

Monetary Policy Inclinations*

Hans Gersbach
CER-ETH
Center of Economic Research
at ETH Zurich
ZUE D7
8092 Zurich, Switzerland
hgersbach@ethz.ch

Volker Hahn
CER-ETH
Center of Economic Research
at ETH Zurich
ZUE D13
8092 Zurich, Switzerland
vhahn@ethz.ch

First Version: January 2007

This Version: June 2008

Abstract

We examine whether the publication of forecasts concerning the likely future conduct of monetary policy is socially desirable. Introducing a new central bank loss function that accounts for the deviations from announcements, we incorporate forecasts about future inflation and interest rates into a dynamic monetary model. We show that the announcement of future interest rates is always socially detrimental. However, medium-term inflation projections tend to increase welfare.

Keywords: central banks, transparency, commitment, Federal Reserve, ECB, policy inclinations

JEL: E58.

*We would like to thank Alex Cukierman, Stefan Gerlach, Oliver Grimm, Heinz Hermann, Marina Iozef, Thomas Lanz, Anne Sibert, and participants of the Deutsche Bundesbank/Bank of Finland Conference “Designing Central Banks” in Eltville, 8-9 November 2007, for many valuable comments and suggestions.

1 Introduction

The range of current practice regarding the publication of policy inclinations by central banks is wide, extending from complete silence to explicit quarter-by-quarter numerical projections. Most central banks are reluctant to directly reveal their views on likely future actions (see Faust and Leeper (2005)). Central banks fear that the public would tend to interpret policy inclinations as commitments to future actions, which would reduce flexibility in responding to unexpected developments. A few central banks, however, have provided some direct signals to the public about their policy intentions. In May 1999, the Fed started to publish a policy bias or policy tilt about the likely direction of future policy. Only one year later, however, it abolished this practice because of the “unanticipated confusion” among investors and economists caused by its previous practice.¹ In 2003 the Federal Open Market Committee started to issue indications on policy inclinations to provide some forward guidance on monetary policy decisions. Much more resolute steps have been undertaken by the central banks of New Zealand and Norway, which have begun to publish numerical forecasts of the future path of policy interest rates. However, it is uncertain whether this trend towards more openness regarding policy inclinations will be sustained. For instance, the president of the European Central Bank has stated clearly that the ECB will not publish policy inclinations regarding the path of future policy interest rates (see Trichet (2006)). Poole (2005) has stated that “the most important communications issue facing the FOMC currently is whether and how to continue to provide forward guidance on policy decisions.”

Academics are also divided regarding the social desirability of policy inclinations.² Publishing policy inclinations about future interest-rate changes may be a means of anchoring expectations, as they create, at least partially, a degree of commitment to the course of future policies. Since Kydland and Prescott (1977) the positive value

¹Cf. “The Financial Times”, January 20, 2000, “Fed to No Longer Adopt Policy Bias Toward Rates.” See also Poole (2003).

²For an interesting overview of the arguments against and in favor of forward guidance see Geraats et al. (2008).

of commitment to a properly chosen policy rule has been commonly accepted. It is also a cornerstone of the New Keynesian approach to monetary policy and central banking (cf. Clarida et al. (1999)). Many academics (e.g. Woodford (2005, 2007) and Svensson (2005)) have therefore stressed the importance of central banks talking openly about the policy decisions they are likely to make in the future. It seems intuitively clear that facilitating public understanding about the likely future path of policy can increase policy effectiveness as forward-looking agents will adapt their expectations accordingly.³

Other academics have voiced strong practical objections. Goodhart (2001) notes that “the idea of trying to choose a complete time path by discretionary choice seems entirely fanciful and counterproductive,” and both Blinder (2004) and Mishkin (2004) broadly concur with his pessimistic assessment.

Deviations from previously announced policy inclinations pose a difficult communication problem for the central bank. Suppose that, based on the current economic situation, a central bank has announced and explained an interest-rate decision that it is likely to make in the near future. If shocks occur in the meantime and the central bank would like to adopt a different interest-rate policy from the one it has announced, it needs to explain the reasons underlying such deviations. Otherwise the forecast would lose its bite. Some of the shocks leading to the deviation (such as oil-price shocks) may be easy to observe and to understand. Other shocks (such as technology shocks increasing systemic risks in financial markets) are not easily observable, so central banks will find it very difficult to explain why they would like to deviate from earlier declarations of intent.⁴

Communicating deviations from announcements therefore involves two types of costs. First, the cascade of explanations about deviations from an initial statement of policy

³Rudebusch and Williams (2006) argue that the publication of interest-rate projections is desirable when the public is uncertain about the central bank’s preferences.

⁴Communication problems may be further aggravated by behavioral aspects, as people tend to appreciate, believe and remember messages consistent with their prevailing beliefs and disregard messages that contradict them (see Mullainathan and Shleifer (2005)). Moreover, explaining the reasons underlying future aggregate fluctuations may be difficult if individual firm shocks do not average out in aggregate, which is argued by Gabaix (2005).

deliberations is costly for central banks. For instance, research resources must be employed in the search for hard-to-find evidence that will credibly explain a deviation. When evidence is soft, qualitative efforts may be substantial and may divert resources from other important tasks. While it may not be necessary to give detailed explanations of a forecast that has come true, it may be increasingly laborious to explain the reasons underlying deviations from forecasts.

Second, the central bank's prestige may depend on the precision of its forecast. For example, forecasts that often fail to come about may impair the public perception of the central bank's competence and may also endanger the re-appointment of the central bank's chief executives.

The costly communication of deviations from announcements is a two-edged sword for central banks. On the one hand, it creates commitment precisely because deviations are costly. On the other hand, the central bank actually incurs these costs when it decides to deviate. This reduces its flexibility in responding to unforeseen developments.

In this paper, we develop a framework for examining the social desirability of publishing the likely course of future monetary policy. We introduce a new central bank loss function that accounts for the costs of deviations from policy announcements.⁵ Second, we integrate forecasts into a dynamic monetary model. We choose the dynamic New Keynesian model (see Clarida et al. (1999)) as our underlying workhorse, as this forward-looking framework is frequently argued to support the publication of policy inclinations. Moreover, it can be derived from microeconomic principles (see Woodford (2003a)).

In such a model, gains from commitment are possible, because the optimal policy rule does not correspond to the policy an optimizing central bank chooses under discretion.⁶ We assume that the central bank announces a point forecast in each period. In

⁵Cukierman and Liviatan (1991) and Cukierman (2000) study models with an inflation bias and two types of policy-makers. The first type can deviate from announcements without cost; the second type is perfectly committed. In a similar vein, Gersbach and Hahn (2006) consider a model where the government punishes central bankers' deviations from announcements. Rogoff (1985) proposes a model where deviations from exogenously given intermediate targets affect the central bank's loss function.

⁶There are at least two alternative approaches that may enable the central bank to reap these

particular, we consider four different scenarios. First, the central bank may announce a forecast of future inflation. This is a policy pursued by many inflation-targeting central banks. Second, the central bank may announce a forecast of the nominal interest rate. This is very close to the Fed's former practice of publishing a policy bias as part of the minutes of the FOMC meeting.

We will see that in our model the time horizon with regard to the publication of forecasts will be of the utmost importance. We distinguish two cases. First, the forecasts may concern variables in the near future, and the public's expectations about these variables may already have manifested themselves in the choice of price-setters. Henceforth we will label these forecasts short-term. Second, the forecasts may be published earlier, which means that public inflation expectations are a function of the variables announced. In the following we will call these forecasts medium-term. We analyze four scenarios in this paper: short-term inflation forecasts, short-term interest-rate forecasts, medium-term inflation forecasts, and medium-term interest-rate forecasts.

The main findings of our paper are the following: Short-term projections are always socially detrimental. Short-term forecasts about inflation or interest rates create losses, as the central bank loses some of its flexibility in responding to unexpected shocks. For medium-term forecasts, the publication of policy inclinations creates a trade-off between gains due to commitment and losses from less flexibility. We show that this trade-off is never favorable as far as medium-term interest-rate projections are concerned. By contrast, medium-term forecasts about inflation are socially advantageous, unless the costs of deviating are large.

Accordingly, a society is better off with a central bank that publishes medium-term inflation projections and is concerned about deviations than with a central bank that

potential benefits to some extent. First, delegation of monetary policy to a conservative central banker may be socially beneficial even in the absence of an inflation bias, because it creates commitment to stabilizing inflation more strictly. This stabilizes inflation expectations and hence also inflation itself (see Clarida et al. (1999)). Second, delegation of monetary policy to a central bank with an interest-rate-smoothing objective may serve a similar purpose, as it makes the central bank's policy history-dependent (see Woodford (2003b)).

shares the public's preferences. This is a parallel to the delegation of monetary policy to a conservative central banker.

Our paper is organized as follows: In the next section we present our model. Sections 3 to 6 analyze the four scenarios. We examine the welfare implications for these scenarios in section 7. Section 8 concludes.

2 Model

We consider the standard New Keynesian model (see Clarida et al. (1999)). The behavior of price-setters is described by a Phillips curve

$$\pi_t = \delta \pi_{t+1|t} + y_t + \xi_t, \quad (1)$$

where we use π_t and y_t to denote inflation and output in period t . Parameter δ represents the discount factor with $0 < \delta < 1$. The additional subscript $|t$ denotes expectations at period t . Parameter ξ_t represents a cost-push shock, which is given by an $AR(1)$ process

$$\xi_t = \rho \xi_{t-1} + \varepsilon_t \quad (2)$$

where $0 < \rho < 1$. We assume that ε_t are i.i.d. from a normal distribution with variance v^2 .

The IS curve is given by

$$y_t = y_{t+1|t} - \sigma (i_t - \pi_{t+1|t}), \quad (3)$$

where $\sigma > 0$. It can be derived from the consumption Euler equation of a representative household.

Moreover, we assume a quadratic function for per-period social losses

$$l_t = \pi_t^2 + a y_t^2, \quad (4)$$

where $a > 0$ represents the relative significance of output stabilization. Thus social welfare is represented by the expected sum of discounted per-period losses

$$L_t = \mathbb{E}_t \sum_{i=0}^{\infty} \delta^i l_{t+i}. \quad (5)$$

The central bank publishes forecasts for a variable x . The forecasts either refer to inflation ($x = \pi$) or to the interest rate ($x = i$). First, we consider short-term forecasts. In each period t , the central bank publishes the projection of variable x for period $t + 1$. This projection is denoted by $x_{t+1}^{P,t}$. Second, in each period t the central bank announces the value of variable x for period $t + 2$. We use $x_{t+2}^{P,t}$ to denote these announcements.

As discussed in the Introduction, we introduce a new component into the central bank's loss function. We assume that the central bank faces quadratic costs incurred by forecast deviations. Formally, the central bank's losses in period t can be written as

$$l_t^{CB} = \pi_t^2 + ay_t^2 + \begin{cases} b \left(x_t - x_t^{P,t-1} \right)^2 & \text{for short-term forecasts} \\ b \left(x_t - x_t^{P,t-2} \right)^2 & \text{for medium-term forecasts} \end{cases} \quad (6)$$

where $b \geq 0$.

If a central bank announces a forecast value $x_{t-1}^{P,t}$ or $x_{t-2}^{P,t}$, it faces the quadratic costs $b \left(x_t - x_{t-1}^{P,t} \right)^2$ or $b \left(x_t - x_{t-2}^{P,t} \right)^2$, respectively, if the forecasts are not met. The size of these costs depends on parameter b ($b \geq 0$). For $b = 0$ we obtain the standard case because announcements represent cheap talk when deviations are costless.

The central bank minimizes expected intertemporal losses

$$L_t^{CB} = \mathbb{E}_t \sum_{i=0}^{\infty} \delta^i l_{t+i}^{CB} \quad (7)$$

subject to constraints (1) and (3). In the following we discuss the four scenarios separately.

3 Short-Term Inflation Forecasts

We start with the analysis of short-term inflation forecasts. Because the formation of inflation expectations and the announcement of inflation forecasts occur simultaneously, inflation expectations obviously cannot be influenced by inflation forecasts. We introduce \mathcal{E}_t to denote the public's expectations in period t as a function of forecasts announced in previous periods and obtain

$$\frac{\partial \mathcal{E}_{t-1} \pi_t}{\partial \pi_t^{P,t-1}} = 0. \quad (8)$$

We are emphasizing the point at this stage because it constitutes the main difference between short-term and long-term forecast announcements.

If the central bank publishes a short-term inflation forecast, the first-order conditions are given by

$$\pi_t + ay_t + b \left(\pi_t - \pi_t^{P,t-1} \right) = 0, \quad (9)$$

$$b\delta \left(\pi_{t+1|t} - \pi_{t+1}^{P,t} \right) = 0. \quad (10)$$

In the standard case without forecasts, the first-order condition can be written as $\pi_t + ay_t = 0$ (cf. Clarida et al. (1999)). This corresponds to (9) in our model. The additional term $b(\pi_t - \pi_t^{P,t-1})$ in our model captures the impact of past forecasts on present monetary policy. The second condition entails that the central bank will choose the inflation forecast equal to its expectation of future inflation, i.e. $\pi_{t+1}^{P,t} = \pi_{t+1|t}$. It is intuitive that this behavior minimizes the central bank's loss.

By eliminating the central bank's forecasts $\pi_t^{P,t-1}$ from the first-order conditions we obtain

$$\pi_t + ay_t + b(\pi_t - \pi_{t|t-1}) = 0. \quad (11)$$

Taking expectations with respect to period $t - 1$ yields

$$\pi_{t|t-1} + ay_{t|t-1} = 0. \quad (12)$$

We obtain the interesting finding that the first-order condition in the standard case holds for expected values if the central bank publishes short-term inflation forecasts.

Moreover, Equation (12) has another implication. The impact of past shock innovations $\varepsilon_{t'}$ ($t' < t$) on inflation in period t is invariant to the announcement of short-term inflation forecasts, because inflation can always be written as the sum of inflation expectations in the previous period plus a term that is proportional to the new component ε_t of the shock. The publication of short-term inflation expectations only affects the influence that current shock innovations ε_t have on current inflation π_t . In the Appendix, we show that the solution to Equation (11) is given by

$$\pi_t = \frac{a}{1 + a(1 - \delta\rho)} \rho \xi_{t-1} + \left(1 - \frac{b}{1 + a + b} \right) \cdot \frac{a}{1 + a(1 - \delta\rho)} \varepsilon_t. \quad (13)$$

The first term, which is proportional to ξ_{t-1} , corresponds to inflation expectations in the previous period. We have already noted that it is identical to inflation expectations without forecasts. The second term captures the impact of the shock innovation ε_t on inflation. This term is affected by the announcement of forecasts.

For $b \rightarrow 0$, i.e. vanishing costs of forecast deviations, Equation (13) converges to the standard solution $\pi_t = \frac{a}{1+a(1-\delta\rho)} \xi_t$ (cf. Clarida et al. (1999)). However, for $b > 0$ the impact of the shock innovation ε_t on inflation is stabilized somewhat more strongly (because $\frac{b}{1+a+b} > 0$). This is quite plausible. The central bank does not know ε_t when making its forecast in period $t - 1$. Consequently, no information about ε_t can be incorporated into $\pi_t^{P,t-1}$. In period t , deviations from forecasts made in the previous period are costly. As a consequence, the central bank stabilizes ε_t somewhat more strongly than it would without forecast announcements. If b goes to infinity, the central bank perfectly offsets the impact of ε_t on inflation and in this case inflation amounts to $\pi_t = \frac{a}{1+a(1-\delta\rho)} \rho \xi_{t-1}$.

In the Appendix, we also derive the following expression for output:

$$y_t = -\frac{1}{1+a(1-\delta\rho)} \rho \xi_{t-1} - \left(1 + \frac{ab}{1+a+b}\right) \cdot \frac{1}{1+a(1-\delta\rho)} \varepsilon_t \quad (14)$$

This solution again converges to the standard solution without announcements for $b \rightarrow 0$, i.e. to $y_t = -\frac{1}{1+a(1-\delta\rho)} \xi_t$. For positive values of b , the central bank stabilizes the impact of ε_t on inflation more vigorously, thus incurring higher output fluctuations. If b goes to infinity, output amounts to

$$y_t = -\frac{1}{1+a(1-\delta\rho)} \rho \xi_{t-1} - \frac{1+a}{1+a(1-\delta\rho)} \varepsilon_t. \quad (15)$$

Because the central bank eliminates the effect of ε_t on inflation for $b \rightarrow \infty$, the impact of ε_t on output is undamped.

4 Short-Term Interest-Rate Forecasts

Now we compute the solution for the case where the central bank announces a projection of the interest rate for the following period. Again we observe that

$$\frac{\partial \mathcal{E}_{t-1} \pi_t}{\partial \pi_t^{i,t-1}} = 0. \quad (16)$$

Thus the central bank cannot influence inflation expectations by varying the interest-rate announcement.

The first-order conditions for the respective maximization problem are given by

$$-\sigma(\pi_t + ay_t) + b(i_t - i_t^{P,t-1}) = 0, \quad (17)$$

$$b\delta(i_{t+1|t} - i_{t+1}^{P,t}) = 0. \quad (18)$$

Note that the factor $-\sigma$ stems from the derivative of y_t with respect to i_t . As in the previous section, the central bank always chooses its interest-rate projection equal to its expectation, $i_{t+1}^{P,t} = i_{t+1|t}$. The above equations can be combined as follows:

$$-\sigma(\pi_t + ay_t) + b(i_t - i_{t|t-1}) = 0. \quad (19)$$

The condition for optimal policy in the standard model $\pi_t + ay_t = 0$ again holds for expectations in period $t - 1$, i.e. $\pi_{t|t-1} + ay_{t|t-1} = 0$. As a consequence, the dynamics of one-period-ahead inflation and output expectations are identical to those in the standard model.

In the Appendix we show that the solution for π_t can be written as

$$\pi_t = \frac{a}{1 + a(1 - \delta\rho)} \rho \xi_{t-1} + \frac{a}{1 + a(1 - \delta\rho)} \left(1 + \frac{b(a\rho\sigma + 1 - \rho)}{a(b + (1 + a)\sigma^2)} \right) \varepsilon_t. \quad (20)$$

For $b = 0$, this solution converges to the standard solution without announcements $\pi_t = \frac{a}{1 + a(1 - \delta\rho)} \xi_t$. Because $a\rho\sigma + 1 - \rho > 0$, the central bank will stabilize the impact of the shock component ε_t on inflation less strictly if it announces a forecast of the future interest rate rather than making no announcement at all. When the central bank announces its interest-rate forecast in period $t - 1$, the shock innovation ε_t is unknown. In period t the central bank finds it costly to deviate from its previous

interest-rate announcement. Consequently, it is more reluctant to change the interest rate and to stabilize the effect of ε_t on inflation.

In the Appendix we also derive the following expression for output:

$$y_t = -\frac{1}{1+a(1-\delta\rho)}\rho\xi_{t-1} - \frac{1}{1+a(1-\delta\rho)}\left(1 - \frac{b(a\rho\sigma + 1 - \rho)}{b + (1+a)\sigma^2}\right)\varepsilon_t. \quad (21)$$

Again, the solution converges to the standard solution for $b = 0$. For $b = 0$, a marginal increase in b always leads to lower fluctuations in output as $\frac{b}{b+(1+a)\sigma^2}$ is strictly increasing in b . We have already noted that larger values of b make the central bank less willing to stabilize the impact of shock innovations on inflation by varying the interest rate. Consequently, output becomes more stable for marginal increases in b and small values of b .

5 Medium-Term Inflation Forecasts

In this section we assume that the central bank announces an inflation forecast in each period about inflation two periods in the future, i.e. in period t it announces a forecast for period- $(t+2)$ inflation. Obviously, the central bank cannot influence the public's expectation of period- $(t+2)$ inflation in the same period, i.e. $\frac{\partial \mathcal{E}_t \pi_{t+2}}{\partial \pi_t^{P,t}} = 0$. However, the announcement enables the central bank to affect the public's inflation expectations in period $t+1$ about inflation in period $t+2$. This is a crucial observation as it corresponds to the main difference between short-term and medium-term forecasts.

The central bank's optimal choice of π_t in period t is given by the first-order condition

$$\pi_t + ay_t + b\left(\pi_t - \pi_t^{P,t-2}\right) = 0. \quad (22)$$

In order to compute the impact of a change in $\pi_t^{P,t-2}$ on the public's inflation expectations $\mathcal{E}_{t-1}\pi_t$, we now have to calculate how inflation in period t depends on the forecast $\pi_t^{P,t-2}$. Equations (1) and (22) yield

$$\pi_t = \frac{a\delta\pi_{t+1|t} + a\xi_t + b\pi_t^{P,t-2}}{1+a+b}. \quad (23)$$

The public's inflation expectations as a function of $\pi_t^{P,t-2}$ can thus be written as

$$\mathcal{E}_{t-1}\pi_t = \frac{a\delta\pi_{t+1|t-1} + a\rho\xi_{t-1} + b\pi_t^{P,t-2}}{1+a+b}. \quad (24)$$

The impact of an increase in the forecast $\pi_t^{P,t-2}$ on inflation expectations $\mathcal{E}_{t-1}\pi_t$ can be calculated as

$$\frac{\partial \mathcal{E}_{t-1}\pi_t}{\partial \pi_t^{P,t-2}} = \frac{b}{1+a+b}. \quad (25)$$

If the central bank chooses a higher forecast in period $t-2$ about inflation in period t , this will lead to higher inflation expectations in period $t-1$. Because the public knows that the central bank will incur costs if it deviates from announcements, the announcements are credible to some extent. The higher the costs of deviations, i.e. the higher b , the more credible the announcements are. For $b \rightarrow \infty$, an increase in the forecast by one percentage point leads to an increase in inflation expectations by the same amount. If $b = 0$, then announcements cannot be used by the central bank to commit to a certain policy. In this case $\frac{\partial \mathcal{E}_{t-1}\pi_t}{\partial \pi_t^{P,t-2}} = 0$.

In the Appendix we show that

$$\pi_t = \frac{a\alpha\delta\rho\xi_t + a\xi_t + b\alpha\rho^2\xi_{t-2} + \frac{ab}{1+a+b}(\alpha\rho\xi_{t-2} - \delta\alpha\rho^2\xi_{t-2} - \rho\xi_{t-2})}{1+a+b}, \quad (26)$$

where

$$\alpha := \frac{b - \rho(1+a+b)}{b - \left(b\delta + \frac{(1+a+b)(1+a)}{a}\right)\rho + (1+a+b)\delta\rho^2}. \quad (27)$$

It is straightforward to verify that Equation (26) converges to the standard solution for $b = 0$. Note that the dynamics of the model change completely with medium-term forecasts as such forecasts induce the public to revise their inflation expectations.

6 Medium-Term Interest-Rate Forecasts

Now we consider the scenario where in each period the central bank announces an interest rate forecast concerning the interest rate in the next period but one. It is straightforward to show that the first-order condition associated with an optimal choice of i_t in period t yields

$$-\sigma(\pi_t + ay_t) + b(i_t - i_t^{P,t-2}) = 0, \quad (28)$$

which is almost identical to (19). The next step is to derive the public's inflation expectations $\mathcal{E}_{t-1}\pi_t$ as a function of $i_t^{P,t-2}$. In the Appendix we show that

$$\frac{\partial \mathcal{E}_{t-1}\pi_t}{\partial i_t^{P,t-2}} = -\frac{\sigma b}{b + (1+a)\sigma^2}. \quad (29)$$

As a consequence, a higher interest-rate projection indicates a tighter monetary policy in the future and, in turn, reduces the public's inflation expectations. The higher the costs of deviations from announcement b are, the stronger this effect will be. Because the expressions for output and inflation are very complex, we refer the reader to the Appendix, where these expressions are derived.

7 Welfare

In this section we examine the implications of the publication of forecasts for ex-ante social welfare. We consider all four scenarios discussed in the previous sections.

7.1 Short-Term Inflation Forecasts

We start our analysis with the announcement of short-term inflation forecasts $\pi_{t+1}^{P,t}$. By inserting (13) and (14) into the per-period social loss function (4) and taking expected values we obtain

$$l_{\pi_t^{P,t-1}} = \frac{a(1+a)^2(1+a+2b+b^2)}{(1+a(1-\delta\rho))^2(1+a+b)^2}v^2. \quad (30)$$

Note that ex ante expected social losses are identical for all periods. Thus it is sufficient to consider losses in a single period only, as these are proportional to the sum of discounted per-period losses. It is instructive to compute the derivative with respect to b :

$$\frac{dl_{\pi_t^{P,t-1}}}{db} = \frac{2a^2(1+a)^2b}{(1+a(1-\delta\rho))^2(1+a+b)^3}v^2. \quad (31)$$

Because this expression is always positive we obtain the following important proposition:

Proposition 1

If the central bank publishes an inflation forecast for the next period, social losses are always higher than in the case where the central bank does not publish forecasts.

7.2 Short-Term Interest-Rate Forecasts

Now we turn to the publication of forecasts on the interest rate in the following period. In this case, the derivative of expected per-period losses with respect to b is given by

$$\frac{dl_{i_t^{P,t-1}}}{db} = \frac{2b(1+a)^2(\rho a\sigma + 1 - \rho)^2\sigma^2}{(1+a(1-\delta\rho))^2((1+a)\sigma^2 + b)^3}v^2. \quad (32)$$

As this expression is always positive, we obtain the next proposition:

Proposition 2

If the central bank publishes an interest-rate forecast for the next period, social losses are always higher than in the case where the central bank does not publish forecasts.

The intuition for Propositions 1 and 2 runs as follows: Short-term forecasts about inflation or the interest rate are never beneficial because the respective announcements cannot influence inflation expectations. Thus no gains arise from commitment. However, short-term forecasts involve the central bank losing some of its flexibility when unforeseen shocks occur.

7.3 Medium-Term Inflation Forecasts

We also have to examine social losses for forecasts about inflation in the next period but one. It is straightforward to show that

$$\left. \frac{dl_{\pi_t^{P,t-2}}}{db} \right|_{b=0} = -\frac{2a^2\delta}{(1+a)(1-\rho^2)(1+a(1-\delta\rho))^2}v^2 < 0. \quad (33)$$

We obtain the following proposition:

Proposition 3

For sufficiently small values of b , the announcement of a forecast on inflation two periods in the future will increase welfare.

Because the expression for $l_{\pi_t^{P,t-2}}$ is very complex, it is not possible to obtain general results about the impact of the announcement $\pi_t^{P,t-2}$ on welfare. However, numerical computations show

Numerical Finding 1

For $0 < b \leq 4$, $0.8 \leq \rho < 1$, $0 \leq a \leq 4$, and $0.9 \leq \delta \leq 1$, $l_{\pi_t^{P,t-2}}$ is always lower than losses without publication of policy inclinations.

As a consequence, the announcement of forecasts about inflation two periods in the future increases welfare for the range of most plausible parameter values.

7.4 Medium-Term Interest-Rate Forecasts

Finally, we have to examine social losses if the central bank publishes interest-rate projections about period $t + 2$ in every period t . It can be shown that

$$\left. \frac{dl_{i_t^{P,t-2}}}{db} \right|_{b=0} = \frac{2a^2\delta}{\sigma^2(1+a)(1-\rho^2)(1+a(1-\delta\rho))^3} v^2 > 0. \quad (34)$$

This derivative is positive, which implies our next Proposition.

Proposition 4

For sufficiently small values of b , the publication of $i_t^{P,t-2}$ is socially detrimental.

Moreover, a numerical analysis reveals that

Numerical Finding 2

Losses $l_{i_t^{P,t-2}}$ are always larger for $b > 0$ than for $b = 0$.

Therefore we obtain the important result that the publication of an interest-rate forecast concerning the next period but one is always socially detrimental.

8 Conclusions

In this paper we have shown that the publication of interest-rate projections is never desirable if the central bank will be to some extent committed to these projections in the future.⁷ Because the realizations of future shocks are partially unknown when the projections are made, the central bank will be somewhat less successful in stabilizing

⁷In all four scenarios the projections represent cheap talk For $b = 0$ and do not have an effect in our model.

cost-push shocks. The same finding also holds if an inflation projection about the following period is published. In this case the announcement of the forecast cannot have an impact on the public's inflation expectations.

However, the publication of projections about future inflation may be socially beneficial if the public's expectations can adapt to these forecasts, i.e. if the forecasts concern the next period but one. By announcing inflation forecasts, the central bank can commit more strongly to stabilizing the impact of unexpected shocks on inflation. Because inflation depends on inflation expectations, the announcement of future inflation will reduce inflation variation. This is socially beneficial.

Thus our model may provide an explanation of why the Fed quickly reversed its decision to publish policy inclinations. It also gives additional theoretical support for the practice of some central banks that publish inflation forecasts. These forecasts can help to stabilize inflation expectations and hence also inflation.

There are several useful extensions to our model. First, we could allow for a desire of the central bank to push output above its natural level. Interestingly, if monetary policy faced the problem of an inflation bias, short-term inflation or interest-rate projections could not be used to commit to lower inflation rates in our model, because inflation expectations and monetary policy announcements are chosen simultaneously. However, the case would be different with announcements concerning the next period but one. Then medium-term forecasts are likely to be beneficial.

Second, another interesting extension concerns the publication of contingent forecasts, i.e. forecasts that depend on future realizations of shocks. However, the publication of contingent forecasts involves problems because shocks may not be easily observable, so the central bank may need to give a detailed explanation of its estimates of these shocks. If publication of contingent short-term forecasts is possible, then the central bank will simply announce the policy that will be optimal in the future. This will not improve policy outcomes as there are no information asymmetries and the public can foresee the central bank's optimal policy anyhow. Accordingly, the publication of contingent short-term forecasts in our model leads to the same level of welfare as the

standard solution under discretion. Contingent medium-term forecasts, however, are likely to produce higher welfare than unconditional forecasts, as the disadvantage of unconditional forecasts caused by insufficient stabilization of unforeseen shocks would disappear.

Third, we could extend our model by incorporating demand shocks. These shocks would not have any impact on our findings with respect to announcements of future inflation, as these shocks can be perfectly stabilized. However, demand shocks would involve an additional disadvantage militating against the announcement of future interest rates, as future demand shocks may not be perfectly known at the date when the interest-rate projections are made. Later, the costs from forecast deviations would result in insufficient stabilization of demand shocks and higher output variability.

A Derivation of Inflation and Output for Short-Term Inflation Forecasts (Section 3)

If we consider (11) and take expectations at time $t - 1$, we obtain

$$\pi_{t|t-1} + ay_{t|t-1} = 0. \quad (35)$$

Thus the usual first-order condition for optimal policy under discretion, which is given by $\pi_t + ay_t = 0$, holds for expected values in our model. By inserting the Phillips curve Equation (1) we obtain

$$\pi_{t|t-1} + a(\pi_{t|t-1} - \delta\pi_{t+1|t-1} - \rho\xi_{t-1}) = 0, \quad (36)$$

where we have taken account of the fact that $\xi_{t|t-1} = \rho\xi_{t-1}$. Note that (36) is a first-order difference equation for $\pi_{t|t-1}$ which has the general solution

$$\pi_{t|t-1} = \frac{a}{1 + a(1 - \delta\rho)} \rho\xi_{t-1} + C_1\lambda_1^t, \quad (37)$$

where C_1 is some arbitrary constant and $\lambda_1 = \frac{1+a}{a\delta} > 1$. Note that the solution without the announcement of forecasts would imply the same value for the expected value of inflation $\pi_{t|t-1}$. If we insert the Phillips curve Equation (1) into (11), we obtain

$$\pi_t + a(\pi_t - \delta\pi_{t+1|t} - \xi_t) + b(\pi_t - \pi_{t|t-1}) = 0 \quad (38)$$

By inserting (37), we can derive the following equation for π_t

$$\pi_t + a\left(\pi_t - \frac{\delta a\rho}{1 + a(1 - \delta\rho)}\xi_t - \delta C_1\lambda_1^{t+1} - \xi_t\right) + b\left(\pi_t - \frac{a\rho}{1 + a(1 - \delta\rho)}\xi_{t-1} - C_1\lambda_1^t\right) = 0$$

It is tedious but straightforward to show that the solution of this equation is

$$\pi_t = \frac{a}{1 + a(1 - \delta\rho)} \rho\xi_{t-1} + \frac{1 + a}{1 + a + b} \cdot \frac{a}{1 + a(1 - \delta\rho)} \varepsilon_t + C_1\lambda_1^t \quad (39)$$

Finally we compute the value of output by applying the Phillips curve (1):

$$y_t = \pi_t - \delta\pi_{t+1|t} - \xi_t \quad (40)$$

Straightforward algebraic manipulations yield

$$y_t = -\frac{1}{1 + a(1 - \rho)} \rho\xi_{t-1} - \frac{(1 + a)(1 + b)}{1 + a + b} \cdot \frac{1}{1 + a(1 - \rho)} \varepsilon_t - \frac{C_1}{a}\lambda_1^t \quad (41)$$

Because $\lambda_1 > 1$, output would explode to $-\infty$ or ∞ over time. This would violate the household's transversality condition. Thus we set $C_1 = 0$.

□

B Derivations of Inflation and Output for Short-Term Interest-Rate Forecasts (Section 4)

If we take expectations at period $t - 1$, we obtain

$$\pi_{t|t-1} + ay_{t|t-1} = 0 \quad (42)$$

As a consequence, inflation expectations are again given by

$$\pi_{t|t-1} = \frac{a\rho}{1 + a(1 - \delta\rho)} \xi_{t-1}, \quad (43)$$

where we have ruled out explosive solutions. Now we can combine the Phillips curve (1) and the IS curve (3) and solve for i_t .

$$\begin{aligned} i_t &= \pi_{t+1|t} + \frac{1}{\sigma} (y_{t+1|t} - y_t) \\ &= \pi_{t+1|t} + \frac{1}{\sigma} ((1 + \delta)\pi_{t+1|t} - \pi_t - \delta\pi_{t+2|t} + (1 - \rho)\xi_t) \end{aligned} \quad (44)$$

Equations (19), (1), and (44) yield a first-order difference equation for π_t with the solution

$$\pi_t = \frac{a}{1 + a(1 - \delta\rho)} \rho \xi_{t-1} + \frac{a}{1 + a(1 - \delta\rho)} \left(1 + \frac{b(a\rho\sigma + 1 - \rho)}{a(b + (1 + a)\sigma^2)} \right) \varepsilon_t \quad (45)$$

By using the above solution for π_t and Equation (40), output can be written as

$$y_t = -\frac{1}{1 + a(1 - \delta\rho)} \rho \xi_{t-1} - \frac{1}{1 + a(1 - \delta\rho)} \left(1 - \frac{b(a\rho\sigma + 1 - \rho)}{b + (1 + a)\sigma^2} \right) \varepsilon_t. \quad (46)$$

□

C Derivation of Inflation and Output for Medium-Term Inflation Forecasts (Section 5)

Now we analyze the central bank's optimal choice of $\pi_t^{P,t-2}$ in period $t - 2$. The choice of $\pi_t^{P,t-2}$ affects the central bank's losses in two ways. First it affects the public's inflation expectations $\mathcal{E}_{t-1}\pi_t$ and hence output y_{t-1} . Second, it affects the costs resulting from

the deviation of the forecast from inflation in period t . Thus the first-order condition is given by

$$\frac{\partial}{\partial \pi_t^{P,t-2}} \mathbb{E}_{t-2} \left[a\delta (\pi_{t-1} - \delta \mathcal{E}_{t-1} \pi_t - \xi_{t-1})^2 + b\delta^2 (\pi_t - \pi_t^{P,t-2})^2 \right] = 0 \quad (47)$$

$$\mathbb{E}_{t-2} \left[a\delta (\pi_{t-1} - \delta \mathcal{E}_{t-1} \pi_t - \xi_{t-1}) \left(-\frac{\delta b}{1+a+b} \right) - b\delta^2 (\pi_t - \pi_t^{P,t-2}) \right] = 0, \quad (48)$$

where we have used the fact that $\frac{\partial \mathcal{E}_{t-1} \pi_t}{\partial \pi_t^{P,t-2}} = \frac{b}{1+a+b}$. The optimal choice of $\pi_t^{P,t-2}$ is therefore

$$\pi_t^{P,t-2} = \pi_{t|t-2} + \frac{a}{1+a+b} (\pi_{t-1|t-2} - \delta \pi_{t|t-2} - \rho \xi_{t-2}). \quad (49)$$

By combining (23) and (49) we obtain

$$\pi_t = \frac{a\delta \pi_{t+1|t} + a\xi_t + b\pi_{t|t-2} + \frac{ab}{1+a+b} (\pi_{t-1|t-2} - \delta \pi_{t|t-2} - \rho \xi_{t-2})}{1+a+b}. \quad (50)$$

Taking expectations at time $t-2$ and rearranging yields

$$\left(1 + a + \frac{ab\delta}{1+a+b} \right) \pi_{t|t-2} = a\delta \pi_{t+1|t-2} + a\rho^2 \xi_{t-2} + \frac{ab}{1+a+b} (\pi_{t-1|t-2} - \rho \xi_{t-2}). \quad (51)$$

If we substitute $t-2$ for t , we obtain

$$\left(1 + a + \frac{ab\delta}{1+a+b} \right) p_{t+1|t} = a\delta p_{t+2|t} + a\rho^2 \xi_t + \frac{ab}{1+a+b} (p_t - \rho \xi_t) \quad (52)$$

where, in addition, we have introduced $p_t = \pi_{t+1|t}$. With the forward operator $\mathbb{F}p_t := \mathbb{E}_t p_{t+1}$ this can be written as

$$\left(1 - \left(\delta + \frac{(1+a)(1+a+b)}{ab} \right) \mathbb{F} + \frac{\delta(1+a+b)}{b} \mathbb{F}^2 \right) p_t = \rho \left(1 - \frac{(1+a+b)\rho}{b} \right) \xi_t \quad (53)$$

This second-order linear difference equation has the following general solution:

$$p_t = \rho \alpha \xi_t + C_3 \lambda_3^t + C_4 \lambda_4^t, \quad (54)$$

where we have introduced

$$\alpha := \frac{B - \rho}{B - (B\delta + \frac{1}{A})\rho + \delta\rho^2} \quad (55)$$

$$\lambda_{3,4} = \pm \sqrt{\frac{1}{4} \left(B + \frac{1}{A\delta} \right)^2 - \frac{B}{\delta}} + \frac{1}{2} \left(B + \frac{1}{A\delta} \right). \quad (56)$$

$$A := \frac{a}{1+a} \quad (A \in]0; 1[). \quad (57)$$

$$B := \frac{b}{1+a+b} \quad (B \in]0; 1[). \quad (58)$$

Both λ_3 and λ_4 are always real numbers because

$$\frac{1}{4} \left(B + \frac{1}{A\delta} \right)^2 - \frac{B}{\delta} > \frac{1}{4} \left(B + \frac{1}{\delta} \right)^2 - \frac{B}{\delta} = \frac{1}{4} \left(B - \frac{1}{\delta} \right)^2 > 0$$

We also note that $\lambda_3 > 1$ because

$$\sqrt{\frac{1}{4} \left(B + \frac{1}{A\delta} \right)^2 - \frac{B}{\delta}} > 1 - \frac{1}{2} \left(B + \frac{1}{A\delta} \right), \quad (59)$$

which follows from

$$-\frac{B}{\delta} > 1 - \left(B + \frac{1}{A\delta} \right), \quad (60)$$

which in turn follows from

$$\frac{1}{A} > 1 > \delta(1 - B) + B. \quad (61)$$

Explosive solutions can be ruled out because they would violate resource constraints.

Therefore we set $C_3 = 0$. With respect to the other root, $0 < \lambda_4 < 1$ holds.

With the definition of p_t we can write (50) as follows:

$$\pi_t = \frac{a\delta p_t + a\xi_t + bp_{t-1|t-2} + \frac{ab}{1+a+b} (p_{t-2} - \delta p_{t-1|t-2} - \rho\xi_{t-2})}{1 + a + b} \quad (62)$$

or equivalently as

$$\pi_t = \frac{a\alpha\delta\rho\xi_t + a\xi_t + b\alpha\rho^2\xi_{t-2} + \frac{ab}{1+a+b} (\alpha\rho\xi_{t-2} - \delta\alpha\rho^2\xi_{t-2} - \rho\xi_{t-2})}{1 + a + b}. \quad (63)$$

It is straightforward to show that, for $b = 0$, inflation is given by the solution for the case without the announcement of an inflation forecast, i.e. by $\pi_t = \frac{a}{1+a(1-\delta\rho)}\xi_t$.

According to Equation (40) output can be written as

$$y_t = \pi_t - \delta p_t - \xi_t. \quad (64)$$

Together with (54), (55), and (63), this gives the solution for output y_t .

□

D Derivations of Inflation and Output for Medium-Term Interest-Rate Forecasts (Section 6)

By inserting (1) and (44) into (28) we obtain

$$\begin{aligned}
 & -\sigma \left[\pi_t + a(\pi_t - \delta\pi_{t+1|t} - \xi_t) \right] \\
 & + b \left(\pi_{t+1|t} + \frac{1}{\sigma} \left[(1 + \delta)\pi_{t+1|t} - \pi_t - \delta\pi_{t+2|t} + (1 - \rho)\xi_t \right] - i_t^{P,t-2} \right) = 0.
 \end{aligned} \tag{65}$$

This can be solved for π_t as follows:

$$\pi_t = \frac{a(\delta\pi_{t+1|t} + \xi_t) + \frac{b}{\sigma} \left(\pi_{t+1|t} + \frac{1}{\sigma} \left[(1 + \delta)\pi_{t+1|t} - \delta\pi_{t+2|t} + (1 - \rho)\xi_t \right] - i_t^{P,t-2} \right)}{1 + a + \frac{b}{\sigma^2}}. \tag{66}$$

It is again crucial to calculate $\frac{\partial \mathcal{E}_{t-1}\pi_t}{\partial i_t^{P,t-2}}$ because this expression gives the impact on inflation expectations of a change in the announcement. Equation (66) implies

$$\frac{\partial \mathcal{E}_{t-1}\pi_t}{\partial i_t^{P,t-2}} = -\frac{b\sigma}{b + (1 + a)\sigma^2} \tag{67}$$

The next step is the analysis of the central bank's optimal choice of $i_t^{P,t-2}$ in period $t-2$. The choice of $i_t^{P,t-2}$ affects the central bank's intertemporal losses in two ways. First, it affects the public's inflation expectations $\mathcal{E}_{t-1}\pi_t$ and thus output y_{t-1} . Second, it affects the costs resulting from the forecast deviations in period t . Thus the first-order condition is given by

$$\begin{aligned}
 & \frac{\partial}{\partial i_t^{P,t-2}} \mathbb{E}_{t-2} \left[a\delta (\pi_{t-1} - \delta\mathcal{E}_{t-1}\pi_t - \xi_{t-1})^2 + b\delta^2 (i_t - i_t^{P,t-2})^2 \right] = 0 \\
 & \mathbb{E}_{t-2} \left[a\delta (\pi_{t-1} - \delta\mathcal{E}_{t-1}\pi_t - \xi_{t-1}) \left(-\frac{b\sigma\delta}{b + (1 + a)\sigma^2} \right) - b\delta^2 (i_t - i_t^{P,t-2}) \right] = 0,
 \end{aligned}$$

where we have used Equation (67). The optimal choice of $i_t^{P,t-2}$ is therefore

$$i_t^{P,t-2} = i_{t|t-2} + \frac{a\sigma (\pi_{t-1|t-2} - \delta\pi_{t|t-2} - \rho\xi_{t-2})}{b + (1 + a)\sigma^2}. \tag{68}$$

Equation (44) can be used to replace $i_{t|t-2}$, which yields

$$\begin{aligned}
 i_t^{P,t-2} = & \pi_{t+1|t-2} + \frac{1}{\sigma} \left((1 + \delta)\pi_{t+1|t-2} - \pi_{t|t-2} - \delta\pi_{t+2|t-2} + (1 - \rho)\rho^2\xi_{t-2} \right) \\
 & + \frac{a\sigma (\pi_{t-1|t-2} - \delta\pi_{t|t-2} - \rho\xi_{t-2})}{b + (1 + a)\sigma^2}.
 \end{aligned} \tag{69}$$

If we use (65), take expectations at date $t - 2$ and use (69) to replace $i_t^{P,t-2}$, we obtain

$$\sigma \left[\pi_{t|t-2} + a(\pi_{t|t-2} - \delta\pi_{t+1|t-2} - \rho^2\xi_{t-2}) \right] + \frac{ab\sigma (\pi_{t-1|t-2} - \delta\pi_{t|t-2} - \rho\xi_{t-2})}{b + (1+a)\sigma^2} = 0. \quad (70)$$

Using the definition $p_t = \pi_{t+1|t}$, this equation can be rewritten as

$$p_{t+1|t} + a(p_{t+1|t} - \delta p_{t+2|t} - \rho^2\xi_t) + \frac{ab(p_t - \delta p_{t+1|t} - \rho\xi_t)}{b + (1+a)\sigma^2} = 0. \quad (71)$$

This is equivalent to the following second-order difference equation for p_t :

$$\begin{aligned} & \left[1 + \left\{ \frac{(b + (1+a)\sigma^2)(1+a)}{ab} - \delta \right\} \mathbb{F} - \frac{\delta(b + (1+a)\sigma^2)}{b} \mathbb{F}^2 \right] p_t \\ & = \left[\frac{\rho(b + (1+a)\sigma^2)}{b} + 1 \right] \rho\xi_t \end{aligned} \quad (72)$$

This equation has the solution

$$p_t = \beta\rho\xi_t + C_5\lambda_5^t + C_6\lambda_6^t, \quad (73)$$

where we have introduced variable β as follows:

$$\beta := \frac{B' + \rho}{B' + \left(\frac{1}{A} - B'\delta\right)\rho - \delta\rho^2}. \quad (74)$$

Variables λ_5 and λ_6 are given by

$$\lambda_{5,6} = \pm \sqrt{\frac{B'}{\delta} + \frac{1}{4} \left(\frac{1}{A\delta} - B' \right)^2} + \frac{1}{2} \left(\frac{1}{A\delta} - B' \right), \quad (75)$$

where we have introduced

$$B' := \frac{b}{b + (1+a)\sigma^2} \quad (0 < B' < 1). \quad (76)$$

It is straightforward to show that the roots $\lambda_{5,6}$ are real numbers and that $\lambda_5 > 1$ and $-1 < \lambda_6 < 0$. Because explosive solutions would violate resource constraints, we can set $C_5 = 0$. Because $-1 < \lambda_6 < 0$, the term $C_6\lambda_6^t$ converges to zero over time.

Interestingly, for $b = 0$ variable B' is equal to zero and thus β is given by $\frac{a}{1+a(1-\delta\rho)}$. Consequently, inflation expectations for medium-term interest-rate projections are identical to inflation expectations without the announcement of interest-rate forecasts in this case.

The solution for π_t can be found by combining Equations (66), (69), and (73). Output y_t can be derived from (40).

□

References

- Alan Blinder. *The Quiet Revolution: Central Banking Goes Modern*. New Haven, CT: Yale University Press, 2004.
- Richard Clarida, Jordi Gali, and Mark Gertler. The Science of Monetary Policy: A New Keynesian Perspective. *Journal of Economic Literature*, 37:1661–1707, December 1999.
- Alex Cukierman. Establishing a Reputation for Dependability by Means of Inflation Targets. *Economics of Governance*, 1(1):53–76, March 2000.
- Alex Cukierman and Nissan Liviatan. Optimal Accomodation by Strong Policymakers Under Incomplete Information. *Journal of Monetary Economics*, 27(1):99–127, January 1991.
- Jon Faust and Eric M. Leeper. Forecasts and Inflation Reports: An Evaluation. mimeo, December 2005.
- Xavier Gabaix. The Granular Origins of Aggregate Fluctuations. mimeo, December 2005.
- Petra Geraats, Francesco Giavazzi, and Charles Wyplosz. *Transparency and Governance*. CEPR, London, 2008. Monitoring the European Central Bank 6.
- Hans Gersbach and Volker Hahn. Signaling and Commitment: Monetary versus Inflation Targeting. *Macroeconomic Dynamics*, 10(5):595–624, 2006.
- Charles A.E. Goodhart. Monetary Transmission Lags and the Formulation of the Policy Decision on Interest Rates. *Federal Reserve Bank of St. Louis Review*, 83(4):165–186, July 2001.
- Finn Kydland and Edward Prescott. Rules Rather than Discretion: The Inconsistency of Optimal Plans. *Journal of Political Economy*, 85(3):473–492, 1977.
- Frederic S. Mishkin. Can Central Bank Transparency Go Too Far? NBER Working Papers 10829, National Bureau of Economic Research, Inc, October 2004.

- Sendhil Mullainathan and Andrei Shleifer. Persuasion in Finance. mimeo, October 2005.
- William Poole. Fed Transparency: How, Not Whether. *Federal Reserve Bank of St. Louis Review*, 85(6):1–18, November/December 2003.
- William Poole. How Should the Fed Communicate?, 2005. speech, Nov. 30, Federal Reserve Bank of St. Louis.
- Kenneth Rogoff. The Optimal Degree of Commitment to an Intermediate Monetary Target. *Quarterly Journal of Economics*, 100(4):1169–1189, November 1985.
- Glenn D. Rudebusch and John C. Williams. Revealing the Secrets of the Temple: The Value of Publishing Central Bank Interest Rate Projections. Working Paper Series 2006-31, Federal Reserve Bank of San Francisco, 2006.
- Lars E O Svensson. Monetary Policy with Judgment: Forecast Targeting. *International Journal of Central Banking*, 1(1):1–54, May 2005.
- Jean-Claude Trichet. The State of the Economy: Overcoming Challenges to Sustainable Economic Growth, 2006. speech, Feb. 6, ECB.
- Michael Woodford. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press, 2003a.
- Michael Woodford. Optimal Interest-Rate Smoothing. *Review of Economic Studies*, 70(4):861–886, October 2003b.
- Michael Woodford. Central-Bank Communication and Policy Effectiveness. mimeo, September 2005.
- Michael Woodford. The Case for Forecast Targeting as a Monetary Policy Strategy. *Journal of Economic Perspectives*, 21(4):3–24, 2007.