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Inflation Targeting*

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Abstract

Inflation targeting is a monetary-policy strategy that is characterized by an announced numerical inflation target, an implementation of monetary policy that gives a major role to an inflation forecast and has been called forecast targeting, and a high degree of transparency and accountability. It was introduced in New Zealand in 1990, has been very successful in terms of stabilizing both inflation and the real economy, and has, as of 2010, been adopted by about 25 industrialized and emerging-market economies. The chapter discusses the history, macroeconomic effects, theory, practice, and future of inflation targeting.

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1. Introduction

Inflation targeting is a monetary-policy strategy that was introduced in New Zealand in 1990. It has been very successful, and had as of 2010 been adopted by around 25 industrialized and non-industrialized countries. It is characterized by (1) an announced numerical inflation target, (2) an implementation of monetary policy that gives a major role to an inflation forecast and has been called forecast targeting, and (3) a high degree of transparency and accountability (Svensson (2008)). Inflation targeting is highly associated with an institutional framework that is characterized by the trinity of (1) a mandate for price stability, (2) independence, and (3) accountability for the central bank, but there are examples of highly successful inflation targeters, such as Norges Bank, that lack formal independence (although their de facto independence may still be substantial).

1.1. An announced numerical inflation target

The numerical inflation target is for advanced countries typically around 2 percent at an annual rate for the Consumer Price Index (CPI) or core CPI, in the form of a range, such as 1-3 percent in New Zealand; or a point target with a range, such as a 2 percent point target with a range/tolerance interval of ±1 percentage points in Canada; or a point target without any explicit range, such as 2 percent in Sweden and the U.K. and 2.5 percent in Norway. The difference between these forms does not seem to matter in practice. A central bank with a target range seems to aim for the middle of the range. The edges of the range are normally interpreted as "soft edges," in the sense that they do not trigger discrete policy changes and inflation just outside the range is not considered much different from just inside. Numerical inflation targets for emerging markets and developing countries are typically a few percentage points higher than 2 percent.

In practice, inflation targeting is never "strict" but always "flexible," in the sense that all inflation-targeting central banks ("central bank" is used here as the generic name for monetary authority) not only aim at stabilizing inflation around the inflation target but also put some weight on stabilizing the real economy, for instance, implicitly or explicitly stabilizing a measure of resource utilization such as the output gap; that is, the gap between actual and potential output. Thus, the "target variables" of the central bank include not only inflation but other variables as well, such as the output gap.[1] The objectives under flexible inflation targeting seem well approximated by a

[1] The term "inflation nutter" for a central bank that is only concerned about stabilizing inflation was introduced in a paper by Mervyn King at a conference in Gerzensee, Switzerland, in 1995 and later published as King (1997). The

standard quadratic loss function consisting of the sum of the squared inflation gap to the target and a weight times the squared output gap, and possibly also a weight times squared policy-rate changes (the last part corresponding to a preference for interest-rate smoothing).[2] However, for new inflation-targeting regimes, where the establishment of "credibility" is a priority, stabilizing the real economy probably has less weight than when credibility has been established (more on credibility below). Over time, when inflation targeting matures, it displays more flexibility in the sense of putting relatively more weight on stabilizing resource utilization. Inflation-targeting central banks have also become increasingly transparent about being flexible inflation targeters. Section 4.1 discusses some such developments of inflation targeting.

1.2. Forecast targeting

Because there is a lag between monetary-policy actions (such as a policy-rate change) and its impact on the central bank's target variables, monetary policy is more effective if it is guided by forecasts. The implementation of inflation targeting therefore gives a main role to forecasts of inflation and other target variables. It can be described as forecast targeting, that is, setting the policy rate (more precisely, deciding on a policy-rate path) such that the forecasts of the target variables conditional on that policy-rate path "look good", where "look good" means that the forecast for inflation stabilizes inflation around the inflation target and the forecast for resource utilization stabilizes resource utilization around a normal level.[3]

1.3. A high degree of transparency and accountability

Inflation targeting is characterized by a high degree of transparency. Typically, an inflation-targeting central bank publishes a regular monetary-policy report which includes the bank's forecast of inflation and other variables, a summary of its analysis behind the forecasts, and the motivation for its policy decisions. Some inflation-targeting central banks also provide some information on, or even forecasts of, its likely future policy decisions.

This high degree of transparency is exceptional in view of the history of central banking. Traditionally, central-bank objectives, deliberations, and even policy decisions have been subject to

terms "strict" and "flexible" inflation targeting were to my knowledge first introduced in a paper of mine presented at a conference at the bank of Portugal in 1996, later published as Svensson (1999b).

[2] The policy rate (instrument rate) is the short nominal interest rate that the central bank sets to implement monetary policy.

[3] The idea that inflation targeting implies that the inflation forecast can be seen as an intermediate target was introduced in King (1994). The term "inflation-forecast targeting" was introduced in Svensson (1997), and the term "forecast targeting" in Svensson (2005). See Woodford (2007) and Woodford (2010a) for more discussion and analysis of forecast targeting.

considerable secrecy. It is difficult to find any reasons for that secrecy beyond central bankers' desire not to be subject to public scrutiny (including scrutiny and possible pressure from governments or legislative bodies). The current emphasis on transparency is based on the insight that monetary policy to a very large extent is the "management of expectations." Monetary policy has an impact on the economy mostly through the private-sector expectations that current monetary-policy actions and announcements give rise to. The level of the policy rate for the next few weeks matter very little to most economic agents. What matters is the expectations of future policy rates, which expectations affect longer interest rates that do matter for economic decisions and activity.

Furthermore, private-sector expectations of inflation affect current pricing decisions and inflation for the next few quarters. Therefore, the anchoring of private-sector inflation expectations on the inflation target is a crucial precondition for the stability of actual inflation. The proximity of private-sector inflation expectations to the inflation target is often referred to as the "credibility" of the inflation-targeting regime. Inflation-targeting central banks sometimes appear to be obsessed by such credibility, but this obsession is for good reason. If a central bank succeeds in achieving credibility, a good part of the battle to control inflation is already won. A high degree of transparency and high-quality, convincing monetary-policy reports are often considered essential to establishing and maintaining credibility. Furthermore, a high degree of credibility gives the central bank more freedom to be "flexible" and also stabilize the real economy (see Svensson (2002) for more discussion).

Whereas many central banks in the past seem to have actively avoided accountability, for instance by not having explicit objectives and by being very secretive, inflation targeting is normally associated with a high degree of accountability. A high degree of accountability is now considered generic to inflation targeting and an important component in strengthening the incentives faced by inflation-targeting central banks to achieve their objectives. The explicit objectives and the transparency of monetary-policy reporting contribute to increased public scrutiny of monetary policy. In several countries inflation-targeting central banks are subject to more explicit accountability. In New Zealand, the Governor of the Reserve Bank of New Zealand is subject to a Policy Target Agreement, an explicit agreement between the Governor and the government on the Governor's responsibilities. In the U.K., the Chancellor of the Exchequer's remit to the Bank of England instructs the Bank to write a public letter explaining any deviation from the target larger than one percentage point and what actions the Bank is taking in response to the deviation. In several countries, central-bank officials are subject to public hearings in the Parliament where monetary policy is scrutinized; and in several countries, monetary policy is regularly or occasionally subject to extensive reviews by independent experts (for instance, New Zealand, the U.K., Norway, and Sweden).[4]

1.4. Outline

This chapter is organized as follows. Section 2 briefly discusses the short history of inflation targeting and the macroeconomic effects of inflation targeting so far. Section 3 presents a theory of inflation targeting and "forecast targeting" more generally, where projections of the target variables (inflation and resource utilization) take center stage and where the policy problem is to choose a policy-rate path rather than a policy function so as to minimize a forecast. The section also discusses the role of uncertainty about the state of the economy and the model of the transmission mechanism, and the role and use of judgment in monetary policy. Section 4 discusses the practice of inflation targeting, more precisely the developments of practical inflation targeting since its inception in 1990 in New Zealand, the special issue of the publication of policy-rate paths, and the examples of Sveriges Riksbank (the central bank of Sweden), which is ranked as one of the world's most transparent central banks, and Norges Bank (the central bank of Norway), which is a late-comer to the inflation-targeting camp but is a pioneer in applying explicit optimal policy as an input in the policy decision. These two examples are also chosen because I know more about them than about other inflation targeters. The section also reports on the debate and research on possible preconditions for emerging-market economies to join the inflation-targeting camp. The final section, section 5, discusses two potential future issues for inflation targeting, whether it would be advantageous to move on to price-level targeting and whether inflation targeting needs to be modified in the light of the recent financial crisis and deep recession.

2. History and macroeconomic effects

So far, since its inception in the early 1990s in New Zealand, Canada, the U.K., and Sweden, inflation targeting has been a considerable success, as measured by the stability of inflation and the stability of the real economy. There is no evidence that inflation targeting has been detrimental to growth, productivity, employment, or other measures of economic performance. The success is

[4] Reviews of monetary policy or aspects thereof include, for New Zealand, Svensson (2001), for the U.K., Kohn (2008), for Norway, the annual *Norges Bank Watch*, for instance, Svensson, Houg, Solheim, and Steigum (2002), and for Sweden, Giavazzi and Mishkin (2006). Svensson (2010a) provides a general discussion of the evaluation of inflation targeting, including the possibility of continuous real-time evaluation.

both absolute and relative to alternative monetary-policy strategies, such as exchange-rate targeting or money-growth targeting. No country has so far abandoned inflation targeting after adopting it (except to join the euro area), or even expressed any regrets.[5] For both industrial and non-industrial countries, inflation targeting has proved to be a most flexible and resilient monetary-policy regime and has succeeded in surviving a number of large shocks and disturbances, including the recent financial crisis and deep recession.[6] [7]

Although inflation targeting has been an unqualified success in the small- and medium-sized industrial countries that have introduced it, the United States, the euro area, and Japan have not yet adopted all the explicit characteristics of inflation-targeting, but they all seem to be taking steps in that direction. Reservations against inflation targeting have mainly suggested that it might give too much weight to inflation stabilization to the detriment of the stability of the real economy or other possible monetary-policy objectives. The fact that real-world inflation targeting is flexible rather than strict and the empirical success of inflation targeting in the countries where it has been implemented seem to confound those reservations (Roger and Stone (2005)).

A possible alternative to inflation targeting is money-growth targeting; that is, the central bank has an explicit target for the growth of the money supply. Money-growth targeting has been tried in several countries but been abandoned, since practical experience has consistently shown that the relation between money growth and inflation is too unstable and unreliable for money-growth targeting to provide successful inflation stabilization. Although Germany's Bundesbank officially conducted money-growth targeting for many years, it often deliberately missed its money-growth target in order to achieve its inflation target, and is therefore arguably better described as an implicit inflation targeter (see Svensson (1999c, 2009d) for more discussions and references).

[5] However, there has certainly been some criticism of aspects of inflation targeting in some countries and over time considerable developments, some in response to criticism, within the practice of inflation targeting (see section 4.1).

[6] As summarized by Rose (2007): "A stable international monetary system has emerged since the early 1990s. A large number of industrial and a growing number of developing countries now have domestic inflation targets administered by independent and transparent central banks. These countries place few restrictions on capital mobility and allow their exchange rates to float. The domestic focus of monetary policy in these countries does not have any obvious international cost. Inflation targeters have lower exchange rate volatility and less frequent 'sudden stops' of capital flows than similar countries that do not target inflation. Inflation targeting countries also do not have current accounts or international reserves that look different from other countries. This system was not planned and does not rely on international coordination. There is no role for a center country, the IMF, or gold. It is durable; in contrast to other monetary regimes, no country has been forced to abandon an inflation-targeting regime. Succinctly, it is the diametric opposite of the post-war system; Bretton Woods, reversed."

[7] A study from the IMF, Carvalho Filho (2010), gives a preliminary appraisal of how countries with inflation targeting have fared during the current crisis. It finds that, since August 2008, IT countries lowered nominal policy rates by more and this loosening translated into an even larger differential in real interest rates relative to other countries. IT countries were less likely to face deflation scares and saw sharp real depreciations not associated with a greater perception of risk by markets. There is also some weak evidence that IT countries did better on unemployment rates and that advanced IT countries had relatively stronger industrial production performance and higher GDP growth rates than their non-IT peers.

Many small and medium-sized countries have tried exchange-rate targeting in the form of a fixed exchange rate, that is, fixing the exchange rate relative to a center country with an independent monetary policy. For several reasons, including increased international capital flows and difficulties in defending misaligned fixed exchange rates against speculative attacks, fixed exchange rates have become less viable and less successful in stabilizing inflation. This has led many countries to instead pursue inflation targeting with flexible exchange rates.

2.1. History

New Zealand was the first country to introduce an explicit inflation target. Like most OECD countries, New Zealand had experienced high and variable inflation in the 1970s and the first part of the 1980s. Monetary policy was tightened and inflation fell in the latter part of 1980s. The Reserve Bank Act of 1989 established the policy framework that is now call inflation targeting. The key aspects of the framework were (1) an inflation target for monetary policy, (2) central bank independence, (3) accountability of the central bank (through making the target public and holding the Governor of the Reserve Bank responsible for achieving it). The framework chosen was part of a more far-reaching reform of the central government administration in New Zealand. As noted above, an institutional framework of the trinity of (1) a mandate for price stability, (2) independence, and (3) accountability is highly associated with inflation targeting, although there are examples of highly successful inflation targeters, such as Norges Bank, that lack formal independence.

As noted by Goodhart (2010), "one of the most interesting facets of the 1989 RBNZ Act is that one of the main motives for it did not come from monetary policy or monetary analysis at all. Instead, intense dissatisfaction had developed with the intervention, meddling, and direct (micro) management with all aspects of the economy by the previous (National) government, led by Sir Robert Muldoon." Thus, a significant purpose of the Act was to make the Reserve Bank "Muldoon-proof." Although the formulation of the Reserve Bank Act received strong support from Charles Goodhart, the path-breaking Act was the result of the efforts of far-sighted policymakers and civil servants of the Reserve Bank and Treasury in New Zealand rather than academic research on suitable monetary-policy frameworks.[8] Furthermore, as emphasized by Nelson (2005), until the mid-1980s, many politicians, and policy circles generally, in New Zealand subscribed to a

[8] Singleton, Hawke, and Grimes (2006) provides an authorative history of the origin of the Reserve Bank Act and the development of the Reserve Bank and monetary policy in New Zealand 1973-2002. Goodhart (2010) discusses the political economy of creation of the Act.

nonmonetary view of inflation. Behind the introduction of the Reserve Bank Act was also a fundamental change in policymaking doctrine from a nonmonetary to a monetary approach to inflation analysis and control.

Inflation targeting spread quickly to other advanced economies, see table 2.1. Canada adopted inflation targeting in 1991. The U.K. and Sweden adopted inflation targeting in 1992 and 1993 after currency crises and the collapse of their fixed exchange-rate regimes. Finland and Australia also adopted inflation targeting in 1993. By 2010, about 10 industrialized and 15 emerging-market and developing countries had adopted explicit inflation targeting.[9]

Table 2.1: Approximate adoption dates of inflation targeting

Country	Date	Country	Date
New Zealand	1990 q1	Korea	2001 m1
Canada	1991 m2	Mexico	2001 m1
United Kingdom	1992 m10	Iceland	2001 m3
Sweden	1993 m1	Norway	2001 m3
Finland	1993 m2	Hungary	2001 m6
Australia	1993 m4	Peru	2002 m1
Spain	1995 m1	Philippines	2002 m1
Israel	1997 m6	Guatemala	2005 m1
Czech Republic	1997 m12	Slovakia	2005 m1
Poland	1998 m10	Indonesia	2005 m7
Brazil	1999 m6	Romania	2005 m8
Chile	1999 m9	Turkey	2006 m1
Colombia	1999 m9	Serbia	2006 m9
South Africa	2000 m2	Ghana	2007 m5
Thailand	2000 m5		

Source: Roger (2009)

While the new inflation targeters during the 1990s were mostly advanced economies, an increasing number of developing and emerging-market economies have adopted inflation targeting since 1997. By 2010, the majority of inflation targeters were emerging-market and developing countries. Among these countries, the shift toward inflation targeting has been a gradual process. In South America, movement toward inflation targeting began in the early 1990s, but full-fledged inflation targeting was adopted only in the late 1990s and early 2000s, following the 1998 financial crisis. In Europe, the transition economies of Central and Eastern Europe began introducing inflation targeting in the late 1990s as part of their comprehensive economic reforms, while in East Asia, inflation targeting began to be adopted in the early 2000s as countries emerged from monetary tar-

[9] Pétursson (2004b) and Freedman and Ötker-Robe (2009) provide an overview of the countries' background/motivation for adopting inflation targeting. See also Freedman and Laxton (2009).

geting under International Monetary Fund-supported programs following the 1997 Asian financial crisis. Inflation targeting will probably continue to spread among emerging-market economies and developing economies.

As mentioned above, the U.S., the euro area, and Japan have not yet adopted all the explicit characteristics of inflation targeting, but they have all taken steps in that direction, and the practical remaining differences to explicit inflation targeting are arguably small. As noted by Walsh (2009a), "... even if no additional central banks adopt inflation targeting, or if some current inflation targeters abandon it, inflation targeting will have had a lasting impact on the way central banks operate. Even among central banks that do not consider themselves inflation targeters, many of the policy innovations associated with inflation targeting are now common. Most prominently, transparency has spread from inflation targeters to non-inflation targeters."

2.2. Macroeconomic effects

Early empirical work on the macroeconomic effects of inflation targeting provided some support for the view that inflation targeting improves macroeconomic performance (for instance, Bernanke, Laubach, Mishkin, and Posen (1999), Corbo, Landerretche, and Schmidt-Hebbel (2001), Neumann and von Hagen (2002), and Truman (2003)), but these studies suffer from having a relatively small number of observations. In the following I briefly summarize some more recent studies.

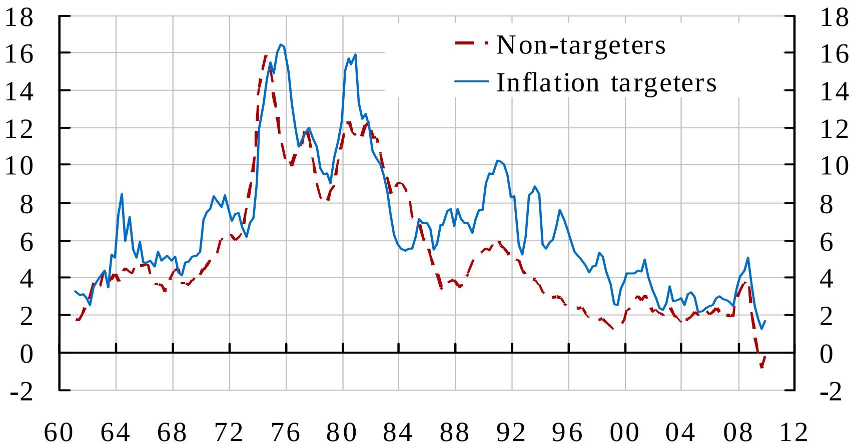
2.2.1. Inflation

Figures 2.1 and 2.2 plot average inflation for inflation targeting and non-inflation-targeting OECD countries and for a group of emerging-market economies, respectively.[10] Evidently, all groups of countries have enjoyed lower and more stable inflation. However, there seems to be a difference between the inflation targeters and the non-inflation targeters in the two groups. For the OECD countries, the development is more or less the same for inflation targeters and non-inflation targeters. For the emerging-market economies, inflation in the group of inflation targeters has come down from a higher level than in the non-inflation targeting countries.

[10] In figure 2.1, all countries with hyper-inflation periods are excluded. Inflation targeters: Australia, Canada, Czech Republic, Hungary, South Korea, New Zealand, Norway, Slovak Republic, Sweden, and the United Kingdom. Non-inflation targeters: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Japan, Luxembourg, Netherlands, Portugal, Spain, Switzerland, and the United States. (The OECD countries excluded are thus Iceland, Mexico, Poland, and Turkey.)

In figure 2.2, the inflation targeters include: Chile, Columbia, Indonesia, Israel, South Africa, Mexico, Philippines, and Thailand. The non-inflation targeters in 2.2 include: China, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, India, Malaysia, Morocco, Nigeria, Pakistan, Panama, Tunisia, Singapore, and Taiwan.

Figure 2.1: Average inflation in inflation targeting and non-inflation targeting OECD-countries. Percent per year Source: EcoWin.



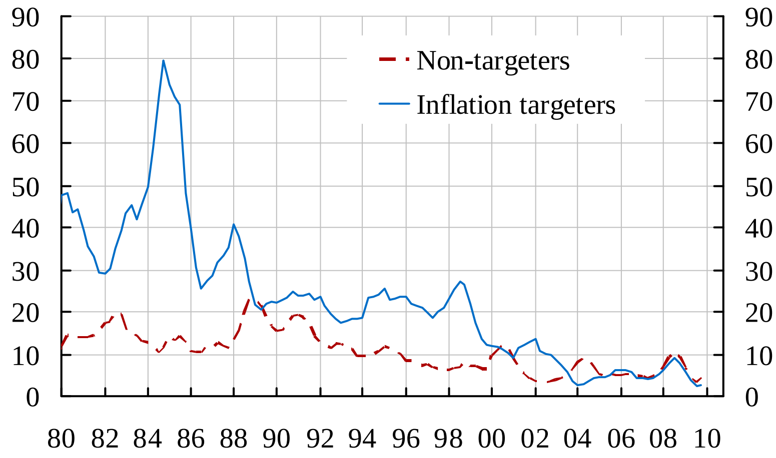
Formal empirical analysis reaffirms the visual impression from the figures. Ball and Sheridan (2005), Lin and Ye (2007), and Angeriz and Arestis (2008) consider subgroups of the OECD-countries and find that the effects of inflation targeting on average inflation and inflation variability is insignificant. Mishkin and Schmidt-Hebbel (2007) find the same for the OECD countries in their sample.[11] Batini and Laxton (2007), Gonçalves and Salles (2008), and Lin and Ye (2009) consider groups of emerging-market economies and find significant effect of inflation targeting on average inflation and typically also on inflation variability.[12]

As pointed out by Gertler (2005) in the discussion of Ball and Sheridan (2005), many of the non-inflation targeters in OECD sample (if not just about all) have adopted monetary policies that are very similar in practice to formal inflation targeting. This lack of sharpness in the classification scheme make the results for the OECD-countries hard to interpret. In fact, it may suggest the opposite conclusion, namely that inflation targeting has indeed been quite effective for the OECD countries. Empirical studies using samples including both OECD and developing/emerging-market economies typically find beneficial effects of inflation targeting on average inflation and inflation volatility (for instance, Hyvonen (2004), Pétursson (2004a), Vega and Winkelried (2005), Mishkin and Schmidt-Hebbel (2007), and Pétursson (2009)).

[11] Fang, Miller, and Lee (2009) consider OECD countries and include lagged effects of inflation targeting. They report significant evidence that inflation targeting does lower inflation rates for the targeting countries in the short run. The effects occur after the year of adopting inflation targeting and decay gradually.

[12] Surprisingly, Gonçalves and Salles (2008) does not find a significant effect of inflation targeting on the volatility of inflation.

Figure 2.2: Average inflation in inflation targeting and non-inflation-targeting emerging economies. Percent per year. Source: Ecowin.



2.2.2. Inflation expectations

There is relatively robust empirical evidence that an explicit numerical target for inflation anchors and stabilizes inflation expectations (Johnson (2002), Levin, Natalucci, and Piger (2004), Gürkaynak, Levin, and Swanson (2006), Batini and Laxton (2007), Gürkaynak, Levin, Marder, and Swanson (2007), and Ravenna (2008)). In particular, Gürkaynak, Levin, and Swanson (2006) compare the behavior of daily bond yield data in the U.K. and Sweden (both inflation targeters) to that in the U.S. (a non-inflation targeter). They use the difference between far-ahead forward rates on nominal and inflation-indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons. For the U.S., they find that forward inflation compensation exhibits highly significant responses to economic news. For the U.K., they find a level of sensitivity similar to that in the U.S. prior to the Bank of England gaining independence in 1997, but a striking absence of such sensitivity since the central bank became independent. For Sweden, they find that forward inflation compensation has been insensitive to economic news over the whole period for which they have data. These findings support the view that a well-known and credible inflation target helps to anchor the private sector's long-run inflation expectations. Recently, International Monetary Fund (2008) considered which monetary-policy frameworks had been most successful in anchoring inflation expectations in the wake of the oil and food price shocks in 2007, and found that "in emerging economies, inflation targeting seems to have recently been more effective than alternative monetary-policy frameworks in anchoring expectations." Table 2.2 reports the percentage-point response of expected headline inflation 1, 3, 5 and 6–10 years ahead to a 1 percentage-point change in actual inflation for emerging-market economies. In inflation-targeting emerging economies, the response of expected headline inflation 1, 3, and 5 years ahead is zero, whereas it is positive for non-inflation targeters.

Table 2.2: Changes in expected inflation in response to changes in actual inflation in emerging-market economies.

	1 year	3 years	5 years	6-10 years
Inflation targeters	0.00	0.00	0.00	0.024
Non-inflation targeters	0.23	0.12	0.07	0.00

Note: Expected inflation 1, 3, 5, and 6–10 years ahead; percentage-point responses to a 1 percentage point change in actual inflation.
Source: International Monetary Fund (2008, figure 3.12)

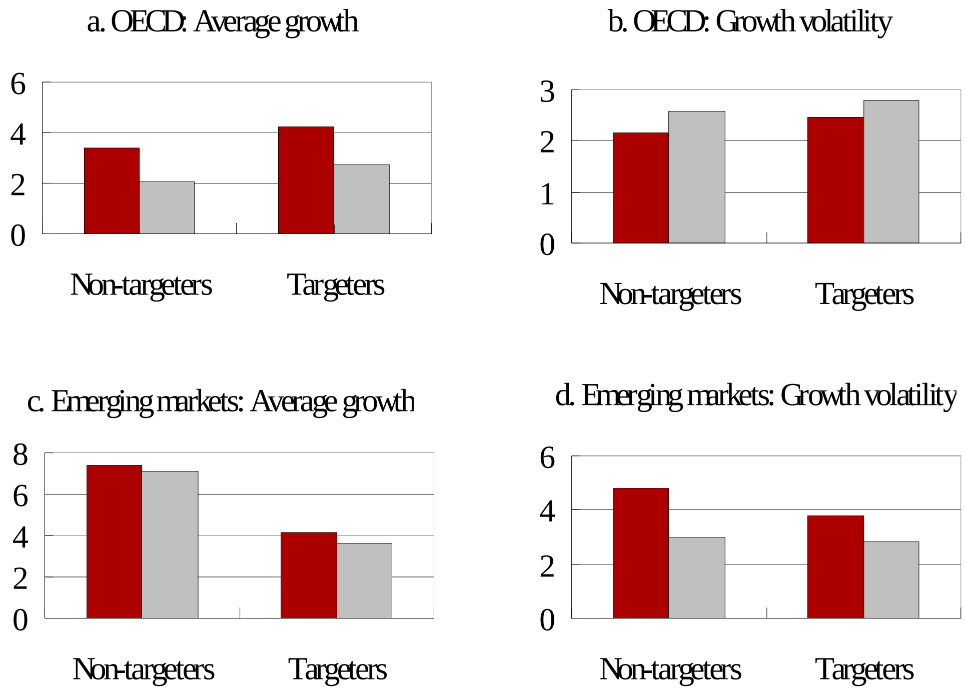
2.2.3. Output

Skeptics of inflation targeting worry that the regime is too focused on inflation and that attempts to control inflation will generate instability in the real economy and possibly also lower growth (see, for instance, Friedman and Kuttner (1996), Friedman (2002), and Cecchetti and Ehrmann (2002)). Figure 2.3 shows the average output growth and volatility before and after the adoption of inflation targeting for inflation-targeting countries in OECD and for a group of emerging-market economies.[13] It also gives the output performance for the non-inflation targeting (NT) countries in OECD and for the NT countries in the group of emerging-market economies. For the NT countries, the threshold years are 1998 for the OECD countries and 2001 for the emerging-markets economies. The panels give no basis for the pessimistic claim that inflation targeting adversely affects growth or average growth volatility.

Formal empirical analysis confirms the impression from the figure. Ball and Sheridan (2005) find no significant effect of inflation targeting on average output growth or output volatility in their sample of 20 OECD countries.[14] However, as for the results on inflation discussed above, the lack of sharpness in the classification scheme for the OECD-countries makes the results hard to interpret. Goncalves and Carvalho (2009) show that among 30 OECD countries the inflation-

[13] The group of countries are the same as in figures 2.1 and 2.2 (see footnote 10).
[14] Fang, Miller, and Lee (2009) find that the inflation targeters in their sample of OECD countries achieve lower output growth and higher output-growth variability in the short run while this effect disappears in the longer run.

Figure 2.3: Output performance before (left bar) and after (right bar) adoption of inflation targeting before and after 1998 (OECD) and 2001 (emerging markets). Average and standard deviation of growth, percent per year. Source: EcoWin.



targeting countries suffer smaller output losses in terms of sacrifice ratios during disinflationary periods than non-targeting counterparts. According to their estimates a targeter saves around 7 percent in output losses relative to a non-targeter for each percentage point of inflation decline. Batini and Laxton (2007) and Gonçalves and Salles (2008) consider emerging-market economies and find that inflation targeting reduce the volatility in output growth/the output gap. There is no significant effect of inflation targeting on growth.

2.2.4. Summary of effects of inflation targeting

While macroeconomic experiences among both inflation targeting and non-inflation targeting developed economies have been similar, inflation targeting has improved macroeconomic performance among developing economies. Importantly, there is no evidence that inflation targeting has been detrimental to growth, productivity, employment, or other measures of economic performance in either developed and developing economies. Inflation targeting has stabilized long-run inflation expectations. No country has so far abandoned inflation targeting after adopting it (except to join the euro area), or even expressed any regrets. For both industrial and non-industrial countries, inflation targeting has proved to be a most flexible and resilient monetary-policy regime, and has succeeded in surviving a number of large shocks and disturbances, including the recent financial crisis and deep recession.[15] The success is both absolute and relative to alternative monetary-policy strategies, such as exchange-rate targeting or money-growth targeting.

3. Theory

As mentioned above, in practice, inflation targeting is never "strict" but always "flexible", in the sense that all inflation-targeting central banks not only aim at stabilizing inflation around the inflation target but also put some weight on stabilizing the real economy, for instance, implicitly or explicitly stabilizing a measure of resource utilization such as the output gap between actual output and potential output. Thus, the target variables of the central bank include not only inflation but other variables as well, such as the output gap. The objectives under flexible inflation targeting seem well approximated by a quadratic loss function consisting of the sum of the squared inflation deviation from target and a weight times the squared output gap, and possibly also a weight times the squared policy-rate change (the last part corresponding to a preference for interest-rate smoothing).

Because there is a lag between monetary-policy actions (such as a policy-rate change) and its impact on the central bank's target variables, monetary policy is more effective if it is guided by forecasts. The implementation of inflation targeting therefore gives a main role to forecasts of inflation and other target variables. It can be described as forecast targeting, that is, setting the policy rate (more precisely, deciding on a policy-rate path) such that the forecasts of the target variables conditional on that policy-rate path stabilize both inflation around the inflation target and resource utilization around a normal level.

Because of the clear objective, the high degree of transparency and accountability, and a systematic and elaborate decision process using the most advanced theoretical and empirical methods as well as a sizeable amount of judgment, inflation targeting provides stronger possibilities and incentives to achieve optimal monetary policy than previous monetary-policy regimes. Therefore, a theory of inflation targeting is to a large extent a theory of optimal policy, with the objective function given by the objective function of flexible inflation targeting.

[15] See footnote 7.

However, there are a few aspects that make inflation targeting differ from standard textbook treatments of optimal policy that I would like to take into account. Textbook optimal policy consists of setting up an optimization problem, where the objective function is maximized subject to the model of the economy once and for all, which results in an optimal policy function that expresses the policy rate(s) as a function of the state of the economy. The implementation of the optimal policy then consists of mechanically setting the policy rate according to the optimal policy function, assuming that the private sector understands and believes that policy is set that way and can use that and other information to form rational expectations.

This textbook approach to optimal policy does not rely on forecasts. However, in inflation targeting, forecasts take a central place. Indeed, flexible inflation targeting can be said to consist of choosing at each policy decision not only a policy rate but a whole (explicitly or implicit, announced or not) policy-rate path such that the forecast of inflation conditional on that policy-rate path stabilizes inflation around the inflation target and the forecast of the real economy stabilizes resource utilization around a normal level. Thus, forecasts are essential tools in the policy process, and policy is not about picking a policy function once and for all and then following it but about picking a policy-rate path at each policy decision.

Thus, the theory I will try to develop in this section will emphasize the use of *forecasts* and that the object of choice is, counter to most theory of optimal policy, not a policy *function* but a policy-rate *path*. First, I will start from the standard treatment of optimal monetary policy in a linear-quadratic setting. Then I will emphasize the role of forecasts, reformulate the optimal policy problem in terms of choice between alternative feasible projections. I will show how the optimal policy projection and the set of feasible forecasts can be illustrated with the help of a modified Taylor curve, a forecast Taylor curve, which is closely related to the original Taylor curve in Taylor (1979) that illustrates the tradeoff between stabilizing inflation and stabilizing the output gap. Then I will briefly discuss so-called targeting rules and take up some issues about implementation and determinacy of the equilibrium. Although most of the discussion is under the assumption of commitment in a timeless equilibrium (Woodford 2003, 2010b), I will also briefly discuss optimization under discretion and degrees of commitment. Finally, I will discuss issues of uncertainty and the application of judgment in monetary policy.

I am not implying that the policy of all inflation-targeting central banks are well described by this theory.[16] The theory is by nature an idealization, in a similar way in which standard

[16] Although most inflation-targeting policymakers would probably agree that inflation targeting is about choosing

consumption theory is an idealization of actual consumer behavior. The theory is a theory of mature inflation targeting, a theory of my view of what is *potential* best-practice inflation targeting, although not quite yet *actual* best-practice inflation targeting. But I believe actual inflation targeting, with one innovation and improvement after another, is moving in this direction, and that some inflation-targeting central bank are pretty close. In section 4, I will discuss the developments of practical inflation targeting and give some indication that inflation targeting in Norway and Sweden, for instance, may not be far from this theory.

Since there may still be some misunderstandings of what real-world inflation targeting is, let me also emphasize and repeat two things that inflation targeting is not.[17] First, real-world inflation targeting is not strict inflation targeting, that is, it does not have a loss function such as $L_t = (\pi_t - \pi^*)^2$, where π_t denotes inflation in period t and π^* is the inflation target. That is, inflation targeting is not only about stabilizing inflation around the inflation target. Inflation targeting is in practice always flexible inflation targeting, in the sense that there is also weight on stabilizing the real economy. Second, real-world inflation targeting is not that the policy rate responds only to current inflation, with an instrument rule such as $i_t = \alpha(\pi_t - \pi^*)$ or $i_t - i_{t-1} = \alpha(\pi_t - \pi^*)$, where i_t is the policy rate in period t and α is a positive constant. Inflation targeting instead implies that the policy rate responds to much more than current inflation, namely to all information that affects the forecast of inflation and the real economy. Thus, a theory of inflation targeting cannot start from such a loss function or such an instrument rule.

3.1. A linear-quadratic model of optimal monetary policy

A linear model of an economy with forward-looking variables can be written in the following practical state-space form,[18]

$$\begin{bmatrix} X_{t+1} \\ Hx_{t+1|t} \end{bmatrix} = A \begin{bmatrix} X_t \\ x_t \end{bmatrix} + Bi_t + \begin{bmatrix} C \\ 0 \end{bmatrix} \varepsilon_{t+1}. \tag{3.1}$$

Here, X_t is an n_X-vector of *predetermined* variables in period t (where the period is typically a quarter); x_t is an n_x-vector of *forward-looking* variables; i_t is generally an n_i-vector of (policy)

a policy-rate path so that the resulting forecast of inflation and the real economy "looks good," they may not agree on the precise criteria for what "looks good" means, for instance, that this can assessed with an explicit quadratic loss function.

[17] Some misunderstandings were aired at the ECB conference "Key Developments in Monetary Economics" where a preliminary version of this chapter was presented.

[18] The linear model can be derived as the standard loglinearization of a nonlinear DSGE model. For monetary policy, the changes in variables are usually no more than a few percent, so the assumptions underlying the linearization are likely to be fulfilled. Adolfson, Laséen, Lindé, and Svensson (2009) shows in detail how the Riksbank's operational DSGE model, Ramses, can be written in this form.

instruments but in most cases there is only one policy instrument, the policy rate, so $n_i = 1$; ε_t is an n_ε-vector of i.i.d. shocks with mean zero and covariance matrix I_{n_ε}; A, B, and C, and H are matrices of the appropriate dimension; and, for the stochastic process of any variable y_t, $y_{t+\tau|t}$ denotes $\mathrm{E}_t y_{t+\tau}$, the rational expectation of the realization of $y_{t+\tau}$ in period $t+\tau$ conditional on information available in period t. The forward-looking variables and the instruments are the *nonpredetermined* variables.[19]

The variables can be measured as differences from steady-state values, in which case their unconditional means are zero. Alternatively, one of the components of X_t can be unity, so as to allow the variables to have nonzero means. The elements of the matrices A, B, C, and H are in practice often estimated with Bayesian methods and their point estimates are then assumed fixed and known for the policy simulations. Then the conditions for certainty equivalence are satisfied.

The upper block of (3.1) provides n_X equations determining the n_X-vector X_{t+1} in period $t+1$ for given X_t, x_t, i_t, and ε_{t+1},

$$X_{t+1} = A_{11}X_t + A_{12}x_t + B_1 i_t + C\varepsilon_{t+1}, \tag{3.2}$$

where A and B are partitioned conformably with X_t and x_t as

$$A \equiv \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}, \qquad B = \begin{bmatrix} B_1 \\ B_2 \end{bmatrix}. \tag{3.3}$$

The lower block provides n_x equations determining x_t in period t for given $x_{t+1|t}$, X_t, and i_t,

$$x_t = A_{22}^{-1}(Hx_{t+1|t} - A_{21}X_t - B_2 i_t). \tag{3.4}$$

We hence assume that the $n_x \times n_x$ submatrix A_{22} is nonsingular. In particular, the matrix H need not be singular.[20 21]

[19] A variable is predetermined if its one-period-ahead prediction error is an exogenous stochastic process (Klein (2000)). Hence, the non-predetermined variables have one-period-ahead prediction errors that are endogenous. For (3.1), the one-period-ahead prediction error of the predetermined variables is the stochastic vector $C\varepsilon_{t+1}$.

[20] Without loss of generality, we assume that the shocks ε_t only enter in the upper block of (3.1), since any shocks in the lower block of (3.1) can be redefined as additional predetermined variables and introduced in the upper block.

[21] In a backward-looking model, a model such as the one of Rudebusch and Svensson (1999), there are no forward-looking variables. That is, there is no vector x_t of forward-looking variables, no lower block of equations in (3.1), and the vector of target variables Y_t only depends on the vector of predetermined variables X_t and the (vector of) instrument(s) i_t.

As an example, we can take a standard New Keynesian model,

$$\pi_t - \pi^* = \delta(\pi_{t+1|t} - \pi^*) + \kappa(y_t - \bar{y}_t) + u_t, \tag{3.5}$$

$$y_t - \bar{y}_t = (y_{t+1|t} - \bar{y}_{t+1|t}) - \sigma(i_t - \pi_{t+1|t} - \bar{r}_t), \tag{3.6}$$

$$u_{t+1} = \rho_u u_t + \varepsilon_{u,t+1}, \tag{3.7}$$

$$\bar{y}_{t+1} = \rho_y \bar{y}_t + \varepsilon_{y,t+1}, \tag{3.8}$$

$$\bar{r}_{t+1} = \frac{\rho_y - 1}{\sigma}(\rho_y \bar{y}_t + \varepsilon_{y,t+1}). \tag{3.9}$$

Equation (3.5) is the Phillips curve (aggregate-supply relation), where π_t denotes inflation, π^* is the inflation target, δ is a discount factor, y_t denotes output, $\bar{y}_t$ denotes potential output, $y_t - \bar{y}_t$ is the output gap, and u_t is a so-called cost-push shock.[22] Equation (3.6) is the aggregate-demand relation, where i_t denotes the policy rate and $\bar{r}_t$ the neutral real rate. Equations (3.7)-(3.9) give the dynamics of the cost-push shock, potential output, and the neutral rate. The neutral rate and potential output satisfy

$$\bar{r}_t = \frac{1}{\sigma}(\bar{y}_{t+1|t} - \bar{y}_t),$$

This equation is satisfied by (3.8) and (3.9). The vector of predetermined variables is $X_t \equiv (u_t, \bar{y}_t, \bar{r}_t)'$, and the vector of forward-looking variables is $x_t \equiv (\pi_t, y_t)$. This example is special in that all predetermined variables are exogenous variables and there are no endogenous predetermined variables. It is straightforward to rewrite the equations (3.5)-(3.9) on the form (3.1) and thereby identify the matrices A, B, C, and H.

Let Y_t be an n_Y-vector of *target* variables, measured as the gap to an n_Y-vector Y^* of *target levels*. This is not restrictive, as long as we keep the target levels time invariant. If we would like to examine the consequences of different target levels, we can instead let Y_t refer to the absolute level of the target variables and replace Y_t by $Y_t - Y^*$ everywhere below. We assume that the target variables can be written as a linear function of the predetermined, forward-looking, and instrument variables,

$$Y_t = D \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix} \equiv [D_X \quad D_x \quad D_i] \begin{bmatrix} X_t \\ x_t \\ i_t \end{bmatrix}, \tag{3.10}$$

where D is an $n_Y \times (n_X + n_x + n_i)$ matrix and partitioned conformably with X_t, x_t, and i_t.[23]

[22] Calvo-style price setters that are not reoptimizing prices are assumed to index prices to the inflation target.

[23] For plotting and other purposes, and to avoid unnecessary separate program code, it is often convenient to expand the vector Y_t to include a number of variables of interest that are not necessary target variables or potential target variables. These will then have zero weight in the loss function.

Let the quadratic intertemporal loss function in period t be the sum of expected discounted future period losses,

$$\mathrm{E}_t \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau}, \tag{3.11}$$

where $0 < \delta < 1$ denotes a discount factor, L_t denotes the period loss and is given by

$$L_t \equiv Y_t' \Lambda Y_t, \tag{3.12}$$

and Λ is a symmetric positive semidefinite matrix containing the weights on the individual target variables.

As an example, under flexible inflation targeting with no interest-rate smoothing, the period loss function can be written as the standard quadratic loss function,

$$L_t = (\pi_t - \pi^*)^2 + \lambda(y_t - \bar{y}_t)^2, \tag{3.13}$$

where π^* denotes the inflation target, the output gap is used as a measure of resource utilization around a normal level, and the relative weight on output-gap stabilization, λ, is positive under flexible inflation targeting. The target variables are here the inflation gap, $\pi_t - \pi^*$, the gap between inflation and the inflation target π^*, and the output gap, $y_t - \bar{y}_t$, the gap between output and potential output, so the vector of target variables satisfies $Y_t \equiv (\pi_t - \pi^*,\, y_t - \bar{y}_t)'$. Then the matrix Λ is a diagonal matrix with the diagonal $(1, \lambda)$.

The optimization is here under the assumption that commitment in a timeless perspective is possible. The case of optimization under discretion is discussed in section 3.8.[24] The optimization results in a set of first-order conditions which, combined with the model equations (3.1), results in a system of difference equations (see Söderlind (1999) and Svensson (2009b)). The system of difference equations can be solved with several alternative algorithms, for instance, those developed by Klein (2000) and Sims (2002) (see Svensson (2005) and Svensson (2009b) for details of the derivation and application of the Klein algorithm).[25]

Under the assumption of optimization under commitment in a timeless perspective, the solution

[24] See Woodford (2010b) for a detailed discussion of optimization under commitment, commitment in a timeless perspective, and discretion.

[25] The system of difference equations can also be solved with the so-called AIM algorithm of Anderson and Moore (1983) and Anderson and Moore (1985) (see Anderson (2010) for a recent formulation). Whereas the Klein algorithm is easy to apply directly to the system of difference equations, the AIM algorithm requires some rewriting of the difference equations. Previously, the AIM algorithm have appeared to be significantly faster for large systems (see Anderson (2000) for a comparison between AIM and other algorithms), but a new Matlab function, ordqz, makes the Klein algorithm much faster. The appendix of Adolfson, Laséen, Lindé, and Svensson (2009) discusses the relation between the Klein and AIM algorithms and shows how the system of difference equations can be rewritten to fit the AIM algorithm.

and intertemporal equilibrium can be described by the following difference equation,

$$\begin{bmatrix} x_t \\ i_t \end{bmatrix} = F \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} \equiv \begin{bmatrix} F_x \\ F_i \end{bmatrix} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix}, \tag{3.14}$$

$$\begin{bmatrix} X_{t+1} \\ \Xi_t \end{bmatrix} = M \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix} + \begin{bmatrix} C \\ 0 \end{bmatrix} \varepsilon_{t+1}, \tag{3.15}$$

$$Y_t = \tilde{D} \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix}, \tag{3.16}$$

for $t \geq 0$, where

$$\tilde{D} \equiv D \begin{bmatrix} I & 0 \\ & F \end{bmatrix}$$

and X_0 and Ξ_{-1} are given. The Klein algorithm returns the matrices F and M. The submatrix F_i in (3.14) represents the optimal policy function, the optimal instrument rule,

$$i_t = F_i \begin{bmatrix} X_t \\ \Xi_{t-1} \end{bmatrix}. \tag{3.17}$$

The matrices F and M depend on A, B, H, D, Λ, and δ, but they are independent of C. That they are independent of C demonstrates certainty equivalence (the certainty equivalence that holds when the model is linear, the loss function is quadratic, and the shocks and the uncertainty are additive); only probability means of current and future variables are needed to determine optimal policy (and the optimal projections to be discussed in section 3.3). The n_X-vector Ξ_{t-1} consists of the Lagrange multipliers of the lower block of (3.20), the block determining the projection of the forward-looking variables.[26]

Instead of a solution under optimal policy, we can consider a solution under a given arbitrary instrument rule that satisfies

$$i_t = f \begin{bmatrix} X_t \\ x_t \end{bmatrix} \equiv [f_X \quad f_x] \begin{bmatrix} X_t \\ x_t \end{bmatrix} \tag{3.18}$$

for $t \geq 0$, where the $n_i \times (n_X + n_x)$ matrix $f \equiv [f_X \quad f_x]$ is a given (linear) instrument rule and partitioned conformably with X_t and x_t. If $f_x \equiv 0$, the instrument rule is an *explicit* instrument rule; if $f_x \neq 0$, the instrument rule is an *implicit* instrument rule. In the latter case, the instrument rule is actually an equilibrium condition, in the sense that the policy rate in period t and the forward-looking variables in period t are then simultaneously determined.[27]

If the instrument rule is combined with (3.1), the resulting system of difference equations can be solved for a solution (3.14)-(3.16), except that there is no vector of Lagrange multipliers Ξ_t. In that case the matrices F and M depend on A, B, H and f, but not on C.

[26] Adolfson, Laséen, Lindé, and Svensson (2009) discusses how the initial value for Ξ_{t-1} can be chosen.
[27] See Svensson (2003b) and Svensson and Woodford (2005) for more discussion of explicit and implicit instrument rules.

The model (3.1) can also be solved for a given targeting rule, a linear combination of leads and lags of the target variables projection (Giannoni and Woodford (2003), Svensson and Woodford (2005)),

$$\mathrm{E}_t \sum_{\tau=-a}^{b} g_\tau Y_{t+\tau} = 0 \tag{3.19}$$

where a denotes the largest lag, b denotes the largest lead in the targeting rule, and g_τ for $\tau = -a, -a+1, ..., b$ are $n_i \times n_X$ matrices (we need as many rows in (3.19) as the number of instruments). As shown by Giannoni and Woodford (2003) and Giannoni and Woodford (2010), the first-order conditions for an optimum can be written in the form (3.19) after elimination of the Lagrange multipliers. Targeting rules are further discussed in section 3.6.

How could optimal policy or policy with a given instrument rule be implemented? The standard theory of optimal monetary policy is not very explicit on this point. One interpretation of the above analysis would be that the central bank once and for all calculates the optimal instrument rule F_i in (3.17), alternatively picks a given instrument rule f in (3.18), and then publishes the instrument rule and makes a public commitment to use it to set its policy rate forever. The private sector then believes in the commitment to the instrument rule, combines it with the model in (3.1), calculates the corresponding rational-expectations equilibrium, and makes its decisions accordingly. The resulting equilibrium is then the equilibrium described by the equations (3.14)-(3.16) (for the given instrument rule (3.18), without the Lagrange multipliers).

However, this is not the way monetary policy is implemented by any real-word central bank. No central bank announces a specific instrument rule and commits to follow it forever. For one thing, the optimal instrument rule would depend on a long list of predetermined variables (not to speak of the Lagrange multipliers), and the optimal instrument rule would be much too complicated to be communicated. Any simple given instrument rule, such as a Taylor rule, would be too simple and imperfect for the central bank to stick with it (see Svensson (2003b)).

In the real world, an inflation-targeting central bank instead announces the current level of the policy rate, gives some indication of future policy rates or even publishes a full policy-rate forecast, and usually also publishes a forecast of inflation and the real economy. The private sector then responds to this information, and the actual equilibrium results. This is the kind of monetary policy and its implementation that I try to model next. In particular, forecasts and projections of the policy rate, inflation, and the real economy take center stage.

3.2. The projection model and the feasible set of projections

Let $u^t \equiv \{u_{t+\tau,t}\}_{\tau=0}^{\infty}$ denote a *projection* (a conditional mean forecast) in period t for any vector of variables u_t, where $u_{t+\tau,t}$ denotes the mean forecast of the realization of the vector in period $t+\tau$ conditional on information available in period t. We refer to τ as the horizon of the forecast $u_{t+\tau,t}$. The *projection model* for the projections (X^t, x^t, i^t, Y^t) in period t uses that the projection of the zero-mean i.i.d. shocks is zero, $\varepsilon_{t+\tau,t} = 0$ for $\tau \geq 1$. It can then be written as

$$\begin{bmatrix} X_{t+\tau+1,t} \\ Hx_{t+\tau+1,t} \end{bmatrix} = A \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \end{bmatrix} + Bi_{t+\tau,t}, \tag{3.20}$$

$$Y_{t+\tau,t} = D \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \\ i_{t+\tau,t} \end{bmatrix}, \tag{3.21}$$

for $\tau \geq 0$, where

$$X_{t,t} = X_{t|t}, \tag{3.22}$$

where $X_{t|t}$ is the estimate of predetermined variables in period t conditional on information available in the beginning of period t. The introduction of this notation here allows the realistic possibility that the central bank has imperfect information about the current state of the economy and, for instance, as in Svensson and Woodford (2005) estimates the current state of the economy with the help of a Kalman filter, a case that is further discussed in section 3.9.1. Thus, "$,t$" and "$|t$" in subindices refer to projections (forecasting) and estimates ("nowcasting" and "backcasting") in the beginning of period t, respectively. The *feasible set of projections* for given $X_{t|t}$, denoted $\mathcal{T}(X_{t|t})$, is the set of projections (X^t, x^t, i^t, Y^t) that satisfy (3.20)-(3.22). We call $\mathcal{T}(X_{t|t})$ the set of feasible projections in period t. It is conditional on the estimates of the matrices A, B, H, and D and the estimate of the current realization of the predetermined variables $X_{t|t}$.

3.3. Optimal policy choice

The policy problem in period t is to determine the optimal projection in period t. The optimal projection is the projection $(\hat{X}^t, \hat{x}^t, \hat{\imath}^t, \hat{Y}^t)$ that minimizes the intertemporal forecast loss function,

$$\mathcal{L}(Y^t) = \sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau,t}, \tag{3.23}$$

where the period forecast loss, $L_{t+\tau,t}$, is specified as

$$L_{t+\tau,t} = Y_{t+\tau,t}{}'\Lambda Y_{t+\tau,t} \tag{3.24}$$

for $\tau \geq 0$. The minimization is subject to the projection being in the feasible set of projections for given $X_{t|t}$, $\mathcal{T}(X_{t|t})$.[28]

For the standard quadratic loss function (3.13), the corresponding period forecast loss function is

$$L_{t+\tau,t} = (\pi_{t+\tau,t} - \pi^*)^2 + \lambda(y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2, \tag{3.25}$$

where $\pi_{t+\tau,t}$ and $y_{t+\tau,t} - \bar{y}_{t+\tau,t}$ are the forecast in period t of inflation and the output gap, respectively, in period $t+\tau$.

When the policy problem is formulated in terms of projections, we can allow $0 < \delta \leq 1$, since the above infinite sum in (3.23) will normally converge also for $\delta = 1$. Again, the optimization is done under commitment in a timeless perspective (Woodford (2003), Woodford (2010b)).

The intertemporal loss function (3.23) with the period forecast loss function (3.24) introduces a preference ordering over projections of the target variables, Y^t. We can express this preference ordering as the modified intertemporal loss function,

$$\mathcal{L}(Y^t) + \frac{1}{\delta}\Xi'_{t-1}H(x_{t,t} - x_{t,t-1}) \equiv \sum_{\tau=0}^{\infty} \delta^\tau Y'_{t+\tau,t}\Lambda Y_{t+\tau,t} + \frac{1}{\delta}\Xi'_{t-1}H(x_{t,t} - x_{t,t-1}), \tag{3.26}$$

where the modification is the added term $\frac{1}{\delta}\Xi'_{t-1}(x_{t,t} - x_{t,t-1})$. In that term, Ξ_{t-1} is as mentioned the vector of Lagrange multipliers for the equations for the forward-looking variables from the optimization problem in period $t-1$, $x_{t,t}$ is the projection of the vector of forward-looking variables in period t that satisfies the projection model (3.20) and the initial condition (3.22), and $x_{t,t-1}$ is the optimal projection in period $t-1$ of the vector of forward-looking variables in period t ($x_{t,t-1}$ is predetermined in period t and normalizes the added term and makes it zero in case the projection $x_{t,t}$ coincides with the projection $x_{t,t-1}$ but does not affect the choice of optimal policy). As discussed in Svensson and Woodford (2005), the added term and the dependence on the Lagrange multiplier Ξ_{t-1} ensure that the minimization of (3.26), under either discretion or commitment, results in the optimal policy under commitment in a timeless perspective.[29]

The optimal policy choice, which results in the optimal policy projection, can now be formalized as choosing Y^t in the set of feasible projections in period t so as to minimize the modified

[28] It follows from the certainty-equivalence theorem that the minimization of the expected value of discounted future losses, $\mathrm{E}_t \sum_{\tau=0}^{\infty} \delta^\tau Y_{t+\tau}{}' W Y_{t+\tau}$ in (3.11), results in the same optimal instrument rule in period t as the minimization of the intertemporal forecast loss function, $\sum_{\tau=0}^{\infty} \delta^\tau Y_{t+\tau,t}{}' W Y_{t+\tau,t} = \sum_{\tau=0}^{\infty} \delta^\tau (\mathrm{E}_t Y_{t+\tau})' W (\mathrm{E}_t Y_{t+\tau})$ in (3.23). The expected value of discounted future losses will exceed the intertemporal forecast loss function by the term $\sum_{\tau=0}^{\infty} \delta^\tau \left[\mathrm{E}_t (Y_{t+\tau} - \mathrm{E}_t Y_{t+\tau})' W (Y_{t+\tau} - \mathrm{E}_t Y_{t+\tau})\right]$ due to the forecast errors $Y_{t+\tau} - \mathrm{E}_t Y_{t+\tau}$, but the effect of policy on those forecasts errors and that term can be disregarded under certainty equivalence.

[29] This added term is closely related to the recursive saddlepoint method of Marcet and Marimon (1998), see Svensson (2009b) and Woodford (2010b) for more discussion.

intertemporal loss function, that is, to solve the problem

$$\text{minimize } \mathcal{L}(Y^t) + \frac{1}{\delta}\Xi'_{t-1}H(x_{t,t} - x_{t,t-1}) \text{ subject to } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}). \tag{3.27}$$

The set of feasible projections $\mathcal{T}(X_{t|t})$ is obviously very large and contains infinitely many different policy projections. The presentation of the alternative policy projections generated by alternative policy-rate paths (for instance, as described in Laséen and Svensson (2010)), can be seen as an attempt to narrow down the set of infinite alternative feasible policy projections to a finite number of alternatives for the policymaker to choose between.

For a given linear projection model and a given modified quadratic intertemporal loss function, it is possible to compute the optimal policy projection exactly. By varying the parameters of the modified intertemporal loss function it is possible to generate alternative policy projections. Generating alternative policy projections in that way has the advantage that the policy projections are on the efficient frontier, to be specified below. However, the policymaker may still prefer to see a few representative alternative policy projections constructed with alternative policy-rate paths that are not constructed as optimal policy projections. The methods to construct policy projections for alternative anticipated policy-rate paths presented in Laséen and Svensson (2010) is one way to do this.

As discussed in Svensson and Woodford (2005) and Giannoni and Woodford (2003), commitment in a timeless perspective can alternatively be implemented by imposing the constraint

$$x_{t,t} = F_x \begin{bmatrix} X_{t|t} \\ \Xi_{t-1} \end{bmatrix} \tag{3.28}$$

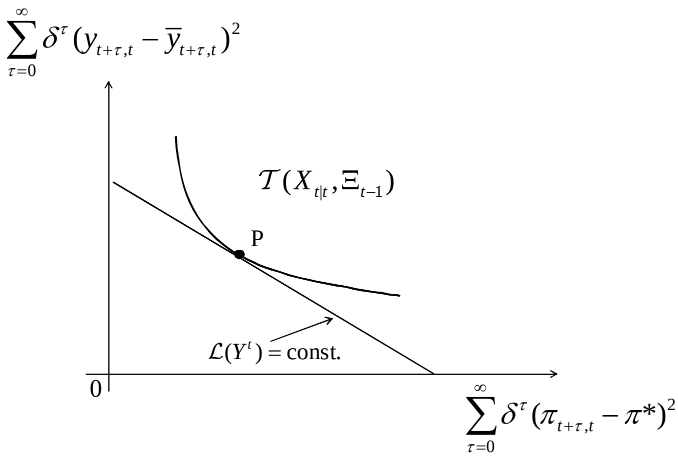
instead of adding the extra term to the period loss function. Let $\mathcal{T}(X_{t|t}, \Xi_{t-1})$ denote the subset of the feasible set of projections that satisfy (3.28) for given $X_{t|t}$ and Ξ_{t-1} and call this the restricted feasible set of projections. Then the optimal policy projection is also the solution to the problem

$$\text{minimize } \mathcal{L}(Y^t) \text{ subject to } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}, \Xi_{t-1}). \tag{3.29}$$

3.4. The forecast Taylor curve

The optimal policy projection, the restricted set of feasible projections, and the efficient restricted set of projections can be illustrated using a modified Taylor curve, a forecast Taylor curve. Whereas the original Taylor curve involves unconditional variances (to be precise, standard deviations in figure 1 of Taylor (1979)) of *ex post* outcomes, the forecast Taylor curve involves the discounted sum of squared inflation-gap and output-gap forecasts *ex ante* (see Svensson (2010a) for applications

Figure 3.1: Forecast Taylor curve



of forecast Taylor curves to policy evaluation). With the loss function (3.25), the intertemporal forecast loss function can be written

$$\mathcal{L}(Y^t) = \sum_{\tau=0}^{\infty} \delta^{\tau} (\pi_{t+\tau,t} - \pi^*)^2 + \lambda \sum_{\tau=0}^{\infty} \delta^{\tau} (y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2.$$

Let us call the discounted sums $\sum_{\tau=0}^{\infty} \delta^{\tau} (\pi_{t+\tau,t} - \pi^*)^2$ and $\sum_{\tau=0}^{\infty} \delta^{\tau} (y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2$ the sum of squared inflation gaps and output gaps, respectively (keeping in mind that we actually mean inflation-gap and output-gap *forecasts*). We can now illustrate the restricted set of feasible projections, $\mathcal{T}(X_{t|t}, \Xi_{t-1})$, in the space of sum of squared inflation and output gaps. In figure 3.1, the sum of squared inflation gaps is plotted along the horizontal axis and the sum of squared output gaps is plotted along the vertical axis. The restricted set of feasible projections is the set on and above the curve through the point P. The efficient restricted set of feasible projections, the efficient frontier of the restricted set of feasible projections, is given by the boundary, the curve through the point P.

In the figure, we can also illustrate isoloss lines of the intertemporal forecast loss function as negatively sloped lines with the slope $1/\lambda$. An isoloss line closer to the origin corresponds to a lower loss. The optimal policy projection is given by the tangency point P between the efficient frontier and an isoloss line, the policy projection in the restricted set of feasible projections that gives the lowest intertemporal loss.

The efficient frontier consists of the projections in the set of restricted feasible projections that are efficient, in the sense that there is no other projection in the restricted feasible set that has a lower sum of squared inflation gaps without having a higher sum of squared output gaps. Obviously, the optimal policy projection is in the efficient set.

Section 4.3 and 4.4 show applications of these ideas in practical policy.

3.5. Optimal policy projections

Under the assumption of optimization under commitment in a timeless perspective, the optimal policy projection can be described by the following difference equation,

$$\begin{bmatrix} \hat{x}_{t+\tau,t} \\ \hat{\imath}_{t+\tau,t} \end{bmatrix} = \begin{bmatrix} F_x \\ F_i \end{bmatrix} \begin{bmatrix} \hat{X}_{t+\tau,t} \\ \Xi_{t+\tau-1,t} \end{bmatrix}, \tag{3.30}$$

$$\begin{bmatrix} \hat{X}_{t+\tau+1,t} \\ \Xi_{t+\tau,t} \end{bmatrix} = M \begin{bmatrix} \hat{X}_{t+\tau,t} \\ \Xi_{t+\tau-1,t} \end{bmatrix}, \tag{3.31}$$

$$\hat{Y}_{t+\tau,t} = \tilde{D} \begin{bmatrix} \hat{X}_{t+\tau,t} \\ \Xi_{t+\tau-1,t} \end{bmatrix}, \tag{3.32}$$

for $\tau \geq 0$, where $\hat{X}_{t,t} = X_{t|t}$ and $\Xi_{t-1,t} = \Xi_{t-1}$. The matrices F, M, and $\tilde{D}$ are the same as above.

Alternative optimal projections can be constructed by varying the weights in the matrix Λ and the discount factor δ. The use of alternative optimal projections has the advantage that the projections considered are efficient in the sense of minimizing an intertemporal loss function. That is, each projection is such that it is not possible to reduce the discounted sum of squared future projected deviations of a target variable from its target level without increasing the discounted sum of squared such future projected deviations of another target variable (this assumes that the positive symmetric semidefinite matrix Λ is diagonal). In figure 3.1, the efficient subset of the set of feasible projections, the efficient frontier of the set of feasible projections, is given by the negatively sloped curve through the point P. There are obvious advantages to restricting policy choices to be among efficient alternatives. Projections constructed with an arbitrary instrument rule (or with arbitrary deviations from an optimal instrument rule) are generally not efficient in this sense. That is, they correspond to points in the interior of the feasible set of projections, points north-east of the curve through point P in figure 3.1.

Projections can obviously also be constructed for a given instrument rule,

$$i_{t+\tau,t} = f \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \end{bmatrix} \equiv [f_X \quad f_x] \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \end{bmatrix}.$$

The resulting projection will satisfy equations such as (3.30)-(3.32), although without any Lagrange multipliers, where the matrices F and M depend on A, B, H and f. For arbitrary instrument rules, the projections will not be efficient.

3.6. Targeting rules

As discussed in Svensson (2003b) and Svensson (2005), the monetary-policy decision process makes the current instrument-rate decision a very complex policy function of the large amounts of data and judgment that have entered into the process. I believe that it is not very helpful to summarize this policy function as a simple instrument rule such as a Taylor rule. Furthermore, the resulting complex policy function is a *reduced form*, which depends on the central-bank objectives, its view of the transmission mechanism of monetary policy, and the judgment it has exercised. It is the endogenous complex result of a complex process. In no way is this policy function *structural*, in the sense of being invariant to the central bank's view of the transmission mechanism and private-sector behavior, or the amount of information and judgmental adjustments. Still, much current literature treats monetary policy as characterized by a given instrument rule that is essentially structural and invariant to changes in the model of the economy. Realizing that the policy function is a reduced form is a first step in a sensible theory of monetary policy. But, fortunately, this complex reduced-form policy function need not be made explicit. It is actually not needed in the modern monetary-policy process.

There is a convenient, more robust representation of monetary policy, namely in the form of a *targeting rule*, as discussed in some detail in Svensson and Woodford (2005) and Svensson (2003b) and earlier in more general terms in Svensson (1999a). An *optimal* targeting rule is a first-order condition for optimal monetary policy. It corresponds to the standard efficiency condition of equality between the marginal rates of substitution and the marginal rates of transformation between the target variables, the former given by the monetary-policy loss function, the latter given by the transmission mechanism of monetary policy. An optimal targeting rule is invariant to everything else in the model, including additive judgment and the stochastic properties of additive shocks. Thus, it is a compact and robust representation of monetary policy, much more robust than the optimal policy function. A *simple* targeting rule can potentially be a practical representation of robust monetary policy, a robust monetary policy that performs reasonably well under different circumstances. Giannoni and Woodford (2003) and Giannoni and Woodford (2010) provide general derivations of optimal targeting rules/target criteria, and they are further discussed in Woodford (2007), Woodford (2010a), and Woodford (2010b).[30] [31]

[30] Walsh (2004) shows a case of equivalence between targeting rules and robust control.

[31] Previously, Bank of England and the Riksbank assumed a constant interest rate underlying its inflation forecasts, with the implication that a constant-interest-rate inflation forecasts that overshoots (undershoots) the inflation target at some horizon such as two years indicates that the policy rate needs to increased (decreased). This is a far-from-optimal targeting rule that has now been abandoned, as discussed in section 4.2.

In this framework, a given targeting rule would have the form

$$\sum_{s=-a}^{b} g_s Y_{t+s+\tau,t} = 0$$

for $\tau \geq 0$. In the simplest New Keynesian model with the Phillips curve (3.5) and the loss function (3.13), the optimal targeting rule has the projection form

$$\pi_{t+\tau,t} - \pi^* + \frac{\lambda}{\kappa}[(y_{t+\tau,t} - \bar{y}_{t+\tau,t}) - (y_{t+\tau-1,t} - \bar{y}_{t+\tau-1,t})] = 0 \tag{3.33}$$

for $\tau \geq 0$ (Svensson and Woodford (2005)).

Optimal targeting rules remain a practical way of representing optimal monetary policy in the small models usually applied for academic monetary-policy analysis. However, for the larger and higher-dimensional operational macromodels used by many central banks in constructing projections, the optimal targeting rule becomes more complex and arguably less practical as a representation of optimal monetary policy. Optimal policy projections, the projections corresponding to optimal policy under commitment in a timeless perspective, can however easily be derived directly with simple numerical methods, without reference to any optimal targeting rule. For practical optimal monetary policy, policymakers actually need not know the optimal targeting rule. Even less do they need to know any policy function. They only need to ponder the graphs of the projections of the target variables that are generated in the policy process and choose the projections of the target variables and the policy rate that look best relative to the central bank's objectives, as illustrated in section 4.3.

3.7. Implementation and equilibrium determination

The policy decision can be characterized by $(\hat{\imath}^t, \hat{Y}^t)$, the optimal projection of the policy rate and the target variables. The policy decision also determines the Lagrange multipliers Ξ_t to be used in the loss function and policy decision in period $t+1$.

How can we model how the policy is implemented and how the (rational-expectations) equilibrium is determined? The central bank announces (or somehow communicates) $\hat{\imath}^t$ and $\hat{Y}^t$ (and possibly more details of its optimal projection) and sets the current policy rate in line with the policy-rate path, $i_t = \hat{\imath}_{t,t}$. Let us assume that the central-bank projections are credible and hence believed by the private sector.

In particular, assume that private-sector expectations of next period's forward-looking variables are equal to the central bank's forecast and are rational and equal to $\mathrm{E}_t x_{t+1}$. The forward-looking variables x_t and the target variables Y_t in period t are then determined by Eq. (3.4), given X_t and $\mathrm{E}_t x_{t+1}$, and (3.10), given X_t, x_t, and i_t. The next period's predetermined variables X_{t+1} are then determined next period by (3.2), given X_t, x_t and next period's shocks ε_{t+1}. Then next period's policy decision then determines $\hat{\imath}^{t+1}$ and $\hat{Y}^{t+1}$, given $X_{t+1|t+1}$ and $\Xi_{t,t+1} \equiv \Xi_t$. This way a rational-expectations equilibrium is implemented.

Is the equilibrium determinate? As discussed in Svensson and Woodford (2005), this may require an out-of-equilibrium commitment which may be explicit or implicit.[32] That is, the central bank commits to deviate from $\hat{\imath}_{t,t}$ if the economy deviates from the optimal projection.[33] For instance, if realized inflation π_t exceeds the inflation projection $\hat{\pi}_{t,t}$, the central-bank may set a higher policy rate according to

$$i_t = \hat{\imath}_{t,t} + \varphi(\pi_t - \hat{\pi}_t),$$

where $\varphi > 0$. In the example discussed in Svensson and Woodford (2005), the Taylor Principle of $\varphi > 1$ ensures determinacy. Another example of an out-of-equilibrium commitment in that example is

$$i_t = \hat{\imath}_{t,t} + \varphi\{\pi_t - \pi^* + \frac{\lambda}{\kappa}[(y_t - \bar{y}_t) - (y_{t-1} - \bar{y}_{t-1})]\}, \tag{3.34}$$

where

$$\pi_t - \pi^* + \frac{\lambda}{\kappa}[(y_t - \bar{y}_t) - (y_{t-1} - \bar{y}_{t-1})] = 0$$

is the optimal targeting rule, the first-order condition for optimal policy, in the standard New Keynesian model with the Phillips curve (3.5) and the loss function (3.13). Here, the out-of-equilibrium commitment (3.34) implies that any positive deviation from the optimal targeting rule (in the sense of too high inflation or too high output) would result in a higher policy rate. A sufficiently high value of φ, usually not very different from unity, ensures determinacy.

Importantly, in this setup the object of choice of the central bank and what is communicated to the private sector is i^t, the policy-rate path, not the policy function, F_i (although there is a one-to-one correspondence between the optimal policy-rate path and the optimal policy function).[34]

[32] For instance, in the standard New Keynesian model, the predetermined variables are exogenous. If the central bank implements policy by letting the policy rate respond to the predetermined variables only, the policy rate will be exogenous. Then, by the arguments of Sargent and Wallace (1975), the equilibrium may be indeterminate.

[33] In Svensson and Woodford (2005) the precise timing of these operations is made explicit so as to avoid any simultaneity problems.

[34] There is a one-to-one correspondence between the optimal policy-rate path and the optimal policy function $i_t = F_i \tilde{X}_t$ (for which the policy instrument responds to the predetermined variables $\tilde{X}_t \equiv (X_t', \Xi_{t-1}')'$), but there is a continuum of implicit instrument rules (for which the policy instrument responds also to forward-looking variables) consistent with the optimal policy. For instance, the implicit instrument rule $i_t = (F_i - \varphi F_x)\tilde{X}_t + \varphi x_t$ is consistent with the optimal policy for any value of the scalar φ, since in equilibrium $x_t = F_x \tilde{X}_t$. However, the determinacy properties (the eigenvalue configuration) may of course depend on φ.

3.8. Optimization under discretion and the discretion equilibrium

The previous discussion is under the assumption that commitment in a timeless perspective is possible. Under optimization under discretion, the central bank minimizes the intertemporal loss function (3.11) in period t, taking into account that it will reoptimize again in period $t+1$ (and that this reoptimization is anticipated by the private sector). Oudiz and Sachs (1985) derive an iterative algorithm for the solution of this problem (with the unnecessary simplification of $H = I$), which is further discussed in Backus and Driffill (1986), Currie and Levine (1993), and Söderlind (1999). This algorithm is briefly described here.[35]

Since the loss function is quadratic and the constraints are linear, it follows that the solution will be linear and the minimized intertemporal loss will be quadratic. Reoptimization in period $t+1$ subject to (3.1) and given X_{t+1} will result in the policy rate i_{t+1}, the forward-looking variables x_{t+1}, and the minimized intertemporal loss in period $t+1$ satisfying

$$i_{t+1} = F_{i,t+1} X_{t+1}, \tag{3.35}$$

$$x_{t+1} = F_{x,t+1} X_{t+1}, \tag{3.36}$$

$$\mathrm{E}_{t+1} \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+1+\tau} = X'_{t+1} V_{t+1} X_{t+1} + w_{t+1}, \tag{3.37}$$

where the matrices $F_{i,t+1}$, $F_{x,t+1}$, and V_{t+1} and the scalar w_{t+1} are determined by the decision problem in period $t+1$. These matrices and the scalar are assumed to be known in period t; only $F_{x,t+1}$ and V_{t+1} will matter for the decision problem in period t.

By taking expectations of (3.36) and using (3.2), we have

$$x_{t+1|t} = F_{x,t+1} X_{t+1|t} = F_{x,t+1}(A_{11} X_t + A_{12} x_t + B_1 i_t). \tag{3.38}$$

Using (3.38) in the lower block of (3.1) and solving for x_t results in

$$x_t = \bar{A}_t X_t + \bar{B}_t i_t, \tag{3.39}$$

where

$$\bar{A}_t \equiv (A_{22} - H F_{x,t+1} A_{12})^{-1} (H F_{x,t+1} A_{11} - A_{21}), \tag{3.40}$$

$$\bar{B}_t \equiv (A_{22} - H F_{x,t+1} A_{12})^{-1} (H F_{x,t+1} B_1 - B_2) \tag{3.41}$$

(we assume that $A_{22} - H F_{x,t+1} A_{12}$ is nonsingular). Using (3.39) in the upper block of (3.1) then gives

$$X_{t+1} = \tilde{A}_t X_t + \tilde{B}_t i_t + C \varepsilon_{t+1}, \tag{3.42}$$

[35] See Svensson (2009b) for more details of this algorithm.

where

$$\tilde{A}_t \equiv A_{11} + A_{12}\bar{A}_t, \tag{3.43}$$

$$\tilde{B}_t \equiv B_1 + A_{12}\bar{B}_t. \tag{3.44}$$

The optimization problem in period t is now to minimize

$$L_t + \delta \mathrm{E}_t(X'_{t+1}V_{t+1}X_{t+1} + w_{t+1})$$

subject to (3.42). The problem has been transformed to a standard linear-quadratic regulator problem without forward-looking variables, albeit with time-varying parameters. The solution will satisfy[36]

$$\begin{aligned} i_t &= F_{it}X_t, \\ x_t &= F_{xt}X_t, \\ X_t'V_tX_t + w_t &\equiv L_t + \delta \mathrm{E}_t(X'_{t+1}V_{t+1}X_{t+1} + \delta w_{t+1}), \end{aligned}$$

where F_{xt} and F_{it} must satisfy

$$F_{xt} = \bar{A}_t + \bar{B}_t F_{it}. \tag{3.45}$$

Equation (3.40)-(3.45) define a mapping from $(F_{x,t+1}, V_{t+1})$ to (F_{xt}, V_t), which also determines F_{it}. The solution to the problem is a fixed point (F_x, V) of the mapping and a corresponding F_i. It can be obtained as the limit of (F_{xt}, V_t) when $t \to -\infty$.

Thus, the solution and the discretion equilibrium is

$$\begin{aligned} \begin{bmatrix} x_t \\ i_t \end{bmatrix} &= \begin{bmatrix} F_x \\ F_i \end{bmatrix} X_t \;\equiv\; FX_t, \\ X_{t+1} &= (\tilde{A} + \tilde{B}F_x)X_t + C\varepsilon_{t+1} \;\equiv\; MX_t + C\varepsilon_{t+1}, \\ Y_t &= D \begin{bmatrix} I \\ F_x \\ F_i \end{bmatrix} X_t \;\equiv\; \tilde{D}X_t, \end{aligned}$$

for $t \geq 0$, where $(\tilde{A}, \tilde{B})$ is the limit of $(\tilde{A}_t, \tilde{B}_t)$ when $t \to -\infty$. We note that, by (3.45), F_x and F_i will satisfy

$$F_x = \bar{A} + \bar{B}F_i, \tag{3.46}$$

where $(\bar{A}, \bar{B})$ is the limit of $(\bar{A}_t, B_t)$ when $t \to -\infty$.

The matrices F and M depend on A, B, H, D, Λ, and δ, but they are independent of C. This demonstrates the certainty equivalence of the discretionary equilibrium.

[36] Svensson (2009b) provides details.

3.8.1. The projection model, the feasible set of projections, and the optimal policy projection

Under discretion, the projection model for the projections (X^t, x^t, i^t, Y^t) can be written

$$X_{t+\tau+1,t} = \tilde{A}X_{t+\tau,t} + \tilde{B}i_{t+\tau,t}, \tag{3.47}$$

$$x_{t+\tau,t} = \bar{A}X_{t+\tau,t} + \bar{B}i_{t+\tau,t}, \tag{3.48}$$

$$Y_{t+\tau,t} = D \begin{bmatrix} X_{t+\tau,t} \\ x_{t+\tau,t} \\ i_{t+\tau,t} \end{bmatrix} \tag{3.49}$$

for $\tau \geq 0$, where

$$X_{t,t} = X_{t|t}. \tag{3.50}$$

The feasible set of projections for given $X_{t|t}$, $\mathcal{T}(X_{t|t})$, is then the set of projections that satisfy (3.47)-(3.50). The optimal policy projection is then the solution to the problem

$$\text{minimize } \mathcal{L}(Y^t) \text{ subject to } (X^t, x^t, i^t, Y^t) \in \mathcal{T}(X_{t|t}).$$

Policy under discretion is here modeled as assuming that in each period $t+\tau \geq t$, private-sector expectations in period $t+\tau$ of the forward-looking variables and the policy rate in period $t+\tau+1$, $x_{t+\tau+1|t}$ and $i_{t+\tau+1|t}$, are determined by its belief that the central bank will reoptimize in period $t+\tau+1$.[37] This means that the private-sector expectations of the forward-looking variables and the policy rate satisfy

$$\begin{bmatrix} x_{t+\tau+1|t} \\ i_{t+\tau+1|t} \end{bmatrix} = FX_{t+\tau+1|t+\tau},$$

where $X_{t+\tau+1|t+\tau}$, the private-sector expectations in period $t+\tau$ of the predetermined variables in period $t+\tau+1$ is given by

$$X_{t+\tau+1|t+\tau} = \tilde{A}X_{t+\tau|t+\tau} + \tilde{B}i_{t+\tau}.$$

In particular, private-sector expectations in period t of the forward-looking variables and the policy rate in period $t+1$ satisfy

$$\begin{bmatrix} x_{t+1|t} \\ i_{t+1|t} \end{bmatrix} = FX_{t+1|t} = F(\tilde{A}X_{t|t} + \tilde{B}i_t). \tag{3.51}$$

The central bank's forecast in period t of the forward-looking variables in period $t+1$ depends on its forecast for both its policy rate in period $t+1$, $i_{t+1,t}$, according to

$$x_{t+1,t} = \bar{A}X_{t+1,t} + \bar{B}i_{t+1,t} = \bar{A}(\tilde{A}X_{t|t} + \tilde{B}i_t) + \bar{B}i_{t+1,t}.$$

[37] Recall that private-sector rational expectations are denoted by a vertical bar in the subindex $t+\tau|t$, whereas central-bank projections are denoted by a comma in the subindex $t+\tau, t$.

If the central bank's forecast of its policy rate is consistent with its reoptimization in period $t+1$, it will satisfy

$$i_{t+1,t} = F_i X_{t+1,t} = F_i(\tilde{A} X_{t|t} + \tilde{B} i_t)$$

and be equal to the private-sector expectations of the policy rate, $i_{t+1|t}$. Then the central bank's forecast of the forward-looking variables, $x_{t+1,t}$, will be equal to the private-sector expectations, $x_{t+1|t}$, since

$$x_{t+1,t} = \bar{A} X_{t+1,t} + \bar{B} i_{t+1,t} = \bar{A} X_{t+1,t} + \bar{B} F_i X_{t+1,t} = F_x X_{t+1,t} = F_x(\tilde{A} X_{t|t} + \tilde{B} i_t) = x_{t+1|t},$$

where we have used (3.46).

Thus, the specification of the projection model under discretion, (3.47)-(3.50), implies that the central bank considers alternative policy-rate paths and associated forecasts for the predetermined and forward-looking variables, taking into account that those forecasts would not be credible and deviate from private-sector expectations. The private-sector expectations are here consistently equal to the optimal policy projection under discretion. In contrast, the specification of the projection model under commitment, (3.20)-(3.22), implies that the central bank considers alternative policy-rate paths and associated forecasts for the predetermined and forward-looking variables under the assumption that these alternative forecasts are credible.

3.8.2. Degrees of commitment

Commitment and discretion raise intriguing issues. Which is the more realistic description of actual monetary-policy decisions is not obvious. In Bergo (2007), the then Deputy Governor of Norges Bank provides a fascinating discussion of how Norges Bank tries to implement optimal policy under commitment. My own view so far has been that central-bank staff should propose to policymakers policy alternatives that are consistent with commitment in a timeless perspective, in the hope that policymakers would restrict their choices to those alternatives. This is the view underlying Adolfson, Laséen, Lindé, and Svensson (2009), for instance. How different the outcomes under commitment and discretion will depend on many things and how relevant these differences are for policymaking is an empirical issue that to my knowledge has not been resolved.[38]

An interesting idea is to consider not only the extremes of commitment and discretion but also a continuum in between. Schaumburg and Tambalotti (2007) present a simple framework for

[38] Furthermore, as discussed by Dennis (2008), the relative performance of commitment in a timeless perspective and discretion is an intriguing issue and depends on circumstances and how policy performance is evaluated. See Woodford (2010b) for more discussion of commitment, commitment in a timeless perspective, and discretion.

analyzing monetary policy in such a continuum, what they call quasi-commitment, between the extremes of commitment and discretion. Quasi-commitment is characterized by a given probability of a central bank reneging from a commitment. That probability can be interpreted as a measure of the lack of credibility of the central bank's policy, and they examine the welfare effects of a marginal increase in credibility. The main finding in their simple framework is that most of the welfare gain from increased commitment accrues at relatively low levels of credibility. The magnitude of the welfare gain is smaller when there is less inflation bias under discretion, that is, less average excess of inflation over the inflation target.

3.9. Uncertainty

In this subsection, I briefly discuss two kinds of uncertainty, namely uncertainty about an imperfectly observed state of the economy and uncertainty about the model and the transmission mechanism of monetary policy.

3.9.1. Uncertainty about the state of the economy

It is a truism that monetary policy operates under considerable uncertainty about the state of the economy and the size and nature of the disturbances that hit the economy. This is a particular problem for forecast targeting, under which the central bank, in order to set its interest-rate instrument, needs to construct conditional forecasts of future inflation, conditional on alternative interest-rate paths and the bank's best estimate of the current state of the economy and the likely future development of important exogenous variables. Often, different indicators provide conflicting information on developments in the economy. In order to be successful, a central bank then needs to put the appropriate weights on different information and draw the most efficient inference. In the case of a purely backward-looking model (of the evolution of the bank's target variables and the indicators), the principles for efficient estimation and signal extraction are well known. But in the more realistic case where important indicator variables are forward-looking variables, the problem of efficient signal-extraction is inherently more complicated.

In the case where there are no forward-looking variables, it is well known that a linear model with a quadratic loss function and a partially observable state of the economy (partial information) is characterized by *certainty equivalence*. That is, the optimal policy is the same as if the state of the economy were fully observable (full information), except that one responds to an efficient estimate of the state vector rather than to its actual value. Furthermore, a *separation principle* applies, according to which the selection of the optimal policy (the optimization problem) and the estimation of the current state of the economy (the estimation or signal-extraction problem) can be treated as separate problems. In particular, the observable variables will be predetermined and the innovations in the observable variables (the difference between the current realization and previous prediction of each of the observable variables) contain all new information. The optimal weights to be placed on the innovations in the various observable variables in one's estimate of the state vector at each point in time are provided by a standard Kalman filter (see, for instance, Chow (1973), Kalchbrenner and Tinsley (1975), and LeRoy and Waud (1977)).

The case without forward-looking variables is, however, very restrictive. In the real world, many important indicator variables for central banks are forward-looking variables, variables that depend on private-sector expectations of the future developments in the economy and future policy. Central banks routinely watch variables that are inherently forward-looking, like exchange rates, bond rates and other asset prices, as well as measures of private-sector inflation expectations, industry order-flows, confidence measures, and the like. Forward-looking variables complicate the estimation or signal-extraction problem significantly. They depend, by definition, on private-sector expectations of future endogenous variables and of current and future policy actions. However, these expectations in turn depend on an estimate of the current state of the economy, and that estimate in turn depends, to some extent, on observations of the current forward-looking variables. This circularity presents a considerable challenge for the estimation problem in the presence of forward-looking variables. Pearlman, Currie, and Levine (1986) showed in a linear (non-optimizing) model with forward-looking variables and partial symmetric information that the solution can be expressed in terms of a Kalman filter, although the solution is much more complex than in the purely backward-looking case. Pearlman (1992) later used this solution in an optimizing model to demonstrate that certainty equivalence and the separation principle apply under both discretion and commitment in the presence of forward-looking variables and symmetric partial information.

Svensson and Woodford (2003) extended this previous work on partial information with forward-looking variables by providing simpler derivations of the optimal weights on the observable variables, and clarifying how the updating equations can be modified to handle the circularity mentioned above.[39] They also provided a simple example, in the standard New Keynesian model, that clarifies several issues raised by Orphanides (2003). He has argued, for instance, with reference to real-time

[39] Gerali and Lippi (2008) provide a toolkit of Matlab routines that applies the algorithms of Svensson and Woodford (2005).

U.S. data from the 1970s, that it is better that monetary policy disregards uncertain data about the output gap and responds to current inflation only. The findings in Svensson and Woodford (2003) are different and in line with the conventional wisdom. First, they found that the monetary-policy response to the optimal *estimates* of the current output gap is the same as under certainty, that is, that certainty equivalence applies. Second, the optimal weights put on the noisy observations, the *indicators*, used in constructing the optimal estimate of the output gap depends on the degree of uncertainty. For instance, when the degree of noise in an indicator of potential output is large, the optimal weight on that indicator becomes small.[40]

3.9.2. Uncertainty about the model and the transmission mechanism

Recognizing the uncertain environment that policymakers face, recent research has considered broader forms of uncertainty for which certainty equivalence no longer applies. While this may have important implications, in practice the design of policy becomes much more difficult outside the classical linear-quadratic framework.

One of the conclusions of the Onatski and Williams (2003) study of model uncertainty is that, for progress to be made, the structure of the model uncertainty has to be explicitly modeled. In line with this, Svensson and Williams (2007b) develop a very explicit but still relatively general form of model uncertainty that remains quite tractable. They use a so-called Markov jump-linear-quadratic (MJLQ) model, where model uncertainty takes the form of different "modes" (or regimes) that follow a Markov process. The approach allows the user to move beyond the classical linear-quadratic world with additive shocks, yet remains close enough to the linear-quadratic framework that the analysis is transparent. Optimal and other monetary policies are examined in an extended linear-quadratic setup, extended in a way to capture model uncertainty. The forms of model uncertainty the framework encompasses include: simple i.i.d. model deviations; serially correlated model deviations; estimable regime-switching models; more complex structural uncertainty about very different models, for instance, backward- and forward-looking models; time-varying central-bank judgment—information, knowledge, and views outside the scope of a particular model (Svensson (2005))—about the state of model uncertainty; and so forth. Moreover, the methods also apply to other linear models with changes of regime which may capture boom/bust cycles, productivity slowdowns and accelerations, switches in monetary and/or fiscal policy regimes, and so forth.

[40] Svensson and Woodford (2004) derive an equlibrium with optimal monetary policy in a general linear-quadratic model with asymmetric information, where then central bank has less information than the private sector. Aoki (2006) provides an application to the standard New Keynesian model with a particular assumption about the central bank's information set. See Woodford (2010b) for more discussion of the case of asymmetric information.

With algorithms for finding the optimal policy as well as solutions for arbitrary policy functions it is possible to compute and plot consistent distribution forecasts—fan charts—of target variables and instruments. The methods hence extend certainty equivalence and "mean forecast targeting," where only the mean of future variables matter (Svensson (2005)), to more general certainty non-equivalence and "distribution forecast targeting," where the whole probability distribution of future variables matter (Svensson (2003b)).

Certain aspects of the MJLQ approach have been known in economics since the classic works of Aoki (1967) and Chow (1973), who allowed for multiplicative uncertainty in a linear-quadratic framework. The insight of those papers, when adapted to the MJLQ setting, is that in MJLQ models the value function for the optimal policy design problem remains quadratic in the state, but now with weights that depend on the mode. MJLQ models have also been widely studied in the control-theory literature for the special case when there are no forward-looking variables (see Costa and Fragoso (1995), Costa, Fragoso, and Marques (2005), do Val, Geromel, and Costa (1998), and the references therein). More recently, Zampolli (2006) uses an MJLQ model to examine monetary policy under shifts between regimes with and without an asset-market bubble, although still in a model without forward-looking variables. Blake and Zampolli (2005) provide an extension of the MJLQ model to include forward-looking variables, although with less generality than in Svensson and Williams (2007b) and with the analysis and the algorithms restricted to observable modes and discretion equilibria.

The MJLQ approach is also closely related to the Markov regime-switching models which have been widely used in empirical work. These methods first gained prominence with Hamilton (1989) which started a burgeoning line of research. Models of this type have been used to study a host of empirical phenomena, with many developments and techniques summarized in Kim and Nelson (1999). More recently, the implications of Markov switching in rational expectations models of monetary policy have been studied by Davig and Leeper (2007) and Farmer, Waggoner, and Zha (2009). These papers focus on (and debate) the conditions for uniqueness or indeterminacy of equilibria in forward-looking models, taking as given a specified policy rule.

Relative to this previous literature, Svensson and Williams (2007b) provides a more general approach for solving for the optimal policy in MJLQ models that include forward-looking variables. This extension is key for policy analysis under rational expectations, but the forward-looking variables make the model nonrecursive. The recursive saddlepoint method of Marcet and Marimon (1998) can then be applied to express the model in a convenient recursive way, and an algorithm for determining the optimal policy and value functions can be derived.

The more general case where modes are unobservable and decision makers infer from their observations the probability of being in a particular mode is much more difficult to solve. The optimal filter is nonlinear, which destroys the tractability of the MJLQ approach.[41] Additionally, as in most Bayesian learning problems, the optimal policy will also include an experimentation component. Thus, solving for the optimal decision rules will be a more complex numerical task. Due to the curse of dimensionality, it is only feasible in models with a relatively small number of state variables and modes. Confronted with these difficulties, the literature has focused on approximations such as linearization or adaptive control.[42] Svensson and Williams (2007a) develops algorithms to solve numerically for the optimal policy in these cases.[43] Due to the curse of dimensionality, the Bayesian optimal policy (BOP) is only feasible in relatively small models. Confronted with these difficulties, Svensson and Williams (2007a) also considers *adaptive* optimal policy (AOP).[44] In this case, the policymaker in each period does update the probability distribution of the current mode in a Bayesian way, but the optimal policy is computed each period under the assumption that the policymaker will not learn in the future from observations. In the MJLQ setting, the AOP is significantly easier to compute, and in many cases provides a good approximation to the BOP. Moreover, the AOP analysis is of some interest in its own right, as it is closely related to specifications of adaptive learning which have been widely studied in macroeconomics (see Evans and Honkapohja (2001) for an overview). Further, the AOP specification rules out the experimentation which some may view as objectionable in a policy context.

[41] The optimal nonlinear filter is well-known, and it is a key component of the estimation methods as well (Hamilton (1989) and Kim and Nelson (1999)).

[42] In the first case, restricting attention to (sub-optimal) linear filters preserves the tractability of the linear-quadratic framework. See Costa, Fragoso, and Marques (2005) for a brief discussion and references. In adaptive control, agents do not take into account the informational role of their decisions. See do Val, Geromel, and Costa (1998) for an application of an adaptive control MJLQ problem in economics. In a different setting, Cogley, Colacito, and Sargent (2007) have recently studied how well adaptive procedures approximate the optimal policies.

[43] In addition to the classic literature (on such problems as a monopolist learning its demand curve), Wieland (2000), Wieland (2006) and Beck and Wieland (2002) have recently examined Bayesian optimal policy and optimal experimentation in a context similar to ours but without forward-looking variables. Eijffinger, Schaling, and Tesfaselassie (2006) examine passive and active learning in a simple model with a forward-looking element in the form of a long interest rate in the aggregate-demand equation. Ellison and Valla (2001) and Cogley, Colacito, and Sargent (2007) study situations like ours but where the expectational component is as in the Lucas-supply curve ($E_{t-1}\pi_t$, for example) rather than our forward-looking case ($E_t\pi_{t+1}$, for example). Ellison (2006) analyzes active and passive learning in a New Keynesian model with uncertainty about the slope of the Phillips curve.

[44] Optimal policy under no learning, adaptive optimal policy, and Bayesian optimal policy have in the literature also been referred to as myopia, passive learning, and active learning, respectively.

3.10. Judgment

Throughout the monetary-policy decision process in central banks, a considerable amount of judgment is applied to assumptions and projections. Projections and monetary-policy decisions cannot rely on models and simple observable data alone. All models are drastic simplifications of the economy, and data give a very imperfect view of the state of the economy. Therefore, judgmental adjustments in both the use of models and the interpretation of their results—adjustments due to information, knowledge, and views outside the scope of any particular model—are a necessary and essential component in modern monetary policy. Any existing model is always an approximation of the true model of the economy, and monetary-policy makers always find it necessary to make some judgmental adjustments to the results of any given model. Such judgmental adjustments could refer to future fiscal policy, productivity, consumption, investment, international trade, foreign-exchange and other risk premia, raw-material prices, private-sector expectations, and so forth.

One way to represent central-bank judgment is as the central-bank's conditional mean estimate of arbitrary multidimensional stochastic "deviations"—"add factors"—to the model equations, as in Reifschneider, Stockton, and Wilcox (1997) and Svensson (2005). The deviations represent additional determinants—determinants outside the model—of the variables in the economy, the difference between the actual value of a variable and the value predicted by the model. It can be interpreted as model perturbations, as in the literature on robust control.[45] Svensson (2005) discusses optimal monetary policy, taking judgment into account, in backward- and forward-looking models. Svensson and Tetlow (2005) show how central-bank judgment can be extracted according to the method of Optimal Policy Projections (OPP). This method provides advice on optimal monetary policy while taking policymakers' judgment into account. Svensson and Tetlow (2005) demonstrate the usefulness of OPP with a few example projections for two Greenbook forecasts and the FRB/US model. An early version of the method was developed by Robert Tetlow for a mostly backward-looking variant of the Federal Reserve Board's FRB/US model. The resulting projections have been referred to at the Federal Reserve Board as "policymaker perfect-foresight projections"—somewhat misleadingly. A description and application of the method is given in Federal Reserve Board (2002), the Federal Reserve Board's Bluebook for the FOMC meeting on May 2, 2002.

Section 4.3 gives another example of the application of judgment, from the Riksbank's policy

[45] See, for instance, Hansen and Sargent (2008). However, that literature deals with the more complex case when the model perturbations are endogenous and chosen by nature to correspond to a worst-case scenario.

decision on February 2009. In the middle of the recent financial crisis and rapidly deteriorating economic situation, the Riksbank posted forecasts quite different from the forecasts generated by the Riksbank's models.

4. Practice

In this section on the practice of inflation targeting, I first discuss some development of practical inflation targeting since its introduction in New Zealand in 1990. Then I make some brief comments on the publication of policy-rate paths and describe the recent practice of two inflation-targeting central banks that I know more about; the Riksbank, which is ranked as one of the world's most transparent central banks, and Norges Bank, which has been a pioneer in applying explicit optimal monetary policy as an input in its policy decision. Finally I also comment on the issue of what preconditions are appropriate for emerging-market economies that consider inflation targeting.

4.1. Some developments of inflation targeting

Inflation targeting was introduced in New Zealand in 1990.[46] The Reserve Bank of New Zealand was the first central bank in the world to implement such a monetary policy setup, so it could not rely on the experience of other inflation-targeting central banks. Likewise, it had little experience in constructing inflation projections. During the 1990s, the Bank gradually established credibility and anchored inflation expectations on the inflation target. The Bank also accumulated an increased understanding of the transmission mechanism of monetary policy and increased confidence in its ability to fulfil the inflation target. This allowed the Bank some more degrees of freedom, and a gradual move towards more flexible and medium-term inflation targeting was to a large extent a natural consequence. It is possible that a shorter horizon and somewhat higher weight on inflation stabilization in the beginning may have contributed to establishing initial credibility.

Initially, the Bank had a rather rudimentary view of the transmission mechanism and mostly emphasized the direct exchange rate channel to CPI inflation.[47] The Bank also had a rather short policy horizon of 2–4 quarters within which it would attempt to meet the inflation target (see the Bank's *Briefing* of October 1996, Reserve Bank of New Zealand (1996)). The Bank's view of the transmission mechanism evolved gradually over the years to emphasize other channels

[46] See Svensson (2001) and, in particular, Singleton, Hawke, and Grimes (2006) for the developments of inflation targeting in New Zealand.
[47] See Svensson (2000) and Svensson (2001) for a discussion of the channels of the transmission mechanism of monetary policy.

of transmission, especially the aggregate-demand channel. The *Monetary Policy Statement* of December 1995, for instance, contains a box with a brief and preliminary discussion of the concept of potential output, which is so central in modern views of the transmission mechanism. With the introduction of the Forecasting and Policy System (FPS) in 1997 (Black, Cassino, Drew, Hansen et al. (1997)), which built on Bank of Canada's then state-of-the-art Quarterly Projection Model (QPM) (Poloz, Rose, and Tetlow (1994)), the Bank had developed a fully-fledged modern view of the transmission mechanism in an open economy in line with best international practice. With the introduction of the FPS, the Bank started to publish an interest-rate forecast in 1997, much earlier than any other inflation-targeting central bank.

Parallel to these developments, the Bank lengthened its policy horizon and took a more flexible interpretation of the inflation target. Indeed, in its *Briefing* of November 1999, Reserve Bank of New Zealand (1999), the Bank completely subscribes to the idea of flexible inflation targeting:

> "Our conclusion, on the whole, has been to adopt a more medium-term approach, which attaches more weight to the desirability of stabilising output, interest rates and the exchange rate, while still aiming to keep inflation within the target range."

The Bank mentioned some steps taken in this direction that include:

- "The widening of the inflation target range, from 0 to 2 percent to 0 to 3 percent..."
- "A lengthening of the horizon at which policy responses to inflation pressures are directed, from 6 to 12 months to something more like 12 to 24 months. This means that, provided the medium-term inflation outlook is in line with the target, near-term shifts in the price level are more likely to be accepted without policy reaction."
- "Some de-emphasis of the edges of the target range as hard and precise thresholds..."
- "The shift from an MCI target to a cash interest rate instrument for implementing monetary policy. This change has lessened the need for frequent intervention in the financial markets, and has resulted in more interest rate stability."[48]

[48] From June 1997 to March 1999, the Reserve Bank used a so-called Monetary Conditions Index (MCI) both as an indicator and as an instrument in implementing monetary policy. The real MCI was constructed by combining the 90-day real interest rate with the real exchange rate (expressed in terms of a trade-weighted index, the TWI), with a weight of 0.5 on the exchange rate. (Using the nominal interest rate and exchange rate results in the nominal MCI.) The MCI was supposed to measure the overall stance of monetary policy: the degree to which monetary policy is deemed to resist either inflationary or deflationary tendencies. However, from the complexity of the transmission mechanism, with different channels, different lags and different strengths of the effects, it is apparent that a simple summary index like the MCI will be unreliable. For instance, the relative effect of interest rate and exchange rate

Regarding the policy horizon, inflation targeting has sometimes been associated with a fixed horizon, such as two years, within which the inflation target should be achieved. However, as is now generally understood, under optimal stabilization of inflation and the real economy there is no such fixed horizon at which inflation goes to target or resource utilization goes to normal. The horizon at which the inflation forecast is close to the target and/or the resource-utilization forecast is close to normal depends on the initial situation of the economy, the initial deviation of inflation and resource utilization from target and normal and the nature and size of the estimated shocks to the economy (Faust and Henderson (2004), Giavazzi and Mishkin (2006), Smets (2003)). In line with this, many or even most inflation-targeting central banks have more or less ceased to refer to a fixed horizon and instead refer to the "medium term."[49]

With the linear models of the transmission mechanism that are standard for central banks, reasonable equilibrium and optimal paths for inflation and resource utilization approach the target and a normal level asymptotically, including the case when the policy rate is an estimated empirical function of observable variables. More precisely, the resulting equilibrium forecasts on period t of such models for the inflation and output gaps in period $t + \tau$, $\pi_{t+\tau,t} - \pi^*$ and $y_{t+\tau,t} - \bar{y}_{t+\tau,t}$,

changes on output and inflation varies with the channel, the time horizon, and how persistent these changes are expected to be by households and firms. Thus, there is no reason to believe that the relative weight on the exchange rate, taken to be 0.5 by the Reserve Bank, is stable. In line with this, attempts to estimate the relative weights have resulted in different and very uncertain estimates. The numerous problems of the MCI are discussed in Stevens (1998). In my review of monetary policy 1990-2000 in New Zealand (Svensson (2001)), one of my conclusions was that the uncritical use of the MCI had contributed to too tight policy in 1997/98 during the Asian crisis. In March 1999, the Reserve Bank abandoned this unusual way of implementing monetary policy and instead moved to a completely conventional implementation, by setting the Official Cash Rate (OCR).

With regard to the operational framework and how monetary policy was managed in pursuit of the inflation target, my overall conclusion was that "the period (mid 1997 to March 1999) when the Reserve Bank used a Monetary Conditions Index (MCI) to implement monetary policy represents a significant deviation from best international practice. This has now been remedied, and monetary policy in New Zealand is currently entirely consistent with the best international practice of flexible inflation targeting, with a medium-term inflation target that avoids unnecessary variability in output, interest rates and the exchange rate. Only some marginal improvements, mostly of a technical nature, are recommended."

[49] The Policy Target Agreement for the Reserve Bank of New Zealand (Reserve Bank of New Zealand (2007)) states that "the policy target shall be to keep future CPI inflation outcomes between 1 and 3 per cent on average over the medium term." The Bank of England (Bank of England (2007)) states that "the MPC's aim is to set interest rates so that inflation can be brought back to target within a reasonable time period without creating undue instability in the economy." The Reserve Bank of Australia states (Reserve Bank of Australia (2008)) "[m]onetary policy aims to achieve this [a target for consumer price inflation of 2-3 per cent per annum] over the medium term." Norges Bank states in its Monetary Policy Report that "Norges Bank sets the interest rate with a view to stabilising inflation close to the target in the medium term." In contrast, the Bank of Canada (Bank of Canada (2006)) mentions a more specific target time horizon: "[T]he present policy of bringing inflation back to the 2 per cent target within six to eight quarters (18 to 24 months) is still appropriate generally, although specific occasions may arise in which a somewhat shorter or longer time horizon might be appropriate." At the time of writing (March 2010) the Riksbank mostly uses the phrase "in a couple of years," but some documents (hopefully not for very long) still use the phrase "within two years."

respectively, are all of the basic form

$$\pi_{t+\tau,t} - \pi^* = \sum_{j=1}^{n} a_j \mu_j^\tau, \quad 1 > |\mu_1| \geq |\mu_2| \geq ...,$$

$$y_{t+\tau,t} - \bar{y}_{t+\tau,t} = \sum_{j=1}^{n} b_j \mu_j^\tau,$$

where a_j and b_j are constants determined by the initial state of the economy, μ_j for $j = 1, ..., n$ denote eigenvalues with modulus below unity, and $\tau = 0, 1, ...,$ denotes the forecast horizon. This means that the inflation-gap and the output-gap forecast for a particular forecast horizon are a linear combination of terms that approach zero exponentially and asymptotically. There is hence no particular horizon at which the forecast for the inflation or output gap is zero. Generally, a lower (higher) relative weight (λ) on output-gap stabilization implies that the inflation gap (the output gap) goes to zero faster (slower) (Svensson (1997)). Furthermore, for any given horizon, the size of the inflation or output gap depends on the initial inflation and output gap. Because of this, half-time, meaning the horizon at which the gap has been reduced to a half of the initial gap, is a more appropriate concept than a fixed horizon for describing the convergence of the forecast to the long-term mean values.[50]

4.2. Publishing an interest-rate path

As mentioned, inflation targeting is characterized by a high degree of transparency. Typically, an inflation-targeting central bank publishes a regular monetary-policy report which includes the bank's forecast of inflation and other variables, a summary of its analysis behind the forecasts, and the motivation for its policy decisions. Some inflation-targeting central banks also provide some information on, or even forecasts of, its likely future policy decisions.

Indeed, a current much-debated issue concerning the further development of inflation targeting is the appropriate assumption about the policy-rate path that underlies the forecasts of inflation and other target variables and the information provided about future policy actions. Traditionally, inflation-targeting central banks have assumed a constant interest rate underlying its inflation forecasts, with the implication that a constant-interest-rate inflation forecast that overshoots (undershoots) the inflation target at some horizon such as two years indicates that the policy rate needs to increased (decreased) (Jansson and Vredin (2003), Vickers (1998)). Increasingly, central banks have become aware of a number of serious problems with the assumption of constant interest rates.

[50] A possible definition of half-time, H, is the solution to the equation $|\mu_1|^H = 1/2$, where μ_1 is the eigenvalue with the largest modulus, so $H = -\ln 2 \,/\, \ln |\mu_1|$.

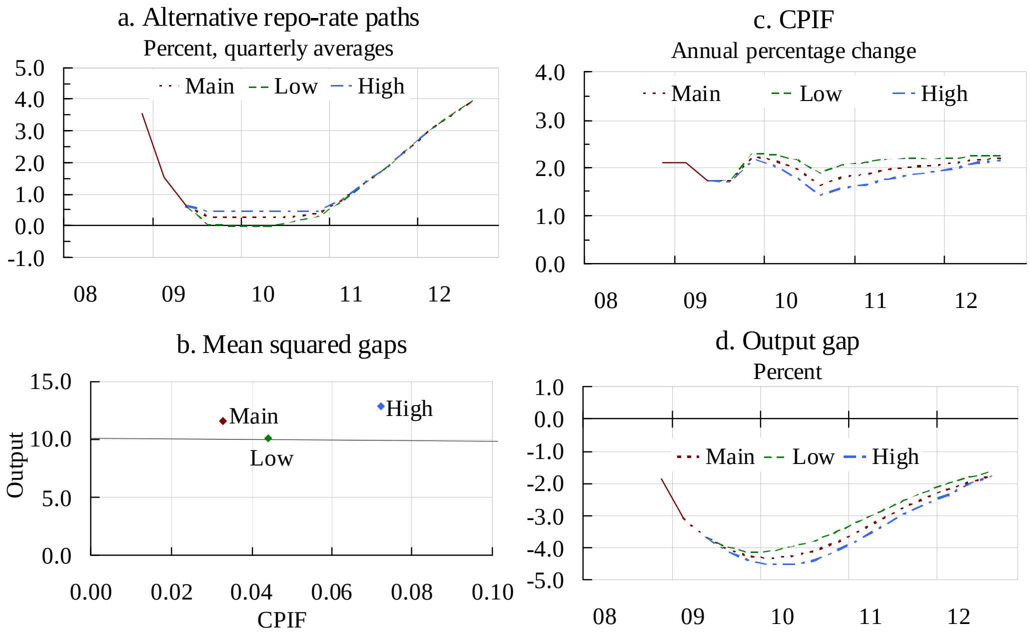
These problems include that the assumption may often be unrealistic and therefore imply biased forecasts, imply either explosive or indeterminate behavior of standard models of the transmission mechanism of monetary policy, and at closer scrutiny be shown to combine inconsistent inputs in the forecasting process (such as some inputs such as asset prices that are conditional on market expectations of future interest rates rather than constant interest rates) and therefore produce inconsistent and difficult-to-interpret forecasts (Leitemo (2003), Woodford (2005))). Some central banks have moved to a policy-rate assumption equal to market expectations at some recent date of future interest rates, as they can be extracted from the yield curve. This reduces the number of problems mentioned above but does not eliminate them. For instance, the central bank may have a view about the appropriate future interest-rate path that differs from the market's view. A few central banks (notably the Reserve Bank of New Zealand already in 1997, Norges Bank in 2005, the Riksbank in 2007, and the Czech National Bank in 2008) have moved to deciding on and announcing a policy-rate path; this approach solves all the above problems, is the most consistent way of implementing inflation targeting, and provides the best information for the private sector. The practice of deciding on and announcing optimal policy-rate paths is now likely to be gradually adopted by other central banks in other countries, in spite of being considered more or less impossible, or even dangerous, only a few years ago (Svensson (2007), Woodford (2005), Woodford (2007), Svensson (2009c)).[51]

4.3. The Riksbank

In January 1993, the Riksbank announced an inflation target of 2 percent for the CPI, with a tolerance interval of ±1 percent, to apply from 1995. (The tolerance interval was considered unnecessary and abolished in June 2010.) In 1999, the Riksbank became independent, and a six-member executive board was appointed. The board members are individually accountable with one vote each and the Governor has the tie-braking vote. There are normally six monetary-policy meetings per year. After a meeting the policy decision and a *Monetary Policy Report* or *Update* are released the next morning. Since February 2007, the Riksbank publishes not only a forecast of inflation and the real economy but also a policy-rate path in its report/update. Minutes from the policy meeting are published about two weeks after the meeting. Since June 2007, the minutes are attributed. Since April 2009, the votes and any dissents are published in the press release the

[51] Gosselin, Lotz, and Wyplosz (2008) provide a theoretical analysis of transparency and opaqueness about the central bank's policy-rate path.

Figure 4.1: Policy options for the Riksbank, July 2009



day after the meeting and not only in the minutes two weeks later. The Riksbank ranks as one of the most transparent central banks in the world (Dincer and Eichengreen (2009), Eijffinger and Geraats (2006)).

The Riksbank has announced that it conducts flexible inflation targeting and aims at stabilizing both inflation around the inflation target and resource utilization around a normal level. Figure 4.1 shows some policy options for the Riksbank at the policy meeting in July 2009. Panel a shows three alternative repo-rate paths (the repo rate is the Riksbank's policy rate), named Main, Low, and High. Panel c shows the corresponding forecasts for CPIF inflation (the CPI calculated with a fixed interest rate regarding housing costs) for the three repo-rate paths. Panel d shows corresponding output-gap forecasts for the three repo-rate paths. Panel b, finally, shows the tradeoff between the mean squared gaps for the inflation- and output-gap forecasts. The mean squared gap for the inflation- and output-gap forecast is the sum of the squared gaps over the forecast horizon divided by the number of periods within the forecast horizon.[52] The point marked Main shows, for the Main repo-rate path, the mean squared gap for the inflation- and output-gap forecasts along the horizontal and vertical axis, respectively. The points marked Low and High show the

[52] Mean squared gaps were introduced in Svensson (2010a). They appeared in the Riksbank's *Monetary Policy Report* the first time in October 2009. The mean squared gap for the inflation- and output-gap forecasts are $\sum_{\tau=0}^{T}(\pi_{t+\tau,t} - \pi^*)^2/(T+1)$ and $\sum_{\tau=0}^{T}(y_{t+\tau,t} - \bar{y}_{t+\tau,t})^2/(T+1)$, respectively, where T is the forecast horizon.

corresponding mean squared gaps for the Low and High repo-rate paths. The almost horizontal line shows an isoloss line corresponding to equal weight on inflation and output-gap stabilization ($\lambda = 1$). (The line is almost horizontal because the scales of the axes are so different.) We see that the High repo-rate path is dominated by the Main and Low repo-rate path. The majority of the board voted in favor of the Main alternative. Thanks to the high level of transparency of the Riksbank, the attributed minutes from the meeting (available in English on the Riksbank's web page, www.riksbank.com) reveal a lively debate about the decision, including whether a zero repo-rate was a feasible alternative or not. (I dissented in favor of the Low alternative.)

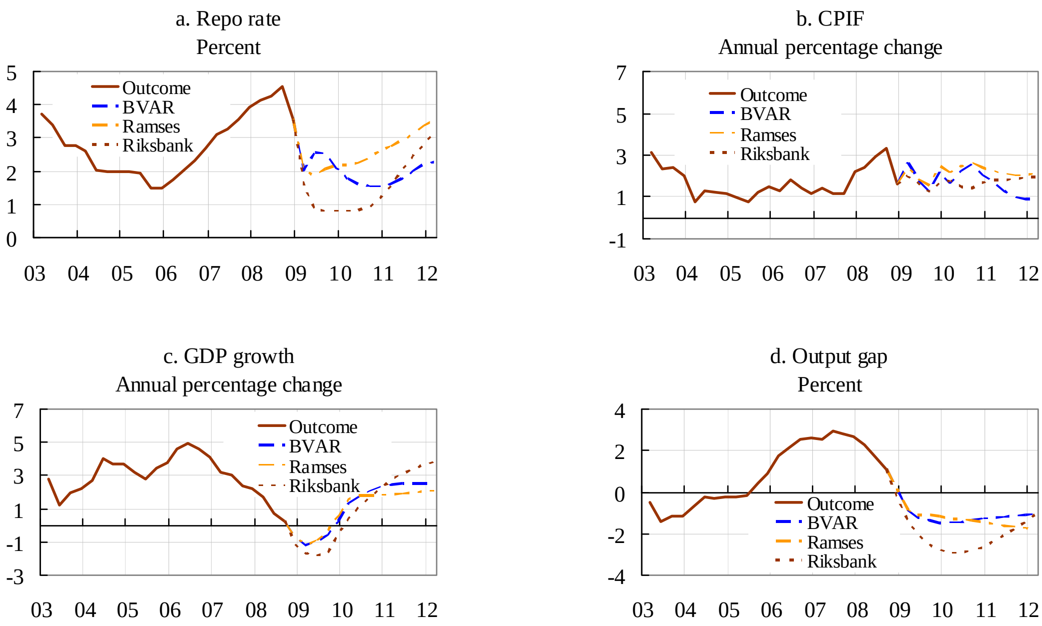
Figure 4.2 shows an example of how judgment is applied to result in a different forecast than the model one. The four panels a-d show the forecast of the repo-rate, CPIF, GDP growth, and the output gap at the policy meeting in February 2009. The dash-dotted curves show the forecast from the Riksbank's DSGE model Ramses (Adolfson, Laseen, Lindé, and Villani (2007), Adolfson, Laseen, Lindé, and Villani (2008)) when an estimated policy function is applied. The dashed curve shows the forecast from the Riksbank's Bayesian VAR model BVAR. The dotted curves, finally, shows the Riksbank's forecast of the four variables as presented in the *Monetary Policy Report*. Taking into the account the severe financial crisis and the rapidly deteriorating economic situation, the Riksbank lowered the repo-rate by 100 basis points to 1 percent, much lower than the repo-rate paths suggested by the models, and still had a more pessimistic view of GDP growth and the output gap than the models.

4.4. Norges Bank

Norway adopted an inflation target of 2.5 percent for monetary policy in March 2001. Norges Bank focuses on an index for core inflation. It is explicit about being a flexible inflation targeter and in explaining what that means: "Norges Bank operates a flexible inflation targeting regime, so that weight is given to both variability in inflation and variability in output and employment" (Norges Bank (2009)). Thus, Norges Bank can be seen as attempting to stabilize both the inflation gap and the output gap, which is consistent with minimizing a conventional intertemporal quadratic loss function.

The policy rate is set by the Bank's executive board. Decisions concerning the policy rate are normally taken at the executive board's monetary-policy meeting every sixth week. At three of these meetings, normally in March, June and October/November, Norges Bank publishes its *Monetary Policy Report* with an explicit instrument-rate path and corresponding projections of

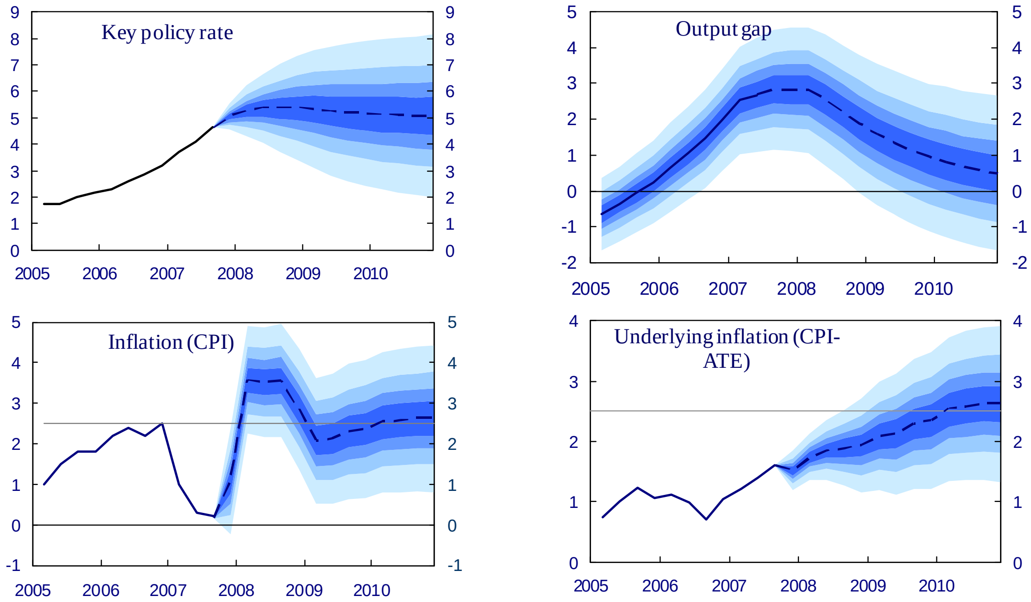
Figure 4.2: The application of judgment by the Riksbank, February 2009.



CPI inflation, a measure of core inflation, the output gap, and the policy rate. The uncertainty of the forecast is illustrated with probability distributions (uncertainty intervals), as in figure 4.3 from the policy meeting in January 2008 (Bank of England and the Riksbank, for instance, also illustrate the uncertainty with the help of uncertainty intervals). The main scenario is the mean of the probability distributions. It is normally assumed that the distribution is symmetric.

Officially, Norges Bank started to publish its own policy-rate forecast in the *Inflation Report* of November 2005. However, already in the *Inflation Report* of March 2005, it published graphs of alternative policy-rate paths and corresponding inflation and output-gap forecasts. These are reproduced in figure 4.4, panels a, c, and d. In panel b, I have computed and plotted the corresponding mean squared gaps for the three alternatives. The two negatively sloped lines show an isoloss line for $\lambda = 1$ and $\lambda = 0.3$ (the latter is the steeper line). The bank chose the Main alternative. Norges Bank is the only central bank that has announced that it applies a specific λ when it computes optimal policy in its macroeconomic model. Bergo (2007) and Holmsen, Qvigstad, and Røisland (2007) report that optimal policy with $\lambda = 0.3$ has replicated policy projections published by Norges Bank (with a discount factor of 0.99 and a weight on interest-rate smoothing of 0.2). Disregarding interest-rate smoothing, panel b shows that the Main alternative is marginally better then the High alternative for $\lambda = 0.3$.

Figure 4.3: Main scenario and uncertainty intervals, Norges Bank, January 2008



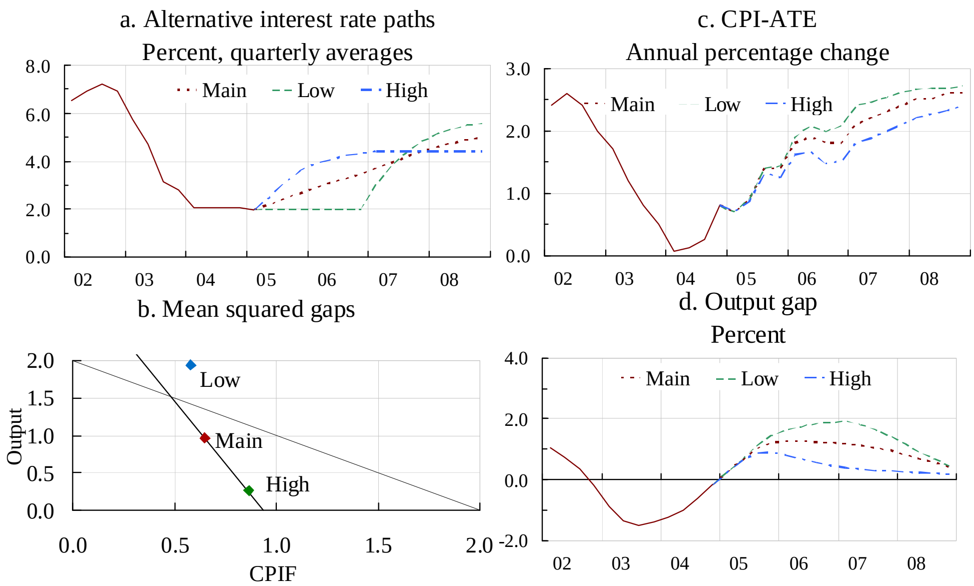
The decision process starts with the staff producing optimal policy projections under commitment.[53] Although optimal policy projections with the medium-sized DSGE-model NEMO (Brubakk and Sveen (2009)) is used as an input in the decision process, weight is also put on simple interest-rate rules, such as the Taylor rule. Judgements are then added to the model-based projections. The projections are then discussed by the board which might ask for additional adjustments based on their judgments.

Norges Bank has also published a set of criteria that it uses when judging between different instrument-rate paths. The first two criteria can be understood as verbal forms of optimality conditions. The other three provide for interest-rate smoothing, robustness and cross-checking. The criteria also work as an agenda for the internal discussions, see Holmsen, Qvigstad, Røisland, and Solberg-Johansen (2008).

Like many other central banks, Norges Bank indicates how it will react should certain disturbances occur by presenting alternative scenarios in the *Monetary Policy Report*. The exact specification of the shocks in the illustrations differs over time. The shifts are specified such that, if shocks of the same type and size occur, the alternative instrument-rate path is the Bank's best estimate of how it would react in such a situation. The shifts are consistent with the main scenario

[53] The staff normally use commitment in a timeless perspective as the main normative benchmark, but they have also considered alternatives such as the quasi-commitment in Schaumburg and Tambalotti (2007) (see section 3.8.2).

Figure 4.4: Policy options for Norges Bank, March 2005



in the sense that they are based on the same loss function guiding the response of the central bank.

The *Monetary Policy Report* includes an account of the disturbances that have led to a change in the instrument-rate forecast from the previous report. This "interest-rate account" is a model-based illustration of how the change in the policy-rate forecast from the previous report can be decomposed by different exogenous shocks to the model. The illustration shows how changes in the assessment of international and domestic economic variables as well as changes in the shock processes have affected the policy-rate path. The interest-rate account serves as a tool for communicating commitment. When the central bank commits to a reaction pattern under commitment, a change in the instrument-rate forecast should reflect economic news and not re-optimization of monetary policy. With an interest-rate account, the public is better able to check whether the central bank responds to news only or whether it re-optimizes.

4.5. Preconditions for inflation targeting in emerging-market economies

An oft-heard objection to inflation targeting (at least before Batini and Laxton (2007)) is that it is costly in terms of institutional and technical requirements, making the framework unsuitable for some emerging-market economies. A detailed exposition of this point was made in Eichengreen, Masson, Savastano, and Sharma (1999), who argued that technical capabilities and central bank autonomy were severely lacking in most emerging-market economies (including several that subsequently adopted inflation targeting).[54] Such countries, the argument goes, would be better off sticking with a "conventional" policy framework, such as an exchange-rate peg or money-growth targeting. The preconditions include (International Monetary Fund (2005, chapt. 4) and Batini and Laxton (2007)) institutional independence of the central bank; a well-developed technical infrastructure in terms of forecasting, modeling and data availability; an economy with fully deregulated prices, not overly sensitive to commodity prices and exchange rates, and with minimal dollarization; and a healthy financial system with sound banks and well-developed capital markets.

To assess the role of preconditions for the adoption of inflation targeting, Batini and Laxton (2007) administered a survey to 21 inflation-targeting central banks and 10 non-targeting central banks in emerging-market countries. The version of the survey given to inflation-targeting central banks focused on how policy was formulated, implemented, and communicated and how various aspects of central banking practice had changed before and during the adoption of targeting. Survey responses were cross-checked with independent primary and secondary sources and in many cases augmented with "hard" economic data. The evidence indicates that no inflation targeter had all the preconditions in place before adopting inflation targeting. Furthermore, their evidence suggests that it does not appear to be necessary for emerging-market countries to meet a stringent set of institutional, technical, and economic preconditions before successfully adopting inflation targeting. Instead, the feasibility and success of targeting appears to depend more on the authorities' commitment and ability to plan and drive institutional change after introducing targeting. Consequently, policy advice to countries that are interested in adopting targeting could usefully focus on the institutional and technical goals central banks should strive for during and after adopting targeting in order to maximize its potential benefits.

In a study of the experiences of Brazil, Chile, the Czech Republic, Indonesia, South Africa, and Turkey, de Mello (2008) concludes that many of the preconditions associated with inflation targeting had not been fulfilled when these countries adopted inflation targeting. Nevertheless, he finds that "these deficiencies have not undermined the implementation of inflation targeting where policy efforts have been focused on addressing them" (p. 10).

In an extensive survey, Freedman and Ötker-Robe (2009) describe the experiences of a number

[54] Others who stressed the conceptual relevance of "preconditions" include Agenor (2000); Schaechter, Stone, and Zelmer (2000); Carare, Schaechter, Stone, and Zelmer (2002); Khan (2003); and the May 2001 World Economic Outlook. See also Masson, Savastano, and Sharma (1997). More neutral or benign views on the conceptual relevance of "preconditions" can instead be found in Truman (2003); Jonas and Mishkin (2003); Debelle (2001); and Amato and Gerlach (2002).

of countries with the introduction and implementation of inflation targeting regimes, and discuss how they fared in meeting the various conditions that some have argued are needed in advance of introducing inflation targeting. They find that the country experiences are *not* supportive of the view that countries have to satisfy a long list of preconditions before adopting inflation targeting but that some elements were important in making the inflation-targeting framework more feasible and less challenging: (i) price stability as the overriding monetary policy goal; (ii) absence of fiscal dominance; (iii) central bank instrument independence; (iv) broad domestic consensus on the prominence of the inflation target; (v) some basic understanding of the transmission mechanism, and a reasonable capacity to affect short-term interest rates; and (vi) reasonably well-functioning financial system and markets. They suggest that these elements could perhaps be viewed as the conditions conducive to the introduction of a successful inflation-targeting framework. In particular, they conclude: "There is no single most effective path toward adoption of inflation targeting. It would certainly be a mistake to think that all the conditions for a successful implementation of inflation targeting need to be in place before the framework could be launched. As country experiences show, in many countries that now have successful inflation targeting, some of the conditions were not in place at the outset, but the authorities worked over time to establish them, and also learned by doing. It would similarly be a mistake, however, to think that all the conventional conditions would arrive spontaneously. The central banks have to initiate the process and make their best effort to establish the true conditions and work with the government toward that objective" (p. 19–20).

5. Future

This section discusses two potential future issues for inflation targeting – whether it would be advantageous to move on to price-level targeting and whether inflation targeting needs to be modified in the light of the recent financial crisis and deep recession.

5.1. Price-level targeting

A possible future issue is whether flexible inflation targeting should eventually be transformed into flexible price-level targeting. Inflation targeting as practised implies that past deviations of inflation from target are not undone. This introduces a unit root in the price level and makes the price level not trend-stationary, that is, nonstationary even after the removal of a deterministic trend. That is, the conditional variance of the future price level increases without bound with the horizon. In spite of this, inflation targeting with a low inflation rate is referred to as "price stability'. An alternative monetary-policy regime would be "price-level targeting', where the objective is to stabilize the price level around a price-level target.[55] That price-level target need not be constant but could follow a deterministic path corresponding to a steady inflation of two percent, for instance. Stability of the price level around such a price-level target would imply that the price level becomes trend-stationary, that is, the conditional variance of the price level becomes constant and independent of the horizon. One benefit of this compared with inflation targeting is that long-run uncertainty about the price level is smaller. Another benefit is that, if the price level falls below a credible price-level target, inflation expectations would rise and reduce the real interest rate even if the nominal interest rate is unchanged. The reduced real interest rate would stimulate the economy and bring the price level back to the target. Thus, price-level targeting may imply some automatic stabilization. This may be highly desirable, especially in situations when the zero lower bound on nominal interest rates is binding, the nominal interest rate cannot be further reduced, and the economy is in a liquidity trap, as has been the case for several years in Japan (and during the recent deep recession in several other countries). Whether price-level targeting would have any negative effects on the real economy remains a topic for current debate and research (Svensson (2002)). Recently several central banks, especially Bank of Canada, have shown new interest in price-level targeting and several reviews of new and old research have been published, for instance, Ambler (2009), Amano, Carter, and Coletti (2009), Deutsche Bundesbank (2010), and Kahn (2009).

5.2. Inflation targeting and financial stability: Lessons from the financial crisis[56]

At the time of writing (April 2010), the world economy was beginning to recover from the financial crisis and the resulting deep recession of the global economy, and there is a lively debate about what caused the crisis and how the risks of future crises can be reduced. Some blame loose monetary policy for laying the foundation for the crisis, and there is also a lively debate about the future of monetary policy and its relation to financial stability. In this section I discuss the lessons for inflation targeting after the crisis. My view is that the crisis was not caused by monetary policy but mainly by regulatory and supervisory failures in combination with some special circumstances,

[55] See Berg and Jonung (1999) for a discussion of the good experience of price-level targeting in Sweden during the Great Depression.

[56] This section builds on Svensson (2009a) and Svensson (2010b). I thank Hanna Armelius, Charles Bean, Claes Berg, Alan Blinder, Stephen Cecchetti, Hans Dellmo, Chuck Freedman, Charles Goodhart, Björn Lagerwall, Lars Nyberg, Irma Rosenberg, Hyun Shin, Frank Smets, and Staffan Viotti for discussions of these issues.

such as low world real interest rates and U.S. housing policy. Ultimately, my main conclusion for monetary policy from the crisis so far is that flexible inflation targeting, applied in the right way and using all the information about financial factors that is relevant for the forecast of inflation and resource utilization at any horizon, remains the best-practice monetary policy before, during, and after the financial crisis. But a better theoretical, empirical, and operational understanding of the role of financial factors in the transmission mechanism is urgently required and needs much work, work that is already underway in academia and in central banks.

As described in the previous sections, flexible inflation targeting means that monetary policy aims at stabilizing both inflation around the inflation target and resource utilization around a normal level, keeping in mind that monetary policy cannot affect the long-term level of resource utilization. Because of the time lags between monetary-policy actions and their effect on inflation and the real economy, flexible inflation targeting is more effective if it relies on forecasts of inflation and the real economy. Therefore, flexible inflation targeting can be described as "forecast targeting": the central bank chooses a policy-rate path so that the forecast of inflation and resource utilization stabilizes both inflation around the inflation target and resource utilization around a normal level or achieves a reasonable compromise between the two. The forecasts of inflation and the real economy are then conditional on the central bank's view of the transmission mechanism, an estimate of the current state of the economy and a forecast of important exogenous variables. The central bank uses all relevant information that has an impact on the forecast of inflation and the real economy. In this framework, the central bank takes financial conditions such as credit growth, asset prices, imbalances, potential asset price bubbles and so on into account only to the extent that they have an impact on the forecast of inflation and resource utilization. Inflation and resource utilization are target variables, that is, variables that the central bank tries to stabilize. Financial conditions are not target variables. Instead, they are only indicators, as they provide information to the central bank about the state of the economy, the transmission mechanism and exogenous shocks. Financial conditions then affect policy rates only to the extent that they have an impact on the forecast of inflation and resource utilization.

Now, is there any reason to modify this view of monetary policy given the experience of the financial crisis so far? Let me approach this question by first asking what the causes of the financial crisis were, whether monetary policy contributed to the crisis, and whether a different monetary policy was warranted and could have prevented or reduced the size of the crisis.

5.2.1. Did monetary policy contribute to the crisis, and could different monetary policy have prevented the crisis?

Many have claimed that excessively easy monetary policy by the Federal Reserve after 2001 helped cause a bubble in house prices in the U.S., a bubble whose inevitable bursting proved to be a major source of the financial crisis.[57] However, as I see it, the crisis was mainly caused by factors that had very little to do with monetary policy and were mostly due to background macro conditions, distorted incentives in financial markets, regulatory and supervisory failures (also when central banks have been responsible for regulation and supervision), information problems, and some specific circumstances, including the U.S. housing policy to support home ownership for low-income households.[58]

The macro conditions preceding the crisis included low world real interest rates associated with global imbalances, as well as the Great Moderation, with a long period of very stable growth and stable low inflation, which led to a systematic underestimation of risk and very low risk premia in financial markets. There were distorted incentives for commercial and investment banks to increase leverage that were made possible by lax regulation and supervision and the lack of an appropriate bank resolution regime. There were also distorted incentives to exercise less due diligence in loan origination because of securitization and to conduct regulatory arbitrage by setting up off-balance-sheet entities, which for various specific reasons ended up still effectively remaining on the balance sheet. There were also distorted incentives for traders and fund managers to take excessive risks because of myopic and asymmetric remuneration contracts. There were eventually enormous information problems in assessing the risks of extremely complex asset-backed securities, and there was a huge underestimation of the potential for correlated systemic risks. None of these causes had anything to do with monetary policy, except that monetary policy may have contributed to the Great Moderation.

Regarding the role of Federal Reserve monetary policy in the crisis, there are two relevant questions. First, was the low interest rate reasonable given the information available at the time? Second, could a different monetary policy with higher interest rates have prevented the crisis? The first question, whether the low interest rate was reasonable given the available information, is the

[57] See, for instance, Taylor (2007).

[58] See Bean (2009) for an extensive and excellent discussion of the crisis, including the credit expansion and housing boom, the macroeconomic antecedents, the distorted incentives, the information problems, the amplification and propagation of the crisis into the real economy, the policy responses, and the lessons for monetary policy and economics generally. Bank for International Settlements (2009) provides a more detailed account of the possible macro- and microeconomic causes of the crisis.

relevant one when evaluating monetary policy. It is more relevant to evaluate policy taking into account the information available ex ante to the policymaker rather than information ex post that was unknown to the policymaker at the time (see Svensson (2010a) on evaluating monetary policy ex ante and ex post). During the period in question, given the information available, there was a genuine and well-motivated fear of the U.S. falling into a Japanese-style deflationary liquidity trap, and the optimal policy in such a situation is a very expansionary monetary policy.[59] It may be that, in retrospect, the risk of deflation was exaggerated, but there was no way to know this ex ante. Hence, I consider the expansionary policy very appropriate. Adding some ex post evaluation, one can note that it did not lead ex post to very high inflation or an overheated economy.[60]

The second question, whether a different monetary policy could have prevented the crisis, is relevant when assessing to what extent monetary policy can be blamed for causing the crisis, notwithstanding if it was reasonable from an ex ante perspective. The credit growth and the housing boom in the U.S. and elsewhere were very powerful. Real interest rates were low to a large extent because of global imbalances, and the global saving glut and investment shortage. I believe that somewhat higher interest rates would have made little or no difference. Empirical evidence indicates that only a small portion of house-price increases can be attributed to monetary policy.[61] Bernanke (2010) shows that the recent phenomenon of a higher share of adjustable-rate mortgages was unlikely to have significantly increased the sensitivity of house prices to monetary policy. The availability of new, more exotic mortgage types mattered much more for initial mortgage payments than the level of short-term interest rates. In my view, interest rates would probably have had to be raised very high so as to cause considerable damage to the real economy in order to stop the credit growth and housing boom. That could have thrown the U.S. right into Japanese-style deflation and eventually a liquidity trap.[62] Certainly, higher interest rates would have had no impact on the regulatory problems, distorted incentives and information problems mentioned above (although they could have ended the Great Moderation with a deep recession and deflation).[63]

[59] See Svensson (2003a) for a discussion of policy options before and in a liquidity trap.

[60] Bernanke (2010) shows that Fed policy rates do not seem excessively low given real-time FOMC forecasts. See also Dokko, Doyle, Kiley, Kim et al. (2009).

[61] See Del Negro and Otrok (2007), Jarocinski and Smets (2008), Edge, Kiley, and Laforte (2008), and Iacoviello and Neri (2008).

[62] Assenmacher-Wesche and Gerlach (2009) study the responses of residential property and equity prices, inflation and economic activity to monetary policy shocks in 17 countries in the period 1986-2007, using single-country VARs and panel VARs in which they distinguish between groups of countries depending on their financial systems. The effect of monetary policy shocks on GDP is about a third of the effect on property prices. Thus, to increase policy rates so as to lower property prices by 15 percent would result in 5 percent lower GDP.

[63] Kohn (2008), after extensive discussion, concludes that there is insufficient evidence that low interest rates would have contributed much to the house-price boom and that higher interest rates would have had much dampening effect on it.

However, going beyond the Federal Reserve's actual monetary policy, perhaps it is possible that the emphasis on its readiness to relax monetary policy aggressively in the wake of a sharp fall in asset prices, as expressed by Greenspan (2002) for example, may have induced expectations of a floor under future asset prices and contributed to the asset-price boom, the so-called Greenspan put (Miller, Weller, and Zhang (2002)). Arguably, this is more of a communication issue than one of actual policy, and less emphasis on the readiness to clean up after a sharp fall in asset prices might have been a preferable alternative.

The IMF (International Monetary Fund (2009, chapt. 3)) has investigated the role of monetary policy in causing financial crises. A large number of countries and financial crises were included in the sample. The conclusion is that "the stance of monetary policy has not generally been a good leading indicator of future house price busts... There is some association between loose monetary policy and house price rises in the years leading up to the current crisis in some countries, but loose monetary policy was not the main, systematic cause of the boom and consequent bust." Furthermore, the overall relationship between the stance of monetary policy and house-price appreciation across countries in the years before the current crisis is statistically insignificant and economically weak, and monetary policy differences explain only about 5 percent of the variability in house price appreciation across countries.[64]

What conclusions can we draw so far from the financial crisis about the conduct of monetary policy and any need to modify the framework of flexible inflation targeting? One obvious conclusion is that price stability is not enough to achieve financial stability (Carney (2003), White (2006)). Good flexible inflation targeting by itself does not achieve financial stability, if anyone ever believed it would.

Another conclusion is that interest-rate policy is not enough to achieve financial stability. Specific policies and instruments are needed to ensure financial stability. Instruments like supervision and regulation, including appropriate bank resolution regimes, should be the first choice for financial stability. In many countries, the responsibility for these instruments rests on authorities other than the central bank. Generally, to the extent financial instability depends on specific distortions, good regulation should aim to attack these distortions as close to the source as possible. To counter the observed procyclicality of existing regulation, macro-prudential regulation that is contingent on the business cycle and financial indicators may need to be introduced to induce better financial

[64] The relationship for the euro area countries is less weak, but for reasons explained by Bernanke (2010) it is potentially overstated. See also Dokko, Doyle, Kiley, Kim et al. (2009).

stability. Possible macro-prudential regulation includes variable capital, margin, and equity/loan requirements. As expressed by Bean (2009), "the best approach is likely to involve a portfolio of instruments."

5.2.2. Distinguish monetary policy and financial-stability policy

More generally, what is the relation between financial stability and monetary policy? Financial stability is an important objective of economic policy. A possible definition of financial stability is a situation when the financial system can fulfil its main functions (of submitting payments, channeling saving into investment, and providing risk sharing) without disturbances that have significant social costs. I find it helpful to conceptually distinguish financial-stability policy from monetary policy. Different economic policies and policy areas, such as fiscal policy, labor market policy, structural policies to improve competition, etc., can be distinguished according to their objectives, the policy instruments that are suitable for achieving the objectives, and the authority or authorities controlling the instruments and responsible for achieving the objectives.

Monetary policy in the form of flexible inflation targeting has the objective of stabilizing both inflation around the inflation target and resource utilization around a normal level. The suitable instruments are under normal circumstances the policy rate and communication, including possibly a published policy-rate path and a forecast of inflation and the real economy. In times of crisis, as we have seen during the current crisis, other more unconventional instruments can be used, such as fixed-rate lending at longer maturities, asset purchases (quantitative easing), and foreign-exchange intervention to prevent currency appreciation. The authority responsible for monetary policy is typically the central bank.

The objective of financial-stability policy is maintaining or promoting financial stability. Under normal circumstances the available instruments are supervision, regulation, and financial-stability reports with analyses and leading indicators that may provide early warnings of stability threats. In times of crisis, there are instruments such as lending of last resort, variable-rate lending at longer maturities (credit policy, credit easing), special resolution regimes for financial firms in trouble, government lending guarantees, government capital injections, and so forth.[65] The responsible authority or authorities vary across countries. In some countries it is the central bank, in other

[65] Gertler and Kiyotaki (2010) develop a canonical framework to help organize thinking about credit market frictions and aggregate economic activity in the context of the current crisis. They use the framework to discuss how disruptions in financial intermediation can induce a crisis that affects real activity and to illustrate how various credit market interventions by the central bank and/or the Treasury of the type seen during the crisis might work to mitigate the crisis.

countries there is a separate financial supervisory authority, sometimes the responsibility is shared between different institutions. In Sweden, the Financial Supervisory Authority is responsible for supervision and regulation, the Riksbank is responsible for lending of last resort to solvent banks and for promoting a safe and efficient payment system, while the National Debt Office is responsible for bank guarantees and the resolution of failed banks. During times of crisis, these authorities cooperate closely with the Ministry of Finance.

My point here is that financial-stability policy and monetary policy are quite different, with different objectives, instruments, and responsible authorities, the latter with considerable differences across countries. This does not mean that there is no interaction between them. Financial stability directly affects the financial markets, and financial conditions affect the transmission mechanism of monetary policy. Problems in financial markets may have a drastic effect on the real economy, as the current financial crisis has shown. Monetary policy affects asset prices and balance sheets and can thereby affect financial stability. But the fact that financial-stability policy and monetary policy are conceptually distinct, with distinct objectives and distinct suitable instruments, has to be taken into account when considering the lessons of the financial crisis for monetary policy. Thus, because the policy rate is a blunt and unsuitable instrument for achieving financial stability, it makes little sense to assign the objective of financial stability to *monetary policy*, although it may make sense assign that objective to the *central bank*, if the central bank gets control of the appropriate supervisory and regulatory instruments.[66]

5.2.3. Conclusions for flexible inflation targeting

What are the specific conclusions for flexible inflation targeting? One important lesson from the financial crisis is that financial factors may have a very strong and deteriorating effect on the transmission mechanism, making standard interest-rate policy much less effective. This motivates more research on how to incorporate financial factors into the standard models of the transmission mechanism used by central banks. A rapidly-increasing volume of such research is now being produced by academic and central-bank researchers and presented at an increasing number of conferences on financial factors and monetary policy. Important and challenging questions include how potential output and neutral real interest rates are affected by financial factors and financial distortions (Curdia and Woodford (2009), Walsh (2009b)), and what impact financial factors have on the general

[66] Blinder (2010) discusses how much of the responsibility for financial-stability policy should rest with the central bank.

equilibrium effects of alternative policy-rate paths on inflation and resource utilization forecasts.[67] Even with much better analytical foundations concerning the role of financial factors in the transmission mechanism, there will of course, as always, be considerable scope for the application of good judgment in monetary policy.

Another conclusion, which is not new, is that consideration of the impact of financial factors on the forecast of inflation and resource utilization may require longer forecast horizons. Several inflation-targeting central banks (including the Bank of England, Norges Bank, and the Riksbank) have for other reasons already extended their forecast horizon from the previously common two years to three years. There is nothing that in principle prevents an inflation targeter from considering forecasts beyond a three-year horizon, but in practice there is usually little information about anything at longer horizons except the tendency to revert to the long-term average.

What about "leaning against the wind" (as advocated by, for instance, Borio and White (2003) and Cecchetti, Genberg, and Wadhwani (2002)), the idea that central banks should raise the interest rate more than what appears to be warranted by inflation and resource utilization to counter rapid credit growth and rising asset prices? It has sometimes not been quite clear whether advocates of leaning against the wind mean that credit growth and asset prices should be considered targets and enter the explicit or implicit loss functions alongside inflation and resource utilization, or whether they mean that credit growth and asset prices should still be considered just indicators and are emphasized only because credit growth and asset prices may have potential negative effects on inflation and resource utilization at a longer horizon. In the latter case, leaning against the wind is a way to improve the stability of inflation and resource utilization in the longer run. Then it is completely consistent with flexible inflation targeting.[68]

However, in line with the previous discussion, instruments other than interest rates are likely to be much more effective in avoiding excessive credit growth and asset- price booms, and should thus be used as a first best alternative. Interest rates that are high enough to have a noticeable effect on credit growth and asset prices may have strong negative effects on inflation and resource utilization,

[67] Walsh (2009b) points out that when financial factors cause distortions, these distortions will in general introduce corresponding terms in a loss function for monetary policy that is a second-order approximation to household welfare. Curdia and Woodford (2009) present a model where the second-order welfare approximation is a standard quadratic loss function of inflation and the output gap between output and potential output, but where potential output is affected by financial factors. Then inflation and the output gap remain the target variables, with and without financial factors. The neutral rate in the model, that is, the real rate consistent with output equal to potential output, is then also affected by financial factors.

[68] Adrian and Shin (2010a) and Adrian and Shin (2010b) argue, in a model with a risk-taking channel as in Borio and Zhu (2008), that short interest-rate movements may have considerable effects on the leverage of securities broker-dealers in the market-based financial sector outside the commercial-banking sector. However, new regulation may affect the magnitude of these affects, and the size of the market-based financial sector may end up being smaller after the crisis. In Europe, the commercial banks dominate the financial sector.

and a central bank will probably rarely have sufficient information about the likely beneficial longer-horizon effects on inflation and resource utilization for the trade-off to be worthwhile and motivated.[69]

In particular, if there is evidence of rapidly rising house prices and mortgage loans, and these developments are deemed to be unsustainable and a possible bubble, there are much more effective instruments than policy rates. Restrictions on loan-to-value ratios and requirements of realistic cash-flow calculations for house buyers with realistic interest rates are much more effective in putting a break on possible unsustainable developments than a rise in the policy rates. In particular, more transparency about future policy rates, in the form a policy-rate path published by the central bank, may help in providing realistic information about future interest rates.

Suppose, however, that, for some reason, the appropriate and effective instruments to ensure financial stability are not available, for instance, because of serious problems with the regulatory and supervisory framework that cannot be remedied in the short run. In such a second-best situation, if there is a threat to financial stability, one may argue that, to the extent that policy rates do have an impact on financial stability, that impact should be taken into consideration when choosing the policy-rate path to best stabilize inflation and resource utilization. Such considerations could result in a lower or higher policy-rate path than otherwise, in order to trade off less effective stabilization of inflation and resource utilization for more financial stability. However, so far all of the evidence indicates that in normal times that tradeoff is very unfavorable, in the sense that the impact of policy rates on financial stability is quite small and the impact on inflation and resource utilization is significantly larger, so an optimal tradeoff would still have little impact on financial stability. A good financial-stability policy framework is necessary to ensure financial stability. Monetary policy cannot serve as a substitute.

Ultimately, my main conclusion from the crisis so far is that flexible inflation targeting, applied in the right way and using all the information about financial factors that is relevant for the forecast of inflation and resource utilization at any horizon, remains the best-practice monetary policy before, during, and after the financial crisis. But a better theoretical, empirical and operational understanding of the role of financial factors in the transmission mechanism is urgently required and needs much work, work that is already underway in academia and in central banks.

[69] Kohn (2006) specifies three conditions that should be fulfilled for central banks to take "extra action" to deal with a possible asset-price bubble: "First, policymakers must be able to identify bubbles in a timely fashion with reasonable confidence. Second, a somewhat tighter monetary policy must have a high probability that it will help to check at least some of the speculative activity. And third, the expected improvement in future economic performance that would result from the curtailment of the bubble must be sufficiently great." He concludes, also in Kohn (2008) and after thorough considerations, that those conditions would rarely be met. See also Kohn (2009).

The outcome might very well be that financial factors are considered to have a larger role in affecting the transmission mechanism and as indicators of future inflation and resource utilization. If so, central banks would end up responding more to financial indicators, in the sense of adjusting the policy rate and policy-rate path more to a given change in a financial indicator. However, this would not mean that financial factors and indicators have become independent targets besides inflation and resource utilization in the explicit or implicit central-bank loss function. Instead, it would be a matter of responding appropriately to financial indicators in order to achieve over time the best possible stabilization of inflation around the inflation target and resource utilization around a normal level.

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