.

Beetsma and Jensen (1997), building on earlier work on preference uncertainty by Briault, Haldane and King (1996) and Nolan and Schaling (1996), find that the equivalence between the linear Walsh contract and the Svensson inflation target breaks down if the private sector and the political principal have imperfect information about the central banker's preferences. They show that the optimal linear inflation contract performs strictly better than the optimal inflation target when there is uncertainty about the central banker's preferences.

However, in their model there is no effect from preference uncertainty on the private sector's inflation expectations. In this chapter we investigate the effects of relaxing this restriction. Using a model that is otherwise similar to theirs, we find results that are very different - and sometimes exactly the opposite - of the Beetsma and Jensen (1997) model. Contrary to Beetsma and Jensen (1997), we find that it is optimal for the government to impose an inflation target on the central bank that depends on the degree of uncertainty about its preferences. Furthermore, for the case of the Walsh contract we find that it is optimal to offer a linear inflation contract to a central banker that does *not* depend on the degree of uncertainty about its preferences. Here our result is the same as in Walsh (1995) for the case *without* preference uncertainty. Again, this is in contrast to Beetsma and Jensen (1997), who find that the optimal linear contract *does* depend on the degree of preference uncertainty.

Finally, we find that in case of uncertain central banker preferences the *optimal* delegation arrangement is a combination of a linear inflation contract and a *quadratic contract*. Here the quadratic contract is equivalent to a Rogoff (1985a) conservative central banker. Again, this is different from Beetsma and Jensen (1997), who find that a combination of a linear inflation contract, an *inflation target* and a quadratic contract performs best.

Moreover, our result is in line with Herrendorf and Lockwood (1997), and hence suggests that their 'restoration' of Rogoff appears to be a very robust result indeed.

In chapter 7 we present a theoretical model of central bank accountability. As Stiglitz (1998) notes "Monetary policy is a key determinant of economic performance... [and that] ...this key determinant of what happens to society – this key collective action – should be so removed from control of democratically elected officials should at least raise questions." Central banks must be accountable to democratically elected institutions. De Haan, Amtenbrink and Eijffinger (1998) distinguish three features of central bank accountability: the *ultimate objectives* of monetary policy, *transparency* of actual monetary policy and the *final responsibility* for monetary policy.

In this chapter we focus on *transparency* of actual monetary policy and on the *final responsibility* for monetary policy. The third feature of accountability, setting the ultimate objectives of monetary policy, is related to the question of *goal independence* of a central bank and is not discussed here. Our model builds on earlier work by Lohmann (1992) and Nolan and Schaling (1996). The government delegates monetary policy to a conservative central banker. However, the government and society don't know exactly the central banker's preferences for inflation stabilization relative to output stabilization. The extent to which the central bank has private information about its preferences is determined by the transparency of monetary policy. After the central bank has proposed its preferred rate of inflation, the government can decide to override the central bank at a fixed cost. In this set up, the central bank is partially independent. The cost of overriding is related to the question of who has final responsibility for monetary policy. If this cost is prohibitive, final responsibility lies with the central bank. If, on the other hand, this cost is negligible, final responsibility rests with the government.

In this chapter we discuss the implications of these two types of accountability for macroeconomic outcomes. In particular, we look at the effects on the level of inflation and the stabilization of supply shocks.

We show that more transparency leads, in expectation, to a lower rate of inflation and less stabilization of supply shocks. A low cost of overriding leads to a higher rate of inflation and more stabilization of supply shocks.

2 Central Bank Independence: A Sensitivity Analysis

2.1 Introduction

In both economic research and policy making, the issue of central bank independence has been widely investigated and discussed during the last decade. To a large extent, this interest is motivated by the success of the Deutsche Bundesbank in keeping the rate of inflation stable at a low level for several decades. Economic theory as developed by Rogoff (1985a), Neumann (1991) and Lohmann (1992) suggests that countries having an independent central bank can achieve low inflation rates because politicians cannot so easily influence monetary policy. This is good because politicians face a time-inconsistency problem when they try to implement their preferred policies and this leads to inferior outcomes. The time-inconsistency problem can be mitigated by delegating monetary policy to an independent central bank that is more conservative than the government in the sense that it cares more about inflation. However, the improved *credibility* that brings the lower rate of inflation comes at the cost of having less *flexibility*. Since the conservative central bank cares more about a low and stable rate of inflation, it will care less about stabilizing output shocks. In this chapter we want to confront these theoretical results with the data for twenty industrial countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States) for the post-Bretton Woods period (1972-1992). We also want to investigate how sensitive the empirical results are for the measure of central bank independence and the sample period that is chosen. Therefore, we do our regressions with four different measures for central bank independence and for both the whole sample period and two subperiods (1972-1982) and (1983-1992).

There are four important conclusions that follow from our chapter. First, our estimation results show an inverse relationship between central bank independence and the level of inflation that is also found by Alesina (1988, 1989) and Cukierman, Webb and Neyapti (1992). Including openness as an additional explanatory variable as suggested by Romer (1993) doesn't change our results. Secondly, like Alesina and Summers (1993), we find some empirical evidence that the more independent the central bank, the lower the variance of inflation. Thirdly, we do not find empirical support for the implication of the Rogoff (1985a) model that more central bank independence leads to a higher variance of real output growth. Finally, after controlling for other factors that influence economic growth as described by Barro (1991), De Long and Summers (1992) and Levine and Renelt (1992), we find no empirical relationship between central bank independence and the level of real output growth.

The plan of this chapter is as follows. In section 2, building on the Rogoff (1985a) model we briefly analyze the theoretical relationships of central bank independence with the distributions of output and inflation. In section 3 we confront the propositions from the game-theoretic model with empirical evidence. We perform a sensitivity analysis that consists of using various indices of central bank independence, looking at two subperiods and adding control variables. Finally, section 4 concludes.

2.2 Credibility vs. Flexibility

2.2.1 Recapitulation of the Monetary Policy Game

This section offers a short sketch of the theoretical background for the empirical work. It links the Rogoff model to the empirical work on indices of central bank independence (henceforth CBI).

There are two players, wage-setters and the central bank. Wage-setters unilaterally choose the nominal wage every period, and the central bank controls monetary policy. The labor market is characterized by one-period nominal wage contracts [Gray (1976), Fischer (1977a)]. Therefore, output rises with unanticipated inflation. The behavior of wage-setters is captured by a standard Phillips curve and can be derived from a Cobb-Douglas production function and a competitive labor market (Schaling, 1995).

$$y_t = \frac{1}{1-\beta}(\pi_t - E_{t-1}\pi_t + v_t) \qquad 0 < \beta < 1 \qquad \textbf{(2.1)}$$

where y is output, $(1 - \beta)^{-1}$ are the output gains of unanticipated inflation (the slope of the Phillips curve), π is the rate of inflation and v_t is an aggregate supply shock with mean zero and finite variance σ_v^2. The natural level of expected output is normalized at zero.

The social loss function S penalizes both inflation and deviations from output target $y^* > 0$.

$$S_t = \frac{1}{2}(\pi_t)^2 + \frac{\chi}{2}(y_t - y^*)^2 \qquad 0 < \chi < \infty \qquad \textbf{(2.2)}$$

The parameter χ is the relative weight of output stabilization relative to inflation stabilization in the preferences of society. It is well-known that the minimization of **(2.2)** subject to the Phillips curve **(2.1)** results in a counterproductive inflation bias [Kydland and Prescott (1977) and Barro and Gordon (1983)] with no gains in the form of systematic higher output.

2.2.2 The Legislative Approach

In this chapter we consider the *legislative* approach to monetary stability, namely to create by law a very independent central bank with an unequivocal mandate to focus on price stability. Academic contributions in this area are Rogoff (1985a) and Lohmann (1992).

Rogoff proofs that society (the principal) can reduce the time-consistent inflation rate, at the expense of a less flexible response to output shocks, by delegating monetary policy to an agent who is known to place a greater weight on inflation stabilization than is embodied in the social loss function **(2.2)**.

This agent minimizes

$$L_t = \frac{1+\varepsilon}{2}(\pi_t)^2 + \frac{\chi}{2}(y_t - y^*)^2 \qquad 0 < \varepsilon < \infty \qquad \textbf{(2.3)}$$

When ε is strictly greater than zero, then this agent is more "conservative" than society.

In the empirical part of this chapter several measures (indices) of central bank independence are used. According to these indices, central banks in which the only or main objective of monetary policy (as specified in the central bank law) is price stability are classified as being more independent than central bank laws with a number of objectives in addition to price stability, or central banks in whose law price stability is not mentioned as an objective at all.

Therefore, following most of the literature we proxy CBI as the strength of the "conservative bias" of the central bank as embodied in the law.[1]

[1] Chapter 4 explicitly distinguishes between conservativeness and independence. De Haan and Kooi (1997) decompose two indices of central bank independence into a conservativeness part and various aspects of independence.

2.2.3 Implications of the Credibility vs. Flexibility Model

The algorithm for deriving the time-consistent equilibrium under central bank independence (equation **(2.3)**) is standard. The resulting output and inflation rates are given by

$$y_t = \frac{(1-\beta)(1+\varepsilon)}{(1-\beta)^2(1+\varepsilon)+\chi} v_t \qquad \textbf{(2.4)}$$

$$\pi_t = \frac{\chi}{(1-\beta)(1+\varepsilon)} y^* - \frac{\chi}{(1-\beta)^2(1+\varepsilon)+\chi} v_t \qquad \textbf{(2.5)}$$

From **(2.4)** and **(2.5)** we can easily derive the expressions for the variance of output and inflation

$$\text{Var(y)} = \left(\frac{(1-\beta)(1+\varepsilon)}{(1-\beta)^2(1+\varepsilon)+\chi} \right)^2 \sigma_v^2 \qquad \textbf{(2.6)}$$

$$\text{Var}(\pi) = \left(\frac{\chi}{(1-\beta)^2(1+\varepsilon)+\chi} \right)^2 \sigma_v^2 \qquad \textbf{(2.7)}$$

Following Cukierman (1992, pp. 353-355) in this section we investigate the effects of CBI on the implied distributions of output and inflation. As is suggested by the main intuition of the Rogoff model (see **(2.6)** and **(2.7)**), there is an *inverse* relation between CBI (ε) and the mean and variance of the inflation rate and a *positive* relation between CBI and the variance of output. The reason is simple, increasing the central bank's commitment to fighting inflation reduces society's *credibility* problem (and hence the mean and variance of inflation) at the expense of a distorted response to output shocks, - i.e. *flexibility* - increasing the variance of output. Finally, the mean output level is unaffected by CBI, as is to be expected in a natural rate model.[2]

We now move on to confront the implications of the credibility vs. flexibility model with some empirical evidence.

2.3 Empirical Evidence on Central Bank Independence

This section takes a hard look into the empirical evidence regarding the link between central bank independence and the level and variability of inflation and economic growth, respectively. Unfortunately, most existing research has focused on one measure of central bank independence only, so that it is not clear whether conclusions drawn are 'measure specific'. To overcome this difficulty, we use the measures of Alesina (1988, 1989), Grilli, Masciandaro and Tabellini (1991), Eijffinger and Schaling (1992, 1993a) and Cukierman (1992) as explanatory variables. We compare the outcomes of our empirical analysis on the relationship between central bank independence and the level and variability of inflation and economic growth with results reported in the literature.

2.3.1 The Level of Inflation

According to Alesina (1988, 1989), countries with an independent central bank will have lower rates of inflation than do countries with a dependent central bank. This well-known inverse relationship between central bank independence and the level of inflation is also

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2 Formally this can be shown by taking the first derivative of both moments of output and inflation with respect to ε.

supported by empirical studies of De Haan and Sturm (1992), Alesina and Summers (1993) and Eijffinger and Schaling (1993b). It should, however, be noted that a negative correlation between central bank independence and inflation does not necessarily imply causation. The correlation between both variables could be explained by a third factor, e.g. the culture and tradition of monetary stability in a country, explaining both an independent central bank and low inflation.[3]

Still, the degree of central bank independence may be an important factor in explaining the level of inflation, because central bank independence reflects the ability and willingness to conduct an autonomous monetary policy directed at price stability. If not seriously hampered by wage increases, budget deficits and government debt, such policy will eventually lead to a low and sustainable level of inflation. The ultimate determinants of central bank independence are discussed more extensively in Eijffinger and De Haan (1996).

Using OLS regressions we investigate the link between the average level of inflation (annual percentage change of the Consumer Price Index) and the degree of central bank independence according to the measures of Alesina (AL), Grilli, Masciandaro and Tabellini (GMT), Eijffinger and Schaling (ES) and Cukierman (LVAU). The countries considered are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The relationship between average inflation in these countries and the four indices of central bank independence is analyzed for the post-Bretton-Woods period 1972-1992. Under the Bretton-Woods system of fixed exchange rates, countries were committed to an exchange rate target and had little room to conduct an autonomous domestic monetary policy. Thus, the relationship between central bank independence and inflation is likely to be much less straightforward before 1972. Regression analysis by De Haan and Sturm (1992) supports this view. These authors found no significant relationship between both variables for the period 1961-1969.

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[3] The standard example is the case of Germany, where the hyperinflation in the 1920s led to a culture and tradition of monetary stability.

In our analysis the post-Bretton-Woods period is divided into two subperiods (1972-1982 and 1983-1992) in order to distinguish between EMS countries (Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands and, partly, Austria, Portugal, Spain and the United Kingdom) on the one hand and non-EMS countries (Australia, Canada, Finland, Japan, New Zealand, Norway, Sweden, Switzerland and the United States) on the other. Although the Exchange Rate Mechanism of the EMS (ERM) was enacted in March 1979 after the 'snake arrangement', Ungerer (1990) characterizes the first phase of the EMS (1979-1982) as a period of 'initial orientation' full of frequent and, sometimes, large realignments of central rates. From 1982 onwards, the EMS enters a second phase of 'consolidation' (1982-1987), and - after the accord of Basle-Nyborg - moves into a third phase of 're-examination' (1987-present).[4] Consequently, the negative correlation between central bank independence and inflation is expected to be less clear cut during the second subperiod (1983-1992) than during the first subperiod (1972-1982), because of the priority EMS countries gave at that time to exchange rate stability. After 1982 monetary policy in these countries - except Germany as the anchor country - has become increasingly endogenous because exchange rate targets became dominant.

Table 2.1 shows our estimation results for average inflation and the four measures of central bank independence during the whole period (1972-1992) and both subperiods (1972-1982 and 1983-1992). Following Romer (1993) we have also included the variable "openness" as measured by the percentage share of imports in GDP in the regression equation as an explanatory variable for the level of inflation. During the post-Bretton-Woods period and both subperiods, the inverse relationship between inflation and central bank independence appears to be significant for all measures. It should also be noted that including the variable openness doesn't change the results much, indicating that the estimated coefficients are robust.

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4 According to Ungerer (1990) the phase of consolidation was marked by "...a widespread consensus to follow stability-oriented policies, an increasing convergence in the development of costs, prices and monetary aggregates, and by long periods without realignments of central rates." (p. 338).

The conclusion that follows from table 2.1 is that the more independent a central bank is, the lower the rate of inflation in the long run will be. The table also confirms our intuition that the inflation reducing effect of a one-unit increase in an index of CBI is larger in the first subperiod than in the second. This holds for all four indices of CBI.
Cukierman has elaborated his legal independence index (LVAU) for 68 countries - i.e. 21 developed industrial countries and 47 developing countries. Cukierman found no significant link between central bank independence and inflation for the group of developing countries. In his opinion, this is a consequence of the fact that these countries have "less regard for the law."[5]
Because the four indices of CBI that we used in our analysis are all defined on a different scale, the size of the parameters is difficult to interpret. Therefore, we also calculated the elasticities of inflation with respect to the different measures of CBI. We did this by estimating a regression equation in which the log of inflation is explained by the log of CBI and a constant. The results are presented in table 2.2.

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5 This is only valid for the legal measure of Cukierman for central bank independence. If the 'turnover rate' of central bank governors is used as a measure of actual independence, Cukierman (1992) finds a significant negative relationship for developing countries.

Table 2.1 Average Inflation and the Measures of CBI

Explanatory variables	1972-1992		1972-1982		1983-1992	
Constant	12.40	14.10	16.05	18.40	8.38	9.33
	(12.74)	(12.51)	(12.58)	(12.27)	(9.51)	(8.61)
Alesina (AL)	-2.24	-2.27	-2.78	-2.82	-1.65	-1.66
	(-5.33)**	(-6.14)**	(-5.04)**	(-5.84)**	(-4.34)**	(-4.50)**
Openness		-5.75		-8.01		-3.23
		(-2.23)*		(-2.35)*		(-1.43)
R^2 (adjusted)	0.63	0.72	0.60	0.70	0.52	0.56
Constant	15.27	15.85	19.46	20.03	7.85	8.89
	(9.53)	(7.46)	(11.05)	(8.42)	(7.41)	(6.79)
Grilli et al. (GMT)	-0.92	-0.93	-1.11	-1.12	-0.42	-0.43
	(-4.81)**	(-4.69)**	(-5.30)**	(-5.16)**	(-3.28)**	(-3.43)**
Openness		-1.74		-1.77		-3.01
		(-0.43)		(-0.38)		(-1.30)
R^2 (adjusted)	0.58	0.56	0.63	0.61	0.38	0.41
Constant	12.27	11.88	15.53	15.35	7.56	7.67
	(7.47)	(5.75)	(8.43)	(6.53)	(8.60)	(7.12)
Eijffinger-Schaling (ES)	-1.60	-1.65	-1.90	-1.93	-1.03	-1.01
	(-2.85)*	(-2.75)*	(-3.03)**	(-2.84)*	(-3.42)**	(-3.14)**
Openness		1.78		0.84		-0.53
		(0.32)		(0.13)		(-0.19)
R^2 (adjusted)	0.28	0.24	0.31	0.27	0.37	0.34
Constant	10.74	11.49	14.28	14.95	6.84	7.61
	(9.06)	(7.19)	(8.43)	(6.84)	(7.14)	(6.16)
Cukierman (LVAU)	-8.83	-8.78	-11.50	-11.50	-5.89	-5.79
	(-2.92)**	(-2.86)*	(-2.87)*	(-2.80)*	(-2.41)*	(2.36)*
Openness		-2.52		-2.25		-2.58
		(-0.72)		(-0.46)		(-0.99)
R^2 (adjusted)	0.29	0.27	0.29	0.25	0.21	0.21

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level, two asterisks indicate that the coefficient is significant at a 99% confidence level.

Table 2.2 Elasticity of Inflation with Respect to the Measures of CBI

Explanatory variables	1972-1992	1972-1982	1983-1992
Constant	2.44	2.70	2.04
	(25.58)	(28.34)	(12.80)
Alesina (AL)	-0.68	-0.63	-0.82
	(-5.67)**	(-5.29)**	(-4.08)**
R^2 (adjusted)	0.66	0.63	0.49
Constant	3.54	3.73	2.66
	(11.83)	(13.11)	(6.02)
Grilli et al. (GMT)	-0.78	-0.73	-0.62
	(-5.26)**	(-5.15)**	(-2.85)*
R^2 (adjusted)	0.62	0.61	0.31
Constant	2.42	2.66	1.98
	(15.35)	(18.17)	(11.02)
Eijffinger-Schaling (ES)	-0.48	-0.44	-0.57
	(-3.06)**	(-2.99)**	(-3.17)**
R^2 (adjusted)	0.32	0.31	0.34
Constant	1.54	1.84	1.07
	(8.11)	(9.95)	(4.00)
Cukierman (LVAU)	-0.38	-0.38	-0.35
	(-2.42)*	(-2.51)*	(-1.58)
R^2 (adjusted)	0.21	0.23	0.08

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level, two asterisks indicate that the coefficient is significant at a 99% confidence level.

From table 2.2 we conclude that for the whole sample period and for the first subperiod a one- percent increase in CBI as measured by the GMT index yields the highest reduction in the rate of inflation. For the second subperiod, the elasticity of inflation with respect to the Alesina index is the highest. Interestingly, a comparison between the first and the second subperiod doesn't give a clear-cut result in table 2.2, as it did in table 2.1. The elasticity of inflation with respect to CBI $\left(\frac{\partial \pi}{\partial CBI} \cdot \frac{CBI}{\pi}\right)$ is more or less constant over the subperiods, whereas the marginal effects of CBI on inflation are lower in the second subperiod. The reason for this difference lies in the fact that inflation in the second subperiod (on average, for the whole sample 4.8%) was much lower than in the first one (10.7%). The decline for the low CBI - high inflation countries was larger than for the high CBI - low inflation countries which explains the lower marginal effect in the second subperiod. Inflation has decreased substantially and CBI hasn't changed. So the factor $\left(\frac{CBI}{\pi}\right)$ makes that the elasticity is constant over the subperiods.

Finally, it is interesting to note that Debelle and Fischer (1995) have shown that if the GMT measure is split into various components (lack of goal independence, political independence and economic independence) the two variables that most closely tied to inflation performance are lack of goal independence (i.e. the bank has a statutory requirement to pursue price stability) and economic independence (i.e. instrument independence); the variables relating to appointment procedures are not significantly related to inflation.

2.3.2 The Variability of Inflation

What is the empirical relationship between central bank independence and the *variability of inflation*? Chowdhury (1991) has investigated the relation between the level and variability of inflation in 66 countries for the period from 1955 to 1985. He concludes that during this period there exists a significant, positive correlation between both variables. De Haan and Sturm (1992) have also examined this relation in eighteen industrial countries for the period

1961-1987. They found a clear, positive correlation between both variables for the post-Bretton-Woods subperiods 1970-1978 and 1979-1987, but no for the subperiod 1961-1969. We expect that greater independence should lead to less variability of inflation. We assume the various measures of central bank independence (AL, GMT, ES and LVAU) to be the explanatory variables of the variance of inflation (CPI) for the sample. Again, the relationship between the four indices and the variance of inflation is examined for the complete post-Bretton-Woods period (1972-1992) and our two subperiods (1972-1982 and 1983-1992). During the second subperiod, the negative correlation between central bank independence and inflation variability is also expected to be less clear cut than during the first subperiod as a consequence of growing exchange rate stability between EMS countries. Table 2.3 shows the results for the variance of inflation and the four measures of central bank independence using data from the sample. The inverse relationship between inflation variability and independence is significant for the index of Grilli et al. (all periods), for the Cukierman index (whole period and first subperiod) and for the Alesina index (second subperiod). For the other indices and periods, we find a negative but insignificant relation for both the whole period, and its two subperiods. From this table, it may be concluded that there is some evidence that greater independence of a central bank guarantees a more stable inflation.[6] Hence there is some empirical evidence that the more independent the central bank, the lower the variance of the inflation rate.

6 De Haan and Sturm (1992) find a significant negative relationship for the modified measure of Grilli et al. and for the Alesina and ES indices during the period 1961-1987. Alesina and Summers (1993) report similar results for an average of the Alesina and GMT index.

Table 2.3 Variance of Inflation and the Measures of CBI

Explanatory variables	1972-1992	1972-1982	1983-1992
Constant	25.34	11.85	12.02
	(4.61)	(2.23)	(4.06)
Alesina (AL)	-4.61	-0.72	-3.31
	(-2.02)	(-0.31)	(-2.59)*
R^2 (adjusted)	0.16	-0.06	0.26
Constant	45.51	30.93	25.25
	(8.15)	(5.77)	(4.28)
Grilli et al. (GMT)	-3.40	-2.35	-2.31
	(-5.09)**	(-3.41)**	(-3.27)**
R^2 (adjusted)	0.61	0.40	0.38
Constant	26.38	17.70	11.59
	(4.13)	(2.99)	(1.93)
Eijffinger-Schaling (ES)	-3.63	-2.31	-1.79
	(-1.66)	(-1.15)	(-0.87)
R^2 (adjusted)	0.09	0.02	-0.01
Constant	27.04	18.60	8.60
	(5.09)	(4.59)	(3.08)
Cukierman (LVAU)	-30.41	-23.10	-10.60
	(-2.24)*	(-2.24)*	(-1.49)
R^2 (adjusted)	0.18	0.18	0.06

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level, two asterisks indicate that the coefficient is significant at a 99% confidence level.

We have also calculated, for each measure of CBI, how much of the strong positive association between the mean and the variance of inflation is due to their common association with CBI. This analysis is performed along the lines of Cukierman (1992) and Cukierman and Webb (1995). We predicted the mean and the variance of inflation, using only CBI as an explanatory variable. The ratio between the covariance of the predictions and the covariance of the actual mean and variance of inflation are a measure for the extent to which the positive association between variance and mean can be attributed to CBI. We find the following ratios as presented in table 2.4.[7] Cukierman (1992) reports a value of 0.19 for developed countries for the period 1950-1989. This comes close to our value of 0.21 for the LVAU index for our sample period. The most striking result that we find in table 2.4 is that between 86 and 100% of the positive covariance between the mean and the variance of inflation can be explained by cross country variations of the GMT index.

Table 2.4 CBI and the Association between Mean and Variance of Inflation

Index	1972-1992	1972-1982	1983-1992
AL	0.24	0.06	0.50
GMT	0.86	0.89	1.02
ES	0.25	0.23	0.30
LVAU	0.21	0.26	0.19

Note: The figures in the table represent the fraction of the covariance between the mean and the variance of inflation that is due to their common association with the index of CBI for the different periods.

7 The fact that for the GMT index the ratio is larger than one must be due to negative correlation between the residuals of the two regressions.

2.3.3 Economic Growth

Central bank independence may stimulate economic growth in the longer run because with a low and stable rate of inflation the functioning of the price mechanism will be better. Empirical research by Grimes (1991) and Fischer (1993) shows that inflation reduces economic growth.[8] This may be explained by the positive correlation between the level and variability of inflation. Greater variation in the rate of inflation can imply increasing uncertainty about inflation and may, thereby, lead to lower economic growth. This relationship between inflation variability and economic growth is, however, not supported by most studies.

Various studies have examined directly whether central bank independence affects economic growth. Grilli, Masciandaro and Tabellini (1991), De Haan and Sturm (1992), Eijffinger and Schaling (1993b) and Alesina and Summers (1993) all conclude that central bank independence has no effect on economic growth.

This conclusion is supported by results reported in table 2.5 which presents estimates for the average annual growth rate of per capita real Gross Domestic Product, and the four measures of central bank independence. The literature on long-run economic growth identifies various factors that determine the growth rate of a country. Based on Barro (1991), De Long and Summers (1992) and Levine and Renelt (1992) we have chosen two additional variables to be included in the regression: Initial GDP per capita (Y60) and the share of investment in GDP (I/Y). The relationship between real economic growth and central bank independence appears to be insignificant except for the GMT index during the second subperiod (1983-1992) where central bank independence has a positive effect on growth. The coefficients for the other indices and periods have mixed signs and are insignificant. In general, empirical evidence shows that there is no relationship between

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8 This conclusion of Grimes (1991) and Fischer (1993) is contradicted in a study by Karras (1993).

central bank independence and average real output growth.[9] We also note that a one-unit increase in an index for CBI leads to more expected output growth in the second subperiod than in the first one.

2.3.4 The Variability of Output Growth

Another question is whether there exists a relationship between central bank independence and the *variation of economic growth*. Theory predicts different outcomes. According to Rogoff (1985a), independent central banks purchase a lower level of inflation at the price of a higher variability of real economic growth. In contrast, Alesina and Summers (1993) argue that an autonomous central bank will be less inclined to conduct a 'stop-go' policy which may limit fluctuations in economic growth. Alesina and Gatti (1995) formalize this point.

Table 2.6 shows the results of our regression analysis where the four measures of central bank independence try to explain the variance of annual economic growth rates. For none of the four measures, the coefficient appears to be significantly different from zero. On top of that, we also find most coefficients to be negative, indicating that more central bank independence is associated with lower variance of output growth. Consequently, we may conclude that a higher degree of central bank independence is not associated with greater variation of real economic growth rates. Alesina and Gatti (1995) provide a possible theoretical explanation for this empirical finding. They suggest that variance of output growth consists of two components. Apart from productivity shocks that are also present in Rogoff (1985a), Alesina and Gatti (1995) have politically induced output shocks in their

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9 Cukierman (1993, p. 284) reports that when similar experiments are repeated for LDCs, again, no association is found between *legal* independence and growth. Using several behavioral measures of central bank independence, like the turnover rate of central bank governors, and controlling for other determinants of growth Cukierman, Kalaitzidakis, Summers and Webb (1993) find a *ceteris paribus* positive association between growth and central bank independence.

model. They show that the effect of these shocks can be reduced by making the central bank more independent. So there are two opposite effects, which may explain these empirical findings. Comparing the two subperiods shows us that an increase in CBI leads to a larger expected reduction of the variance of output growth in the second subperiod than in the first one.

Table 2.5 Average Economic Growth and the Measures of CBI

Explanatory variables	1972-1992	1972-1982	1983-1992
Constant	3.50	1.73	4.44
	(3.64)	(1.26)	(3.80)
Alesina (AL)	0.20	0.04	0.38
	(1.52)	(0.20)	(2.03)
I/Y	-0.00	0.06	-0.05
	(-0.00)	(1.65)	(-1.24)
Y60	-0.31	-0.25	-0.33
	(-4.62)**	(-2.49)*	(-3.81)**
R^2 (adjusted)	0.62	0.52	0.43
Constant	3.89	3.19	4.40
	(5.85)	(2.78)	(6.18)
Grilli et al. (GMT)	0.07	0.04	0.11
	(2.06)	(0.75)	(2.24)*
I/Y	-0.01	0.01	-0.03
	(-0.34)	(0.34)	(-0.95)
Y60	-0.37	-0.32	-0.41
	(-7.42)**	(-3.99)**	(-6.27)**
R^2 (adjusted)	0.81	0.62	0.72
Constant	3.61	1.81	4.70
	(4.49)	(1.69)	(4.67)
Eijffinger-Schaling (ES)	-0.03	-0.11	0.04
	(-0.33)	(-0.97)	(0.32)
I/Y	0.01	0.07	-0.03
	(0.42)	(2.19)*	(-0.95)
Y60	-0.29	-0.23	-0.32
	(-5.41)**	(-3.14)**	(-4.13)**
R^2 (adjusted)	0.66	0.59	0.46
Constant	3.45	1.95	4.26
	(3.82)	(1.58)	(3.95)
Cukierman (LVAU)	0.26	-0.47	1.17
	(0.36)	(-0.51)	(1.17)
I/Y	0.01	0.06	-0.02
	(0.47)	(1.85)	(-0.70)
Y60	-0.30	-0.24	-0.33
	(-4.65)**	(-2.70)*	(-3.86)**
R^2 (adjusted)	0.62	0.57	0.41

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level, two asterisks indicate that the coefficient is significant at a 99% confidence level.

Table 2.6 Variance of Economic Growth and the Measures of CBI

Explanatory variables	1972-1992	1972-1982	1983-1992
Constant	7.95	7.96	7.33
	(3.59)	(4.06)	(2.25)
Alesina (AL)	-0.65	-0.14	-1.11
	(-0.68)	(-0.17)	(-0.79)
R^2 (adjusted)	-0.03	-0.06	-0.03
Constant	11.63	12.31	10.48
	(4.36)	(5.12)	(2.98)
Grilli et al. (GMT)	-0.60	-0.50	-0.69
	(-1.88)	(-1.74)	(-1.63)
R^2 (adjusted)	0.14	0.11	0.09
Constant	9.06	8.40	9.30
	(3.32)	(3.73)	(2.55)
Eijffinger-Schaling (ES)	-0.71	-0.10	-1.34
	(-0.77)	(-0.14)	(-1.08)
R^2 (adjusted)	-0.02	-0.06	0.01
Constant	6.97	6.64	6.75
	(3.69)	(4.01)	(2.39)
Cukierman (LVAU)	-1.51	2.11	-4.84
	(-0.31)	(0.50)	(-0.67)
R^2 (adjusted)	-0.05	-0.04	-0.03

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level, two asterisks indicate that the coefficient is significant at a 99% confidence level.

2.4 Conclusion

The main conclusions of this theoretical and empirical analysis of central bank independence with respect to the level and variability of inflation and economic growth are the following. First of all, both our model and estimation results give further support to the well-known inverse relationship between the degree of central bank independence and the level of inflation found by Alesina (1988, 1989) and Cukierman, Webb and Neyapti (1992). Secondly, we find some empirical evidence - especially for the Cukierman and GMT indices - supporting our proposition that the more independent the central bank is, the lower the variability of inflation.

Thirdly, according to our proposition that the level of economic growth does not depend on the prevailing monetary regime, no relationship can be found between central bank independence and the level of real output growth in the long run. Our interpretation of this outcome is that the attainment and maintenance of low inflation by an independent central bank is not accompanied by large costs or benefits in terms of sustainable economic growth. Fourthly and finally, our estimation results clearly reject the proposition of a positive relation between independence and the variability of real output growth. An independent central bank does not lead to more variable economic growth in the short run. In other words, inflation-averse central banks do not bear the costs of triggering recessions nor do politically sensitive central banks reap the benefits of avoiding recessions. The absence of a long-run trade off between CBI and the mean and variance of economic growth implies that the establishment of central bank independence in countries which did not use to have this, is a *"free lunch"* (Grilli, Masciandaro and Tabellini, 1991).

When looking at the differences between the subperiods that we distinguish, there are three observations with respect to the point estimates of CBI that can be made for all four indices. First, the inflation reducing effect of a one-unit increase of CBI, according to all indices, was larger in the first subperiod than in the second. Interestingly, this doesn't hold in terms of elasticities. Secondly, after controlling for initial GDP and the share of investment, a one unit increase of CBI leads to more output growth in the second subperiod than in the first. Thirdly, a one-unit increase of CBI leads to a larger reduction of the variance of output growth in the second subperiod than in the first.

2.5 Appendix

The Data

The mean and variance of inflation have been calculated from Consumer Prices- All Items, Non-adjusted, OECD Main Economic Indicators;
The mean and variance of per capita output growth, initial (1960) per capita real GDP and the share of investment over GDP are calculated from Penn World Tables;
Openness as measured by the share of imports in GDP is calculated from the National Accounts of OECD Countries, 1960-1977, 1977-1989, 1978-1992. (Imports of goods and services/GDP), in current prices. OECD Paris, 1979, 1991, 1994.
The indices for CBI can be found in Eijffinger and De Haan (1996). Some observations are not available for the sample of 20 countries. For AL, Austria, Ireland and Portugal are not available, for GMT, Finland, Norway and Sweden, for ES, Ireland and for LVAU Portugal are lacking.

3 Optimal Central Bank Conservativeness in an Open Economy

3.1 Introduction

Recently, in many countries both political and monetary authorities have shown an increasing interest in the objective of monetary stability and the position of the central bank. As pointed out by Persson and Tabellini (1993) recent policy reform, as well as historical experience, suggests two different routes to price stability.

The first way is the *legislative* approach, namely to create by law a very independent central bank with an unequivocal mandate to focus on price stability. Interest in this approach is motivated by the success of the Deutsche Bundesbank in maintaining one of the lowest rates of inflation for several decades. Moreover, the accepted statute of the European Central Bank is strongly influenced by the law governing the Bundesbank and France and Spain made their central banks more independent of government. Furthermore, the Czech Republic, Hungary and Poland increased the legal independence of their central banks. Academic contributions in this area are Rogoff (1985a), Neumann (1991) and Lohmann (1992).

The second way is the *targeting* or *contracting* approach, namely to let the political principal of the central bank impose an explicit inflation target for monetary policy, and make the central bank governor explicitly accountable for his success in meeting this target. Recently, New Zealand, Canada, and the United Kingdom have made some progress on this route.[1] Important theoretical work on this approach is done by Persson and Tabellini (1993) and Walsh (1995).

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[1] For recent surveys see Haldane (1995) and Leiderman and Svensson (1995).

In this chapter we build on the Rogoff (1985a) model and therefore restrict the analysis to the legislative approach. Empirical work on the legislative approach [Alesina (1989), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Eijffinger and Schaling (1993a, 1996, 1998), Alesina and Summers (1993)] has focused on the quantification of independence using a number of legal attributes from central bank laws. These studies focus on the *positive* issue of the relation between monetary regimes and economic performance. Broadly speaking, the conclusion is that the more independent the central bank, the lower the inflation rate, whilst the rate of output growth is unaffected. However, this literature does not explain the observed differences in central bank independence. For instance, no explanation is offered for the high independence of the Bundesbank. It has often been pointed out that this fact may be explained by Germany's underlying aversion to inflation associated with its experience of hyper-inflation in the 1920s.[2]
This brings us to a key issue in the political economy of central banking: the relation between institutional design and individual and collective preferences. An important study in this field is Cukierman (1994). Building on the seminal paper of Lohmann (1992), he identifies the economic and political factors that induce politicians to delegate authority to the central bank. His theory predicts that central bank independence will be higher the larger the employment-motivated inflationary bias, the higher political instability and the larger the government debt.

These predictions were tested and, subsequently, rejected by De Haan and Van 't Hag (1995). In testing the model, they employ measures of central bank independence that in - Rogoff's (1985a) terminology - reflect the strength of the 'conservative bias' of the central bank as embodied in the law. In Cukierman's model, following Lohmann (1992), central bank independence is defined as the *cost of overriding* the central bank, rather than as the degree of *conservativeness*. Cukierman's (1994) theory also generates propositions about *optimal* regimes, whilst the legal measures describe *actual* monetary regimes.

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2 See for instance Issing (1993) and Eijffinger and De Haan (1996).

In this chapter we try to overcome these pitfalls. We extend the Rogoff (1985a) model to the open economy case and allow for deviations from purchasing power parity. Using a graphical method, we determine the optimal degree of conservativeness and express the boundaries of the interval containing the optimal degree of conservativeness in terms of the structural parameters of the model.

Furthermore, we derive propositions concerning the relation between economic and political factors and the optimal degree of central bank conservativeness. We show that optimal central bank conservativeness is higher, the higher the natural rate of unemployment, the greater the benefits of unanticipated inflation (the slope of the Phillips curve), the less inflation-averse society, the smaller the variance of productivity shocks, the smaller real exchange rate variability and the smaller the openness of the economy. These propositions are tested for nineteen industrial countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States) for the period 1960-1993. We employ a *latent variables* approach (LISREL) in order to distinguish between actual and optimal monetary regimes.

The chapter is organized into four remaining sections, followed by an appendix. In Section 2 we present the theoretical model. Section 3 contains the derivation of the optimal degree of central bank conservativeness. In Section 4 we test the model with the latent variables method. Our conclusions are given in Section 5.

3.2 A Simple Macromodel

We assume that there are two types of agents, *wage-setters (the union)* and the *central bank*. Wage-setters unilaterally choose the nominal wage every period, and the central bank controls monetary policy.

The sequence of events is standard. In the first stage wage-setters sign nominal wage contracts. Wage-setters know the domestic monetary regime. They take this information into account in forming their expectations. In the second stage stochastic shocks to productivity and the real exchange rate realize. These shocks are random and cannot be observed at the time wage contracts are signed. In the third stage the central bank observes the values of the shocks and — contingent on the chosen regime — reacts to the shocks accordingly. In the fourth and final stage employment is determined by competitive firms.

3.2.1 Aggregate Supply

Consider the following supply block. Capital will be assumed fixed, and output is given by a short-run Cobb-Douglas production function

$$y_t = \beta \ell_t + v_t \qquad 0 < \beta < 1 \qquad \textbf{(3.1)}$$

where lower-case letters refer to logarithmic deviations from steady state values. Thus, y is the log of output, ℓ the log of employment, and v a measure of productivity. β is the exponent of labor and is less than unity.

For simplicity we assume that shocks to productivity are normally distributed with zero mean and finite variance

$$v_t \sim N(0, \sigma_v^2) \qquad \textbf{(3.2)}$$

Firms determine employment by equalizing the marginal product of labor to the real wage $w_t - p_t$. This yields the following employment function

$$\ell_t = -\frac{1}{1-\beta}(w_t - p_t - \log \beta - v_t) \qquad \textbf{(3.3)}$$

where w is the log of the nominal wage and p the log of the price level.

The nominal wage is set at the beginning of each period and remains fixed for one period. The objective of wage-setters is to stabilize the real consumer wage around a target level. Thus, wages in each period are set to minimize

$$W_t = E_{t-1}\left[\frac{1}{2}(w_t - p_{c_t} + \log\beta - \tau)^2\right] \tag{3.4}$$

where E_{t-1} is the operator of rational expectations, conditional on information at the end of period t - 1. $\tau > 0$ is the real wage target of the union.[3]
The consumer price index p_c is defined as

$$p_{c_t} = (1-\mu)p_t + \mu(p_t^* + e_t) = p_t + \mu(p_t^* + e_t - p_t) \tag{3.5}$$

where μ is the share of imports in GDP, e is the nominal exchange rate (defined as the domestic currency price of foreign exchange) and p^* is the foreign price level.
Having redefined the CPI in terms of the producer's price level (p) and the real exchange rate, it remains to specify how the *nominal* exchange rate is determined.

Here we are concerned with the factors that ultimately determine the degree of central bank conservativeness, that is, with the longer-term behavior of the exchange rate. As pointed out by Mussa (1991, p. 14), long-term relationships between movements in nominal exchange rates and the ratio of national price levels support the empirical relevance of purchasing power parity.[4] Therefore, we assume the nominal exchange rate to be governed by

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3 Alternatively, the loss function **(3.4)** could be assumed quadratic in both the deviations of employment and the real wage from certain target levels. For an analysis along these lines see Schaling (1995), Chapter 7.

4 It is well known that this theory has, generally, provided a poor explanation of shorter term movements of exchange rates. See e.g. Dornbusch (1976, 1988).

$$e_t = p_t - p^*_t + z_t \qquad z_t \sim N(0,\sigma_z^2) \tag{3.6}$$

where z is a shock to the real exchange rate with zero mean and finite variance σ^2_z. We assume this shock is uncorrelated with the supply shock, i.e. $E_{t-1}v_t z_t = 0$. From the first-order conditions for a minimum of **(3.4)**, the CPI-indexed nominal wage is given by[5]

$$w_t = E_{t-1}p_{c_t} + \log\beta + \tau \tag{3.7}$$

Taking account of **(3.6)** and **(3.7)** and of the fact that shocks to the real exchange rate cannot be observed at the time wage contracts are signed, we get

$$w_t = E_{t-1}p_t + \log\beta + \tau \tag{3.8}$$

Substituting **(3.8)** in the labor demand function **(3.3)** and subtracting this expression from the labor force ℓ^s (using the approximation that the rate of unemployment $u \approx \ell^s - \ell$) we get the following expression for the short-run determination of unemployment

$$u_t = \tilde{u} - \frac{1}{1-\beta}(p_t - E_{t-1}p_t + v_t) \tag{3.9}$$

where $\tilde{u} := \ell^s + \frac{\tau}{1-\beta}$. can be thought of as the *equilibrium* or "*natural*" rate of unemployment in this model. Thus, **(3.9)** is the well-known expectations augmented Phillips curve. We can now incorporate the Phillips curve into a monetary policy game.

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5 For a similar specification see Rogoff (1985b, p. 212). Note that the nature of the employment contract is such that the union agrees to supply whatever amount of labor is determined by firms in period t, provided firms pay the negotiated wage.

3.2.2 Time-Consistent Equilibrium under a "Conservative" Central Banker

As stated by Rogoff (1985a, p. 1180), the adoption of central bank conservativeness may be viewed as an institutional response to the time-consistency problem. He demonstrates that society can make itself better off by selecting an agent to head the central bank who is known to place a greater - but finite - weight on inflation stabilization (relative to unemployment stabilization) than is embodied in the social loss function S_t. The social loss function S depends on deviations of unemployment and CPI inflation from their *optimal* (socially desired) levels

$$S_t = \frac{1}{2}(\pi_{ct})^2 + \frac{\chi}{2}(u_t - u^*)^2 \tag{3.10}$$

where $0 < \chi < \infty$, CPI inflation is $\pi_{ct} = p_{ct} - p_{ct-1}$ and u^* is society's unemployment target. Society's CPI inflation target has been normalized to zero. The parameter χ is the weight of unemployment stabilization relative to inflation stabilization in the preferences of society. Normalizing p_{ct-1} at zero we get [6]

$$S_t = \frac{1}{2}p_{ct}^2 + \frac{\chi}{2}(u_t - u^*)^2 \tag{3.11}$$

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[6] This means that the Svensson (1997a) approach of designing a "too low" inflation target is not considered here. He shows that the latter can mimic the incentive structure of the optimal [Walsh (1995)] contract. Moreover, price-level targeting and inflation-rate targeting are equivalent here, since $p_{c_{t-1}}$ is known at the time the central bank commits itself to achieving a target for $p_{c_t} - p_{c_{t-1}}$. Once monetary control errors are taken into account it becomes important to make the distinction between a *zero inflation target* and a *target of price stability*. See Fischer (1994, pp. 33-34).

In period t - 1 society (the principal) selects an agent to head the central bank in period t. The reputation of this individual is such that it is known that, if he is appointed to head the central bank, he will minimize the following loss function

$$L_t = \frac{(1+\varepsilon)}{2} p_{ct}^2 + \frac{\chi}{2}(u_t - u^*)^2 \quad 0 < \varepsilon < \infty \tag{3.12}$$

When ε is strictly greater than zero, then this agent places a greater relative weight on CPI inflation stabilization then society does. Hence, following Rogoff we view the coefficient ε as a measure of the *conservativeness* of the central bank. The higher ε the more conservative the central bank. Note that, if ε = 0, equation **(3.12)** reduces to the social loss function **(3.11).**

The derivation of the time-consistent equilibrium is standard. The resulting GDP price level and unemployment rate are

$$p_t^C = \frac{\chi}{(1-\beta)(1+\varepsilon)}(\tilde{u} - u^*) - \frac{\chi v_t + \mu(1+\varepsilon)(1-\beta)^2 z_t}{(1+\varepsilon)(1-\beta)^2 + \chi} \tag{3.13}$$

$$u_t^C = (\tilde{u} - u^*) - \frac{(1+\varepsilon)(1-\beta)}{(1+\varepsilon)(1-\beta)^2 + \chi}(v_t - \mu z_t) \tag{3.14}$$

where superscript C stands for *conservative* central bank regime, and $\tilde{u} - u^*$ measures the wedge between and the central bank's unemployment target and the natural rate of unemployment; this determines the incentive of the central bank to create surprise inflation, and therefore the intensity of the time-consistency problem.

Following Rogoff (1985a) in the remainder of this chapter we assume that $\tilde{u} - u^* > 0$. This assumption is standard in the credibility literature and ensures that we end up with a positive inflationary bias (see equation **(3.13)**).

Note that a real depreciation *increases* unemployment (it acts like an adverse productivity shock). The reason for this is simple. Shocks that tend to cause real depreciations of the domestic currency are stabilized by the central bank, because of their potentially adverse effects on CPI inflation. The associated monetary tightening causes - given the level of nominal wages - a rise in real labor costs (reducing the producer's wage), thus driving down labor demand. Given the supply of labor, unemployment then increases.

3.3 Optimal Commitment in Monetary Policy

3.3.1 Social Welfare under a "Conservative" Central Banker

We are now able to evaluate central bank conservativeness from the perspective of society. To facilitate exposition in later sections, following Rogoff (1985a, pp. 1175-1176), we shall first develop a notation for evaluating the expected value of society's loss function under any arbitrary monetary policy regime "A", $E_{t-1}S_t^A$:

$$E_{t-1} S_t^A = \frac{\chi}{2} (\tilde{u} - u^*)^2 + \Pi^A + \Gamma^A \tag{3.15}$$

where $\Pi^A \equiv \frac{1}{2} E_{t-1} (p_{ct}^A)^2$, p_{ct}^A is the CPI in period t, and

$$\Gamma^A \equiv \frac{1}{2} E_{t-1} \left\{ \chi \left[\frac{v_t + (p_t^A - E_{t-1} p_t^A)}{1 - \beta} \right]^2 + (p_{ct}^A - E_{t-1} p_{ct}^A)^2 \right\}$$

Again, the first component of $E_{t-1} S_t^A$, $\frac{1}{2}[\chi (\tilde{u} - u^*)^2]$ is non-stochastic and invariant across monetary regimes. It represents the *deadweight loss* due to the labor market distortion ($\tilde{u} - u^* > 0$). This loss cannot be reduced through monetary policy in a time-consistent rational expectations equilibrium. The second term, Π^A, depends on the mean inflation rate. This term is also non-stochastic but does depend on the *choice* of monetary policy regime.

The final term, Γ^A, represents the *stabilization component* of the loss function. It measures how successfully the central bank offsets disturbances to stabilize unemployment and CPI inflation around their mean values.

By substituting the results relevant for the central bank [**(3.13)** and **(3.14)**] into society's loss function **(3.11)** and taking expectations, we obtain the C regime counterpart of expression **(3.15)**. Abstracting from the (common) deadweight loss, one gets

$$\Pi^C + \Gamma^C = \frac{\chi^2}{2[(1+\varepsilon)(1-\beta)]^2}(\tilde{u} - u^*)^2 + \frac{\chi[(1+\varepsilon)^2(1-\beta)^2 + \chi]}{2[(1+\varepsilon)(1-\beta)^2 + \chi]^2}[\sigma_v^2 + \mu^2\sigma_z^2] \qquad \textbf{(3.16)}$$

3.3.2 The Ultimate Determinants of Central Bank Conservativeness

The *optimal degree* of central bank conservativeness ε^* is defined as that value of ε that minimizes the expected value of the loss function of society $E_{t-1}\, S_t^C$.

To solve[7] for the value of ε that minimizes $E_{t-1}\, S_t^C$, differentiate **(3.16)** with respect to ε

$$\frac{\partial E_{t-1} S_t^C}{\partial \varepsilon} = \frac{\partial \Pi^C}{\partial \varepsilon} + \frac{\partial \Gamma^C}{\partial \varepsilon} \qquad \textbf{(3.17)}$$

$$\frac{\partial \Gamma^C}{\partial \varepsilon} = \frac{\chi^2(1-\beta)^2 \varepsilon[\sigma_v^2 + \mu^2\sigma_z^2]}{[(1+\varepsilon)(1-\beta)^2 + \chi]^3} \qquad \textbf{(3.18)}$$

---

7 As pointed out by Rogoff (1985a, p. 1178), it is difficult to write down a closed-form solution for ε^*. The latter is given in an appendix to Chapter 4.

$$\frac{\partial \Pi^C}{\partial \varepsilon} = \frac{-\chi^2 (\tilde{u} - u^*)^2}{(1+\varepsilon)^3 (1-\beta)^2} \qquad \textbf{(3.19)}$$

From **(3.19)** it can be seen that increasing the central bank's commitment to inflation stabilization decreases the credibility component of the social loss function. On the other hand, from **(3.18)** it follows that having a more conservative central bank increases the stabilization component of the loss function.

Hence, optimal commitment in monetary policy involves trading off the *credibility* gains associated with lower average inflation versus loss of *flexibility* due to a distorted response to productivity and real exchange rate shocks.

Rogoff is unable to write down a closed-form solution for ε^* and to derive propositions concerning the comparative static properties of this equilibrium. Using a graphical method, we develop an alternative way of determining the optimal degree of central bank conservativeness. Next, we show how this result is conditioned on the natural rate of unemployment $\tilde{u}$, society's preferences for unemployment stabilization (χ), the variance of productivity shocks (σ_v^2), the slope[8] of the Phillips curve ($(1-\beta)^{-1}$), the variance of shocks to the real exchange rate (σ_z^2) and the degree of openness (μ).

By setting **(3.17)** equal to zero we obtain the first-order condition for a minimum of $E_{t-1}\, S^C_t$

$$0 = \frac{\partial \Pi^C}{\partial \varepsilon} + \frac{\partial \Gamma^C}{\partial \varepsilon} \qquad \textbf{(3.20)}$$

Substituting **(3.18)** and **(3.19)** into **(3.20)**, yields

$$\frac{-\chi^2 (\tilde{u} - u^*)^2}{(1-\beta)^2 (1+\varepsilon)^3} + \frac{\chi^2 (1-\beta)^2 \varepsilon [\sigma_v^2 + \mu^2 \sigma_z^2]}{[(1+\varepsilon)(1-\beta)^2 + \chi]^3} = 0 \qquad \textbf{(3.21)}$$

---

8 Assuming unemployment on the vertical and inflation on the horizontal axis.

Equation **(3.21)** determines ε^* as an implicit function of χ, $\tilde{u}$, σ_v^2, β, σ_z^2 and μ. A solution for ε^* always exists and is unique.

To show this and to do comparative statics we use a graphical method.[9] Rewrite **(3.21)** as

$$\varepsilon = \frac{[(1+\varepsilon)(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4(1+\varepsilon)^3} \equiv F(\varepsilon) \qquad \textbf{(3.22)}$$

The function $F(\varepsilon)$ on the right-hand side of equation **(3.22)** is monotonically decreasing in ε and it can be shown that

$$F(0) = \frac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}, \lim_{\varepsilon\to\infty} F(\varepsilon) = \frac{(1-\beta)^2(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2]} \text{ and}$$

$$\frac{(1-\beta)^2(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2]} < F(\varepsilon) < \frac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}$$

We are now ready to prove:

Proposition 3.1: $\dfrac{(1-\beta)^2(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2]} < \varepsilon^* < \dfrac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}$

Proof: The left-hand side of **(3.22)** is a 45-degree straight line through the origin. Since $F(0) = \dfrac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}$ and $\dfrac{\partial F}{\partial \varepsilon} < 0$, these two functions must intersect at one and only one point. Moreover, since $\dfrac{(1-\beta)^2(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2]} < F(\varepsilon) < \dfrac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}$, the

9 This method was first applied in the context of a dynamic game by Cukierman (1992, pp. 170-172).

intersection occurs at a value of ε that is bounded between $\frac{(1-\beta)^2(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2]}$ and

$\frac{[(1-\beta)^2+\chi]^3(\tilde{u}-u^*)^2}{[\sigma_v^2+\mu^2\sigma_z^2](1-\beta)^4}$.

Figure 3.1 Optimal conservativeness in an open economy

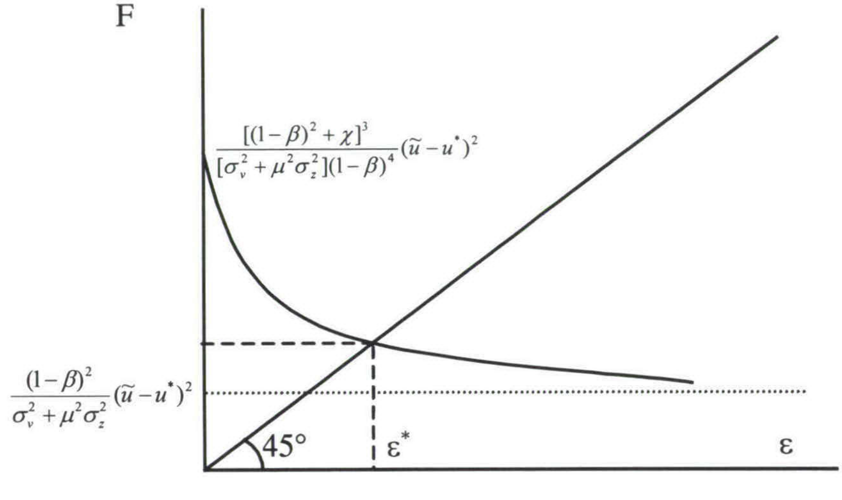

Figure 3.1 illustrates the argument graphically. Clearly, a solution for ε exists and is unique. We are now ready to investigate the factors affecting the *optimal degree of central bank conservativeness* (hereafter OC). Hence, we identify economic and political factors that induce politicians to delegate more or less authority to this institution. We show that the delegation of authority to the central bank depends on the natural rate of unemployment, society's preferences for unemployment stabilization, the variance of productivity shocks, the slope of the Phillips curve, the degree of openness of the economy and the variance of shocks to the real exchange rate. The results are derived by performing comparative static experiments with respect to various parameters on Figure 3.1. Derivations are published in

a separate technical appendix [Eijffinger and Schaling (1998)] which is available to the interested reader on request. We summarize the main results in the following six propositions.

Proposition 3.2: If the central bank partly accommodates the natural rate of unemployment ($\partial u^*/\partial \tilde{u} < 1$), the higher the natural rate of unemployment, the higher OC.

Proof: $\dfrac{\partial F}{\partial \tilde{u}} = \left[1 - \dfrac{\partial u^*}{\partial \tilde{u}}\right] \dfrac{\partial F}{\partial(\tilde{u} - u^*)}$

where $\partial u^*/\partial \tilde{u}$ is the accommodation coefficient and the second term is positive if $\tilde{u} - u^* > 0$.[10] Under the above conditions $\partial F/\partial \tilde{u} > 0$, implying that when $\tilde{u}$ goes up, the curve F(ε) in Figure 3.1 shifts upward. As a consequence, the equilibrium value of ε increases.

The intuition behind this result is the following. A higher natural rate of unemployment implies a higher time-consistent rate of inflation (see equation **(3.13)**) and, consequently, a higher credibility component of the social loss function. This means that society's credibility problem is increased. Hence, with an unaltered relative weight placed on inflation versus unemployment stabilization the monetary authorities' commitment to fight inflation is now too low.

Note that, if either society's and wage-setters' preferences are consistent ($u^* = \tilde{u}$) or target unemployment rates fully adjust one for one to changes in the natural rate ($\partial u^*/\partial \tilde{u} = 1$), we should observe no relationship between the natural rate of unemployment and optimal central bank conservativeness.

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10 See the last part of Section 3.2. In the (less plausible) case that $\tilde{u} - u^* < 0$, $\dfrac{\partial F}{\partial(\tilde{u} - u^*)}$ becomes negative and the condition on the accommodation coefficient becomes $\dfrac{\partial u^*}{\partial \tilde{u}} > 1$.

Proposition 3.3: The higher society's preferences for unemployment stabilization relative to inflation stabilization (the higher χ), the higher OC.

Proof: The technical appendix shows that $\frac{\partial F}{\partial \chi} > 0$, implying that when χ goes up, the curve $F(\varepsilon)$ in Figure 3.1 shifts upward. Thus, the equilibrium value of ε increases.

The underlying intuition is that, if society becomes more concerned with unemployment and more lax about inflation, the time-consistent inflation rate goes up (See equation **(3.13)**). Therefore, society's credibility problem becomes more pressing. With an unchanged weight placed on inflation stabilization, the balance between credibility and flexibility needs to be adjusted in favor of increased commitment of fighting inflation.

Proposition 3.4: The higher the *variance of productivity shocks* (the higher σ_v^2), the lower OC.

Proof: The technical appendix shows that $\frac{\partial F}{\partial \sigma_v^2} < 0$, implying that when σ_v^2 goes up, the curve $F(\varepsilon)$ in Figure 3.1 shifts downward. Therefore, the equilibrium value of ε decreases.

This result may be explained as follows. If the variance of productivity shocks increases, ceteris paribus, the economy becomes more unstable. Thus, the need for active stabilization policy increases (the Γ^C component of the social loss function goes up).
With an unaltered relative weight placed on inflation stabilization the balance between credibility and flexibility then needs to be shifted towards more monetary accommodation.

Proposition 3.5: If society is relatively unconcerned with inflation $\left(\chi > \frac{(1+\varepsilon)(1-\beta)^2}{2} \right)$, the greater the *benefits of unanticipated inflation* (the higher $(1-\beta)^{-1}$), the higher OC.

Proof: The technical appendix shows that, if $\chi > \frac{(1+\varepsilon)(1-\beta)^2}{2}$, $\frac{\partial F}{\partial (1-\beta)^{-1}} > 0$, implying that when $(1-\beta)^{-1}$ goes up, the curve $F(\varepsilon)$ shifts upward. Consequently, the equilibrium value of ε increases.

The intuition behind this proposition is that, if the benefits of unanticipated inflation rise (See equation **(3.9)**), it becomes more tempting to inflate the economy. Therefore, society's credibility problem gains in importance. With the same emphasis on inflation stabilization, the balance between credibility and flexibility needs to be shifted towards increased commitment to price stability.

Proposition 3.6: If the economy is more open to international trade (the higher μ), the *lower* OC.

Proof: The technical appendix shows that $\frac{\partial F}{\partial \mu} < 0$, implying that when μ goes up, the curve $F(\varepsilon)$ in Figure 3.1 shifts downward. Therefore, the equilibrium value of ε decreases.

The underlying argument is the following. If the economy becomes more open, domestic inflation and unemployment become more vulnerable to shocks to the real exchange rate. This means that if μ goes up, ex ante variability of both inflation and unemployment increase (see equations **(3.13)** and **(3.14)**). Note that this implication is consistent with empirical evidence found by Romer (1993) that openness accounts for a substantial fraction of the variation in inflation among countries. As a consequence the need for active stabilization policy by the central bank increases. Thus, the balance between credibility and flexibility needs to be shifted towards more monetary accommodation.

Proposition 3.7: The higher real exchange rate variability (the higher σ_z^2), the lower OC.

Proof: The technical appendix shows that $\frac{\partial F}{\partial \sigma_z^2} < 0$, implying that when σ_z^2 goes up, the curve F(ε) in Figure 3.1 shifts downward. Therefore, the equilibrium value of ε decreases. The intuition is similar to that behind the previous proposition. If ex ante real exchange rate variability rises, both domestic inflation and unemployment will become more volatile (see equations **(3.13)** and **(3.14)**). Thus, the need for active stabilization policy increases (the Γ^C component of the social loss function goes up). So, the balance between credibility and flexibility must be shifted towards less commitment.

In order to confront these propositions with some cross-country evidence, we can now move on to the empirical evidence. This is the subject of the next section.

3.4 Empirical Evidence

In this section, the ultimate determinants of central bank conservativeness are empirically investigated. We will use, for that purpose, a *latent variables* approach (LISREL) to make a distinction between the *optimal* and *actual* degree of central bank conservativeness. The reason for this distinction is that the propositions derived in the former section are related to the optimal degree of central bank conservativeness and *not* to the actual degree. Importantly, the former is an *unobservable* conceptual variable. Therefore we need an *observable* proxy for OC. As a proxy we use the *legal* degree of central bank independence according to the four main measures in the literature. According to these measures central banks in which the only or main objective of monetary policy (as specified in the law) is price stability, are classified as being more independent than central banks with a number of objectives in addition to price stability, or banks in whose law price stability is not mentioned as an objective at all. Therefore, these measures reflect the central bank's mandate for price stability and hence the strength of the *conservative bias* as embodied in the CB law.

3.4.1 The Data

As proxies for the ultimate determinants of central bank conservativeness, we have chosen the following economic and political variables (See for a detailed account of these variables: Appendix A). For the natural rate of unemployment, the non-accelerating inflation rate of unemployment (*NAIRU*) is taken from Layard, Nickell and Jackman (1991). They estimated the NAIRU for nineteen industrial countries in the period 1960-1988. The proxy for society's preferences for unemployment stabilization relative to inflation stabilization is the number of years that a *left-wing* (socialist) party has been in government as a share of the total number of years (WLEFT). For, a left-wing government has a higher preference for unemployment stabilization and, thereby, the optimal degree of central bank conservativeness increases under a left-wing government.[11] The variance of productivity shocks is proxied by the *variance of output growth* (GDP) on an annual basis (VPROD). We compute the slope of the Phillips curve, using labor's income share in GDP.[12] Because data for labor's income share are not available for all countries in our sample, we have taken the ratio between the *compensation of employees* paid by resident producers to resident households and GDP (SLOPE).

The degree of openness is measured by the ratio between the *imports* of goods and services and GDP (OPEN). The proxy for the variance of *shocks to the real exchange rate* is the variance of the ratio between the CPI inflation minus GDP deflator and the degree of openness (VREER).

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11 According to Alesina (1989, p. 61), empirical evidence provides support for the view that redistributional considerations provide an incentive for the left to be expansionary and unemployment fighting and for the right to be inflation-fighting and less concerned about unemployment.

12 Since we use a Cobb-Douglas production function (equation (3.1)), the production elasticity of labor, β, equals labor's income share in GDP.

3.4.2 The Latent Variables Method

According to Bentler (1982), the essential characteristic of a *latent variable* is revealed by the fact that the system of linear structural equations in which the latent variable appears cannot be manipulated so as to express this variable as a function of *measured* variables only.[13]

Aigner et al. (1984) state that, since 1970, there has been a resurgence of interest in econometrics in the topic of models involving latent variables. "That interest in such models had to be restimulated at all may seem surprising since there can be no doubt that economic quantities frequently are measured with error and, moreover, that many applications depend on the use of observable proxies for otherwise unobservable conceptual variables" (p. 1323).

Estimation of a simultaneous equations model with latent variables can be done by means of a computer program for the analysis of covariance structures, such a LISREL (Linear Structural Relations). The idea behind LISREL is to compare a sample covariance matrix with the parametric structure imposed on it by the hypothesized model. Under normality, LISREL delivers *Full Information Maximum Likelihood* (FIML) estimates of the model parameters. The specification of the latent variables model to be analyzed by LISREL is as follows. Let OCN be the latent *dependent* variable, i.e. the latent optimal degree of central bank conservativeness -*normalized* between zero and unity-, and x a vector of observed explanatory variables being the six ultimate determinants of central bank conservativeness. OCN and x are measured in deviations from their means and satisfy the following linear system:

$$\begin{array}{l} \qquad\qquad\quad (?)(+)(-)(+)(-)(-) \\ OCN - M = [b_1\ \ b_2\ \ b_3\, b_4\, b_5\, b_6] \ .\ x + \zeta \end{array} \qquad \textbf{(3.23)}$$

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13 For this definition of a latent variable, see: P.M. Bentler (1982). A clear overview of the latent variable approach is given by: D.J. Aigner (et al) (1984).

$$x = \begin{bmatrix} \text{NAIRU-M} \\ \text{WLEFTM} \\ \text{VPRODM} \\ \text{SLOPEM} \\ \text{OPENM} \\ \text{VREERM} \end{bmatrix}$$

The expected signs are denoted above the vector of coefficients and ζ is a disturbance term.

Instead of the latent vector OCN-M, a vector y of legal indices of central bank independence is *observed* (similarly normalized and measured in deviations from their means),[14] such that

$$y = \begin{bmatrix} \text{ALN-M} \\ \text{GMTN-M} \\ \text{ESN-M} \\ \text{LVAU-M} \end{bmatrix} \tag{3.24}$$

and

$$\begin{bmatrix} \text{ALN-M} \\ \text{GMTN-M} \\ \text{ESN-M} \\ \text{LVAU-M} \end{bmatrix} = \text{OPCBCN-M} + \gamma \tag{3.25}$$

Hence, the optimal degree of central bank conservativeness is approximated by the legal degree, according to the four main indices of central bank independence in the literature.

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14 The legal index of Cukierman (LVAU) is already normalized on its theoretical scale i.e. in theory is lowest value is 0 and its highest value 1.

The index of Alesina (AL) is a narrow measure of independence and based on Alesina (1989). The total index of political and economic independence of Grilli, Masciandaro and Tabellini (GMT) is a broad measure based on Grilli, Masciandaro and Tabellini (1991). The index of policy independence of Eijffinger and Schaling (ES) is, however, a narrow measure based on Eijffinger and Schaling (1993a, 1998) and extended by Eijffinger and Van Keulen (1995). The unweighted legal index of Cukierman (LVAU) is a very broad measure of independence and derived from Cukierman (1992).

For our cross-country analysis, a set of nineteen industrial (OECD) countries is taken which are ranked - with some exceptions - by the above-mentioned indices. The sample period that we have chosen covers more than thirty years, namely the period 1960-1993 (for NAIRU: 1960-1988). The argument to choose such a long period is that it contains many political and business cycles and, thus, comprises changes of the political and economic structure affecting the optimal degree of central bank conservativeness. Of course, γ is the vector of measurement errors with $E(\gamma) = E(\gamma\zeta) = 0$.

Furthermore, Φ and Ψ are defined as the covariance matrix of x and the variance of ζ, respectively and Θ as the variance-covariance matrix of γ. Then it follows from the above assumptions that the variance-covariance matrix $\sum$ of [y', x']' is

$$\Sigma = \begin{bmatrix} (B\Phi B'+\Psi)+\Theta & B\Phi + C \\ \Phi B'+C' & \Phi \end{bmatrix} \qquad \textbf{(3.26)}$$

where $B \equiv [b_1\ b_2\ b_3\ b_4\ b_5\ b_6]$ and C is the covariance matrix of x and γ. The parameters occurring in $\sum$ (B, C, Φ, Ψ, Θ) are estimated on the basis of the matrix S of second sample moments of x and y. In order to identify all parameters, a restriction on Θ has to be imposed. Given this restriction and the structure that equation **(3.26)** imposes on the data, LISREL computes FIML estimates of the parameters when [y', x'] is normally distributed, i.e. when the following criterion is minimized

$$\ln |\Sigma| + \text{tr}\,[S\Sigma^{-1}] \qquad \textbf{(3.27)}$$

For the moment we assume that Θ is diagonal and C is the null matrix. The latter are sufficient conditions for identification. Of course, the meaning of those restrictions is that the correlation between the observed legal indices of central bank independence (y) is *only* caused by the latent optimal degree and that the measurement errors (γ) are uncorrelated with the observed explanatory variables (x).

3.4.3 The Empirical Results

Now we will estimate the relationship between the *optimal* degree of central bank conservativeness and the *economic* and *political* factors in a country as specified by equations **(3.23)** - **(3.25)**.

Next, given the parameter estimates we compute ("predict") OC for each country and make a comparison between the *optimal* degree of conservativeness and the *legal* indices of central bank independence.

The first row of Table 3.1 shows the estimation results, based on Θ diagonal and C the null matrix. From this row it can be seen that all explanatory variables, except for NAIRU have the expected sign. However, only the VPROD is significant at a 90% confidence level. The relatively low t-values of the explanatory variables could perhaps be attributed to the imposed restrictions.[15] In order to investigate the validity of these restrictions univariate Lagrange Multiplier tests are carried out.

The last four rows of Table 3.1 give the estimation results if we relax *cumulatively* five restrictions on C and Θ respectively. When the test statistic, having a χ^2_1-distribution, has a value larger than 2.71 the restriction is rejected at a significance level of 10%.

15 See in this respect: Aigner, Hsiao, Kapteyn and Wansbeek (1984, p. 1371).

In the first regression, with all restrictions imposed, the constraint that the disturbances of the GMT-index and the variance of productivity shocks (σ_v^2) are uncorrelated [E (γ_2 x_3) = 0] is rejected. The test statistic has a value of 6.74 which is the highest of all restrictions. Therefore, we have lifted this restriction and tested the modified model.
Now the restriction on the covariance of the disturbances of the GMT-index and the variance of shocks to the real exchange rate (VREER) [E(γ_2 x_6) =0] is rejected with the highest test statistic. So, this restriction has been lifted. This process goes on until there is no restriction left with a test statistic higher than 2.71.

Then the Likelihood Ratio-test for the model to be of the specified structure gives a test-statistic of 16.36 which is well below the critical value of 25.99 for a χ^2_{18}-distribution at a significance level of 10%.
From the last row of Table 3.1 it can be seen that all explanatory variables, except VPROD and NAIRU, have the expected sign.[16]
Now, we turn to the computation of OC for each country and make a comparison between the *optimal* degree of conservativeness and the legal indices of central bank independence. Such a comparison is possible since both the optimal degree and the legal indices have been normalized.
The values for the normalized indices are given in the first four columns of Table 3.2.[17]
Next the thus normalized indices are expressed as deviations from their means, called transformed indices. The numerical values of the transformed indices (ALN-M etc.) can be found in columns 5-8 of this Table. From these columns, it can be seen that all indices classify the Bundesbank's independence as above average, whereas the opposite holds for the Bank of England.

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16 As said before, the coefficient on the NAIRU may be explained by accommodation of this variable into the authorities' target. In the latter case higher unemployment rates imply less ambitious policies.

17 For example, according to the normalized Alesina index (ALN) the Netherlands is classified as 0.33. This number was computed using the following formula ALN = [AL-AL_{min}]/[AL_{max}-AL_{min}], where AL = 2, AL_{max} = 4 and AL_{min} = 1.

In order to confront the transformed indices with the optimal degree of conservativeness for each country, we compute OC based on the last row of Table 3.1. The 'predictions' for OC (similarly normalized and in deviation from its mean) can be found in the next column.
Of course, the numbers reflect the "distribution" of the determinants (the economic and political factors) across the sample. Now, a comparison between the *optimal* degree of conservativeness and the *legal* indices can be made. We do this by calculating the *average difference* defined as

$$\text{AVDIF} = \frac{[\text{ALN-M}]+[\text{GMTN-M}]+[\text{ESN-M}]+[\text{LVAU-M}]}{4} - [\text{OPCBCN-M}] \qquad \textbf{(3.28)}$$

The average difference is *positive*, if the average of legal indices exceeds the optimal degree, and *negative*, if the optimal degree exceeds the average of legal indices.
A positive difference indicates that the actual monetary regime in a country - as proxied by the central bank laws - can be seen as too conservative, whereas a negative average difference indicates that the legal degree should be increased to bring it closer to the social optimum.
Positive average differences - of 0.24 or higher - are found for Germany and Switzerland, implying that the monetary regimes in those countries can be seen as "too conservative".
Negative average differences - of -0.21 or lower - are observed for Sweden and the United Kingdom, meaning that OC exceeds the legal degree of central bank independence and that the latter should be increased.
For the other countries the average differences are relatively small, indicating that there is no reason to adjust the central bank law in these countries from the perspective of the ultimate determinants.[18] In some countries - notably France and Spain - the central bank

[18] In a separate technical appendix (available on request) we also calculate the average differences for the cases with more restrictions (rows 1-4 of Table 3.1). The positive numbers for Germany and Switzerland remain in place. Also, the negative differences for Australia, Norway, Sweden and the United Kingdom are robust. Again, relatively small differences are found for Belgium, Canada, Finland, France, Italy, Japan and the United States.

has, recently, been made more independent from government which can be explained by another argument: a prerequisite for entering the third phase of Economic and Monetary Union in Europe is, among others, the independence of the *national* central banks of the participating countries.

Table 3.1 Table Based on Estimation with Cumulative Relaxation of Restrictions

Lifted Restriction	Estimated Equation	R^2 and DF
no lifted restriction	OCN-m = -0.016 * Nairu-m + 0.003 * Wleft-m - 0.012 * Vprod-m + 0.374 * Slope-m - 0.188 * Open-m - 0.001 * Vreer-m (1.041) (0.019) (0.669) (1.858) (0.618) (0.359)	R^2=0.42 DF=23
γ_2, x_3	OCN-m = -0.013 * Nairu-m + 0.024 * Wleft-m + 0.037 * Vprod-m + 0.651 * Slope-m - 0.392 * Open-m - 0.003 * Vreer-m (0.713) (0.135) (2.255) (3.091) (1.126) (2.628)	R^2=0.55 DF=22
γ_2, x_6	OCN-m = -0.010 * Nairu-m + 0.108 * Wleft-m + 0.013 * Vprod-m + 0.529 * Slope-m - 0.078 * Open-m - 0.000 * Vreer-m (0.580) (0.657) (0.573) (2.366) (0.212) (0.140)	R^2=0.35 DF=21
γ_2, γ_1	OCN-m = -0.005 * Nairu-m + 0.119 * Wleft-m + 0.010 * Vprod-m + 0.418 * Slope-m - 0.061 * Open-m - 0.000 * Vreer-m (0.344) (0.925) (0.604) (2.411) (0.213) (0.273)	R^2=0.40 DF=20
γ_3, γ_1	OCN-m = -0.005 * Nairu-m + 0.124 * Wleft-m + 0.011 * Vprod-m + 0.445 * Slope-m - 0.033 * Open-m - 0.000 * Vreer-m (0.336) (0.816) (0.556) (2.151) (0.099) (0.201)	R^2=0.33 DF=19
γ_3, x_5	OCN-m = -0.004 * Nairu-m + 0.121 * WLeft-m + 0.010 * Vprod-m + 0.421 * Slope-m - 0.069 * Open-m - 0.001 * Vreer-m (0.280) (0.849) (0.561) (2.164) (0.252) (0.332)	R^2=0.35 DF=18

Notes: N stands for normalized variables; m stands for deviations of variables from their means; t-values in parentheses; Sample period 1960 - 1993 for all variables (except for Nairu and Vreer)

Table 3.2 Table Based on Estimation with Minimal Restrictions

OCN-M = -0.004 * NAIRU-M + 0.121 * WLEFT-M + 0.010 * VPROD-M + 0.421 * SLOPE-M - 0.069 * OPEN-M - 0.001 * VREER-M
$R^2 = 0.35$ DF=18

COUNTRY	ALN	GMTN	ESN	LVAU	ALN-M	GMTN-M	ESN-M	LVAU-M	OCN-M	AVDIF
Australia	0.00	0.56	0.00	0.31	-0.38	0.07	-0.42	-0.05	-0.034	-0.16
Austria		0.56	0.50	0.58		0.07	0.08	0.22	0.008	0.12
Belgium	0.33	0.44	0.50	0.19	-0.05	-0.05	0.08	-0.17	-0.037	-0.01
Canada	0.33	0.69	0.00	0.46	-0.05	0.20	-0.42	0.10	-0.054	0.01
Denmark	0.33	0.50	0.75	0.47	-0.05	0.01	0.33	0.11	0.021	0.08
Finland	0.33		0.50	0.27	-0.05		0.08	-0.09	0.043	-0.06
France	0.33	0.44	0.25	0.28	-0.05	-0.05	-0.17	-0.08	-0.090	0.00
Germany	1.00	0.81	1.00	0.66	0.62	0.32	0.58	0.30	0.001	0.45
Ireland		0.44		0.39		-0.05		0.03	-0.063	0.05
Italy	0.17	0.31	0.25	0.22	-0.22	-0.18	-0.17	-0.14	-0.100	-0.08
Japan	0.67	0.38	0.50	0.16	0.28	-0.11	0.08	-0.20	-0.087	0.10
Netherlands	0.33	0.63	0.75	0.42	-0.05	0.14	0.33	0.06	-0.003	0.12
New Zealand	0.00	0.19	0.50	0.27	-0.38	-0.30	0.08	-0.09	-0.047	-0.13
Norway	0.33		0.25	0.14	-0.05		-0.17	-0.22	-0.010	-0.14
Spain	0.00	0.31	0.00	0.21	-0.38	-0.18	-0.42	-0.15	-0.116	-0.17
Sweden	0.33		0.25	0.27	-0.05		-0.17	-0.09	0.193	-0.30
Switzerland	1.00	0.75	1.00	0.68	0.62	0.26	0.58	0.32	0.202	0.24
United Kingdom	0.33	0.38	0.25	0.31	-0.05	-0.11	-0.17	-0.05	0.112	-0.21
United States	0.67	0.75	0.50	0.51	0.28	0.26	0.08	0.15	0.103	0.09

Notes: Sample period 1960 - 1993 for all variables (except for NAIRU and VREER);N stands for normalized variables; M stands for deviations of variables from their means; t-values in parentheses.

3.5 Conclusion

In this chapter we derived propositions concerning the relation between economic and political factors and the optimal degree of central bank conservativeness (OC).
We have shown that OC is higher, the higher the natural rate of unemployment, the greater the slope of the Phillips curve, the less inflation averse society, the smaller the variance of productivity shocks, the smaller real exchange rate variability and the smaller the openness of the economy. These propositions were tested for nineteen industrial countries, using a latent variables method (LISREL) to distinguish between actual and optimal monetary regimes. We find that some countries (Germany and Switzerland) seem to have a suboptimally high degree of central bank conservativeness, whereas others (Sweden and the UK) appear to have a suboptimally low degree.
Of course, our model could be extended with other determinants of central bank conservativeness. For instance, Lockwood *et al* (1994) show how OC increases with unemployment persistence whilst Levine and Pearlman (1995) demonstrate how this variable relates to both nominal and real wage rigidity. Moreover, Fratianni and Huang (1995) suggest that central bank conservativeness and *reputation* can be treated as partial substitutes. Finally, one could extend the model with uncertainty about the policymaker's preferences due to political pressure.

3.6 Appendix

The Data

NAIRU: R. Layard, S. Nickell and R. Jackman, *Unemployment, Macroeconomic Performance and the Labour Market*, Oxford, Oxford University Press, 1991.
Estimates for NAIRU 1960-1988, Table 14, Chapter 9.

WLEFT: A.J. Day (ed.), *Political Parties of the World*, London, Longman, 1988, (# years that a left-wing party has been in the government, either alone or in a coalition) / (total # years), 1960-1993.

VPROD: OECD Main Economic Indicators.
Growth rate of GDP in US$ in 1985 prices and exchange rates, 1960-1993.

SLOPE: National Accounts of OECD Countries, 1960-1977, 1977-1989, 1978-1992.
1/[1 - (Compensation of employees paid by resident producers/GDP)], in current prices.
OECD, Paris, 1979, 1991, 1994.

OPEN: National Accounts of OECD Countries, 1960-1977, 1977-1989, 1978-1992.
(Imports of goods and services/GDP), in current prices. OECD Paris, 1979, 1991, 1994.

VREER: OECD National Accounts, Main Aggregates, Vol. I, 1960-1989, Paris, 1991. Variance of [(CPI inflation-GDP deflator)/OPEN], CPI inflation and GDP deflator calculated from private final consumption expenditure price index and GDP price index, respectively.

4 The Trade Off Between Central Bank Independence and Conservativeness

4.1 *Introduction*

This chapter deals with the following fundamental question. It tries to explain the optimal degree of central bank *independence and conservativeness* by four economic and political determinants (the natural rate of unemployment, society's preferences for unemployment stabilization relative to inflation stabilization, the variance of productivity shocks and the benefits of unanticipated inflation) both theoretically and empirically. The empirical results are only given for the (twelve) member states of the European Union.

The chapter is organized as follows. Central bank independence is included in the model of a conservative central banker and the trade off between independence and conservativeness is discussed in Section 2. In this Section, also the relationship between (independence and) conservativeness of the central banks and the four economic and political determinants is investigated with an extension of the Rogoff (1985a) model. Furthermore, we test this relationship empirically using a latent variables approach (LISREL) for nineteen industrial countries including the member states of the European Union in Section 3. Also, the optimal degree of conservativeness of the central banks is identified for twelve member states of the European Union. Finally, our conclusions are drawn in Section 4.

4.2 *The Rogoff Model*

In the Rogoff (1985a) model, society can make itself better off by appointing a conservative central banker who does not share the social objective function, but instead places "too large" a weight on inflation rate stabilization relative to output stabilization. In this simplified version, output is given by the Lucas supply function which is reformulated in terms of unemployment u_t:

$$u_t = \widetilde{u} - b(\pi_t - \pi^e + v_t) \tag{4.1}$$

where $b > 0$ denotes the slope of the Phillips curve, π_t is inflation, π^e is expected inflation, $\widetilde{u} > 0$ is the natural rate of unemployment and v_t is a serially uncorrelated productivity shock with mean zero and variance σ_v^2. The timing of events is as follows: first π^e is set (nominal wage contracts are signed), then the shock v_t occurs and finally the central banker sets π_t.

Figure 4.1 The Timing of Events

1	2	3	4
Nominal wage contracts signed	Productivity shocks realize	CB sets monetary policy	Output determined

Society's loss function is given by:

$$S_t = \frac{1}{2}\pi_t^2 + \frac{\chi}{2}u_t^2 \tag{4.2}$$

where the weight on output stabilization $\chi > 0$. The target level of inflation and the target level of unemployment are set to zero. Rogoff now shows that it is optimal for society to choose a conservative central banker who assigns "too large" a weight to inflation in his loss function:

$$L_t = \frac{1+\varepsilon}{2}\pi_t^2 + \frac{\chi}{2}u_t^2 \tag{4.3}$$

where ε, the additional weight on the inflation goal, lies between zero and infinity ($0 < \varepsilon < \infty$).

Substituting **(4.1)** in **(4.3)**, taking first order conditions with respect to π_t and solving for rational expectations, we obtain:

$$\pi_t = \frac{\chi b}{1+\varepsilon}\tilde{u} - \frac{\chi b^2}{1+\varepsilon+\chi b^2} v_t \tag{4.4}$$

$$\pi^e = \frac{\chi b}{1+\varepsilon}\tilde{u} \tag{4.5}$$

$$u_t = \tilde{u} - \frac{b(1+\varepsilon)}{1+\varepsilon+\chi b^2} v_t \tag{4.6}$$

Policy rule **(4.4)** shows that the introduction of a conservative central banker ($\varepsilon > 0$) leads to a lower inflationary bias ($\frac{\chi b}{1+\varepsilon}\tilde{u}$) and a lower variance of inflation $\left(\frac{\chi b^2}{1+\varepsilon+\chi b^2}\right)^2 \sigma_v^2$.

The variance of output $\left(\frac{b(1+\varepsilon)}{1+\varepsilon+\chi b^2}\right)^2 \sigma_v^2$, however, is an increasing function of the conservativeness of the central banker. This is the trade off between credibility and flexibility that is already apparent in the Rogoff model. It can be shown that the optimal value for ε, in terms of social loss function **(4.2)**, is positive but finite.[1] This implies that it is optimal for society to appoint a conservative central banker.

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1 Rogoff uses an envelope theorem to show this. In the appendix we derive a closed-form solution to this problem.

4.2.1 From Conservativeness to Independence

The independence of a central bank can be seen as the extent to which it determines monetary policy without interference of the government. In the Rogoff model, this can be incorporated in the loss function that determines monetary policy, M_t. This function is a *weighted* average of the central bank's loss function L_t and society's loss function S_t where the weight $0<\gamma<1$ is the degree of central bank independence:[2]

$$M_t = \gamma L_t + (1-\gamma) S_t \tag{4.7}$$

Substituting society's loss function **(4.2)** and central bank's loss function **(4.3)** into **(4.7)** gives:

$$M_t = \frac{1+\gamma\varepsilon}{2}\pi_t^2 + \frac{\chi}{2}u_t^2 \tag{4.8}$$

So, what matters for monetary policy is $\gamma\varepsilon$: the *product* of independence and conservativeness of the central bank, or *effective central bank independence*. There is an optimal degree of independence and conservativeness ($\gamma\varepsilon^*$) which minimizes society's loss S_t. In practice, the degree of (legal) independence of a central bank is fixed as measured by the legal indices of independence which reflect the central bank laws in various countries. The level of conservativeness, however, can generally be chosen by the central bank. Hence, a lack of central bank independence can be compensated by choosing more conservative central bankers. On the basis of economic and political determinants, we determine the optimal degree of independence and conservativeness. Then, given the *actual* degree of independence for each country, we are able to identify its *optimal* degree of conservativeness ε^* (see Figure 4.2).

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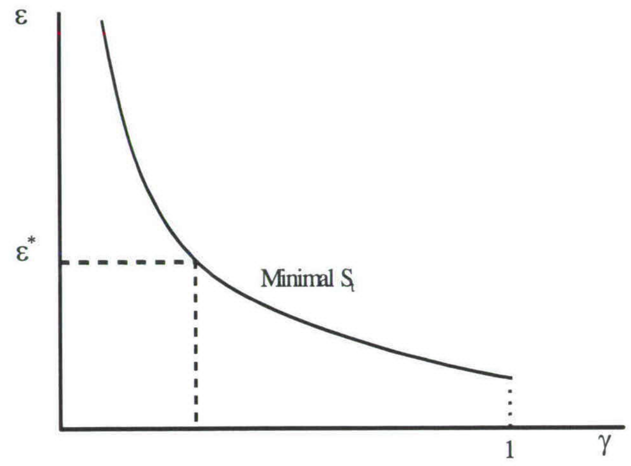
2 This implies that central bank independence (γ) is defined as the degree in which the central bank determines effectively the monetary policy's loss function (M_t).

Figure 4.2 The Trade Off between Independence and Conservativeness



4.2.2 The Optimal Independence and Conservativeness of a Central Bank

This brings us to a key issue in the political economy of central banking: the relationship between institutional design and individual and collective preferences. Here the question to be dealt with is the *normative* issue of how conservative a central bank (CB) should be, i.e. the optimal degree of conservativeness of a CB.

An important study in this field is Cukierman (1994). Building on the seminal paper of Lohmann (1992), he wants to identify the economic and political factors that induce politicians to delegate more or less authority to the central bank. His theory predicts that central bank independence will be higher, the larger the employment-motivated inflationary bias, the higher political instability and the larger the government debt are.

These predictions were tested and, subsequently, rejected by De Haan and Van 't Hag (1995) using regression analysis (OLS method). In testing Cukierman's model, they employ measures of central bank independence that in - Rogoff's (1985a) terminology -

reflect the strength of the 'conservative bias' of the central bank as embodied in the law. In Cukierman's model, following Lohmann (1992), central bank independence is defined as the *cost of overriding* the central bank, rather than as the degree of *conservativeness*. Cukierman's (1994) theory also generates propositions about *optimal* regimes, whilst the legal measures describe *actual* monetary regimes.

In this chapter we try to overcome these pitfalls. Building on the Rogoff (1985a) model, we distinguish between independence and conservativeness of a CB. Using a graphical method, we develop a new way of determining the optimal degree of independence and conservativeness. As in Lohmann (1992), this degree depends on the balance between *credibility* and *flexibility*. However, unlike Rogoff and Lohmann, we are able to express the upper and lower bounds of the interval containing the optimal degree of independence and conservativeness in terms of the structural parameters of the model.

Furthermore, we derive a number of propositions concerning the relationship between economic and political factors and the optimal degree of independence and conservativeness. We show that optimal central bank independence and conservativeness is higher, the higher the natural rate of unemployment, the greater the benefits of unanticipated inflation (the slope of the Phillips curve), the less inflation-averse society and the smaller the variance of productivity shocks.

After we have found the optimal degree of independence and conservativeness for each country and knowing the actual degree of independence of its central bank, we can derive the optimal degree of conservativeness of the CB.

Using $\gamma\varepsilon$ instead of ε in the expression for inflation **(4.4)** and the expression for unemployment **(4.6)**, substituting these two expressions into the Central Bank's loss function **(4.8)** and taking expectations yields the following expected loss for society with a central banker with independence γ and conservativeness ε:

$$E_{t-1}S_t = \frac{\chi^2 b^2 \tilde{u}^2}{2(1+\gamma\varepsilon)^2} + \frac{b^4 \chi^2}{2(1+\gamma\varepsilon+b^2\chi)^2}\sigma_v^2 + \frac{\chi \tilde{u}^2}{2} + \frac{b^2(1+\gamma\varepsilon)^2\chi}{2(1+\gamma\varepsilon+b^2\chi)^2}\sigma_v^2 \qquad \textbf{(4.9)}$$

The first term in **(4.9)** is due to the inflationary bias and can be reduced by making the central bank more independent or conservative (a larger $\gamma\varepsilon$). The second term measures how well the central bank manages to keep inflation constant. This variance can also be reduced by making the central bank more independent or conservative. The third term is a dead-weight loss due to the natural rate of unemployment. Obviously, this cannot be reduced through monetary policy. The last term is the variance of unemployment (or output). This term increases when the central bank becomes more independent or conservative. When we drop the dead-weight loss and take the two variances together, we get the following:

$$E_{t-1} S_t = \underbrace{\frac{\chi^2 b^2 \tilde{u}^2}{2(1+\gamma\varepsilon)^2}}_{credibility} + \underbrace{\frac{\chi b^2 ((1+\gamma\varepsilon)^2 + b^2 \chi)}{2(1+\gamma\varepsilon + b^2 \chi)^2} \sigma_v^2}_{flexibility} \qquad \textbf{(4.9')}$$

The first term in **(4.9')** is related to the natural rate of unemployment and can be seen as the *credibility* component in the social loss; the second term is related to the variance of productivity shocks and represents the *flexibility* component in the social loss. Minimizing the expected social loss with respect to $\gamma\varepsilon$ yields the following first order condition:

$$\frac{d\, E_{t-1} S_t}{d\,(\gamma\varepsilon)} = \underbrace{\frac{-\chi^2 b^2 \tilde{u}^2}{(1+\gamma\varepsilon)^3}}_{negative} + \underbrace{\frac{\chi^2 b^4 \gamma\varepsilon\, \sigma_v^2}{(1+\gamma\varepsilon + \chi b^2)^3}}_{positive} = 0 \qquad \textbf{(4.10)}$$

The first term in **(4.10)** is always *negative* and reflects the credibility effect of a more independent or conservative central bank: a higher $\gamma\varepsilon$ reduces society's credibility problem. The second term is always *positive* and reflects the flexibility effect of more central bank independence or conservativeness: a higher $\gamma\varepsilon$ means less stabilization.

4.2.3 The Determinants of Optimal Independence and Conservativeness

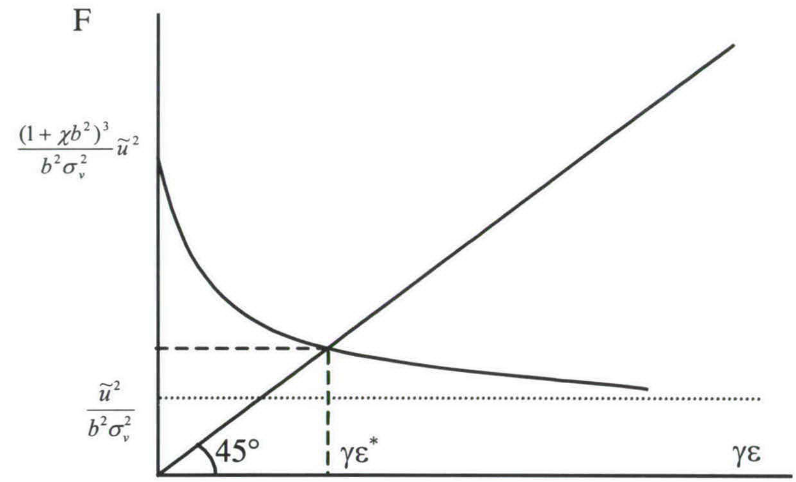
In Eijffinger and Schaling (1998) it is shown that a unique solution for the optimal $\gamma\varepsilon$ exists. Furthermore, the comparative static properties of this equilibrium are derived by means of a graphical method as is illustrated in Figure 3. First, the first-order condition **(4.10)** is rewritten as:

$$\gamma\varepsilon = \frac{\tilde{u}^2 (1+\gamma\varepsilon+\chi b^2)^3}{\sigma_v^2 b^2 (1+\gamma\varepsilon)^3} \equiv \mathrm{F}(\gamma\varepsilon) \qquad \textbf{(4.11)}$$

The function F on the right-hand side of equation **(4.11)** is monotonically decreasing in $\gamma\varepsilon$. The left-hand side is a 45° line through the origin and the intersection point gives the optimal degree of independence and conservativeness $\gamma\varepsilon^*$. The comparative static properties of the optimal degree of independence and conservativeness can be derived from the partial derivatives of the function F. If F shifts upward, the intersection point shifts to the right.[3]

[3] For a formal derivation of the properties of the function F in the first-order condition, see Appendix B in Eijffinger and Schaling (1998).

Figure 4.3: Optimal Independence and Conservativeness



It turns out that the higher the *natural rate of unemployment* (the higher $\tilde{u}$), the higher the optimal degree of conservativeness and independence of the CB. The intuition behind this result is the following. A higher natural rate of unemployment implies a higher time-consistent rate of inflation (See equation **(4.4)**) and, consequently, a higher credibility component of the social loss function. This means that society's credibility problem increases. Hence, with an unaltered relative weight placed on inflation versus unemployment stabilization the monetary authorities' commitment to fight inflation is now too low.

The higher *society's preferences for unemployment stabilization relative to inflation stabilization* (the higher χ) in a country, the higher the optimal degree of conservativeness and independence of the CB. The underlying intuition is that, if citizens become more concerned with unemployment and more lax about inflation, the time-consistent inflation rate goes up (See equation **(4.4)**). Therefore, society's credibility problem becomes more pressing. With an unchanged relative weight placed on inflation stabilization, the balance between credibility and flexibility needs to be adjusted in favor of increased commitment of fighting inflation.

The higher the *variance of productivity shocks* (the higher σ_v^2) in a country, the lower the optimal degree of conservativeness and independence of a CB. This result may be explained as follows. If the variance of productivity shocks increases, ceteris paribus, the economy becomes more unstable. Thus, the need for active stabilization policy increases (the flexibility component of the social loss function goes up). With an unaltered relative weight placed on inflation stabilization the balance between credibility and flexibility needs to be shifted towards more monetary accommodation.

If society is relatively unconcerned with inflation $\left(\chi > \frac{(1+\gamma\varepsilon)}{2b^2}\right)$ the greater the *benefits of unanticipated inflation* (the higher b) in a country, the higher the optimal degree of conservativeness and independence of a CB. The intuition behind this proposition is that, if the benefits of unanticipated inflation rise (See equation **(4.1)**), it becomes more tempting to inflate the economy. Therefore, society's credibility problem gains in importance. With the same emphasis on inflation stabilization, the balance between credibility and flexibility needs to be shifted towards increased commitment to price stability.

4.3 An Empirical Illustration of Optimal Conservativeness

In this Section, the economic and political determinants of the optimal degree of central bank conservativeness and independence ($\gamma\varepsilon^*$) discussed before are empirically investigated. We will use, for that purpose, a latent variables approach (LISREL) to make a distinction between the *optimal* and *actual* degree of conservativeness and independence.[4] The reasons for this distinction are two-fold. First, the propositions derived in the former Section are related to the optimal degree of conservativeness and independence and *not* to the actual degree. These propositions formulate the relationship between the optimal degree and four economic and political factors in a country:

the natural rate of unemployment ($\tilde{u}$);

society's preferences for unemployment stabilization relative to inflation stabilization (χ);

the variance of productivity shocks (σ_v^2); and

the slope of the Phillips curve (b).

These determinants, reflecting the economic and political structure of a country, explain theoretically the optimal degree of conservativeness and independence in that country.[5] Second, there is also an identification and measurement problem. Whereas the determinants will change *frequently* during the sample period, i.e. the period 1960-1993, the actual degree may change much less in the same period. The stickiness may, for example, result from the fact that central bank laws are *very occasionally* adjusted in the industrial countries during the post-war period.

The actual degree of central bank independence is approximated by the *legal* degree, according to the four main indices of central bank independence in the literature. The index of Alesina (AL) is a narrow measure of independence and based on Alesina (1988, 1989). The total index of political and economic independence of Grilli, Masciandaro and Tabellini (GMT) is a broad measure based on Grilli, Masciandaro and Tabellini (1991). The index of policy independence of Eijffinger and Schaling (ES) is, however, a narrow measure based on Eijffinger and Schaling (1992, 1993a) and extended by Eijffinger and Van Keulen

4 A clear overview of the latent variables approach is given by Aigner, Hsiao, Kapteyn and Wansbeek (1984). For an application of this approach to the determinants of central bank independence only, see chapter 3 and Appendix A.

5 The proxies for these economic and political variables and the sources of the data are given in Appendix C.

(1995). The unweighted legal index of Cukierman (LVAU) is a very broad measure of independence and derived from Cukierman (1992). These four legal indices have been *lognormalized (AL, GMT, ES* and *LVAU*) so that the natural logarithms of their values range from zero to one.

For our cross-country analysis, initially, a set of nineteen industrial (OECD) countries - Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States - is taken which are ranked by the above-mentioned indices.[6] The sample period that we have chosen covers more than thirty years, namely the period 1960-1993 (for $\widetilde{u}$: 1960-1988). The argument to choose such a long period is that it contains many political and business cycles.

The idea behind the model is the following. The optimal degree of conservativeness and independence is a function of the determinants, $\gamma\varepsilon^* = f(X)$, where f is a function and X are the determinants. Taking logs, we rewrite the equation as $\log(\gamma) = g(X) - \log(\varepsilon^*)$, where g is a function. Now, we use the log of the legal indices as proxies for $\log(\gamma)$ which we interpret as actual independence. The residual ($-\log(\varepsilon^*)$), which we calculate by the difference between the average of the (log) legal indices and g(X), can be interpreted as a measure for optimal conservativeness. Using this approach has several implications. First, by interpreting the residual as optimal conservativeness, we implicitly assume that optimal conservativeness is uncorrelated with the determinants. Put differently, the part of independence that cannot be explained by the determinants, will be compensated by conservativeness. Furthermore, it means that every CB has the optimal degree of independence as long as the right level of conservativeness is chosen.

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6 By including not only the twelve member states of the European Union but also seven non-member states, we have sufficient data to estimate the LISREL model. For two member states - Greece and Portugal - no data on the natural rate of unemployment ($\widetilde{u}$, proxied by NAIRU) were available, whereas Luxembourg has a monetary union with Belgium.

On the basis of the restrictions given in Appendix A, LISREL computes *Full Information Maximum Likelihood* estimates of the parameters of the model, explaining the relationship between the degree of central bank independence (γ) and the explanatory variables (NAIRU, WLEFT, VPROD and SLOPE). Then, using the parameters we have estimated, we predict the optimal degree of central bank independence and conservativeness for each country (OCI). The comparison between the *optimal* degree of independence and conservativeness and the *legal* indices of central bank independence (AL, GMT, ES and LVAU) can be made. The difference between the optimal degree of independence and conservativeness on one hand and the average of the lognormalized legal indices of central bank independence (CBI) on the other hand, is interpreted as optimal conservativeness (OC).
If the predicted optimal degree of independence and conservativeness (OCI) exceeds the average of legal indices (CBI), then the optimal degree of conservativeness (OC) is positive, indicating that the central bank should be more conservative than the average central bank. So optimal conservativeness, which is distributed around zero by definition, is a property relative to the other countries in the sample. Of course, the optimal degree of conservativeness is negative if the optimal degree of conservativeness and independence is smaller than CBI.

4.3.1 Estimation Results

Table 4.1 shows the estimation results for the optimal degree of conservativeness and independence ($\gamma\varepsilon^*$) using a latent variables approach (LISREL).[7] For convenience the restriction that the disturbance terms in the model are uncorrelated is imposed.[8] From Table

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[7] The idea behind LISREL (Linear Structural Relations) is to compare a sample covariance matrix with the parametric structure imposed on it by the hypothesized model. Under normality, LISREL delivers Full Information Maximum Likelihood (FIML) estimates of the model parameters. For more details, see Appendix A. See also Aigner et al. (1984).

[8] Two of these restrictions, however, have to be rejected according to a univariate Lagrange Multiplier-test and are, thereby, lifted. For the relaxation of the restrictions, see Appendix B. Imposing or

4.1, it can be seen that only one explanatory variable (θ) is significant at a 5% significance level. Apparently, the benefits from unanticipated inflation do play an important role. The other explanatory variables have relatively low t-values which could, probably, be attributed to the many restrictions still imposed on the model. Nevertheless, the model as such is not rejected according to a Likelihood Ratio-test for the model to be of the specified structure (see Appendix B).

Therefore, we have calculated the *optimal* degree of conservativeness and independence (henceforth OCI) on the basis of the economic and political determinants for each country. Given the *actual* independence being the unweighted average of the legal indices of central bank independence (CBI), we are able to determine the optimal conservativeness (OC) for the twelve member states of the European Union. Here we use an average of broad and narrow indices. As the indices are highly correlated (see Eijffinger and De Haan (1996)) splitting the broad and narrow indices up wouldn't yield much different results.

Rogoff (1985a) has shown that society can make itself better off by appointing a "conservative" central banker who places an *additional* weight on inflation stabilization (price stability) than society. From Section 4.2 it is evident that central bank independence and conservativeness are (close) *substitutes* of each other. An independent central bank can afford to be less conservative than a dependent central bank. Therefore, the optimal conservativeness may be interpreted as the degree of *discretion* (flexibility) in monetary policy which can be afforded by the central bank: the lower the optimal conservativeness of the central bank, the higher the degree of discretion it can afford in monetary policy making.

relaxing these restrictions has no serious consequences. They are imposed initially because there is no theoretical reason to assume a covariance.

4.4 Conclusions

What are the main conclusions from the theoretical and empirical analysis on the optimal degree of conservativeness? The optimal degree of central bank independence and conservativeness depends positively on the natural rate of unemployment, society's preferences for unemployment stabilization relative to inflation stabilization and the benefits of unanticipated inflation and negatively on the variance of productivity shocks. Using a LISREL-model we estimated the relationship between four proxies of legal central bank independence and the four economic and political determinants. Then, we determine the optimal degree of independence and conservativeness for each country based on the determinants. Given the actual degree of independence we calculate the optimal degree of conservativeness. Consequently, there appears to be a trade off between central bank independence and conservativeness.

Table 4.1: The Optimal Conservativeness

$$\gamma\varepsilon^* = -0.019 * \bar{u} + 0.171 * \chi + 0.015 * \sigma_v^2 + 0.706 * b \quad R^2 = 0.37 \quad DF = 15$$
$$(-0.822) \quad (0.800) \quad (0.696) \quad (2.501)$$

Country	Indices				Log Normalized Indices					Optimal Conservativeness	
	AL	GMT	ES	LVAU	*AL*	*GMT*	*ES*	*LVAU*	*CBI*	*OCI*	*OC*
Austria		9	3	0.58		*0.71*	*0.62*	*0.90*	*0.74*	*0.55*	*-0.19*
Belgium	2	7	3	0.19	*0.45*	*0.52*	*0.62*	*0.15*	*0.44*	*0.47*	*0.03*
Denmark	2	8	4	0.47	*0.45*	*0.62*	*0.83*	*0.74*	*0.66*	*0.57*	*-0.09*
Finland	2		3	0.27	*0.45*		*0.62*	*0.36*	*0.48*	*0.60*	*0.12*
France	2	7	2	0.28	*0.45*	*0.52*	*0.36*	*0.38*	*0.43*	*0.37*	*-0.06*
Germany	4	13	5	0.66	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*0.56*	*-0.44*
Ireland		7		0.39		*0.52*		*0.60*	*0.56*	*0.38*	*-0.18*
Italy	1.5	5	2	0.22	*0.25*	*0.30*	*0.36*	*0.23*	*0.28*	*0.34*	*0.06*
Netherlands	2	10	4	0.42	*0.45*	*0.79*	*0.83*	*0.66*	*0.68*	*0.54*	*-0.14*
Spain	1	5	1	0.21	*0.00*	*0.30*	*0.00*	*0.21*	*0.13*	*0.26*	*0.13*
Sweden	2		2	0.27	*0.45*		*0.36*	*0.36*	*0.39*	*0.86*	*0.47*
United Kingdom	2	6	2	0.31	*0.45*	*0.42*	*0.36*	*0.45*	*0.42*	*0.70*	*0.28*

Notes: t-statistics in parentheses: Italics refer to lognormalized indices of central bank independence; Actual central bank independence: *CBI = (AL + GMT + ES + LVAU)/4;* Optimal central bank conservativeness and independence: *OCI* ($\gamma\varepsilon^*$); Optimal conservativeness: *OC = OCI - CBI.*

4.5 Appendices

A. The Estimated Model

Let γ be the latent *dependent* variable, i.e. the latent degree of central bank independence, and x be the observed *explanatory* variables, in our case the four ultimate determinants of central bank independence, satisfying a system of linear structural relations

$$\gamma = B \cdot x - \varepsilon \quad \textbf{(A.1)}$$

with B being the vector of coefficients and ε the disturbances. It is assumed that γ, x and ε have *zero* expectations, and that x and ε are *uncorrelated*. Instead of the latent variable γ, the vector of proxies y is *observed*, such that

$$y = \Lambda \gamma + \delta \quad \textbf{(A.2)}$$

with δ the vector of measurement errors, *uncorrelated* with γ and ε, but possibly correlated among themselves and $\Lambda=[1\ 1\ 1\ 1]'$. The observed vectors x and y are measured as deviations form their means, thus, having *zero* expectations and a covariance equal to E[x y]. Also, γ and δ have zero expectations.

Therefore, y is a vector of *observed* legal indices of central bank independence (AL, GMT, ES and LVAU), lognormalized so that the natural logarithm of their values range from 0 to 1 and measured in deviation from their means,

$$y = \begin{bmatrix} AL.NM \\ GMT.NM \\ ES.NM \\ LVAU.M \end{bmatrix} \tag{A.3}$$

and x is a vector of *observed* explanatory variables, being the non-accelerating inflation rate of unemployment (NAIRU), the percentage of years of a left-wing government (WLEFT), the variance of output growth (VPROD) and the compensation of employees as share of GDP (SLOPE) measured in deviation from their means

$$x = \begin{bmatrix} NAIRU.M \\ WLEFT.M \\ VPROD.M \\ SLOPE.M \end{bmatrix} \tag{A.4}$$

So, equation **(A.2)** becomes

$$\begin{bmatrix} AL.NM \\ GMT.NM \\ ES.NM \\ LVAU.M \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \cdot \gamma + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix} \tag{A.2'}$$

Furthermore, Φ and Ψ are defined as the covariance matrix of x and the variance of ε, respectively, and Θ_δ as the true variance-covariance matrix of δ. Then it follows from the above assumptions that the variance-covariance matrix Σ of [y', x']' is

$$\Sigma = \begin{bmatrix} \Lambda(B\Phi B' + \Psi)\Lambda' + \Theta_\delta & \Lambda B\Phi \\ \Phi B'\Lambda' & \Phi \end{bmatrix} \tag{A.5}$$

where $\Lambda=[1\ 1\ 1\ 1]'$ and Θ_δ is diagonal, which implies that the correlation between the observed legal indices of central bank independence (y) is *only* caused by the latent optimal degree (η).

The parameters occurring in Σ (B, Φ, Ψ, Θ_δ) are estimated on the basis of the matrix S of second sample moments of x and y. Given the structure that matrix **(A.5)** imposes on the sample covariance matrix, LISREL computes FIML estimates of the parameters when [y', x'] is normally distributed, i.e. when the following criterion is minimized

$$\ln |\Sigma| + \text{tr}\,[S\Sigma^{-1}] \qquad \textbf{(A.6)}$$

B. The Relaxation of Restrictions

In the first model, we imposed the restriction that the disturbance terms in the model are uncorrelated. The statistics of this model show a Likelihood Ratio-test for the null hypothesis that the predicted covariance matrix is of the specified structure against the alternative that the covariance matrix is unconstrained. For the first model, the null hypothesis is rejected implying that the specified structure was not correct. Apparently, too many restrictions were imposed. Testing structural models, a univariate Lagrange Multiplier-test is carried out for most elements in the model matrices that are constrained to equal constants. When the test statistic, having a χ^2_1-distribution, has a value larger than 3.84 the restriction is rejected at a significance level of 5%.

In the first regression, with all restrictions imposed, the constraint that the disturbances of the GMT-index and the variance of productivity shocks (σ_v^2) are uncorrelated is rejected. The test statistic has a value of 10.00 which is the highest of all restrictions. Therefore, we have lifted this restriction and tested the modified model. Now the restriction on the covariance of the GMT-index and the ES-index is rejected with the highest test statistic. So we lifted this restriction. The modified model gives no restriction with a test statistic higher than 3.84 and the Likelihood Ratio-test for the model to be of the specified structure gives a test-statistic of 14.86 which is well below the critical value of 22.31 for a χ^2_{15}-distribution at a significance level of 10%.

Table 4.2: Table based on Estimation with Cumulative Relaxation of Restrictions

Lifted Restriction	Estimated Equation	R^2 and DF
No Lifted Restriction	$\gamma\varepsilon^* = -0.028 * \tilde{u} + 0.037 * \chi - 0.009 * \sigma_v^2 + 0.565 * b$ (-1.283) (0.189) (-0.452) (2.070)	$R^2=0.43$ DF=17
GMT, σ_v^2	$\gamma\varepsilon^* = -0.019 * \tilde{u} + 0.121 * \chi + 0.012 * \sigma_v^2 + 0.700 * b$ (-0.867) (0.591) (0.647) (2.669)	$R^2=0.41$ DF=16
GMT, ES	$\gamma\varepsilon^* = -0.019 * \tilde{u} + 0.171 * \chi + 0.015 * \sigma_v^2 + 0.706 * b$ (-0.822) (0.800) (0.696) (2.501)	$R^2=0.37$ DF=15

Note: t-values in parentheses.

C. The Data

As proxies for the ultimate determinants of the optimal degree of central bank conservativeness and independence, we have chosen the following economic and political variables. For $\tilde{u}$, the *non-accelerating inflation rate of unemployment* (NAIRU) is taken from Layard, Nickell and Jackman (1991). They estimated the NAIRU for nineteen industrial countries in the period 1960-1988. The proxy for society's preferences for unemployment stabilization relative to inflation stabilization (χ) is the number of years that a *left-wing (socialist) party* has been in government as a share of the *total* number of years. For, a left-wing government has a higher preference for unemployment stabilization[9] and, thereby, the

9 We think that *in general* a left-wing government is more concerned with employment relative to inflation than a right-wing government.

optimal degree of central bank conservativeness and independence increases under a left-wing government. The variance of productivity shocks (σ_v^2) is proxied by the *variance of output growth* (GDP) on an annual basis. We compute the slope of the Phillips curve (b), using labor's income share in GDP. Here we assume a Cobb-Douglas production function and a competitive labor market (See also Schaling (1995)). Because data for labor's income share are not available for all countries in our sample, we have taken the ratio between the *compensation of employees* paid by resident producers to resident households and GDP.

$\widetilde{u}$: R. Layard, S. Nickell and R. Jackman, *Unemployment, Macroeconomic Performance and the Labour Market*, Oxford, Oxford University Press, 1991. Estimates for NAIRU 1960-1988, Table 14, Chapter 9.

χ: A.J. Day (ed.), *Political Parties of the World*, London, Longman, 1988.
(# years that a left-wing party has been in the government, either alone or in a coalition)/(total # years), 1960-1993.

σ_v^2: OECD, *Main Economic Indicators,* various issues.
Variance of growth rate of GDP in US$ in 1985 prices and exchange rates, 1960-1993.

b: OECD, *National Accounts of OECD Countries*, 1960-1977, 1977-1989, 1978-1992.
1/[1 - (Compensation of employees paid by resident producers/GDP)], in current prices.
OECD, Paris, 1979, 1991, 1994.

D. Closed-Form Solution

In this appendix we derive an expression for the optimal degree of independence and conservativeness of a central bank as a function of the exogenous variables. We solve the first-order condition, which is an equation of fourth degree, using Ferrari's method.

For notational convenience, we introduce the parametric abbreviations $\psi := \frac{\chi}{1+\gamma\varepsilon}$ and

$D := \frac{1}{b^2}$. The first-order condition **(4.10)** can be rewritten as:

$$\psi^4 + 3D\psi^3 = -3D^2\psi^2 - \left(D^3 + \frac{D^2\sigma_v^2}{\widetilde{u}^2}\right)\psi + \frac{D^2\sigma_v^2\chi}{\widetilde{u}^2} \qquad \textbf{(D.1)}$$

Adding $\frac{9D^2}{4}\psi^2 + Y(\psi^2 + \frac{3}{2}D\psi) + \frac{Y^2}{4}$ to both sides yields[10]:

$$\left(\psi^2 + \tfrac{3}{2}D\psi + \frac{Y}{2}\right)^2 = \left(-\tfrac{3}{4}D^2 + Y\right)\psi^2 + \left(\tfrac{3}{2}DY - \frac{D^2\sigma_v^2}{\tilde{u}^2} - D^3\right)\psi + \left(\tfrac{1}{4}Y^2 + \frac{D^2\sigma_v^2\chi}{\tilde{u}^2}\right) \quad \textbf{(D.2)}$$

The left-hand side of this expression is a perfect square. If we can write the right-hand side as a perfect square as well, then we will be able to solve the equation. We want to determine the auxiliary variable *Y* so that the right hand side of this equation can be written in the form $(e\psi + f)^2$. In general, $A\psi^2 + B\psi + C = (e\psi + f)^2$ if $B^2 - 4AC = 0$. Applied to the right-hand side of equation **(D.2)** this condition yields:

$$\left(\tfrac{3}{2}DY - \frac{D^2\sigma_v^2}{\tilde{u}^2} - D^3\right)^2 - 4(Y - \tfrac{3}{4}D^2)\left(\tfrac{1}{4}Y^2 + \frac{D^2\sigma_v^2\chi}{\tilde{u}^2}\right) = 0 \quad \textbf{(D.3)}$$

This is an equation of third degree in *Y*. Now we define $Z := Y - D^2$ so that $Y = Z + D^2$.[11] Substituting this equation into equation **(D.3)**, we obtain a third order polynomial in *Z*. In order to solve this third order polynomial in *Z* by Cardan's method, we first define the following symbols:

$$p := \frac{D^2\sigma_v^2}{\tilde{u}^2}(3D + 4\chi) \quad \textbf{(D.4)}$$

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10 In general, with $f(x) := x^4 + ax^3 + bx^2 + cx + d = 0$, add $\frac{a^2}{4} + y\left(x^2 + \frac{a}{2}x\right) + \frac{y^2}{4}$ to both sides.

11 When $f(x) := x^3 + ax^2 + bx + c = 0$, choose $z := x - \frac{a}{3}$ and $f(z) := z^3 + pz + q$ will follow.

$$q := \frac{D^4 \sigma_v^2}{\tilde{u}^2}\left(D + \chi - \frac{\sigma_v^2}{\tilde{u}^2}\right) \tag{D.5}$$

$$\Lambda := 4p^3 + 27q^2 \tag{D.6}$$

$$A := -\frac{q}{2} + \sqrt{\frac{\Lambda}{108}} \tag{D.7}$$

$$B := -\frac{q}{2} - \sqrt{\frac{\Lambda}{108}} \tag{D.8}$$

Now, a solution for $Z^* = \sqrt[3]{A} + \sqrt[3]{B}$.

$$\begin{aligned} Z^* = & \sqrt[3]{\frac{D^4\sigma_v^2}{2\tilde{u}^2}\left(\frac{\sigma_v^2}{\tilde{u}^2} - D - \chi\right) + \frac{D^3\sigma_v^2}{\tilde{u}^2}\sqrt{\frac{\sigma_v^2}{27\tilde{u}^2}(3D+4\chi)^3 + \frac{D^2}{4}\left(D + \chi - \frac{\sigma_v^2}{\tilde{u}^2}\right)^2}} \\ & + \sqrt[3]{\frac{D^4\sigma_v^2}{2\tilde{u}^2}\left(\frac{\sigma_v^2}{\tilde{u}^2} - D - \chi\right) - \frac{D^3\sigma_v^2}{\tilde{u}^2}\sqrt{\frac{\sigma_v^2}{27\tilde{u}^2}(3D+4\chi)^3 + \frac{D^2}{4}\left(D + \chi - \frac{\sigma_v^2}{\tilde{u}^2}\right)^2}} \end{aligned} \tag{D.9}$$

With $Y^* = Z^* + D^2$ we know that the right-hand side of equation **(D.2)** can be written in the form $(e\psi + f)^2$. Take $e = \sqrt{Z^* + D^2}$ and $f = \dfrac{\frac{3}{2}DZ^* + \frac{1}{2}D^3 - \frac{D^2\sigma_v^2}{\tilde{u}^2}}{\sqrt{4Z^* + D^2}}$.

Now, the whole problem boils down to solving the following equation for ψ:

$$\left(\psi^2 + \frac{3D}{2}\psi + \frac{Z^* + D^2}{2}\right)^2 = \left(\psi\sqrt{Z^* + \tfrac{1}{4}D^2} + \frac{\frac{3}{2}DZ^* + \frac{1}{2}D^3 - \frac{D^2\sigma_v^2}{\tilde{u}^2}}{\sqrt{4Z^* + D^2}}\right)^2 \tag{D.10}$$

This biquadratic equation can be split up into two quadratic equations with two (real and complex) solutions each. The second-order condition for a minimal loss that:

$$4\psi^{*3} + 9D\psi^{*2} + 6D^2\psi^{*} + D^3 + \frac{D^2\sigma_v^2}{\tilde{u}^2} > 0 \qquad \textbf{(D.11)}$$

is satisfied for every $\psi > 0$. This is in line with the result in Rogoff (1985a) that it is optimal to have a conservative central banker. Eliminating the solutions for the first-order condition that maximize the loss, we obtain two candidates for the optimum:

$$\psi_{1,3}^{*} = -\tfrac{3}{4}D \pm \tfrac{1}{2}\sqrt{\tfrac{1}{4}D^2 + Z^{*}} + \tfrac{1}{2}\sqrt{\tfrac{1}{2}D^2 - Z^{*} \pm \frac{D^2}{\sqrt{D^2 + 4Z^{*}}}\left(\tfrac{1}{2}D - \frac{4\sigma_v^2}{\tilde{u}^2}\right)} \qquad \textbf{(D.12)}$$

Only one of these two roots is real. Which one is real, is determined by the last term in the last square root. If $D > \frac{8\sigma_v^2}{\tilde{u}}$, then "±" should be read as " + ", otherwise as "-". The optimal degree of central bank conservativeness and independence, $\gamma\varepsilon^{*}$, can be computed with $\gamma\varepsilon^{*} = \frac{\chi}{\psi^{*}} - 1$.

5 Monetary Uncertainty and Mystique

5.1 Introduction

In writing about central bankers Milton Friedman once said: “From revealed preference, I suspect that by far and away the two most important variables in their loss function are avoiding accountability on the one hand and achieve public prestige on the other”. More recently, Alan Greenspan, ‘the Delphic oracle of global financial markets’, speaking to Congress said: “If I’ve made myself too clear, you must have misunderstood me.”

Hence, an important feature of central bank institutions is their adherence to *secrecy*. The latter is generally believed to be unjustifiable on moral grounds. For instance, Mayer (1987, p.16) argues that: “If governments derive their legitimacy from the consent of the governed, this should be informed consent”. And Goodfriend (1986) reports on an intriguing case study involving a graduate law student, David R. Merrill, who under the auspices of the Freedom of Information Act of 1966, filed a freedom of information request with the Board of Governors of the Federal Reserve System over its failure to disclose its minutes.

This chapter investigates society’s incentives to design monetary institutions that allow for central bank secrecy. We find that the main reason for central bank secrecy is its potentially beneficial effect on stabilization policy. Contrary to Cukierman and Meltzer (1986), we obtain this result even with a zero degree of persistence in the central bank’s objectives. Unlike Lewis (1991), this result does not require the social planner’s future preferences for policy objectives to change over time with changing economic circumstances.

More specifically, optimal central bank secrecy involves trading-off the harmful effects of uncertainty about monetary policy and the associated higher expected inflation, versus the potentially beneficial effects on the stabilization of output. The latter trade-off depends on the severity of society's time-consistency problem vis-à-vis its need for stabilization policy. The analysis predicts that if the credibility problem is large relative to the need for flexibility, optimal central bank institutions will be very open and transparent and vice versa. This reverses an earlier result by Garfinkel and Oh (1995).

Moreover it explains why high credibility institutions such as the Bundesbank and the future European Central Bank (ECB), *can afford* to be relatively closed, and why low credibility institutions such as the Reserve Bank of New Zealand and Banco d'España *need to* be very open and need to publish *e.g.* inflation and monetary policy reports of some kind, in addition to standard bank bulletins. Put differently, we clarify why "nouveau riche" institutions with poor credibility "talk", and why institutions that have a great "wealth" of credibility can afford to whisper.

The chapter is organized into three remaining sections followed by four appendices. In section 2 we present the model. Section 3 contains the derivation of the relationship between central bank secrecy, i.e. monetary policy uncertainty, and social welfare. In section 4 we look at three different cases with respect to the effects of monetary policy uncertainty. Our conclusions are given in section 5. The appendices provide the derivations of the policy outcomes, a generalization of the model and the optimal degree of central bank secrecy.

5.2 The Model

In what follows, we model monetary policy uncertainty as a monetary policy game with uncertainty about the central bank's inflation stabilization preferences. We assume that there are two types of actors, *wage-setters* and the *central bank*. Wage-setters unilaterally choose the nominal wage every period, and the central bank controls monetary policy. The sequence of events is as follows. In the first stage, wage-setters sign one period nominal wage contracts [Gray (1976), Fischer (1977)]. Wage-setters know the domestic monetary regime *on average* but there are random shocks to central bank preferences that cannot be observed at the time wage contracts are signed. However, they know the variance of the shocks and take this information into account in forming their expectations. In the second stage a stochastic shock to the central bank's preferences realizes. In the third stage stochastic shocks to productivity realize. Similarly these shocks cannot be observed at the time contracts are negotiated. As will be shown below, the uncertainty associated with the second and third stages of the game is, respectively, of the *multiplicative* [Brainard (1967)] kind and the *additive* kind. In the fourth stage, the central bank observes the value of the productivity shock and, given its own preferences, reacts to the productivity shocks accordingly. In the fifth and final stage, competitive firms determine output. This timing of events is summarized in Figure 5.1.

Figure 5.1 The Timing of Events

1	2	3	4	5
Nominal wage contracts signed	Shocks to CB preferences realize	Productivity shocks realize	CB sets monetary policy	Output determined

5.2.1 Uncertainty about Inflation Stabilization Preferences

Adopting the specification commonly used in the literature, output is described by a reduced-form Lucas supply function:

$$y = b(\pi - \pi^e) + v \qquad \textbf{(5.1)}$$

where y is (the log of) output, inflation is denoted by π, nominal wage contracts signed at time t-1 are proxied by the expected inflation rate π^e, v is a white noise shock to productivity with zero mean and variance σ_v^2 and b is the slope of the Phillips curve. The natural level of output is normalized at zero. Society's loss function is given by

$$S = \alpha\,\pi^2 + (y - y^*)^2 \qquad 0 \le \alpha < \infty \qquad \textbf{(5.2)}$$

where α is society's relative weight of inflation stabilization relative to output stabilization. We assume that $y^* > 0$ so that the desired level of output is above the natural level. The central bank's loss function is

$$L = a_t \pi^2 + (y - y^*)^2 \qquad 0 < a_t < \infty \qquad \textbf{(5.3)}$$

Note that in both loss functions the target rate of inflation is normalized to 0. In contrast to Cukierman and Meltzer (1986) (hereafter CM), deviations from the output target feature quadratically in the central bank's loss function. This gives the central bank a role in stabilizing supply shocks. Moreover, unlike CM, this feature will enable us to establish a link between preference uncertainty and the *level* of inflation, even with a zero degree of persistence in the central bank's preferences. Equation **(5.4)** specifies the stochastic behavior[1] of the parameter a_t

$$a_t = \bar{a} - x_t \qquad \text{with} \quad \mathrm{Var}[x_t] = \sigma_x^2,\ E_{t-1}[x_t] = 0 \text{ and } E_{t-1}[v x_t] = 0 \qquad \textbf{(5.4)}$$

The wage setters expect the central bank's preference for inflation stabilization to be $\bar{a}$. However, at any particular point in time because of the shock x_t, the central bank may be overly "conservative" or advocate too loose a monetary stance (be too "liberal"). A shock to the central bank's preferences may occur if monetary policy is set by a monetary policy board with changing membership, as *e.g.* the FOMC in the US and the Zentralbankrat in

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1 Cukierman and Meltzer (1986) introduce persistence and dynamize their problem by letting $a_t = \alpha - e_t$ where $e_t = \rho e_{t-1} + x_t$ and $0 < \rho < 1$. Because - unlike their analysis - we do not require the stochastic central bank preferences to be serially correlated for secrecy to be desirable we set $\rho = 0$.

Germany. One might argue that the state of the economy or the realization of the productivity shock v influences the appointment of new members. During a recession there may be political pressure to appoint a more "liberal" member to the monetary policy board. This implies that the assumption that $E_{t-1}[vx_t] = 0$ does not hold. However, changing this assumption will not qualitatively change our results.

We see the variance of the agent's inflation stabilization preferences (σ_x^2) as monetary policy uncertainty. In the limiting case that $\sigma_x^2 = 0$ (and $a_t = \bar{a}$), we are back in the original Rogoff (1985a) model. Importantly, the distribution of x_t must be chosen in such a way that a_t is always positive. A negative preference weight on inflation implies a central banker who actually loves inflation and therefore will set an infinite rate of inflation. If the wage setters know that there is a positive chance of having a central banker who loves inflation, this probability, however small, will count heavily in the formation of inflationary expectations. Although there is no need to specify the distribution of x_t, one could think of it to be uniformly distributed on the [$-h$, h] interval with $h < \bar{a}$. A normal distribution clearly doesn't work here, because of its infinite support we can never exclude the chance that a large shock occurs and a_t becomes negative.

5.2.2 Time-Consistent Equilibrium

For simplicity, and with no loss of generality, we assume that the control variable of the central bank is inflation. Substituting **(5.1)** into **(5.3)**, the first-order conditions for a minimum indicate

$$\pi = \frac{b}{a_t + b^2}(b\pi^e + y^* - v) \qquad \textbf{(5.5)}$$

where $y^* > 0$. Solving for rational expectations yields[2]

[2] See Appendix A for details on the derivations in this Section.

$$\pi^e = \Phi(.)\frac{b}{a}y^* \tag{5.6}$$

where

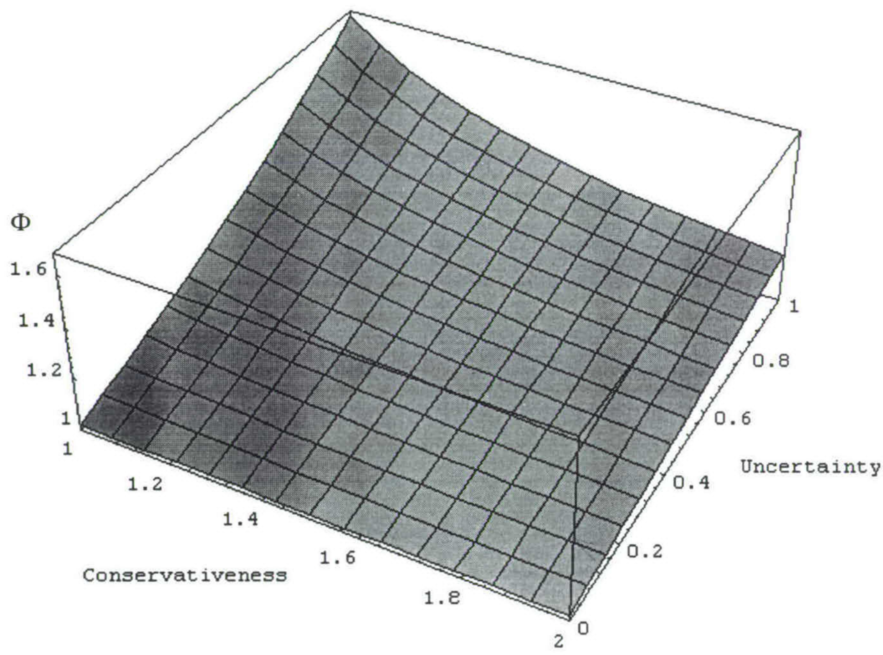
$$\Phi(.) = \frac{\bar{a}[(\bar{a}+b^2)^2 + \sigma_x^2]}{\bar{a}(\bar{a}+b^2)^2 - b^2\sigma_x^2} \tag{5.7}$$

This function $\Phi(.)$ is shown graphically in Figure 5.2 with b = 1. In order to ensure that $\Phi(.) > 0$, we require that $\sigma_x^2 < \frac{\bar{a}(\bar{a}+b^2)^2}{b^2}$. Note that for x_t uniformly distributed on the interval [$-h$, h], if $h < \bar{a}$, this condition is always satisfied. The exact specification of Φ depends on the assumptions one makes. Details can be found in Appendix B.
For the case without preference uncertainty, it is straightforward to derive the expected rate of inflation under discretion

$$\pi^e = \frac{b}{a}y^* \tag{5.8}$$

Comparing **(5.6)** and **(5.8)**, we can clearly see the effect of preference uncertainty on the expected rate of inflation.

Figure 5.2: The function Φ



Equations **(5.6)** and **(5.8)** indicate that inflation expectations are proportional to the output bias, y^*, a familiar conclusion in this literature. However **(5.6)** differs in a significant way from **(5.8)**, as a result of uncertainty regarding the central bank's preferences.

From **(5.7)**, it is clear that, if the variance is not too large,[3] $\Phi(.) > 0$. Moreover, as can be seen in Figure 5.2, in the limiting case that $\sigma_x^2 = 0$ and therefore $a_t = \bar{a}$, then $\Phi(.) = 1$, and **(5.6)** effectively collapses to the discretionary case given by **(5.8)**.

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3 $\sigma_x^2 < \frac{\bar{a}(\bar{a}+b^2)^2}{b^2}$, see equation **(5.7)**. This condition is satisfied if x_t is uniformly distributed on the interval $[-h, h]$ and if $h < \bar{a}$.

Using the previous results, it is straightforward to write the final solutions for output and inflation, under the case of uncertainty about inflation stabilization preferences. The expression for the rate of inflation becomes

$$\pi_t = \frac{b}{a_t + b^2}\left[1 + \frac{b^2}{\bar{a}}\Phi(.)\right]y^* - \frac{b}{a_t + b^2}v_t \tag{5.9}$$

And similarly for output, the solution is

$$y_t = b(\pi_t - \pi^e) + v_t \tag{5.10}$$

An important point arising from **(5.9)** is that although preference uncertainty exacerbates the existing inflation bias problem, it cannot generate an inflation bias on its own. This fairly intuitive point is clearly a function of the multiplicative nature of the problem.

Figure 5.3: The Central Bank's Reaction to a Preference Shock x

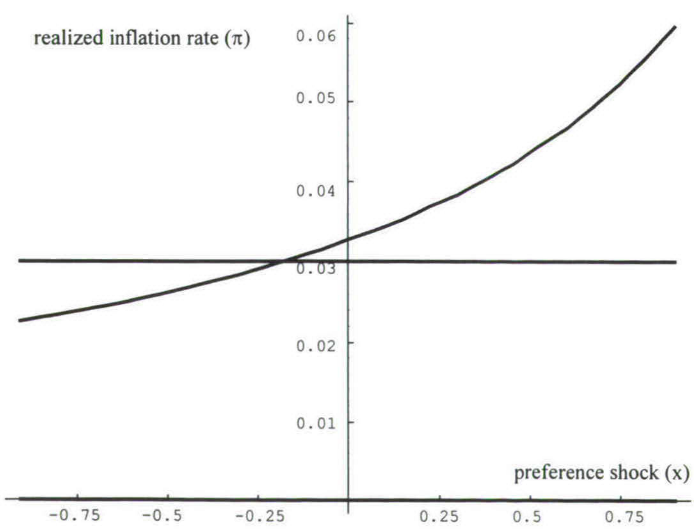

Figure 5.3 shows the central bank's reaction to a preference shock x with the parameters $\bar{a}$ = 1, b = 1, y^* = 0.03 and the productivity shock $v = 0$. A *positive* preference shock makes the central banker less conservative and leads to a higher rate of inflation. Conversely, a *negative* preference shock makes the central banker more conservative and leads to a lower rate of inflation. However, the effect of positive and negative preference shocks on the rate of inflation is asymmetric. More specific, positive realizations of shock x - more emphasis on output stabilization - are *more inflationary* than negative realizations of shock x - more emphasis on inflation stabilization - are *disinflationary*. With equal probabilities of positive and negative shocks to the central banker's preferences[4], expected inflation will be adjusted upwards and the more so the higher the variance of the shocks hitting the central bank's preferences. Therefore, it is clear that with uncertain preferences, expected inflation is higher than in the discretionary case without uncertainty.[5] This can be restated in a more technical way by noting that the expectation of inflation involves the expectation of a convex function (i.e. equation **(5.5)**) of the preference shock, which will always be *higher* than the value of this function at the (zero) expected value of the preference shock. Hence our result is general and follows from Jensen's inequality.[6] Please note that, unlike CM, this effect is present even with a zero degree of persistence in the central bank's objectives. The reason is that in our model, unlike CM, output enters the central bank's utility function *quadratically*. This, together with the rational expectations hypothesis gives rise to the Jensen's inequality effect. The Jensen's inequality effect is not present in the CM model because there economic activity features linearly in the central bank's objective function.

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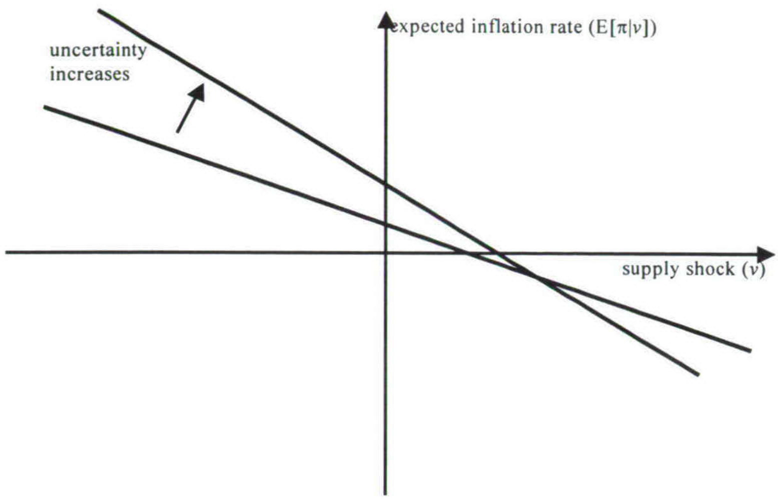
4 However, results do not depend on a particular distribution of the disturbances to the agent's preferences.

5 In the certainty case, the central bank would set an inflation rate of 3%.

6 Let a_t be a random variable with mean $\bar{a}$, and let $g(a_t) := \dfrac{b}{a_t + b^2}$ be a convex function; then $E[g(a_t)] \geq g(\bar{a})$.

Figure 5.4 The Central Bank's Expected Reaction Function with Uncertainty



A similar picture to Figure 5.3 can be drawn for the central bank's reaction to a given productivity shock v. The higher the variance of preference shocks, the stronger the expected reaction to supply shocks, i.e. the higher the expected monetary accommodation of any supply shock. Note that the effect of more uncertainty on expected inflation is the same as the effect of less conservativeness (a lower $\bar{a}$). As is shown in Figure 5.4, more uncertainty about the central banker's preferences rotates the expected reaction function in the same way as less conservativeness would do.

5.3 The Welfare Loss and Monetary Policy Uncertainty

Using the policy outcomes that we derived in the previous section, we can now turn to welfare analysis. Previous studies, in particular Nolan and Schaling (1996) and Lossani, Natale and Tirelli (1998) have argued that uncertainty about the policymaker's preferences leads unambiguously to lower social welfare. We find, however, that this is not necessarily the case. Monetary policy uncertainty may improve output stabilization and as a result the welfare loss may well be lower.

In order to assess the effect of monetary policy uncertainty on welfare, we decompose society's expected loss in the inflationary bias, the variance of inflation, the output bias and the variance of output.

$$E\{S\} = \alpha E\{\pi_t^2\} + E\{(y - y^*)^2\} = \alpha(\pi^{e2} + Var\{\pi_t\}) + y^{*2} + Var\{y_t\} \qquad \textbf{(5.11)}$$

Straightforward comparative statics demonstrate that rising uncertainty does increase the inflationary bias. That is

$$\frac{\partial \pi^e}{\partial \sigma_x^2} = \frac{\partial \Phi(.)}{\partial \sigma_x^2}\frac{b}{\bar{a}}y^* > 0 \qquad \textbf{(5.12)}$$

because

$$\frac{\partial \Phi(.)}{\partial \sigma_x^2} = \frac{\bar{a}(\bar{a}+b^2)^3}{\left[\bar{a}(\bar{a}+b^2)^2 - b^2\sigma_x^2\right]^2} > 0 \qquad \textbf{(5.13)}$$

The interpretation of this expression, which is unambiguously positive, follows on from our remarks above. To the extent that increasing uncertainty threatens agents' real wages, they will build in an inflation rate hedge into their nominal contracts. Similarly,

$$\frac{\partial^2 \Phi(.)}{(\partial \sigma_x^2)^2} = \frac{2b^2\bar{a}(\bar{a}+b^2)^3}{\left[\bar{a}(\bar{a}+b^2)^2 - b^2\sigma_x^2\right]^3} > 0 \qquad \textbf{(5.14)}$$

as long as $\bar{a}(\bar{a}+b^2)^2 - b^2\sigma_x^2 > 0$, which is exactly the condition we imposed on the variance of the shocks to preferences in the context of equation **(5.7)**. Thus, the inflation penalty becomes steeper the higher monetary policy uncertainty.

From **(5.12)** and **(5.13)** we derive the following proposition:

Proposition 5.1: The greater monetary policy uncertainty (the higher σ_x^2), the higher expected inflation.

Proposition 5.1 shows that monetary policy uncertainty leads to higher inflationary expectations.

As is shown in Appendix C the variance of inflation can be found to be

$$Var\{\pi\} = \frac{b^2\sigma_v^2}{(\bar{a}+b^2)^2}\left[1+\frac{3\sigma_x^2}{(\bar{a}+b^2)^2}\right] + \frac{\sigma_x^2}{(\bar{a}+b^2)^4}\left[by^*\left(1+\frac{b^2}{\bar{a}}\Phi\right)\right]^2 \qquad \textbf{(5.15)}$$

As $\Phi(.)$ is a positive function of σ_x^2, it is clear that the variance of inflation increases with monetary policy uncertainty.

Therefore, $\frac{\partial Var\{\pi\}}{\partial \sigma_x^2} > 0$, and we have

Proposition 5.2: The greater monetary policy uncertainty (the higher σ_x^2), the higher the variance of inflation.

This result is very intuitive. Introducing a shock to the parameter that determines inflation stabilization yields a more volatile rate of inflation. Propositions 5.1 and 5.2 also imply a positive relationship between the mean and the variance of inflation. This is in line with a large body of empirical evidence that suggests that the mean level and the variability of inflation are positively correlated across countries (Cukierman 1992, p.180, Eijffinger and De Haan, 1996 and Davis and Kanago, 1998).

To complete the welfare analysis, we now turn to the variance of output, which is the most interesting part. Output variance can easily be calculated from **(5.10)** and **(5.15)**

$$Var\{y\} = \frac{\bar{a}^2}{(\bar{a}+b^2)^2}\sigma_v^2 + \frac{b^2\sigma_x^2}{(\bar{a}+b^2)^4}\left\{\left[by^*\left(\frac{b^2}{\bar{a}}\Phi+1\right)\right]^2 + (b^2-2\bar{a})\sigma_v^2\right\} \qquad \textbf{(5.16)}$$

Again, the first term does not depend on monetary policy uncertainty, but on the variance of supply shocks σ_v^2. However, the second term depends on monetary policy uncertainty through σ_x^2 and $\Phi(.)$. Interestingly, the second part of the equation can be negative if the central bank's expected conservativeness and the variance of productivity shocks σ_v^2 is large and the principal's output target y^* rather low. This means that monetary policy uncertainty can have a stabilizing effect on output. From equation **(5.16)** we derive the following proposition (see Appendix D):

Proposition 5.3: If $\frac{y^{*2}}{\sigma_v^2} < \frac{\bar{a}^2(2\bar{a}-b^2)}{b^2(\bar{a}+b^2)^2}$, the variance of output is minimized at a positive level of preference uncertainty.

The expression for the variance of output also shows that the positive stabilizing effect of monetary policy uncertainty depends on the variance of supply shocks. If the variance of supply shocks σ_v^2 is large enough, uncertainty about the central bank's inflation stabilization preferences leads to a *lower* variance of output. The reason for this surprising effect can be seen from Figure 5.4. The monetary authority's expected reaction to a supply shock is stronger, the larger monetary policy uncertainty. So, in effect an increase in monetary policy uncertainty leads to less conservative behavior of the central bank.

The overall effect on welfare is not easily determined. Looking at equations **(5.6)**, **(5.15)** and **(5.16)**, it is clear that the negative welfare effects of monetary policy uncertainty are increasing in the principal's ambitious output target y^* and independent from the variance of productivity shocks σ_v^2. For the positive output stabilization effect exactly the opposite holds. So, if the ratio y^{*2} / σ_v^2 is small (and, therefore, the credibility problem small relative to the flexibility problem), society may benefit from uncertainty about the policymaker's preferences.

5.4 Optimal Monetary Uncertainty

As was explained in the previous section monetary policy uncertainty may be *beneficial* for society's welfare because the variance of output may be reduced. This implies that the trade off between credibility and flexibility is influenced by uncertainty concerning the agent's preferences. In this Section we will determine the optimal level of monetary policy uncertainty in terms of social welfare. Society's expected loss is given by the following expression[7]

$$E\{S\} = y^{*2} + \underbrace{\frac{\alpha b^2 y^{*2}}{\bar{a}^2}\Phi^2}_{\Pi} + \underbrace{\frac{(\alpha b^2 + \bar{a}^2)}{(\bar{a}+b^2)^2}\sigma_v^2 + \frac{\sigma_x^2 b^2}{(\bar{a}+b^2)^4}\left[y^{*2}(\alpha+b^2)\left(\frac{b^2}{\bar{a}}\Phi+1\right)^2 - 2(\bar{a}+b^2)\sigma_v^2 \right]}_{\Gamma} \quad \textbf{(5.17)}$$

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[7] It can be obtained by substituting **(5.6)**, **(5.15)** and **(5.16)** in **(5.11)**.

Figure 5.5: The Optimal Degree of Monetary Uncertainty

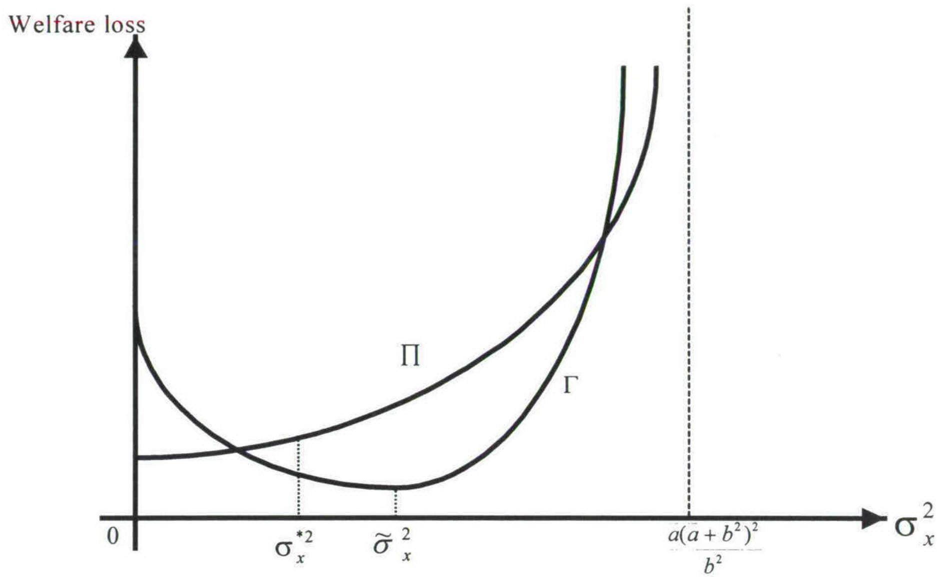

Figure 5.5 shows the credibility component (Π) and the stabilization or flexibility component (Γ) of society's loss. The Π component, reflecting the inflationary bias, is upward sloping because greater monetary uncertainty implies a higher rate of expected inflation (see Proposition 5.1). However, the Γ component, reflecting the variance of inflation and output, is downward sloping and has a minimum at $\tilde{\sigma}_x^2$ (see Appendix D). This reflects Proposition 5.3 which states that greater monetary policy uncertainty may reduce the variance of output and hence society's loss. Figure 5.5 shows that the social loss function S is minimized at σ_x^{*2}. If the credibility/flexibility ratio y^{*2} / σ_v^2 is not too large, the social loss is minimized at a positive level of monetary uncertainty. This is formalized in our next proposition (see Appendix D):

Proposition 5.4: It is optimal for society to have a central bank with uncertain preferences ($\sigma_x^{*2} > 0$) if and only if $\frac{y^{*2}}{\sigma_v^2} < \frac{\bar{a}^3(2\bar{a} - b^2 - 3\alpha)}{(\bar{a} + b^2)^2(\bar{a}b^2 + 3\bar{a}\alpha + 2b^2\alpha)}$.

As can be seen in the picture, $\tilde{\sigma}_x^2$ is an upper bound for the optimal degree of monetary uncertainty. As is shown in Appendix D, this upper bound shifts to the right if the credibility/flexibility ratio y^{*2} / σ_v^2 becomes smaller. This leads to the next proposition:

Proposition 5.5: The optimal degree of monetary uncertainty σ_x^{*2} has an upper bound $\tilde{\sigma}_x^2$ ($\sigma_x^{*2} \leq \tilde{\sigma}_x^2$). This upper bound goes up if the credibility/flexibility ratio y^{*2} / σ_v^2 becomes smaller.

From Proposition 5.4 it can be seen that if society does not care about output stabilization at all - that is if α approaches positive infinity - it is never optimal to have central bank secrecy. The reason is that in this case the beneficial effects of preference uncertainty, i.e. output stabilization, are not valued by society. This can be restated in a more technical way by noting that if $\alpha \to \infty$ the right hand side of the inequality approaches zero. With y^{*2} and σ_v^2 both positive, the inequality will not be satisfied, implying that the optimal degree of central bank secrecy is zero.

We now focus on the more realistic case where society does value output stabilization, meaning that α is both positive and finite. Then it follows that for central bank secrecy to be desirable, the severity of society's time-consistency or credibility problem y^{*2}, should not be too large relative to its need for stabilization policy σ_v^2.

At this point it is interesting and illuminating to contrast our result with Cukierman and Meltzer (1986). Like CM, we find that for central bank secrecy to be desirable three conditions need to be satisfied. First, society must value unanticipated inflation (monetary surprises); i.e. it should not focus exclusively on inflation stabilization. Second, the central bank's preferences must be stochastic. Third, society's credibility problem should not be too pressing, relative to its need for a flexible response to supply shocks. The first two conditions need also be satisfied in CM for secrecy to be beneficial. That is, the monetary authority must value surprises and the monetary authority's preferences must be partly private information. The third condition in CM is that stochastic central bank preferences must be *serially correlated*. To conclude, the main difference between our chapter and CM is that we do not require stochastic central bank preferences to be serially correlated for secrecy to be desirable.

5.5 Conclusions

In this chapter we have analyzed the effects of monetary policy uncertainty on social welfare. We focus on expected inflation and the variance of inflation and output. Five propositions are derived in the chapter. The first one states that more uncertainty about the policymaker's preferences leads to a higher inflationary bias. This is due to the fact that a central banker with uncertain preferences is perceived as less conservative by wage setters. The second proposition states that more monetary policy uncertainty leads to a higher variance of inflation. Intuitively, it is clear that the variance in the central banker's preferences feed through in a more volatile rate of inflation. Proposition 5.1 and 5.2 are in line with a large body of empirical evidence that suggests that the mean and variance of the inflation rate are positively correlated across countries. Our third proposition is that a country with a serious flexibility problem relative to the credibility problem may reduce its variance of output by appointing a central banker with uncertain preferences. Fourthly, combining the three other propositions, we find that a country that faces large supply shocks in relation to its output target may be better off with a central banker that has uncertain preferences. This is due to the fact that the average response of the policymaker to a supply shock is stronger than in the absence of preference shocks. Finally, the fifth proposition derives comparative static properties for the upperbound of the optimal level of monetary uncertainty.

To conclude, optimal central bank secrecy involves trading-off the harmful effects of uncertainty about monetary policy and the associated higher expected inflation versus the potentially beneficial effects on the stabilization of output. The latter trade-off depends on the severity of society's time-consistency problem vis-à-vis its need for stabilization policy. The analysis predicts that if the credibility problem is large relative to the need for flexibility, optimal central bank institutions will be very open and transparent and vice versa. Moreover it explains why high credibility institutions such as the Bundesbank and the future European Central Bank (ECB), *can afford* to be relatively closed, and why low credibility institutions such as the Reserve Bank of New Zealand and Banco d'España *need to* be very open and need to publish *e.g.* inflation and monetary policy reports of some kind, in addition to standard bank bulletins. Put differently, we clarify why "nouveau riche" institutions with poor credibility "talk", and why institutions that have a great "wealth" of credibility can afford to whisper.

5.6 Appendices

A. The Derivation Of Equation **(5.6)**

Taking expectations across expression **(5.5)**:

$$E(\pi) = E\left(\frac{1}{a_t + b^2}\right) b(b\pi^e + y^*) \tag{A.1}$$

This expression requires us to take the expected value of ratios of the inverse of a random variable. This can be achieved through a Taylor series expansion.

Our problem is to expand X/Y about the respective means. Assuming that the first two moments of $E(X/Y)$ exist then we can write down the expression:

$$E\left(\frac{X}{Y}\right) \approx \frac{\mu_X}{\mu_Y} - \frac{1}{\mu_Y{}^2}\operatorname{cov}[X,Y] + \frac{\mu_X}{\mu_Y{}^3}\operatorname{var}[Y] \tag{A.2}$$

This is the (second-order) approximation used in the chapter, therefore we can write

$$E\left(\frac{1}{a_t + b^2}\right) \approx \frac{(\bar{a} + b^2)^2 + \sigma_x^2}{(\bar{a} + b^2)^3}. \tag{A.3}$$

So substituting **(A.3)** in **(A.1)** gives

$$\pi^e = (by^* + b^2\pi^e)\frac{[(\bar{a} + b^2)^2 + \sigma_x^2]}{(\bar{a} + b^2)^3} \tag{A.4}$$

And rearranging gives

$$\pi^e = \frac{by^*}{\bar{a}}\left(\frac{\bar{a}(\bar{a} + b^2)^2 + \sigma_x^2}{\bar{a}(\bar{a} + b^2)^2 - b^2\sigma_x^2}\right) \tag{A.5}$$

which is expression **(5.6)** in the text. It is clear that as $\sigma_x^2 \to 0$ the first part of the expression on the right hand side collapses to unity, and **(A.5)** is equivalent to **(5.8)**.

B. The General Case

If we replace the central bank's loss function **(5.3)** with a more general loss function, the expected rate of inflation changes in the following way.

$$L = a_t \pi^2 + q_t (y - y^*)^2 \qquad \textbf{(B.1)}$$

$a_t = \bar{a} - x_t$ with $Var[x_t] = \sigma_x^2$ and $E_{t-1}[x_t] = 0$

$q_t = \bar{q} - \omega_t$ with $Var[\omega_t] = \sigma_\omega^2$, $E_{t-1}[\omega_t] = 0$ and $E_{t-1}[x_t \omega_t] = \sigma_{x\omega}$

Using the derivations from Appendix A we obtain an expression for the inflationary expectations.

$$\pi^e = \left(\frac{\bar{q}(\bar{a} + b^2 \bar{q})^2 + R}{\bar{a}(\bar{a} + b^2 \bar{q})^2 - b^2 R} \right) \cdot by^* \text{ with } R \equiv \bar{q}\sigma_x^2 - \bar{a}b^2\sigma_\omega^2 - (\bar{a} - \bar{q}b^2)\sigma_{x\omega}$$

We choose $\bar{q} = 1$ and $\sigma_\omega^2 = \sigma_{x\omega} = 0$ so that $R = \sigma_x^2 > 0$ and monetary policy uncertainty leads to higher inflationary expectations.

Beetsma and Jensen (1998) choose $b = 1$ and $\sigma_x^2 = \sigma_\omega^2 = -\sigma_{x\omega}$ so that $R = 0$ and monetary policy uncertainty has no effect on inflationary expectations.

C. The Variance of Inflation

$$\pi_t = \frac{1}{a_t + b^2}\left[by^*\left(1+\frac{b^2}{\bar{a}}\Phi\right) - bv\right] \qquad \textbf{(C.1)}$$

With $X = \frac{1}{a_t + b^2}$ and $Y = by^*\left(1+\frac{b^2}{\bar{a}}\Phi\right) - bv$, X and Y are independent and the variance of XY can be written as

$$Var\{XY\} = \mu_Y^2 Var(X) + \mu_X^2 Var(Y) + Var(X)Var(Y) \qquad \textbf{(C.2)}$$

With $E\left(\frac{1}{a_t + b^2}\right) \approx \frac{(\bar{a}+b^2)^2 + \sigma_x^2}{(\bar{a}+b^2)^3}$ and $Var\left(\frac{1}{a_t + b^2}\right) \approx \frac{\sigma_x^2}{(\bar{a}+b^2)^4}$ we find that

$$Var\{\pi\} \approx \frac{b^2\sigma_v^2}{(\bar{a}+b^2)^2}\left[1 + \frac{3\sigma_x^2}{(\bar{a}+b^2)^2} + \frac{\sigma_x^4}{(\bar{a}+b^2)^4}\right] + \frac{\sigma_x^2}{(\bar{a}+b^2)^4}\left[by^*\left(1+\frac{b^2}{\bar{a}}\Phi\right)\right]^2. \qquad \textbf{(C.3)}$$

For the sake of simplicity we approximate further and find

$$Var\{\pi\} \approx \frac{b^2\sigma_v^2}{(\bar{a}+b^2)^2}\left[1 + \frac{3\sigma_x^2}{(\bar{a}+b^2)^2}\right] + \frac{\sigma_x^2}{(\bar{a}+b^2)^4}\left[by^*\left(1+\frac{b^2}{\bar{a}}\Phi\right)\right]^2 \qquad \textbf{(C.4)}$$

D. Optimal Central Bank Secrecy

1. Condition when preference uncertainty is desirable for the variance of output

In order to derive a necessary and sufficient condition for preference uncertainty to be desirable for the variance of output, we evaluate the first derivative of the variance of output in the point $\sigma_x^2 = 0$.

$$\lim_{\sigma_x^2 \to 0} \frac{\partial Var(y)}{\partial \sigma_x^2} = \frac{b^2 (y^{*2} b(\bar{a} + b^2)^2 + \bar{a}^2 (b^2 - 2\bar{a})\sigma_v^2)}{\bar{a}^2 (\bar{a} + b^2)^4} \qquad \textbf{(D.1)}$$

If the expression in **(D.1)** is *negative*, then the variance of output is minimized for $\sigma_x^2 > 0$. This condition can be rewritten as:

$$\frac{b^2 (y^{*2} b(\bar{a} + b^2)^2 + \bar{a}^2 (b^2 - 2\bar{a})\sigma_v^2)}{\bar{a}^2 (\bar{a} + b^2)^4} < 0 \Leftrightarrow \frac{y^{*2}}{\sigma_v^2} < \frac{\bar{a}^2 (2\bar{a} - b^2)}{b^2 (\bar{a} + b^2)^2} \qquad \textbf{(D.2)}$$

2. Condition when preference uncertainty is desirable for social welfare S ($\sigma_x^{*2} > 0$)

Along similar lines as the previous condition, we can derive:

$$\lim_{\sigma_x^2 \to 0} \frac{\partial S}{\partial \sigma_x^2} < 0 \Leftrightarrow \frac{y^{*2}}{\sigma_v^2} < \frac{\bar{a}^3 (2\bar{a} - b^2 - 3\alpha)}{(\bar{a} + b^2)^2 (\bar{a} b^2 + 3\bar{a}\alpha + 2b^2\alpha)} \qquad \textbf{(D.3)}$$

3. The determination of $\tilde{\sigma}_x^2$

As said before it is crucial to find out where Γ is minimized. From the first-order condition at this point its first derivative will be zero. This first-order condition can be written as

$$\frac{\partial \Upsilon}{\partial \sigma_x^2} = 0 \Leftrightarrow \sigma_x^2 = G(\sigma_x^2) \qquad \textbf{(D.4)}$$

where

$$G(\sigma_x^2) \equiv \frac{(2\bar{a} - b^2 - 3\alpha)\sigma_v^2 \left(\bar{a}(\bar{a} + b^2)^2 - b^2\sigma_x^2\right)^3}{b^2 y^{*2}(\bar{a} + b^2)^6 (b^2 + \alpha)} - \frac{\bar{a}(\bar{a} + b^2)^2}{b^2} \qquad \textbf{(D.5)}$$

If the credibility-flexibility ratio $\frac{y^{*2}}{\sigma_v^2} \leq \frac{\bar{a}^2(2\bar{a} - b^2 - 3\alpha)}{(\bar{a} + b^2)(b^2 + \alpha)}$ a solution for $\tilde{\sigma}_x^2$ exists and is unique. To see this we use Brouwer's fixed point theorem. If the credibility-flexibility ratio is not too large

$$G(0) = \frac{\bar{a}\left(\sigma_v^2 \bar{a}^2 (2\bar{a} - b^2 - 3\alpha) - (\bar{a} + b^2) y^{*2} (b^2 + \alpha)\right)}{b^2 y^{*2} (b^2 + \alpha)} \geq 0 \text{ and}$$

$G\left(\frac{\bar{a}(\bar{a} + b^2)^2}{b^2}\right) = -\frac{\bar{a}(\bar{a} + b^2)^2}{b^2} < 0$. Together with G being a monotonically decreasing function of σ_x^2 we are now ready to prove

$0 \leq \tilde{\sigma}_x^2 \leq G(0)$.

Proof: The left-hand side of equation **(D.4)** is a 45° line through the origin. This line must intersect the function G at one and only one point that is bounded between 0 and G(0).

4. Demonstration that $\frac{\partial \tilde{\sigma}_x^2}{\partial \left(\frac{\sigma_v^2}{y^{*2}}\right)} > 0$.

From **(D.4)** it follows that $\frac{\partial G(\sigma_x^2)}{\partial\left(\frac{\sigma_v^2}{y^{*2}}\right)} > 0$. This implies that if the credibility-flexibility ratio goes down, the function $G(\sigma_x^2)$ shifts upward. As a consequence, the equilibrium value of $\tilde{\sigma}_x^2$ increases.

6 Incentive Contracts for Central Bankers under Uncertainty

6.1 Introduction

In the literature on reform of monetary institutions two ways have been advocated to reach low inflation. A survey of this literature can be found in Eijffinger and De Haan (1996). The first is the *legislative* approach, i.e. to establish by law an independent central bank with an exclusive mandate for price stability. The major academic contribution in this area is Rogoff (1985a). Rogoff develops a model in where monetary policy is delegated to a central banker (the *agent*) who is more inflation averse than society (the *principal*). The result is a lower inflation rate, but this is at the expense of a distorted response to output shocks. Thus, the Rogoff model features the famous *credibility-flexibility* trade-off.
The second is the *targeting* or *contracting* approach to monetary policy. The idea is to let the political principal of the central bank impose an explicit inflation target for monetary policy and make the central bank governor explicitly accountable for his success in meeting this target. Academic contributions in this area are Persson and Tabellini (1993), Walsh (1995) and Svensson (1997a). Walsh has shown that an optimal linear inflation contract can eliminate the inflationary bias without distorting stabilization policy. Thus the credibility-flexibility trade-off is eliminated[1] and makes inflation targeting superior to Rogoff's conservative central banker. Moreover, Svensson (1997a) has shown that the linear contract can be mapped into an optimal *inflation target*. This means that these delegation arrangements are *equivalent*. They are both able to produce the pre-commitment outcome. However, both Walsh (1995) and Svensson (1997a) on the one hand, and Rogoff (1985a) on the other assume *symmetric information* in the principal-agent relationship. More specific,

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1 However, McCallum (1995) argues that the Walsh contract merely shifts the credibility problem from the policymaker to the principal.

they assume that both the political principal and the private sector know the central banker's preferences.

This assumption was abandoned by Herrendorf and Lockwood (1997) and - most recently - by Beetsma and Jensen (1997).

Building on the contracting approach, Herrendorf and Lockwood (1997) demonstrated that if a monopolistic trade union has more information about productivity shocks than the principal, maximum social welfare can be achieved by having a conservative central banker with perverse preferences *on top o*f the contract. Thus, - notwithstanding an optimal contract - Rogoff's conservative central banker is restored.

Beetsma and Jensen (1997), building on earlier work on preference uncertainty by Briault, Haldane and King (1996) and Nolan and Schaling (1996), derive the very interesting result that - if the private sector and the political principal have imperfect information about the central banker's preferences - the equivalence between the linear Walsh contract and the Svensson inflation target breaks down. They show that the optimal linear inflation contract performs strictly better than the optimal inflation target when there is uncertainty about the central banker's preferences.

However, they model the central banker's preference uncertainty as 'pure' uncertainty. This implies that in their model there is no effect from preference uncertainty on the private sector's inflation expectations. Thus, inflation expectations are invariant to this kind of monetary policy uncertainty.

In this chapter, building on earlier work in this area[2], we investigate the effects of relaxing this restriction. Using a model that is otherwise similar to theirs, we find results that are very different - and sometimes - exactly the opposite - of the Beetsma and Jensen (1997) model.

For instance, we find that it is optimal for the government to impose an inflation target on the central bank which depends on the degree of uncertainty about its preferences. This is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal inflation target does *not* depend on the degree of preference uncertainty and is the same as in the Svensson

2 In particular Nolan and Schaling (1996).

(1997a) model. Therefore here - contrary to BJ - certainty equivalence does *not* hold, and the optimal inflation target with uncertain central bank preferences does *not* correspond to the optimal target derived by Svensson (1997a) in the absence of uncertainty about central bank preferences.

Further, for the case of the Walsh contract we find that it is optimal to offer a linear inflation contract to a central banker that does *not* depend on the degree of uncertainty about its preferences. Again, this is in sharp contrast to Beetsma and Jensen (1997) (hereafter BJ), who find that the optimal linear contract *does* depend on the degree of preference uncertainty. Here our result is the same as in Walsh (1995) for the case *without* preference uncertainty. Hence, certainty equivalence *does* hold and the optimal linear inflation contract with uncertain central bank preferences is *identical* to the optimal Walsh contract in the absence of uncertainty about central bank preferences.

Finally, we find that in case of uncertain central banker preferences the *optimal* delegation arrangement is a combination of a linear inflation contract and a *quadratic contract*. Here the quadratic contract is equivalent to a Rogoff (1985a) conservative central banker. Again, this is different from Beetsma and Jensen (1997), who find that a combination of a linear inflation contract, an *inflation target* and a quadratic contract performs best.

Moreover, our result is in line with Herrendorf and Lockwood (1997), and hence suggests that their 'restoration' of Rogoff appears to be a very robust result indeed.

The chapter is organized into six remaining sections followed by four appendices. In Section 2 we present the model. Section 3 looks at the optimal inflation target. In Section 4 we examine the linear inflation contract. Section 5 compares the inflation target with the linear contract. Section 6 considers quadratic contracts. Our conclusions are given in Section 7. The appendices provide the derivation of inflation expectations in the presence of non-linearities, the optimal inflation target, the optimal linear contract and the characterization of quadratic contracts.

6.2 The Model

We use a standard credibility model [Walsh (1995), Svensson (1997a)]. In line with the credibility literature output is described by a standard reduced-form Lucas supply function:

$$y = \pi - \pi^e + v \qquad \textbf{(6.1)}$$

where y is (the natural log of) output; inflation is denoted by π and nominal wage contracts signed at time t-1 are proxied by the private sector's expected inflation rate. v is a supply shock with $E[v]=0$ and $E[v^2]=\sigma_v^2$. From these distributional characteristics it follows that the log of the natural rate of output is zero.

The welfare loss of the government (and of society) is given as

$$S = \frac{1}{2}E^G\left[(y-y^*)^2 + (\pi-\pi^*)^2\right] \qquad y^* > 0 \qquad \textbf{(6.2)}$$

where the government's inflation target is π^*, and y^* denotes the government's preferred value for output. Given this specification it follows that the government's relative weight of inflation stabilization relative to output stabilization - by convenient normalization - is unity. This simplifies the algebra without affecting the generality of results.

6.2.1 No Delegation of Monetary Policy

Now following Svensson (1997a) and Beetsma and Jensen (1997), purely for illustrative purposes we first discuss the benchmark cases of pre-commitment and discretion and then delegation arrangements. This means that for the moment monetary policy is not delegated to an independent central bank, but set directly by the government.

Pre-commitment

Monetary policy involves the choice of the inflation rate, which is assumed to be under the direct control of the authority who is in charge of monetary policy. The benchmark solution is obtained when the government is able to commit ex ante to some announced inflation rate. The optimal state-contingent monetary policy rule is found by minimizing equation **(6.2)** subject to **(6.1)** and the restriction that inflation equals announced inflation on average. The solution is characterized by the following expressions for respectively, expected inflation, the variances of inflation and output, and the government's welfare loss

$$E^G[\pi] = \pi^*, \; Var\pi = \frac{1}{4}\sigma_v^2, \; Vary = Var\pi$$

$$S = \frac{y^{*2}}{2} + \frac{1}{4}\sigma_v^2 \qquad \textbf{(6.3)}$$

Discretion

As is well known, the policy rule that implies **(6.3)** is time-inconsistent and therefore not credible [Persson and Tabellini (1990)] if implemented by a government whose objective function is given by equation **(6.1)**. Once nominal wages have been set, the government has the incentive to raise the inflation rate in order to stimulate output. To satisfy the incentive constraint, the equilibrium inflation rate must be optimal for the government when it takes wages and thus inflationary expectations as given. The discretionary equilibrium is found by minimizing **(6.2)** subject to **(6.1)**, taking inflation expectations as given. This yields[3]:

$$E^G[\pi] = \pi^* + y^*$$

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3 The variances of inflation and output are identical to those under pre-commitment.

$$S = y^{*2} + \frac{1}{4}\sigma_v^2 \tag{6.4}$$

Expected inflation exceeds the optimal inflation rate by y^* because of the incentive to create surprise inflation in order to bring output closer to its target $y^* > 0$. Clearly, social welfare is higher under pre-commitment than under discretion. Hence, the government may try to improve its utility by delegating monetary policy to an independent central bank.

6.2.2 Delegation of Monetary Policy

For the remainder of the chapter we assume that actual monetary policy is delegated to a central bank that has full *instrument* independence but uncertain preferences. More specifically, we assume that the central bank has the following loss function:

$$L = \frac{1}{2}\left[(y - y^*)^2 + (1 - x)(\pi - \pi^*)^2\right] \tag{6.5}$$

where x is a stochastic parameter unobserved by both the government and the private sector. Thus, the central bank's weight on inflation stabilization is continuously hit by the preference disturbance term x, which is a random variable with $E[x] = 0$ and $E[x]^2 = \sigma_x^2$. Moreover, it is assumed that x is independent of v, hence $E[vx] = 0$, and that $x < 1$ with probability one.

This specification follows Briault, Haldane and King (1996) and Nolan and Schaling (1996), and differs from other authors who have stressed the role of imperfect information about the central bank's preferences.[4]

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[4] For example, Beetsma and Jensen (1997) constrain the sum of the weights on $(y - y^*)^2$ and $(\pi - \pi^*)^2$ to be $(1 + x) + (1 - x) = 2$, as in society's loss function, but they assume the relative

The timing of events is as follows. First monetary policy is delegated to the central banker. Then inflation expectations are formed. Next, the supply shock, v, hits the economy and, finally, monetary policy is selected by setting the inflation rate.

6.3 The Optimal Inflation Target

We now consider the case of delegation with an *inflation target*. This means that the central bank no longer has *goal* independence. Rather the government imposes its own inflation target for the central bank to adhere to. This is similar to the situation in the United Kingdom where the Bank of England sets short-term interest rates independently, but where the inflation target (for this period 2.5%) is set by the government. Under the above arrangements the central bank's loss function becomes

$$L=\frac{1}{2}\left[(y-y^{*})^{2}+(1-x)(\pi-\pi^{b})^{2}\right] \tag{6.6}$$

where π^{b} is the central bank's inflation target that is chosen by the government.
The central bank sets monetary policy, which involves the choice of the inflation rate. The central bank then sets inflation[5] so as to minimize **(6.6)** subject to **(6.1)**, having observed the supply shock and taking inflation expectations as given.

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weights on output and inflation variances random. Using the notation of this chapter, the BJ results are obtained by having $L=\frac{1}{2}\left[(1+x)(y-y^{*})^{2}+(1-x)(\pi-\pi^{*})^{2}\right]$. Our specification has the implication that inflation expectations for any given monetary regime depend on σ_x^2. This allows us to derive results that are very different - and sometimes the opposite - of their model.

5 Cukierman and Meltzer (1986) examine the case where the authorities can set the control variable only imperfectly. That is, $\pi_t = \pi^{p} + \psi_t$, where $\psi \sim N(0,\sigma_{\psi}^{2})$ and p indicates a planned variable. We assume that there are no monetary control errors, that is $\sigma_{\psi}^{2} = 0$.

The first-order condition for a minimum implies the following reaction function

$$\pi = \pi^b + \frac{1}{2-x}\left(y^* - \left(\pi^b - \pi^e + v\right)\right) \tag{6.7}$$

The term $\left(\pi^b - \pi^e + v\right)$ is the output level consistent with the inflation target. It follows upon substituting π^b for π in **(6.1)**. If y^* exceeds this level, the central bank has an incentive to set inflation above the inflation target.
An important property of **(6.7)** is that the effects of preference shocks on inflation are *asymmetric*. To see this consider the following example.
Setting $y^* - \left(\pi^b - \pi^e + v\right) = 1$ and $\pi^b = 0$, if there is *no preference uncertainty*, implies that inflation is 0.50%. Now, if $x = +\,0.50$, inflation increases by 17 basispoints to 0.67%. However a negative preference shock of the same size decreases inflation by 10 basispoints to 0.40%. Hence, a positive preference shock has more *inflationary* impact than the *disinflationary* impact of a negative shock.
The above example was constructed for a *given* level of expected inflation. To solve for private sector inflation expectations take the mathematical expectation (at time $t-1$) of equation **(6.7)**.[6] This yields

$$\pi^e = \pi^b + \Phi y^* \qquad \text{where } \Phi = \frac{4+\sigma_x^2}{4-\sigma_x^2} \tag{6.8}$$

It is useful to consider the limiting value of π^e for the case without preference uncertainty

$$\lim_{\sigma_x^2 \to 0} \pi^e = \pi^b + y^* \tag{6.9}$$

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6 The technical issue here, as we show in Appendix A, is that this involves taking expectations in the presence of non-linearities.

Equations **(6.8)** and **(6.9)** indicate that inflation expectations are proportional to the output bias y^* and the inflation target imposed by the government, a familiar conclusion in the literature. However **(6.8)** differs in a significant way from **(6.9)**, as a result of uncertainty regarding the central bank's preferences. It can be seen that with uncertainty about inflation stabilization preferences expected inflation is higher than in the standard case. The reason is that *positive* shocks to x - more emphasis on output stabilization - are *more inflationary* than negative shocks - more emphasis on inflation stabilization - are *disinflationary*. With equal probabilities of positive and negative shocks to the central banker's preferences[7], expected inflation will be adjusted upwards and the more so the higher the variance of the shocks hitting the central bank's preferences.

This can be restated in a more technical way by noting that the expectation of inflation involves the expectation of a *convex* function of the preference shock, which will always be *higher* than the value of this function at the (zero) expected value of the preference shock. Hence the channel through which the uncertainty affects expected inflation is the *Jensen's inequality effect*.[8]

Realized inflation under a given target follows upon inserting **(6.8)** back into **(6.7)**

$$\pi = \pi^e + \left(\frac{1-\Phi(1-x)}{2-x}\right)y^* - \frac{1}{2-x}v \qquad \textbf{(6.10)}$$

It is important to realize that now - unlike BJ - monetary policy will on average *not* coincide with policy in the absence of uncertainty about the central banker's preferences. If we set the preference shock equal to zero in **(6.10)**, monetary policy will still react to the degree of preference uncertainty (through the variance term in Φ). Thus, in this respect certainty

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7 However, results do not depend on the *symmetry* of this distribution.

8 I.e. $E\left(\frac{1}{2-x}\right)(\pi^e + y^*) + \pi^b E\left(\frac{1-x}{2-x}\right) > \pi^b + \frac{1}{2}E\left(y^* - \left(\pi^b - \pi^e + v\right)\right)$. This effect is not present in the BJ model because they constrain the sum of the weights on output and inflation in the central banker's loss function to be the same as in society's loss function.

equivalence does *not* hold. The reason is that the central banker optimizes its policy taking inflation expectations as given. Since private sector inflation expectations depend on the second moment of the distribution of x (see equation **(6.8)**) so does the central bank's monetary policy stance.

Combining **(6.1)** and **(6.10)** yields realized output as

$$y = \left(\frac{1 - \Phi(1 - x)}{2 - x} \right) y^{*} + \frac{1 - x}{2 - x} v \qquad \textbf{(6.11)}$$

From **(6.10)** and **(6.11)** it can be seen that inflation and output differ from their expected values when either x or v differ from their (zero) expected values.

For the moment, assume that the supply shock is zero. Then the way the model works is extremely simple. Suppose there is a positive shock to the central banker's preferences ($\pi > \pi^{e}$). This implies that output will be above the natural rate. Conversely, if there is a negative realization of x (more emphasis on inflation stabilization) actual inflation will be lower than expected. Consequently, output will be below its natural level.

It is important to realize that the inflation surprise (be it positive or negative) is completely unaffected by the level of the imposed inflation target. Put differently, the delegation parameter π^{b}, has no effect on how the uncertainty about the central banker's preferences is transmitted to inflation and output. This important result was derived earlier by Beetsma and Jensen (1997). Here we show that their result continues to hold when private sector inflation expectations reflect the uncertainty about the central banker's preferences (through the term Φ).

To see this consider equation **(6.8)**. A change in π^{b} changes inflation expectations one-for-one. Hence, the central banker's incentive to set inflation above the target is unaffected, because $(\pi^{b} - \pi^{e} + v)$ in **(6.7)** is unaffected.

Put differently, the choice of inflation target has no implications for stabilization policy. By inspecting **(6.10)** and **(6.11)**, it can be seen that the term π^{b} does not affect the deviations

of realized inflation from expectations $\left(\pi - \pi^e\right)$ or output from its (zero) trend. Thus, the variances of output and inflation are *independent* from the choice of inflation target.
For completeness these variances are

$$Var\pi = \left[\frac{\left(y^* + \Phi y^*\right)^2 + \sigma_v^2}{4}\right]\frac{\sigma_x^2}{4} + \frac{\sigma_v^2}{4}\left(1 + \frac{\sigma_x^2}{4}\right)^2 \qquad \textbf{(6.12)}$$

$$Vary = Var\pi + \sigma_v^2 - \left(1 + \frac{\sigma_x^2}{4}\right)\sigma_v^2 \qquad \textbf{(6.13)}$$

To find the optimal inflation target, the government chooses the value of π^b that minimizes L^G subject to **(6.8)**, **(6.10)** and **(6.11)**.
The optimal inflation target, denoted by π^{b*} is:[9]

$$\pi^{b*} = \pi^* - \Phi y^* \qquad \textbf{(6.14)}$$

As before it is useful to consider the limiting value of π^{b*} for the case without preference uncertainty

$$\lim_{\sigma_x^2 \to 0} \pi^{b*} = \pi^* - y^* \qquad \textbf{(6.15)}$$

This is the Svensson (1997a) result about the 'inflation target-conservative' central bank where the inflation target equals the socially best inflation rate less the inflation bias.
If $\sigma_x^2 > 0$, equation **(6.14)** reveals that it is optimal for the government to impose an inflation target on the central bank which depends on the degree of uncertainty about its preferences. This is in sharp contrast to Beetsma and Jensen (1997), who find that the

9 See Appendix B for the derivation.

optimal inflation target does *not* depend on the degree of preference uncertainty and is the same as in the Svensson (1997a) model. Therefore here - contrary to BJ - certainty equivalence does *not* hold, and π^{b*} does not correspond to the optimal target derived by Svensson (1997a) in the absence of uncertainty about central bank preferences.

The intuition behind our result is simple. First, from **(6.12)** and **(6.13)** we know that the choice of inflation target has no effect on the stochastic components of the government's loss function. Thus, the inflation target is chosen so as to equal *expected inflation* to the socially desirable inflation rate. Since, expected inflation depends on σ_x^2 (through Φ), the optimal inflation target also depends on σ_x^2. Finally, comparing **(6.14)** with **(6.15)**, it can be seen that with preference uncertainty the optimal inflation target is 'stricter' (lower) than the Svensson target. The reason is as follows. As is clear from **(6.8)**, central banker uncertainty implies higher inflation expectations. To offset this additional inflation bias the degree of 'target conservativeness' has to increase as well.

6.4 The Optimal Linear Inflation Contract

Having characterized the optimal inflation target, we now turn to the case where delegation takes the form of a simple linear inflation contract. Walsh (1995) has shown that - in the absence of uncertainty about central bank preferences - such a contract can remove the inflation bias under discretion while still allowing the central bank to react optimally to supply shocks.

Thus, the trade-off between credibility and flexibility as emphasized by Rogoff (1985a) and others is eliminated, and the pre-commitment outcome can be attained.

The contract adds a linear cost to the central bank's loss function. Let the added linear cost to inflation be $f_1(\pi - \pi^*)$, where f_1 is a constant.

Then the central bank is assigned the loss function

$$L = \frac{1}{2}\left[\left(y - y^*\right)^2 + \left(1 - x\right)\left(\pi - \pi^*\right)^2\right] + f_1\left(\pi - \pi^*\right) \qquad \textbf{(6.16)}$$

The central bank chooses inflation so as to minimize **(6.16)** subject to **(6.1)** having observed the supply shock and taking inflation expectations as given.

From the first-order condition we obtain the following reaction function:

$$\pi = \pi^* + \frac{1}{2 - x}\left(y^* - \left(\pi^* - \pi^e + v\right)\right) - \frac{f_1}{2 - x} \qquad \textbf{(6.17)}$$

As before, the term $\left(\pi^* - \pi^e + v\right)$ is the output level consistent with the socially optimal inflation rate π^*, i.e. the output level that follows upon substituting π^* for π in **(6.1)**. If y^* exceeds this level, then the central bank has an incentive to set inflation above the social optimum.

Comparing **(6.17)** and **(6.7)** it can be seen that the central bank's reaction function under a linear inflation contract looks very similar to the reaction function under the optimal inflation target. In both cases the effects of preference shocks on inflation are *asymmetric*, with positive shocks increasing inflation by more than negative shocks decreasing it. There are two differences. The first is that in **(6.17)** the government imposed inflation target π^b is replaced by the socially optimal inflation rate. Secondly, under a linear contract inflation decreases with f_1. The reason is that an increase in f_1 raises the central banker's marginal loss from higher inflation.

Taking expectations (at time $t-1$) of the central bank's reaction function under a linear contract gives inflation expectations as

$$\pi^e = \pi^* + \Phi\left(y^* - f_1\right) \qquad \textbf{(6.18)}$$

where the term Φ has the same meaning as in the private sector's forecasting rule under an optimal inflation target.[10]

Please note that, unlike Beetsma and Jensen (1997), uncertainty about the central banker's preferences increases inflation expectations. The intuition is similar to the case of the optimal inflation target. Positive preference shocks are more inflationary than negative shocks are disinflationary. Hence with equal probabilities of positive and negative shocks expected inflation will be adjusted upwards, and the more so the higher the variance term in Φ.

From expression **(6.18)** it is clear that inflation is expected to exceed its social optimum whenever $y^* > f_1$, in which case the marginal benefits of inflation are greater than the marginal costs, i.e. the incentive to inflate dominates the disciplining effect of the contract. Inserting **(6.18)** back into **(6.17)** actual inflation is

$$\pi = \pi^e + \left(\frac{1-\Phi(1-x)}{2-x}\right)\left(y^* - f_1\right) - \frac{v}{2-x} \qquad \textbf{(6.19)}$$

As in the case of the optimal inflation target, it is important to realize that - unlike BJ - monetary policy does not coincide with policy in the absence of uncertainty about the central banker's preferences. If we set the preference shock equal to zero in **(6.19)** monetary policy will still react to the variance term in Φ. Thus, in this respect certainty equivalence does *not* hold. The reason is that the central banker optimizes its policy by taking inflation expectations as given. Since inflation expectations depend on the variance of the preference shocks (through Jensen's inequality; see expression **(6.18)**) so does the central bank's reaction function.

Combining **(6.19)** and **(6.1)** yields realized output:

$$y = \left(\frac{1-\Phi(1-x)}{2-x}\right)\left(y^* - f_1\right) + \frac{1-x}{2-x}v \qquad \textbf{(6.20)}$$

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10 The derivation is similar to the case of an optimal inflation target, for more details see Appendix A.

As in the case of the optimal inflation target, inflation and output deviate from their expected values when either x or v differ from their (zero) expected values. But compared with **(6.10)** and **(6.11)**, the solutions for inflation and output differ in an important aspect: the delegation parameter f_1, now affects how uncertainty about the central banker's preferences feed into inflation and output.

Here we show that their result still holds if private sector inflation expectations depend on the uncertainty about preferences.

For the moment, suppose that the supply shock is zero. Following BJ, from **(6.17)** it can be seen that the contract affects the inflation rate through two channels. The first channel operates *directly* by increasing the marginal loss of inflation. Consider a marginal increase in f_1 starting from $f_1 = 0$. The direct effect is then given by the term $-f_1/2 - x$. So this effect is *uncertain* and ultimately depends on the realization of x. The second, *indirect* channel operates through inflation expectations. Here it is equal to $-\Phi f_1$ (see equation **(6.18)**).[11]

The combined direct and indirect effects of the contract imply that any deviation of x from its (zero) expected value will have *smaller* effects on actual inflation and output. Thus, with a contract in place, i.e. $f_1 > 0$, - contrary to the case of an optimal inflation target - the transmission of preference shocks to inflation and output is dampened.

Now, consider the effects of a supply shock. The transmission of this shock to inflation and output is affected by the preference shock. Consider a positive realization of x. This means that there is more emphasis on output stabilization which increases the willingness of the central bank to accommodate supply shocks. Hence, the higher x the more such shocks are dampened before they pass on to output. The flipside of the coin is that inflation volatility is less well cared for. Of course, if x is negative the reverse is true. Then, the

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11 In the BJ model the direct effect is *deterministic* and - using the notation of this chapter - equal to $-f_1/2$. BJ have no effect from preference uncertainty on expected inflation so $\Phi \rightarrow 1$ and the indirect effect in their model is $-f_1$.

central bank dampens the impact effect from the supply shock on inflation and output is allowed to fluctuate more.

Under a linear contract, i.e. if $f_1 > 0$, it is clear that the role of fluctuating preferences in the transmission of supply shocks to inflation and output is significantly reduced. Thus, there will be less scope for the central bank to impose its 'own' preferences on society and distort stabilization policy by 'overstabilizing' either inflation or output.

This can also be seen from the expressions for the variances of inflation and output

$$Var\pi = \left[\frac{\left(y^* - \pi^* + \pi^e - f_1\right)^2 + \sigma_v^2}{4}\right]\frac{\sigma_x^2}{4} + \frac{\sigma_v^2}{4}\left(1 + \frac{\sigma_x^2}{4}\right)^2 \qquad \textbf{(6.21)}$$

$$Vary = Var\,\pi + \sigma_v^2 - \left(1 + \frac{\sigma_x^2}{4}\right)\sigma_v^2 \qquad \textbf{(6.22)}$$

Through the first term on the right hand side of **(6.21)** the contract affects the variability of inflation and, through **(6.22)**), of output.

To find the *optimal* linear inflation contract, the government chooses f_1 so as to minimize L^G subject to **(6.18)**, **(6.19)**, and **(6.20)**. Using the first-order condition, the optimal value of f_1, denoted by f_1^*, is given by:[12]

$$f_1^* = y^* \qquad \textbf{(6.23)}$$

This expression reveals that it is optimal to offer a linear inflation contract to a central banker that does *not* depend on the degree of uncertainty about its preferences. This is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal linear contract *does* depend on the degree of preference uncertainty.

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12 See Appendix C for the derivation.

Please note that our result is the same as in Walsh (1995) for the case *without* preference uncertainty. Hence, contrary to BJ for the case of a linear contract, certainty equivalence *does* hold. The value f_1^* corresponds to the optimal Walsh contract in the absence of uncertainty about central bank preferences.

6.5 The Linear Walsh Contract versus the Svensson Inflation Target

In this section we compare the outcomes for inflation and output under a Walsh contract with the outcomes under a Svensson inflation target. In absence of uncertainty about the central banker's preferences, Svensson (1997a) has shown that the linear Walsh contract is equivalent with the Svensson inflation target. Both achieve optimal stabilization without an inflationary bias. We will show that this equivalence no longer holds when disturbances to the central banker's preferences are introduced.

Optimal Linear Inflation Contract

Under the optimal linear inflation contract the inflationary bias is eliminated so that expected inflation is equal to the inflation target (this can be seen from **(6.18)**). Thus the credibility problem is solved. To see how the linear contract performs with respect to *stabilization policy* we need to look at the variances on inflation and output. By substituting $f_1 = y^*$ into **(6.21)** and **(6.22)** we get

$$Var\pi = \frac{\sigma_v^2}{4}\left(1 + \frac{3\sigma_x^2}{4} + \frac{\sigma_x^4}{16}\right)$$

$$Vary = \frac{\sigma_v^2}{4}\left(1 - \frac{\sigma_x^2}{4} + \frac{\sigma_x^4}{16}\right) \qquad \textbf{(6.24)}$$

Optimal Inflation Target

The optimal Svensson inflation target also solves the credibility problem. So in this respect it is identical to the linear inflation contract. However, its stabilization properties are different from the linear inflation contract.

The variances of inflation and output under an optimal inflation target can be found by substituting $\pi^b = \pi^* - \Phi y^*$ into **(6.12)** and **(6.13)**. This yields

$$Var\pi = \frac{\sigma_v^2}{4}\left(1+\frac{3\sigma_x^2}{4}+\frac{\sigma_x^4}{16}\right)+\frac{4\sigma_x^2 y^{*2}}{\left(4-\sigma_x^2\right)^2}$$

$$Vary = \frac{\sigma_v^2}{4}\left(1-\frac{\sigma_x^2}{4}+\frac{\sigma_x^4}{16}\right)+\frac{4\sigma_x^2 y^{*2}}{\left(4-\sigma_x^2\right)^2} \qquad \textbf{(6.25)}$$

Comparing **(6.24)** and **(6.25)**, it is clear that in the presence of uncertainty about the central banker's preferences the Walsh contract unambiguously yields a lower variance of inflation and a lower variance of output than the Svensson inflation target. This means that the optimal linear inflation contract yields a lower expected loss to the government and, therefore, is *strictly superior* to the optimal inflation target. This result is similar to BJ. However, in their model stabilization policy under a linear inflation contract is at the cost of expected inflation being *below* the socially optimal inflation rate. This trade-off is not present in this chapter.

The intuition behind this result is simple. In Section 6.3 we showed that with an inflation target, the delegation parameter π^b, has no effect on how the uncertainty about the central banker's preferences is transmitted to inflation and output. Put differently, the choice of the inflation target has no implications for stabilization policy. Thus, the variances of output and inflation are *independent* from the choice of inflation target.

From Section 4 we know that this is no longer true under a linear contract. With the optimal contract in place, i.e. $f_1^* = y^*$, - contrary to the case of an optimal inflation target - the transmission of preference shocks to inflation and output is dampened. Because the role of fluctuating preferences in the transmission of supply shocks to inflation and output is significantly reduced, the variances of inflation and output will be lower than in the case of an optimal inflation target.

The policy implications of this result are clear. It suggests that - in the presence of uncertainty about the central banker's preferences - the best institutional arrangement is to grant the central bank *instrument independence* and to make it *accountable* for its monetary policy performance by imposing a linear inflation contract. Moreover, this delegation arrangement has the appealing property that the optimal linear inflation contract is *independent* from the degree of preference uncertainty. So there is no need for the government (the principal) to make delegation arrangements conditional on this uncertainty. In other words, the legislator needs *less* information than in the case of the optimal inflation target (where the target *does* depend on σ_x^2) and still reaps the rewards of better stabilization policy than in the case where policy is set by a central bank with an optimal inflation target.

6.6 Quadratic Contracts

Even though the optimal linear contract is superior to the optimal inflation target, it does not achieve the pre-commitment solution. The reason is that the interaction between the supply shocks and preference uncertainty generates excess macroeconomic variability.

We address this problem by expanding the set of admissible contracts to include quadratic contracts. A quadratic contract penalizes quadratic (squared) deviations of inflation from some target.

6.6.1 Combination of a Linear and a Quadratic Contract

More specifically, to moderate the excess macroeconomic variability under the linear inflation contract we examine the combination of a linear and a quadratic contract. Let the added quadratic cost to inflation be $f_2(\pi - \pi^*)^2$, where f_2 is a constant. Then the central bank is assigned the loss function

$$L^{CB} = \frac{1-x}{2}(\pi - \pi^*)^2 + \frac{1}{2}(y - y^*)^2 + f_1(\pi - \pi^*) + \frac{f_2}{2}(\pi - \pi^*)^2 \tag{6.26}$$

From **(6.26)** it can be seen that - if $f_2 > 0$ - the quadratic contract is mathematically equivalent to Rogoff's (1985a) conservative central banker. Of course, if this parameter is negative, we have a *liberal* central banker.

The optimal delegation arrangement is found in two steps. The first step is to solve for the optimal linear contract, taking f_2 as given. The second step is to solve for the optimal value of f_2.

As was shown in the previous section, the variances of inflation and output do not depend on the parameters of the Walsh contract when the parameter f_1 is optimally chosen. Adding a quadratic penalty on inflation does not change the optimal Walsh contract. Therefore, in this section we have two independent instruments for two problems. We use the linear penalty term to eliminate the inflationary bias and we use the quadratic term to minimize the welfare loss to society caused by the variance of inflation and output. The quadratic term then brings a trade-off between the variance of inflation and the variance of output as is well-known from the Rogoff model. From Appendix D it follows that the optimal combination of a linear and a quadratic contract is

$$f_1^{**} = y_r^* \qquad 0 < f_2^* < \frac{9\sigma_x^2}{4 + 3\sigma_x^2} \tag{6.27}$$

Thus, in order to mitigate excess macroeconomic variability - due to the interaction between supply shocks and preference shocks - the linear Walsh contract needs to be augmented with a *conservative* central banker. This result was first found by Herrendorf and Lockwood (1997). Here we show that their result - which follows from information asymmetries between a monopolistic trade union and the political principal with respect to productivity shocks - continues to hold in our setting.[13] The Walsh contract *cum* conservative central banker result is also found by Beetsma and Jensen (1997). Thus, the Herrendorf-Lockwood result appears to be very robust indeed.

6.6.2 Combination of an Inflation Target and a Quadratic Contract

As was shown in the previous section the optimal inflation target performs worse - in terms of social welfare - than the optimal linear contract. More specifically, because the inflation target has no effect on the transmission of uncertainty about the central banker's preferences to inflation and output, macroeconomic variability is higher than with an optimal linear contract. Thus, social welfare with an optimal inflation target will be even further away from the first-best pre-commitment outcome than in the case of a linear contract.
To mitigate this sub-optimal volatility, we now consider a combination of an optimal inflation target and a quadratic contract. Under this delegation scheme the central banker minimizes

$$L^{CB} = \frac{1-x}{2}\left(\pi - \pi^{b}\right)^{2} + \frac{1}{2}\left(y - y^{*}\right)^{2} + \frac{f_2}{2}\left(\pi - \pi^{*}\right)^{2} \qquad \textbf{(6.28)}$$

13 As can be seen in Appendix D, the combination of an optimal linear Walsh contract and a quadratic contract gives the Rogoff result that the variance of inflation decreases with f_2 whereas the variance of output increases with f_2 (for σ_x^2 sensibly small).

As before, the optimal delegation arrangement is found in two steps. The first step is to solve for the optimal inflation target, taking f_2 as given. The second step is to solve for the optimal value of f_2. As was shown in the previous section, the variances of inflation and output do not depend on the inflation target π^b. Thus, adding a quadratic penalty on inflation does not change the optimal inflation target. This means that, - as before - we now have two independent instruments for two problems. We use the inflation target to eliminate the inflationary bias, and we use the quadratic contract to minimize the welfare loss to society caused by the excess macroeconomic variability.

From Appendix D it follows that the optimal combination of an inflation target and a quadratic contract is

$$\pi^{b**} = \pi^* - \Phi y^*, \qquad f_2^{**} > f_2^* \tag{6.29}$$

From **(6.29)** it follows that the Svensson optimal inflation target (which already depends on the degree of preference uncertainty), also has to be augmented with a conservative central banker. Moreover, in Appendix D we show that now the central banker has to be even *more conservative*. The additional variance that the inflation target generates, compared to the Walsh result, can unambiguously be reduced by making the central banker more conservative. This explains why the central banker has to be even more conservative when he is assigned a Svensson target instead of a linear Walsh contract.

6.7 Concluding Remarks

In this chapter we have investigated the effects of uncertain central bank preferences for the optimal institutional design of monetary policy. We have studied this in the context of a model that goes beyond 'pure' uncertainty. This means that we have relaxed the Beetsma and Jensen (1997) restriction that the central banker's preference uncertainty has no effect on private sector inflation expectations.

As shown in the chapter this implies that monetary policy will on average *not* coincide with policy in the absence of uncertainty. In this respect certainty equivalence does not hold. The reason is that the central bank optimizes its policy, taking inflation expectations as given. Since private sector inflation expectations now depend on the degree of preference uncertainty (being the variance of the preference shock) so does monetary policy. Hence, through the expectations channel, preference uncertainty now has *systematic* (as opposed to transitory) effects on policy. The implications of allowing the uncertainty to play a bigger role are substantial.

First, the optimal inflation target that has to be imposed on the central banker now depends on the degree of preference uncertainty, and has to be *stricter* (lower) the higher the uncertainty. The reason is that central banker uncertainty implies higher inflation expectations. To offset this additional inflation bias the degree of 'target conservativeness' has to increase as well.

This is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal inflation target does *not* depend on the degree of preference uncertainty and is the same as in the Svensson (1997a) model. Therefore in our model - contrary to BJ - certainty equivalence does *not* hold, and the optimal inflation target with uncertain central bank preferences does *not* correspond to the optimal target derived by Svensson (1997a) in the absence of uncertainty about central bank preferences.

Further, for the case of the Walsh contract we find that it is optimal to offer a linear inflation contract to a central banker that does *not* depend on the degree of uncertainty about its preferences. Again, this is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal linear contract *does* depend on the degree of preference uncertainty. Here our result is the same as in Walsh (1995) for the case *without* preference uncertainty. Hence, contrary to BJ for the case of a linear contract certainty equivalence *does* hold, and the optimal linear inflation contract with uncertain central bank preferences is *identical* to the optimal Walsh contract in the absence of uncertainty about central bank preferences.

Next, comparing the linear Walsh contract and the optimal inflation target, we find that the optimal linear inflation contract yields a lower expected loss to the government and therefore is *strictly superior* to the optimal inflation target. This result is similar to BJ.

However, in their model stabilization policy under a linear inflation contract is at the cost of expected inflation being *below* the socially optimal inflation rate. This trade-off is not present in this chapter.

To conclude, we find that in case of uncertain central banker preferences the *optimal* delegation arrangement is a combination of a linear inflation contract and a *quadratic contract*. Here the quadratic contract is equivalent to a Rogoff (1985a) conservative central banker. Again, this is different from Beetsma and Jensen (1997), who find that a combination of a linear inflation contract, an *inflation target* and a quadratic contract performs best.[14]

The policy implications of this result are clear. It suggests that - in the presence of uncertainty about the central banker's preferences - the best institutional arrangement is to select a central banker that is more inflation averse than society, grant the central bank *instrument independence* and to make it *accountable* for its monetary policy performance by imposing a linear inflation contract. Moreover, this delegation arrangement has the appealing property that the optimal linear inflation contract is *independent* from the degree of preference uncertainty. Thus, there is no need for the government (the principal) to make delegation arrangements conditional on this uncertainty. In other words the legislator needs *less* information than in the case of the optimal inflation target (where the target *does* depend on σ_x^2) and still reaps the rewards of better stabilization policy than in the case where policy is set by a central bank with an optimal inflation target.

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14 It is possible to extend the analysis to the case where the central bank's preferred output level is uncertain as well. This case is analyzed by Walsh (1997). However, he abstracts from a random weight in the central bank's objective function.

6.8 Appendices

A. Private Sector Inflation Expectations

Optimal Inflation Target

Taking expectations across expression **(6.7)**:

$$E(\pi) = E\left(\frac{1}{2-x}\right)(\pi^e + y^*) + \pi^b E\left(\frac{1-x}{2-x}\right) \tag{A.1}$$

This expression requires us to take the expected value of ratios of random variables. This can be achieved through a Taylor series expansion.

Our problem is to expand *X/Y* about the respective means. Assuming that the first two moments of *E(X/Y)* exist we can write down the expression

$$E\left(\frac{X}{Y}\right) \approx \frac{\mu_X}{\mu_Y} - \frac{1}{\mu_Y^{\,2}}\operatorname{cov}[X,Y] + \frac{\mu_X}{\mu_Y^{\,3}}\operatorname{var}[Y] \tag{A.2}$$

This is the (second-order) approximation used in the chapter, therefore we can write

$$E\left(\frac{1}{2-x}\right) \approx \frac{4+\sigma_x^2}{8} \text{ and } E\left(\frac{1-x}{2-x}\right) \approx \frac{4-\sigma_x^2}{8} \tag{A.3}$$

So substituting **(A.3)** in **(A.1)** and rearranging gives

$$\pi^e = \frac{4+\sigma_x^2}{4-\sigma_x^2}.y^* + \pi^b \tag{A.4}$$

which is expression **(6.8)** in the text. Again, it is clear that as $\sigma_x^2 \to 0$ the first part of the expression on the right hand side collapses to unity, and **(A.4)** is equivalent to **(6.9)**.

Linear Inflation Contract

The derivation of private sector expectations for the case of a linear inflation contract is similar to the case of an optimal inflation target (see above).

B. The Optimal Inflation Target

Since the choice of inflation target does not affect the stochastic components of the governments expected loss, its problem is

$$\underset{\pi^b}{Min}\, E^G\left[\frac{1}{2}\left(\pi^e - \pi^*\right)^2\right] \quad \textbf{(B.1)}$$

subject to

$$\pi^e = \pi^b + \Phi y^* \quad \textbf{(6.8)}$$

The first-order condition (FOC) for minimizing **(B.1)** with respect to π^b is

$$\left(\pi^e - \pi^*\right)\frac{\partial \pi^e}{\partial \pi^b} = \left(\pi^e - \pi^*\right) = 0 \quad \textbf{(B.2)}$$

It follows that the FOC can be written as

$$\pi^e = \pi^* \quad \textbf{(B.3)}$$

Substituting **(6.8)** for π^e yields

$$\pi^{b*} = \pi^* - \Phi y^* \quad \textbf{(B.4)}$$

which is equation **(6.14)** in the main text.

C. The Optimal Linear Contract

The government's problem is

$$\underset{f_1}{Min}\, E^G\left[\frac{1}{2}\left(\pi^e - \pi^*\right)^2 + \frac{1}{2}\left(Var\pi + Vary\right)\right] \qquad \textbf{(C.1)}$$

subject to (6.18), (6.21) and (6.22)

The first-order condition (FOC) for minimizing **(B.1)** with respect to f_1 is

$$E^G\left(\pi^e - \pi^*\right)\frac{\partial \pi^e}{\partial f_1} + \frac{1}{2}\left[\frac{\partial Var\pi}{\partial f_1} + \frac{\partial Vary}{\partial f_1}\right] = 0 \qquad \textbf{(C.2)}$$

Substituting for π^e from **(6.18)** and using that $\partial \pi^e / \partial f_1 = -\Phi$ we get

$$E^G\left(-\Phi^2\left(y^* - f_1\right)\right) + \frac{1}{2}\left[\frac{\partial Var\pi}{\partial f_1} + \frac{\partial Vary}{\partial f_1}\right] = 0 \qquad \textbf{(C.3)}$$

Then expanding $\frac{\partial Vary}{\partial f_1}$ as $\frac{\partial Var\, y}{\partial Var\pi}\frac{\partial Var\pi}{\partial f_1} = \frac{\partial Vary}{\partial f_1}$ and rearranging we get

$$-\left(\Phi^2\left(y^* - f_1\right)\right) + \left[\frac{\partial Var\pi}{\partial f_1}\right] = 0 \qquad \textbf{(C.4)}$$

Finally, using that from **(6.22)** $\frac{\partial Var\pi}{\partial f_1} = \frac{-\sigma_x^2(\Phi + 1)\left(y^* - f_1\right)}{4}$

the government's FOC can be written as

$$-\left[\frac{8\Phi^2 + 2(1+\Phi)\sigma_x^2}{8}\right]\left(y^* - f_1\right) = 0 \tag{C.5}$$

It can be easily seen that the optimal linear contract then is

$$f_1^* = y^* \tag{C.6}$$

which is equation **(6.23)** in the main text.

D. Quadratic Contracts

Optimal quadratic contract with optimal Walsh contract

$$Var\pi = \frac{\sigma_v^2}{(f_2+2)^2}\left(1 + \frac{3\sigma_x^2}{(f_2+2)^2} + \frac{\sigma_x^4}{(f_2+2)^4}\right) + \frac{y^{*2}\sigma_x^2(f_2+2)^2}{\left((f_2+1)(f_2+2)^2 - \sigma_x^2\right)^2} \tag{D.1}$$

$$Vary = \frac{\sigma_v^2}{(f_2+2)^2}\left((f_2+1)^2 - \frac{(2f_2+1)\sigma_x^2}{(f_2+2)^2} + \frac{\sigma_x^4}{(f_2+2)^4}\right) \tag{D.2}$$

The optimal value for f_2 is found at

$$f_2 = \frac{6\sigma_x^2}{(f_2+2)^2 + 3\sigma_x^2} + \frac{6\sigma_x^2}{(f_2+2)\left((f_2+2)^2 + 3\sigma_x^2\right)} \equiv G(f_2) \tag{D.3}$$

Since, $G(0) = \dfrac{9\sigma_x^2}{4 + 3\sigma_x^2}$, $G(\infty) = 0$, and G is monotonically decreasing in f_2, there is a unique solution to **(D.3)**.

Optimal quadratic contract with optimal Svensson target

$$Var\pi = \frac{\sigma_v^2}{(f_2+2)^2}\left(1+\frac{3\sigma_x^2}{(f_2+2)^2}+\frac{\sigma_x^4}{(f_2+2)^4}\right)+\frac{y^{*2}\sigma_x^2(f_2+2)^2}{\left((f_2+1)(f_2+2)^2-\sigma_x^2\right)^2} \quad \textbf{(D.4)}$$

$$Vary = \frac{\sigma_v^2}{(f_2+2)^2}\left((f_2+1)^2-\frac{(2f_2+1)\sigma_x^2}{(f_2+2)^2}+\frac{\sigma_x^4}{(f_2+2)^4}\right)+\frac{y^{*2}\sigma_x^2(f_2+2)^2}{\left((f_2+1)(f_2+2)^2-\sigma_x^2\right)^2} \quad \textbf{(D.5)}$$

The optimal value for f_2 is found at

$$f_2 = G(f_2)+\frac{\sigma_x^2 y^{*2}(f_2+2)^6\left((2f_2+3)(f_2+2)^2+\sigma_x^2\right)}{\sigma_v^2\left((f_2+1)(f_2+2)^2-\sigma_x^2\right)^3\left((f_2+2)^2+3\sigma_x^2\right)} \quad \textbf{(D.6)}$$

Comparing **(D.6)** to **(D.3)** it is clear that the solution to **(D.6)** is found at a higher value for f_2. So we need a more conservative central bank under a Svensson inflation target than with a linear Walsh contract.

7 A Theory of Central Bank Accountability

7.1 Introduction

Nowadays, many countries have established an independent central bank. The government delegates monetary policy to an independent institution that focuses primarily on price stability. By delegating monetary policy making to an independent central bank, the government can achieve a lower rate of inflation by reducing the inflationary bias. This benefit of enhanced *credibility* comes at the cost of less *flexibility* in reacting to supply shocks. However, there is an obvious risk in giving away control over monetary policy. There must be a mechanism that ensures that monetary policy is set in a way that is compatible with society's best interest. As Stiglitz (1998) notes "Monetary policy is a key determinant of economic performance... [and that] ...this key determinant of what happens to society – this key collective action – should be so removed from control of democratically elected officials should at least raise questions." One way or the other, central banks must be accountable to democratically elected institutions. Fischer (1994), Levy (1995), Nolan and Schaling (1996), Briault, Haldane and King (1996) and De Haan, Amtenbrink and Eijffinger (1998) have discussed this accountability issue. De Haan, Amtenbrink and Eijffinger (1998) distinguish three features of central bank accountability:

- Who takes the decisions about the *ultimate objectives* of monetary policy?
- How *transparent* is actual monetary policy?
- Who bears *final responsibility* for monetary policy?

In this chapter we present a theoretical model of central bank accountability. We focus on *transparency* of actual monetary policy and on the *final responsibility* for monetary policy. The third feature of accountability, setting the ultimate objectives of monetary policy, is related to the question of *goal independence* of a central bank.

Goal independence can be defined in a strict sense and in a broader sense. Debelle and Fischer (1995) use the strict definition as they write, "...a central bank has goal independence when it is free to set the final goals of monetary policy." According to these authors, this implies that "... a central bank with goal independence could, for instance, decide that price stability was less important than output stability and act accordingly." However, as De Haan, Amtenbrink and Eijffinger (1998) note, "where a central bank has both instrument and goal independence, the body charged with holding the central bank accountable is not provided with an effective statutory yardstick to evaluate the performance of the bank, and thus to hold the bank accountable for its conduct of monetary policy." Therefore, this strict definition of goal independence is not very useful in a discussion of central bank accountability. In a broader sense, the German and Dutch central bank have goal independence because they are free to pursue a low rate of inflation free of political interference, whereas, for instance, the Bank of England has a precisely described inflation target in a contract with the government. This broader definition is more useful in practice. However, as said before, setting the ultimate objectives of monetary policy is not considered in this chapter. For a discussion we refer to chapter 6 of this book.

Our model builds on earlier work by Lohmann (1992) and Nolan and Schaling (1996). The government delegates monetary policy to a conservative central banker. However, the government and society don't know exactly the central banker's preferences for inflation stabilization relative to output stabilization. The extent to which the central bank has private information about its preferences is determined by the transparency of monetary policy. After the central bank has proposed its preferred rate of inflation, the government can decide to override the central bank at a fixed cost. In this set up, the central bank is partially independent. The cost of overriding is related to the question of who has final responsibility for monetary policy. If this cost is prohibitive, final responsibility lies with the central bank. If, on the other hand, this cost is negligible, final responsibility rests with the government.

In this chapter we want to discuss the implications of these two types of accountability for macroeconomic outcomes. In particular, we look at the effects on the level of inflation and the stabilization of supply shocks.

We show that more transparency leads, in expectation, to a lower rate of inflation and less stabilization of supply shocks. A low cost of overriding leads to a higher rate of inflation and more stabilization of supply shocks.

7.2 The Model

Output is determined by a simplified Lucas supply function:

$$y = \pi - \pi^e + v \qquad \text{with } v \sim N(0, \sigma_v^2) \tag{7.1}$$

where y is the log of output, π the actual rate of inflation, π^e the expected rate of inflation and v a random supply shock. The government and society do not like inflation and output to deviate from their desired levels (without loss of generality the desired rate of inflation is normalized at zero). Moreover, the government incurs a fixed cost c if it decides to override the central bank. As in Lohmann (1992), the nature of this cost is determined by the political institutions in the society. The dummy variable δ takes a value of 1 if the central bank is overridden and a value of 0 if it is not overridden. The following loss-function for the government results:

$$L_G = \frac{1}{2}\pi^2 + \frac{1}{2}(y - y^*)^2 + \delta c \tag{7.2}$$

where $y^* > 0$ is the government's output target. The government delegates monetary policy to a conservative central banker with stochastic preferences. The central bank's conservativeness is embodied in a quadratic contract with parameter f_2. The central bank has private information about the realization of the uniformly distributed preference shock x. The central bank's loss function is as follows[1]

$$L_{CB} = \frac{1-x}{2}\pi^2 + \frac{1}{2}(y-y^*)^2 + \frac{f_2}{2}\pi^2 \text{, with } x \sim U[-h,h] \text{ and } h < f_2 \qquad \textbf{(7.3)}$$

Without delegation of monetary policy, the government would set a discretionary inflation rate that minimizes its loss:

$$\pi_G = \frac{y^* + \pi^e - v}{2} \qquad \textbf{(7.4)}$$

If monetary policy is delegated to the central bank, the rate of inflation is set in order to minimize the central bank's loss function:

$$\pi_{CB} = \frac{y^* + \pi^e - v}{2 - x + f_2} \qquad \textbf{(7.5)}$$

Since, as in Rogoff (1985a), the central bank is always more inflation averse than the government ($f_2 - x > 0$), the conservative central bank has a lower inflationary bias than the government but it responds less actively to supply shocks.

After monetary policy is delegated to the central bank and the central bank has set the inflation rate, the government has to decide whether to override the central bank or accept the central bank's inflation rate as is given in **(7.5)**.

If the government overrides, we use **(7.4)** in **(7.2)** with **(7.1)** and $\delta = 1$ to find its loss to be:

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1 We ensure that the central bank is always more conservative than the government by assuming $h < f_2$. Without this assumption, the central bank could be overridden for accommodating too much to supply shocks, which complicates the analysis considerably.

$$L_G(\pi_G) = \frac{1}{4}(y^* + \pi^e - v)^2 + c \tag{7.6}$$

If the government chooses to accept the central bank's inflation rate, we use **(7.5)** in **(7.2)** with **(7.1)** and $\delta = 0$, to find its loss to be equal to:

$$L_G(\pi_{CB}) = \frac{1 + (x - 1 - f_2)^2}{2(x - 2 - f_2)^2}(y^* + \pi^e - v)^2 \tag{7.7}$$

The government's decision problem is whether to override the central bank or accept the inflation rate. Minimizing its loss, the central bank will be overridden if:

$$L_G(\pi_G) < L_G(\pi_{CB}) \tag{7.8}$$

If the government finds that the *cost* of overriding the central bank is higher than the *benefit* of setting the government's preferred inflation rate, the central bank is independent. The region of independence of the central bank depends on the cost of overriding (c), the degree of conservativeness of the central bank (f_2) and the realization of the stochastic supply shock v and the preference shock x. Substituting the government's loss with overriding **(7.6)** and the government's loss with delegation of monetary policy **(7.7)** in the condition for overriding the central bank **(7.8)** we find that the central bank will be independent if

$$c \geq \frac{(x - f_2)^2}{4(x - 2 - f_2)^2}(y^* + \pi^e - v)^2 \tag{7.9}$$

However, if the cost of overriding is low enough ($c < \frac{(x - f_2)^2}{4(x - 2 - f_2)^2}(y^* + \pi^e - v)^2$) the central bank cannot set its preferred rate of inflation without being overridden. Instead, it will act in such a manner that the government is indifferent between overriding or not.

Thus, depending on the realization of the shocks, the central bank will either be independent $\left((x,v)\in I\right)$ or it will accommodate $\left((x,v)\in A\right)$. In the latter case, the central bank will set a rate of inflation that is a weighted average of the government's preferred inflation **(7.4)** and the central bank's preferred rate **(7.5)**:

$$\pi_{ACC} = \phi\pi_G + (1-\phi)\pi_{CB} = \frac{2-\phi(x-f_2)}{2(2-x+f_2)}(y^* + \pi^e - v), 0 \le \phi \le 1 \quad \textbf{(7.10)}$$

If the central bank sets this inflation rate, inserting **(7.10)** in **(7.2)** and using **(7.1)** we find that the government's loss will be:

$$L_G(\pi_{ACC}) = \frac{1+(x-1-f_2)^2 - \phi(x-f_2)^2(1-\frac{1}{2}\phi)}{2(2-x+f_2)^2}(y^* + \pi^e - v)^2 \quad \textbf{(7.11)}$$

The central bank will always accommodate so that the government is indifferent between overriding or not. Therefore, the central bank chooses ϕ such that $L_G(\pi_{ACC}) = L_G(\pi_G)$. Equalizing **(7.2)** and **(7.11)** we find that

$$\phi = \begin{cases} 1 - \dfrac{2(2-x+f_2)\sqrt{c}}{|y^* + \pi^e - v||x-f_2|} & \text{if } (x,v)\in A \\ 0 & \text{if } (x,v)\in I \end{cases} \quad \textbf{(7.12)}$$

Inserting the expression for the weight given to the government's preferred inflation rate **(7.12)** into **(7.10)** this results in the following rate of inflation if the central bank accommodates[2]

$$\pi_{ACC} = \frac{y^* + \pi^e - v}{2} - \sqrt{c}\,\mathrm{sgn}(f_2 - x)\mathrm{sgn}(y^* + \pi^e - v)$$

---

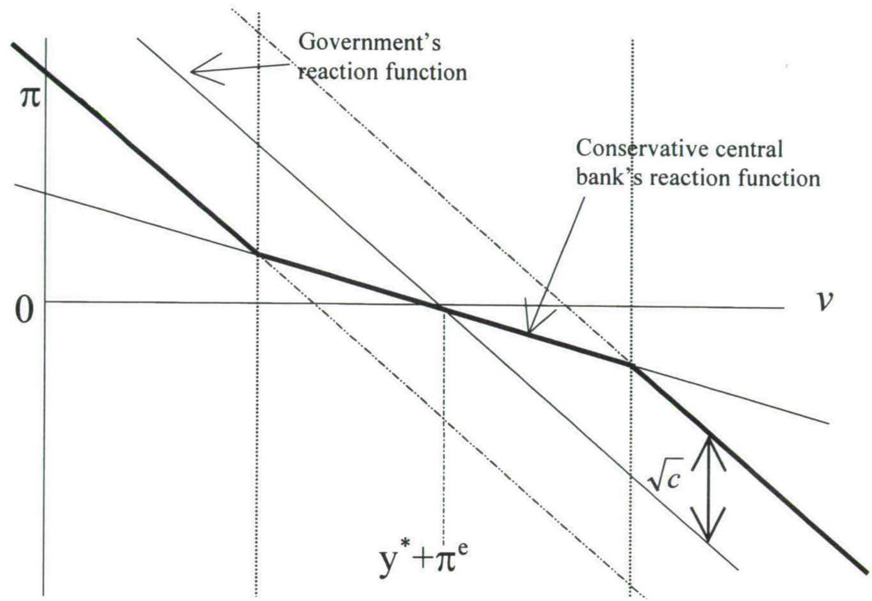
[2] The signum-operator: sgn(x)=1 if x>0, sgn(x)=-1 if x<0 and sgn(x)=0 if x=0.

Using our assumption that the central bank will always be conservative, whatever its preference shock may be ($f_2 > x$), we can write:

$$\pi_{ACC} = \frac{y^* + \pi^e - v}{2} - \sqrt{c}\,\mathrm{sgn}\left(y^* + \pi^e - v\right) \qquad \textbf{(7.13)}$$

Figure 7.1 shows what monetary policy looks like if the government faces a positive cost of overriding a conservative central bank. In the center of the figure, around $v = y^* + \pi^e$, the central bank is independent and sets its preferred rate of inflation. However, on the left-hand side and on the right-hand side of this region of independence, the central bank must accommodate to the government's preferred rate of inflation. In these region of accommodation, the government finds the cost of the (in its view) insufficient stabilization of supply shocks so high that it would not accept the central bank's preferred rate. Parallel to the government's reaction function, at a distance that depends on the cost of overriding ($\sqrt{c}$ to be precise) there are two lines. The crossings of these lines with the reaction function of the conservative central bank determine the region of independence, which lies between the two crossing points.

Figure 7.1 Actual Monetary Policy with a Positive Cost of Overriding



7.3 Accountability through Transparency

Shocks to the central bank's preferences influence the slope of the reaction function of the independent central bank. A positive shock makes the central bank less conservative so that it reacts stronger to supply shocks. In the graph, the reaction function becomes steeper and the region of independence increases. A negative preference shock has an opposite effect. The central bank becomes more conservative, the slope of the reaction function becomes flatter and the region of independence will be smaller. However, the effect of a positive preference shock is stronger than the effect of a negative preference shock. The reason for this asymmetry is the same as the 'Jensen-inequality effect' that is present in the models of chapters 5 and 6. Because of this asymmetry, a lower variance of preference shocks makes the expected slope of the independent central bank's reaction function flatter, as is shown in Figure 7.2. Therefore, the expected region of independence becomes smaller and the expected rate of inflation decreases. This is our next proposition:

Proposition 7.1: The expected region of independence (conditional on the realization of supply shock v) decreases if the central bank becomes more transparent.

Proof: The central bank becomes more transparent if the central bank's preferences become less uncertain, or h decreases. From chapters 5 and 6 (and this chapter's appendix B) we know that less preference uncertainty makes the central bank effectively more conservative. From Figure 7.1 and 7.2 it is clear that more conservativeness, which means a flatter central bank's reaction function, makes the region of independence smaller. For a formal proof, see appendix A.

Next, we want to show the effect of accountability through transparency on the expected rate of inflation. We expect that transparency leads to lower inflationary expectations since lower preference uncertainty leads effectively to a more conservative central bank. This is formalized in the following proposition:

Proposition 7.2: If the transparency of monetary policy increases (h decreases), the expected rate of inflation decreases.

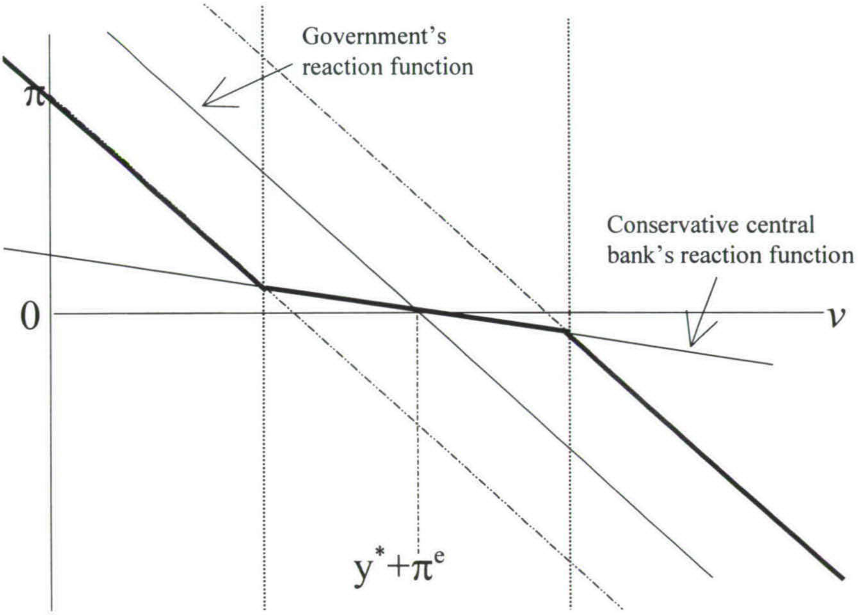
Proof: See appendix B

To complete the analysis of the effects of accountability through transparency, we have looked at the stabilization of supply shocks. This leads to the next proposition:

Proposition 7.3: If the transparency of monetary policy increases (h decreases), there is less stabilization of supply shocks.

Proof: See appendix B

Figure 7.2: The Central Bank Becomes More Conservative



The transparency type of accountability leads to a lower expected rate of inflation and less accommodation of supply shocks, especially within the region of independence. Therefore, this type of accountability is most appropriate for countries with a serious credibility problem (high y^*) relative to their flexibility problem (σ_ν^2). Clearly, this type of accountability does not reduce the effective independence of the central bank. Although the region of independence becomes smaller, the macroeconomic outcomes move in the central bank's preferred direction when transparency is increased.

Transparency can be achieved by a central bank through publication of relevant information. Publishing minutes of meetings and giving a motivation for the actions that are taken increase transparency and reduce the uncertainty about the central bank's preferences.

7.4 Accountability through Final Responsibility

Another way to increase accountability of a central bank is to shift the final responsibility for monetary policy in the direction of the government, away from the central bank. In our model we do this by making the cost of overriding (c) lower. As is shown in Figure 7.3, the distance between the government's reaction function and the two lines parallel to it becomes smaller. Inevitably this also reduces the effective independence of the central bank.

Proposition 7.4: The expected region of independence (conditional on the realization of supply shock v) becomes smaller if the final responsibility for monetary policy shifts in the direction of the government.

Proof: If the final responsibility for monetary policy shifts in the direction of the government, the cost of overriding (c) becomes lower. Comparing Figure 7.1 with Figure 7.3 it is easy to see that the expected region of independence becomes smaller if the cost of overriding becomes lower. In appendix A this is shown formally.

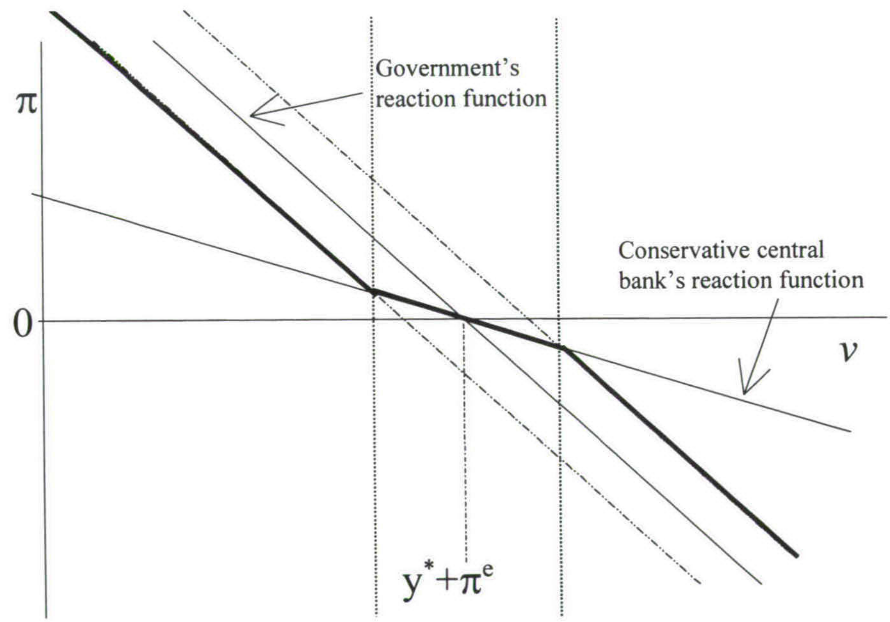
Proposition 7.5: If the final responsibility for monetary policy shifts in the direction of the government (c decreases), the expected rate of inflation increases.

Proof: If c decreases, the inflation rate set by the accommodating central banker increases for $v < y^* + \pi^e$ and decreases by the same amount for $v > y^* + \pi^e$. However, since the probability density of the supply shock v is higher for $v < y^* + \pi^e$, the expected rate of inflation will increase.

Proposition 7.6: If the final responsibility for monetary policy shifts in the direction of the government (c decreases), there is more stabilization of supply shocks.

Proof: From Proposition 7.4 is straightforward that the region of accommodation increases when the final responsibility for monetary policy shifts in the direction of the government. There will be more stabilization for shocks that were within the region of independence before the shift of final responsibility and within the region of accommodation after the shift.

Figure 7.3: The Cost of Overriding Becomes Lower



Achieving accountability by lowering the cost of overriding (lower c) makes the region of independence smaller. However, in this case the expected rate of inflation goes up and the (expected) slope of the reaction functions doesn't change. Lowering the cost of overriding makes the central bank more flexible towards shocks that fell just inside the region of independence before the lowering in the cost of overriding and fall in the region of accommodation after the change. Therefore, achieving central bank accountability by moving the final responsibility for monetary policy in the direction of the government is most appropriate for countries that have a serious flexibility problem relative to the credibility problem.

7.5 Conclusion

In this chapter we have investigated the effects of accountability on macroeconomic outcomes. In the analysis, we have focused on two types of accountability: accountability through transparency and accountability through final responsibility. Transparency reduces the uncertainty about the central bank's preferences and can be achieved by publication of relevant information. For instance, publishing minutes of meetings and inflation reports that give a motivation for the actions that the central bank has taken increase the transparency of monetary policy. We show that, although transparency makes the region of independence smaller, effective central bank independence increases with transparency. This leads to a lower expected rate of inflation and less stabilization of productivity shocks. So, more transparency shifts the balance of credibility vs. flexibility in the direction of credibility. Therefore, achieving accountability through transparency is especially attractive for countries that face a serious credibility problem relative to the flexibility problem.
The other way of achieving accountability that is studied in this chapter is shifting final responsibility for monetary policy in the direction of the government. The government is under democratic control from the parliament. By shifting final responsibility to the government, indirectly the parliament has more influence on monetary policy. In our model, shifting this responsibility is implemented by lowering the cost of overriding the central bank. We find that effective central bank independence decreases when the final responsibility shifts in the direction of the government. This leads to higher inflationary

expectations and more stabilization of supply shocks. Achieving accountability by shifting final responsibility for monetary policy in the direction of the government therefore appears most appropriate for countries that face a serious flexibility problem relative to their credibility problem.

7.6 Appendices

A. The Expected Region of Independence

The central bank is independent if

$$y^* + \pi^e - \frac{2\sqrt{c}(f_2 + 2 - x)}{f_2 - x} < v < y^* + \pi^e + \frac{2\sqrt{c}(f_2 + 2 - x)}{f_2 - x} \tag{A.1}$$

With $x \sim U[-h, h]$ the expected region of independence is:

$$y^* + \pi^e - 2\sqrt{c} - \frac{2\sqrt{c}}{h}\left(\log\frac{f_2 + h}{f_2 - h}\right) < v < y^* + \pi^e + 2\sqrt{c} + \frac{2\sqrt{c}}{h}\left(\log\frac{f_2 + h}{f_2 - h}\right) \tag{A.2}$$

In order to show that the region of independence increases with *h*, it is sufficient to show that $\dfrac{\partial\left(\frac{1}{h}\log\frac{f_2 + h}{f_2 - h}\right)}{\partial h} > 0$ with $0 < h < f_2$.

$$\frac{\partial\left(\frac{1}{h}\log\frac{f_2 + h}{f_2 - h}\right)}{\partial h} = \frac{1}{h^2}\left(\frac{2f_2 h}{f_2^2 - h^2} - \log\frac{f_2 + h}{f_2 - h}\right) =: \frac{1}{h^2}H(h) \tag{A.3}$$

It is easy to show that *H(h)* is a continuous function for $0 < h < f_2$. Furthermore, $\lim_{h \to 0} H(h) = 0$ and $\frac{\partial H(h)}{\partial h} = \frac{4h^2 f_2}{\left(h^2 - f_2^2\right)^2} > 0$ and therefore *H(h)* $>$ 0 and $\frac{1}{h^2} H(h) > 0$.

Therefore, the expected region of independence becomes larger if h increases and, conversely, becomes smaller if h decreases (Proposition 7.1).

From **(A.2)** it is also easy to show that the expected region of independence becomes smaller if the cost of overriding (c) becomes lower (Proposition 7.4).

B. The Expected Slope of the Central Bank's Reaction Function

The expected slope of the conservative central bank's reaction function is given by

$$\frac{1}{2h} \int_{-h}^{h} \frac{1}{2 - x + f_2} dx = \frac{1}{2h} \log\left(\frac{2 + h + f_2}{2 - h + f_2}\right) \tag{B.1}$$

Along the same lines as the proof in appendix A, it is straightforward to show that this slope is increasing with h.

Lemma 1: Changes in the reaction function for supply shocks $v < y^* + \pi^e$ are weighted with more probability density than changes in the reaction function for supply shocks $v > y^* + \pi^e$.

Proof: It is important to note that the monetary reaction function of the conservative central bank, the government and the accommodating central bank have a point of symmetry in $v = y^* + \pi^e$. Therefore, changes in the position or the slope of the monetary reaction functions due to changes in h or c always have opposite effects on the realized rate of inflation on either side of this point of symmetry. However, the distribution of the random supply shocks v is symmetric around $v = 0$ and the probability density becomes smaller the larger the distance between the supply shock and point of symmetry $v = 0$. Because

$y^* + \pi^e > 0$, the changes in the reaction function when $v < y^* + \pi^e$ will be weighted with more probability density then the (opposite) changes in the reaction function when $v > y^* + \pi^e$.

Lemma 2: The expected rate of inflation within the region of independence decreases if transparency of monetary policy increases.

Proof: As shown above, a lower *h* implies a flatter reaction function. So inflation decreases for $v < y^* + \pi^e$ and increases with the same amount for $v > y^* + \pi^e$. However, due to the probability density function of *v*, the expected rate of inflation in the region of independence decreases.

Lemma 3: The central bank's reaction to shocks that were within the expected region of independence before the decrease in *h* and in the expected region of accommodation after the change, will be weaker.

Proof: Monetary policy can be summarized as $\pi = Max\{\pi_{ACC}, \pi_{CB}\}$ if $v < y^* + \pi^e$ and $\pi = Min\{\pi_{ACC}, \pi_{CB}\}$ if $v > y^* + \pi^e$. If, due to a change in π_{CB}, the regime switches from independence to accommodation, then there must have been a decreasing inflation for $v < y^* + \pi^e$ and an increasing inflation for $v > y^* + \pi^e$.

When we apply the probability density function on Lemma 3 we are able to show that the expected rate of inflation for shocks that were within the expected region of independence before the decrease in *h* and in the expected region of accommodation after the change, will be lower. When we combine this with Lemma 2, then we can prove Proposition 7.2.

8 Summary and Concluding Remarks

In this book we have studied the design of monetary institutions. In chapter 2 we have investigated empirically the effect of the design of monetary institutions on macroeconomic performance. Chapter 3 looked at the factors that determine the design of monetary institutions. In chapter 4 we made a clear distinction between central bank independence and conservativeness. Then we introduced preference uncertainty in our model. In chapter 5 we looked at the effect of preference uncertainty on macroeconomic outcomes. Chapter 6 studied the effect of a linear inflation contract and an inflation target in the presence of preference uncertainty. Finally, chapter 7 discussed the issue of accountability of the central bank. In this final chapter we briefly summarize our main results.

Do monetary institutions matter for economic performance?

Chapter 2 is an empirical study into the effect of central bank independence (CBI) on macroeconomic performance, in particular the level and variability of inflation and economic growth. The main conclusions of this analysis are the following.

First of all, both our model and estimation results give further support to the well-known inverse relationship between the degree of central bank independence and the level of inflation found by Alesina (1988, 1989) and Cukierman, Webb and Neyapti (1992).

Secondly, we find some empirical evidence - especially for the Cukierman and Grilli-Masciandaro-Tabellini indices - that the more independent the central bank, the lower the variability of inflation.

Thirdly, no relationship can be found between central bank independence and the level of real output growth in the long run. Our interpretation of this outcome is that the attainment and maintenance of low inflation by an independent central bank is not accompanied by large costs or benefits in terms of sustainable economic growth. Fourthly and finally, our estimation results reject clearly the proposition of a positive relation between independence and the variability of real output growth. An independent central bank does not lead to more variable economic growth in the short run. In other words, inflation-averse central banks do not bear the costs of triggering recessions nor do politically sensitive central banks reap the benefits of avoiding recessions. The absence of a long-run trade off between CBI and the mean and variance of economic growth implies that the establishment of central bank independence in countries which did not use to have this, is a *"free lunch"* (Grilli, Masciandaro and Tabellini, 1991).

When looking at the differences between the two subperiods that we distinguish (1972 - 1982) and (1983 - 1992), there are three observations with respect to the point estimates of CBI that can be made for all four indices. First, the inflation reducing effect of a one-unit increase of CBI, according to all indices, was larger in the first subperiod than in the second. Interestingly, this doesn't hold in terms of elasticities. Secondly, after controlling for initial GDP and the share of investment, a one-unit increase of CBI leads to more output growth in the second subperiod than in the first. Thirdly, a one-unit increase of CBI leads to a larger reduction of the variance of output growth in the second subperiod than in the first.

What determines the design of monetary institutions?

In chapter 3 we discussed the fundamental determinants of central bank conservativeness in an open economy. We derived propositions concerning the relation between economic and political factors and the optimal degree of central bank conservativeness.

We have shown that optimal conservativeness is higher, the higher the natural rate of unemployment, the greater the slope of the Phillips curve, the less inflation averse society, the smaller the variance of productivity shocks, the smaller real exchange rate variability and the smaller the openness of the economy. These propositions were tested for nineteen industrial countries, using a latent variables method (LISREL) to distinguish between actual and optimal monetary regimes. We find that some countries (Germany and Switzerland)

seem to have a suboptimally high degree of central bank conservativeness, whereas others (Sweden and the United Kingdom) appear to have a suboptimally low degree.
Of course, our model could be extended with other determinants of central bank conservativeness. For instance, Lockwood, Miller and Zhang (1994) show how optimal conservativeness increases with unemployment persistence whilst Levine and Pearlman (1995) demonstrate how this variable relates to both nominal and real wage rigidity.

How is central bank independence related to conservativeness?

Chapter 4 explicitly makes a distinction between central bank independence and conservativeness. It turns out that what really matters in monetary policy making is effective central bank independence, the product of central bank independence and conservativeness.
The optimal degree of central bank independence and conservativeness depends positively on the natural rate of unemployment, society's preferences for unemployment stabilization relative to inflation stabilization and the benefits of unanticipated inflation and negatively on the variance of productivity shocks. Using a LISREL-model we estimated the relationship between four proxies of legal central bank independence and the four economic and political determinants. Then, we determine the optimal degree of independence and conservativeness for each country based on the determinants. Given the actual degree of independence we calculate the optimal degree of conservativeness. Consequently, there appears to be a trade off between central bank independence and conservativeness.

What is the effect of preference uncertainty on economic performance?

Chapter 5 investigates the credibility/flexibility trade-off in the presence of uncertainty about the central banker's preferences for inflation stabilization relative to output stabilization.
In this chapter we have analyzed the effects of monetary policy uncertainty on social welfare. We focus on expected inflation and the variance of inflation and output. Five

propositions are derived in the chapter. The first one states that more uncertainty about the policymaker's preferences leads to a higher inflationary bias. This is due to the fact that a central banker with uncertain preferences is perceived as less conservative by wage setters. The second proposition states that more monetary policy uncertainty leads to a higher variance of inflation. Intuitively, it is clear that the variance in the central banker's preferences feed through in a more volatile rate of inflation. These two propositions are in line with a large body of empirical evidence that suggests that the mean and variance of the inflation rate are positively correlated across countries. Our third proposition is that a country with a serious flexibility problem relative to the credibility problem may reduce its variance of output by appointing a central banker with uncertain preferences. Fourthly, combining the three other propositions, we find that a country that faces large supply shocks in relation to its output target may be better off with a central banker that has uncertain preferences. This is due to the fact that the average response of the policymaker to a supply shock is stronger than in the absence of preference shocks. Finally, the fifth proposition derives comparative static properties for the upperbound of the optimal level of monetary uncertainty.

To conclude, optimal central bank secrecy involves trading-off the harmful effects of uncertainty about monetary policy and the associated higher expected inflation versus the potentially beneficial effects on the stabilization of output. The latter trade-off depends on the severity of society's time-consistency problem vis-à-vis its need for stabilization policy. The analysis predicts that if the credibility problem is large relative to the need for flexibility, optimal central bank institutions will be very open and transparent and vice versa. Moreover it explains why high credibility institutions such as the Bundesbank and the future European Central Bank (ECB), *can afford* to be relatively closed, and why low credibility institutions such as the Reserve Bank of New Zealand and Banco d'España *need to* be very open and need to publish *e.g.* inflation and monetary policy reports of some kind, in addition to standard bank bulletins. Put differently, we clarify why "nouveau riche" institutions with poor credibility "talk", and why institutions that have a great "wealth" of credibility can afford to whisper.

A linear contract, a quadratic contract or an inflation target for the central banker?

In chapter 6 we have investigated the effects of uncertain central bank preferences for the optimal institutional design of monetary policy. We have studied this in the context of a model that goes beyond 'pure' uncertainty. This means that we have relaxed the Beetsma and Jensen (1997) restriction that the central banker's preference uncertainty has no effect on private sector inflation expectations.

The implications of allowing the uncertainty to play a bigger role are substantial. First, the optimal inflation target that has to be imposed on the central banker now depends on the degree of preference uncertainty, and has to be *stricter* (lower) the higher the uncertainty. The reason is that central banker uncertainty implies higher inflation expectations. To offset this additional inflation bias the degree of 'target conservativeness' has to increase as well. This is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal inflation target does *not* depend on the degree of preference uncertainty and is the same as in the Svensson (1997a) model. Therefore in our model certainty equivalence does *not* hold, and the optimal inflation target with uncertain central bank preferences does *not* correspond to the optimal target derived by Svensson (1997a) in the absence of uncertainty about central bank preferences.

Further, for the case of the Walsh contract we find that it is optimal to offer a linear inflation contract to a central banker that does *not* depend on the degree of uncertainty about its preferences. Again, this is in sharp contrast to Beetsma and Jensen (1997), who find that the optimal linear contract *does* depend on the degree of preference uncertainty. Here our result is the same as in Walsh (1995) for the case *without* preference uncertainty. Hence, contrary to Beetsma and Jensen for the case of a linear contract certainty equivalence *does* hold, and the optimal linear inflation contract with uncertain central bank preferences is *identical* to the optimal Walsh contract in the absence of uncertainty about central bank preferences.

Next, comparing the linear Walsh contract and the optimal inflation target, we find that the optimal linear inflation contract yields a lower expected loss to the government and therefore is *strictly superior* to the optimal inflation target. This result is similar to Beetsma and Jensen. However, in their model stabilization policy under a linear inflation contract is at the cost of expected inflation being *below* the socially optimal inflation rate. This trade-off is not present in this chapter.

To conclude, we find that in case of uncertain central banker preferences the *optimal* delegation arrangement is a combination of a linear inflation contract and a *quadratic contract*. Here the quadratic contract is equivalent to a Rogoff (1985a) conservative central banker. Again, this is different from Beetsma and Jensen (1997), who find that a combination of a linear inflation contract, an *inflation target* and a quadratic contract performs best.

The policy implications of this result are clear. It suggests that - in the presence of uncertainty about the central banker's preferences - the best institutional arrangement is to select a central banker that is more inflation averse than society, grant the central bank *instrument independence* and to make it *accountable* for its monetary policy performance by imposing a linear inflation contract. Moreover, this delegation arrangement has the appealing property that the optimal linear inflation contract is *independent* from the degree of preference uncertainty. Thus, there is no need for the government (the principal) to make delegation arrangements conditional on this uncertainty. In other words the legislator needs *less* information than in the case of the optimal inflation target (where the target *does* depend on the degree of preference uncertainty) and still reaps the rewards of better stabilization policy than in the case where policy is set by a central bank with an optimal inflation target.

What is the relationship between central bank independence and accountability?

In chapter 7 we have investigated the effects of accountability on macroeconomic outcomes. In the analysis, we have focused on two types of accountability: accountability through transparency and accountability through final responsibility. Transparency reduces the uncertainty about the central bank's preferences and can be achieved by publication of relevant information. For instance, publishing minutes of meetings and inflation reports that give a motivation for the actions that the central bank has taken increase the transparency of monetary policy. Our model shows that, although transparency makes the region of independence smaller, effective central bank independence increases with transparency. This leads to a lower expected rate of inflation and less stabilization of productivity shocks. So, more transparency shifts the balance of credibility vs. flexibility in the direction of credibility. Therefore, achieving accountability through transparency is especially attractive for countries that face a serious credibility problem relative to the flexibility problem.

The other way of achieving accountability that is studied in this chapter is shifting final responsibility for monetary policy in the direction of the government. The government is under democratic control from the parliament. By shifting final responsibility to the government, indirectly the parliament has more influence on monetary policy. In our model, shifting this responsibility is implemented by lowering the cost of overriding the central bank. We find that effective central bank independence decreases when the final responsibility shifts in the direction of the government. This leads to higher inflationary expectations and more stabilization of supply shocks. Achieving accountability by shifting final responsibility for monetary policy in the direction of the government therefore appears most appropriate for countries that face a serious flexibility problem relative to their credibility problem.

In this book we have studied the design of monetary institutions. In the old days, traditional political economy analysis treated monetary institutions as given. The economic environment had to adapt to the way monetary institutions were designed. In the *new* political economy framework that is adopted in this book, the design of monetary institutions is treated as *endogenous*. Monetary institutions should be designed in a way that takes into account the economic environment and the people's preferences. Further analysis of this three-way interaction between the macroeconomic environment, (collective) monetary policy preferences and the design of monetary institutions constitutes our research agenda for today and for the future.

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Samenvatting (Summary in Dutch)

In dit boek wordt ingegaan op het ontwerp van monetaire instituties, in het bijzonder centrale banken. Hoofdstuk 2 is een empirische studie naar het effect van centrale-bankonafhankelijkheid op macro-economische grootheden als inflatie en groei. In hoofdstuk 3 worden de factoren bekeken die bepalend zijn voor de manier waarop centrale banken worden opgezet. In het vierde hoofdstuk wordt een duidelijk onderscheid gemaakt tussen centrale-bank*onafhankelijkheid* ('independence') enerzijds en *conservativiteit* ('conservativeness') anderzijds. Vervolgens introduceren we preferentie onzekerheid in ons model. Het effect van preferentie onzekerheid op macro-economische uitkomsten wordt geanalyseerd in hoofdstuk 5. In hoofdstuk 6 combineren we een centrale bank met onzekere preferenties met een lineair inflatie contract of een expliciete inflatie doelstelling. Tenslotte presenteren we in hoofdstuk 7 een theoretisch model van *democratische verantwoording* ('accountability') van de centrale bank.

Zijn monetaire instituties van belang voor economische uitkomsten?

Hoofdstuk 2 is een empirische studie naar het effect van centrale-bankonafhankelijkheid op macro-economische grootheden, in het bijzonder het niveau en de variantie van inflatie en economische groei. De belangrijkste conclusies van deze studie worden hieronder op een rij gezet.

Ten eerste, zowel in ons theoretisch model als in de empirische resultaten vinden we een negatief verband tussen centrale-bankonafhankelijkheid en het gemiddelde niveau van inflatie. Dit ondersteunt de bevindingen van eerdere studies van Alesina (1988, 1989) en Cukierman, Webb en Neyapti (1992).

Ten tweede vinden we aanwijzingen - vooral voor de Cukierman en Grilli-Masciandaro-Tabellini indices - dat een meer onafhankelijke centrale bank leidt tot een lagere variantie van inflatie.

Ten derde vinden we geen verband tussen centrale-bankonafhankelijkheid enerzijds en lange termijn reële economische groei. Onze interpretatie van dit resultaat is dat het bereiken en behouden van een lage inflatie door een onafhankelijke centrale bank niet gepaard gaat met hoge kosten of baten in termen van reële economische groei. Tenslotte kunnen we op basis van onze resultaten de hypothese dat er een positief verband zou bestaan tussen centrale-bankonafhankelijkheid en de variantie van reële economische groei duidelijk verwerpen. Het ontbreken van een lange-termijn afruil tussen centrale-bankonafhankelijkheid enerzijds en stabiele economische groei anderzijds betekent dat het onafhankelijk maken van een centrale bank gezien kan worden als een "*free lunch*" (Grilli, Masciandaro and Tabellini, 1991).

Als we kijken naar de twee sub-periodes die we onderscheiden (1972 - 1982) en (1983 - 1992), zijn er drie resultaten die in het oog springen. Ten eerste is het marginale effect op inflatie van meer centrale-bankonafhankelijkheid voor alle indices groter in de eerste sub-periode dan in de tweede. Dit resultaat vinden we niet als we naar *elasticiteiten* kijken. Ten tweede, rekening houdend met het initiële output-niveau en de investeringsquote, leidt een stijging van centrale-bankonafhankelijkheid tot meer output groei in de tweede sub-periode dan in de eerste. Tenslotte leidt een meer onafhankelijke centrale bank tot een grotere reductie in de variantie van outputgroei in de tweede sub-periode dan in de eerste.

Wat bepaalt het ontwerp van monetaire instituties?

In hoofdstuk 3 worden de determinanten van centrale bank *conservativeness* in een open economie bestudeerd. We leiden proposities af over het verband tussen economische en politieke factoren enerzijds en de optimale graad van centrale bank conservativeness anderzijds. We laten zien dat optimale conservativeness hoger is naarmate de natuurlijke werkloosheid groter is, de voordelen van onverwachte inflatie groter zijn, de maatschappij minder inflatie avers is, de variantie van productiviteitsschokken lager is, de variantie van de reële wisselkoers lager is en de economie minder open is. Vervolgens hebben we deze proposities getest voor negentien geïndustrialiseerde landen met behulp van een latente variabelen methode (LISREL) om onderscheid te maken tussen werkelijke en optimale monetaire regimes. Het blijkt dat sommige landen (Duitsland en Zwitserland) een sub-optimaal hoge graad van centrale bank conservativiteit hebben, terwijl andere landen (Zweden en het Verenigd Koninkrijk) een sub-optimaal lage graad van conservativiteit hebben.

Uiteraard kan dit model worden uitgebreid met andere determinanten van centrale bank conservativiteit. Lockwood, Miller and Zhang (1994) hebben bijvoorbeeld laten zien hoe optimale conservativiteit stijgt met persistentie in de werkloosheidsgraad en Levine and Pearlman (1995) tonen het verband aan tussen optimale conservativiteit enerzijds en nominale en reële loonstarheid anderzijds.

Wat is het verband tussen centrale-bankonafhankelijkheid en conservativiteit?

In hoofdstuk 4 maken we expliciet onderscheid tussen centrale-bankonafhankelijkheid en conservativiteit. Het blijkt dat *effectieve* centrale-bankonafhankelijkheid (het product van onafhankelijkheid en conservativiteit) datgene is wat echt van belang is voor monetair beleid.

De optimale graad van centrale-bankonafhankelijkheid en conservativiteit hangt positief af van de natuurlijke werkloosheid, de maatschappelijke preferenties voor werkloosheids-stabilisatie relatief ten opzichte van inflatiestabilisatie en de opbrengst van onverwachte inflatie en negatief van de variantie van productiviteitsschokken. Gebruik makend van een LISREL-model schatten we het verband tussen vier proxies voor centrale-bankonafhankelijkheid en vier economische en politieke determinanten. Vervolgens bepalen we de optimale graad van onafhankelijkheid en conservativiteit voor elk land, met behulp van de schattingen en de determinanten. Gegeven de werkelijke graad van onafhankelijkheid berekenen we de optimale graad van conservativiteit. Uiteindelijk blijkt er een afruil te bestaan tussen centrale-bankonafhankelijkheid en conservativiteit.

Wat is het effect van preferentie-onzekerheid op economische grootheden?

In hoofdstuk 5 bestuderen we de afruil tussen *geloofwaardigheid* ('credibility') en *flexibiliteit* ('flexibility') als er sprake is van onzekerheid over de preferenties van de centrale bankier. Er is onzekerheid over het relatieve gewicht dat de centrale bankier toekent aan inflatiestabilisatie ten opzichte van outputstabilisatie.
In dit hoofdstuk kijken we naar het effect van monetaire beleidsonzekerheid op sociale welvaart. We richten ons hierbij op verwachte inflatie en de variantie van inflatie en output. Er worden vijf proposities afgeleid. Ten eerste vinden we dat meer onzekerheid over de preferenties van de beleidsmaker tot een hogere gemiddelde inflatie leidt. Dit komt doordat vakbonden een centrale bankier met onzekere preferenties zien als minder conservatief. De tweede propositie stelt dat meer monetaire beleidsonzekerheid leidt tot een hogere variantie van inflatie. De intuïtie van dit resultaat is duidelijk: meer variantie in de preferenties van de centrale bankier leidt tot meer variantie in de inflatie. Deze twee proposities zijn consistent met een grote hoeveelheid empirische literatuur waarin een positieve correlatie tussen het gemiddelde en de variantie van inflatie wordt gevonden. De derde propositie stelt dat een land met een relatief groot flexibiliteitsprobleem ten opzichte van het geloofwaardigheidsprobleem de variantie van output zou kunnen reduceren door een centrale bankier aan te stellen met onzekere preferenties. Vervolgens combineert de vierde propositie de eerste drie proposities en stelt dat een land dat geconfronteerd wordt met grote aanbodschokken, beter af kan zijn met een centrale bankier met onzekere preferenties. Dit komt doordat de gemiddelde reactie van de beleidsmaker op een aanbodschok sterker is met dan zonder preferentieonzekerheid. Tenslotte geeft de vijfde propositie de comparatief-statische eigenschappen voor de bovengrens van de optimale graad van preferentie onzekerheid.
Samenvattend wordt de optimale graad van onzekerheid omtrent de preferenties van de centrale bank bepaald door de afruil tussen de schadelijke effecten van onzekerheid voor het niveau en de variantie van inflatie en de mogelijk gunstige effecten voor de stabiliteit van output. Deze afruil hangt weer af van de relatieve zwaarte van het tijdsinconsistentie probleem ten opzichte van de noodzaak voor stabilisatie.

Volgens deze analyse moet in landen waar het geloofwaardigheidsprobleem groot is ten opzichte van het flexibiliteitsprobleem de centrale bank zeer open en transparant zijn. Bovendien wordt verklaard waarom instituties met veel geloofwaardigheid zoals de Deutsche Bundesbank en de Europese Centrale Bank (ECB) zich kunnen veroorloven relatief gesloten te zijn terwijl instituties met weinig geloofwaardigheid zoals de Banco d'España en de Reserve Bank of New Zealand zeer open moeten zijn en inflatierapporten en monetaire beleidsrapporten moeten publiceren naast de gebruikelijke verslagen.

Een lineair contract, een kwadratisch contract of een expliciete inflatie doelstelling voor de centrale bankier?

In hoofdstuk 6 gaan we in op de effecten van onzekere centrale bank preferenties voor het optimale ontwerp van de centrale bank. De rol van preferentie-onzekerheid is in ons model groter dan bij Beetsma en Jensen (1997). In ons model introduceren we preferentie-onzekerheid op een zodanige manier dat zij een effect heeft op inflatieverwachtingen van het publiek.

Een gevolg van deze verandering is dat de optimale inflatiedoelstelling die de centrale bank meekrijgt nu afhangt van de mate van preferentieonzekerheid. De inflatiedoelstelling wordt lager (dus strikter) naarmate er meer onzekerheid is over de preferenties. De reden hiervoor is dat meer preferentieonzekerheid leidt tot hogere inflatieverwachtingen. Om deze hogere inflatieverwachtingen te keren, zal de centrale bank een lagere inflatiedoelstelling moeten hebben. De optimale inflatiedoelstelling in ons model is dus lager dan die van Svensson (1997a).

Voor het Walsh-contract vinden we dat het optimaal is een lineair inflatie contract op te stellen dat *niet* afhangt van de mate van preferentie onzekerheid. Ook dit is in contrast met Beetsma en Jensen die vinden dat het optimale Walsh-contract *wel* afhangt van de mate waarin onzekerheid bestaat over de preferenties van de centrale bank.

Vanuit een sociaal welvaartsperspectief blijkt dat, indien er sprake is van preferentie-onzekerheid, het optimale Walsh-contract altijd een lager verlies oplevert dan de optimale expliciete inflatiedoelstelling. Beetsma en Jensen komen ook tot deze conclusie, maar in

hun model leidt stabilisatie onder een lineair inflatie contract tot een verwachte inflatie die lager ligt dan de maatschappelijk gewenste inflatie. Deze afruil is in ons model afwezig. Op basis van ons model kunnen we de conclusie trekken dat in de aanwezigheid van preferentieonzekerheid een combinatie van een lineair inflatiecontract en een kwadratisch contract optimaal is. Een kwadratisch contract is equivalent met een conservatieve bankier à la Rogoff (1985a). Met deze conclusie wijken we ook af van Beetsma en Jensen die vinden dat een combinatie van een lineair inflatiecontract, een inflatiedoelstelling en een kwadratisch contract optimaal is.
De beleidsimplicaties van deze resultaten zijn duidelijk. Ze suggereren dat - als er sprake is van preferentieonzekerheid - het optimaal is een conservatieve bankier aan te stellen en deze verantwoordelijk te maken voor zijn acties door hem een lineair inflatiecontract mee te geven. Deze combinatie van een lineair en een kwadratisch inflatiecontract is bovendien onafhankelijk van de mate van preferentieonzekerheid. Bij het opstellen van het contract hoeft de regering (de principaal) dus geen informatie te hebben over de mate van onzekerheid. Met andere woorden, de regering heeft minder informatie nodig dan in het geval van een optimale inflatiedoelstelling (die wel afhangt van de mate van onzekerheid) en bereikt ook nog betere stabilisatie dan in het geval van een centrale bank met een optimale inflatiedoelstelling.

Wat is het verband tussen centrale-bankonafhankelijkheid en accountability?

In hoofdstuk 7 bestuderen we het effect van accountability op macro-economische uitkomsten. We richten ons op twee soorten accountability: accountability door transparantie ('transparency') en accountability door eindverantwoordelijkheid ('final responsibility'). Transparantie maakt de onzekerheid omtrent de preferenties van de centrale bank kleiner en kan bereikt worden door publicatie van relevante informatie. Zo kunnen bijvoorbeeld het publiceren van de notulen van vergaderingen ('minutes of meetings') en het uitgeven van inflatierapporten die de acties van de centrale bank motiveren de transparantie van het monetaire beleid vergroten. We tonen aan dat met meer transparantie de effectieve centrale-bankonafhankelijkheid toeneemt, hoewel het gebied van

productiviteitsschokken waarin de centrale bank onafhankelijk is kleiner wordt. Transparantie leidt tot een lagere inflatieverwachting en minder stabilisatie van productiviteitsschokken. De balans tussen geloofwaardigheid en flexibiliteit verschuift dus in de richting van geloofwaardigheid. Daarom is accountability door transparantie vooral interessant voor landen met een serieus geloofwaardigheidsprobleem ten opzichte van het flexibiliteitsprobleem.
De andere manier om accountability te bereiken die in hoofdstuk 7 bestudeerd wordt is om de eindverantwoordelijkheid voor het monetair beleid meer bij de regering te leggen. De regering staat op haar beurt weer onder democratische controle van het parlement. Door de eindverantwoordelijkheid voor het monetair beleid in de richting van de regering te schuiven, krijgt het parlement indirect meer invloed op het beleid. In ons model wordt dit bereikt door de kosten die verbonden zijn aan het ingrijpen door de regering in het beleid van de centrale bank te verlagen. We vinden dat effectieve centrale-bankonafhankelijkheid afneemt als de eindverantwoordelijkheid voor monetair beleid meer bij de regering wordt gelegd. Dit leidt tot hogere inflatieverwachtingen en meer stabilisatie van aanbodschokken. Deze manier van accountability leidt tot meer flexibiliteit en daarom vooral geschikt voor landen met een relatief groot flexibiliteitsprobleem.

In dit boek hebben we het ontwerp van monetaire instituties bestudeerd. Vroeger, in de traditionele politieke economie werden instituties als gegeven (exogeen) beschouwd. De economische omgeving moest zich aanpassen aan de manier waarop instituties waren vormgegeven. In de *nieuwe* of *positieve* politieke economie, zoals toegepast in dit boek, wordt het ontwerp van instituties als *endogeen* beschouwd. Monetaire instituties moeten zodanig worden opgezet dat er rekening gehouden wordt met de economische omgeving en de preferenties van de bevolking. Een verdere analyse van deze interactie tussen de macro-economische omgeving, (collectieve) monetaire beleidspreferenties en het ontwerp van monetaire instituties maken onderdeel uit van de onderzoeksagenda voor de toekomst.

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at Tilburg University in 1995. He wrote his Ph.D. thesis on the design of monetary institutions at the Department of Economics and CentER for Economic Research at Tilburg University. As of January 1999 he will be taking up a position as Assistant Professor at the Department of Economics at Tilburg University.

Monetary institutions differ considerably between the main industrial countries. Differences in preferences, labor market characteristics, political stability and the structure of the economy make that different countries have different needs. These different needs are also reflected in the design of monetary institutions or, more specifically, central banks. This book takes a political economy view on monetary policy making. Our starting point is that the central bank and rational agents in the private economy interact strategically. The central bank sets monetary policy (usually the rate of inflation) and the private agents rationally form expectations about the rate of inflation. The monetary policy maker has an information advantage about the state of the economy and in the last part of this book also about its own preferences. Using this simple game-theoretic framework, we analyze the effects of different institutional set-ups on macroeconomic policy outcomes.

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