Juha Kilponen – Kai Leitemo

Discretion and the transmission lags of monetary policy

SUOMEN PANKKI · FINLANDS BANK ·
EUROJÄRJESTELMÄ
EUROSYSTEMET

Bank of Finland Research
Discussion Papers
8 • 2007

Suomen Pankki
Bank of Finland
P.O.Box 160
FI-00101 HELSINKI
Finland
☎ + 358 10 8311

http://www.bof.fi

Bank of Finland Research
Discussion Papers
8 • 2007

Juha Kilponen* – Kai Leitemo**

Discretion and the transmission lags of monetary policy

The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

* Monetary Policy and Research Department, Bank of Finland, Snellmaninaukio, 00101 Helsinki, Finland. E-mail: juha.kilponen@bof.fi

** Norwegian School of Management (BI), Nydalsveien 37, 0442 Oslo, Norway. E-mail: kai.leitemo@bi.no

We are grateful for comments from Nils Gottfries, Espen Moen, Erling Steigum and participants at seminars at Uppsala University and the Norwegian School of Management to previous versions of this paper. The second author thanks the Norwegian Financial Market Fund under the Norwegian Research Council for financial support. Views expressed are those of the authors and do not necessarily reflect those of Bank of Finland.

http://www.bof.fi

ISBN 978-952-462-362-9
ISSN 0785-3572
(print)

ISBN 978-952-462-363-6
ISSN 1456-6184
(online)

Helsinki 2007

Discretion and the transmission lags of monetary policy

Bank of Finland Research Discussion Papers 8/2007

Juha Kilponen – Kai Leitemo
Monetary Policy and Research

Abstract

Monetary policy transmission lags create credibility problems for the inflation-targeting policy maker who acts under discretion. We show that if prices react to monetary policy with a longer lag than output, the welfare maximizing inflation-targeting policy implies no policy stabilization of cost-push shocks in the canonical New Keynesian model. The reason is simple: for the period monetary policy influences output, inflation is predetermined and the best discretionary policy is to stabilize the output gap fully. We find that money growth targeting comes close to replicating the welfare-maximizing policy under commitment if there are transmission lags.

Keywords: discretionary and stabilization bias, monetary policy, transmission lags, inflation targeting, money targeting

JEL classification numbers: E52, E58, E61

Optimaalinen rahapolitiikka ja sen välittymisen viiveet

Suomen Pankin keskustelualoitteita 8/2007

Juha Kilponen – Kai Leitemo
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Kun rahapolitiikka vaikuttaa inflaatioon viiveellä, rahapolitiikan uskottavuusongelmat kärjistyvät. Kun keskuspankilla on inflaatiotavoite ja hinnat reagoivat kustannussokkeihin hitaammin kuin tuotanto, periodeittain optimoitu rahapolitiikka ei johda inflaatiota stabiloivaan korkoreaktioon. Syynä tähän on se, että periodilla, jolla rahapolitiikka voi vaikuttaa tuotantoon, inflaatio on ennalta määrätty ja optimaalisella diskreetioon perustuvalla rahapolitiikalla pyritään stabiloimaan tuotannon vaihtelut täydellisesti. Tutkimuksessa osoitetaan myös, että jos keskuspankin tavoitteena on vakiinnuttaa rahan määrän kasvu, sitä seuraavat korkoreaktiot ovat lähellä optimaalisella sitoutumispolitiikalla saatavia korkoreaktioita.

Avainsanat: diskreetio ja stabilointiharha, rahapolitiikka, viiveet, Friedmanin rahantarjontasääntö, inflaatiotavoite

JEL-luokittelu: E52, E58, E61

Contents

1 Introduction

Since Kydland and Prescott (1977) and Barro and Gordon (1983) we have known that an overly ambitious monetary policy which aims to bring output above the natural level is associated with inflation and stabilization biases. If the central bank tries to systematically exploit the short-run trade off between output and inflation, it will lead to higher inflation, and sub-optimal stabilization of output and inflation. Furthermore, due to the lack of commitment to future policies, discretionary policymaking is unable to appropriately influence expectations about the future. At the time policy is implemented, the advantages of the future commitment may already have been realized and the policymaker has incentives to deviate from the pre-announced policy. In the absence of commitment technology, the best a policymaker can do is to re-optimize policy in every period. Since people form expectations rationally, this will be anticipated and the only equilibrium is the time-consistent optimal discretionary equilibrium which may perform considerably worse than the optimal commitment policy.

This paper studies the impact of delayed effects of monetary policy on the economy in the discretionary equilibrium. Delayed effects are commonly referred to as the transmission lags of monetary policy. It is almost universally accepted that monetary policy is subject to rather long transmission lags and that they create various challenges for monetary policy. In this paper we show that if the transmission lags are caused by implementation lags in the private sector, the credibility problems of a welfare-maximizing policymaker acting under discretion increase. Under the reasonable assumption that pricing decisions of firms are subject to longer implementation lags than household consumption decisions, the discretionary policy involves no policy-induced stabilization of cost-push shocks in the canonical New Keynesian model.[1] The argument is simple: at the horizon the policymaker can affect output, inflation is already predetermined. The best discretionary policy is then to fully stabilize the output gap. The implementation lags have a severe impact on the discretionary equilibrium, in particular if the cost-push shocks are persistent.

Literature suggests several ways of alleviating discretionary biases depending on the source of the problem. Söderström (2005) discusses several delegation schemes that improve on discretionary equilibrium in the New Keynesian model without implementation lags. In particular, he argues that there is a role for money growth targeting in reducing the discretionary bias. We show that the relative benefits of money growth targeting over inflation increase with implementation lags. Our results support the Friedman (1960) conjecture that lags in the transmission mechanism is a reason for adopting money growth targeting.

[1] See Goodfriend and King (1997), Rotemberg and Woodford (1997), McCallum and Nelson (1999) and Clarida et al (1999).

The remainder of the paper is organized as follows. Section 2 present the canonical New Keynesian model and derives the optimal discretionary policy strategies. Section 3 discusses the evolvement of inflation and output under flexible inflation targeting. Welfare comparisons are made in Section 4. Section 5 concludes.

2 The model and monetary policy

The private-sector pricing decisions are carried out within the Calvo (1983) framework. In each period the firm has a fixed probability of changing its price. The firm sets prices in order to maximize profits under the condition that it might not be able to adjust prices in the next period. In addition, we assume that there is a j-period implementation lag of prices,[2] ie prices are set in advance of the actual implementation. This leads to the New Keynesian Phillips curve (see Roberts, 1995 and Woodford, 2003) given by

$$\pi_{t+j} = \delta\pi_{t+j+1|t} + \gamma x_{t+j|t} + \varepsilon_{t+j}, \tag{2.1}$$

where $\pi_t \equiv p_t - p_{t-1}$ is inflation, x_t is the output gap, δ is the representative agent's discount factor and ε_{t+1} is a cost-push shock that represents other factors that influence price setting at time $t+j$, not considered at time t.[3] These factors can be surprise movements in the mark-up of prices. The consumption Euler equation gives rise to an expectational IS-curve of the form (see, eg, Rotemberg and Woodford, 1997, McCallum and Nelson, 1999 and Woodford, 2003)

$$x_{t+m} = x_{t+m+1|t} - \sigma\left(i_{t+m|t} - \pi_{t+m+1|t} - r^n_{t+m}\right), \tag{2.2}$$

in case where there is an m-period implementation lag in consumption decisions. The model has been extensively studied by Woodford (2003) and Clarida et al (1999), and by Svensson and Woodford (2005) in the case of $j = m = 1$ period implementation lags. Furthermore, Woodford (2003, chapter 8) studies the case with $j = m = d$, where d is any arbitrary, positive number.[4] In this paper, we assume that $j \geqslant m$, ie that the implementation lag of prices may be either longer or equal to that of output. Based on evidence from VAR models (eg, Christiano et al, 2005) and other empirical models (eg, Rudebusch, 2002a,b), it is in fact reasonable to assume that inflation and output responds to changes in monetary policy with different delays. Such differences in delays are also featured in several theoretical models of the monetary transmission mechanism (see, eg, Svensson, 1997). The traditional forward-looking New Keynesian Phillips curve without implementation lags suggests that inflation

[2] This could be due staggering of wage/and or price contracts or because of information delays.

[3] We follow Svensson and Woodford (2005) in assuming that the cost-push shock have an immediate influence on pricing. Note that this assumption is not important for the conclusions regarding the credibility problems of monetary policy in this paper.

[4] For any variable z, we use the notation that $z_{t+d|t} \equiv E_t z_{t+d}$, where E_t is mathematical expectation operator.

responds simultaneously with changes in output. Considering the empirical evidence, such a feature seems unrealistic and any policy advice hinging on this could be problematic. By allowing for implementation lags, however, the NK model can generate plausible impulse responses where output precedes inflation movements, see, eg Woodford (2003, section 3.12).

2.1 Monetary policy under flexible inflation targeting

We study first the monetary policy regime where the central bank maximizes welfare directly. The central bank minimizes the expected social loss, ie,

$$(1-\delta)E_{t_0}\sum_{t=t_0}^{\infty}\delta^{t-t_0}L_t, \tag{2.3}$$

where

$$L_t = \pi_t^2 + \lambda x_t^2. \tag{2.4}$$

Woodford (2003) shows that the period loss in (2.4) represents a quadratic approximation to (the negative of) consumer welfare given that $\lambda = \psi^{-1}\gamma$ is a function of the elasticity of substitution between alternative differentiated goods (ψ) and elasticity of inflation with respect to output gap (γ). Thus minimizing the expected loss (2.3) produces the welfare maximizing equilibrium up to a quadratic approximation.[5] Svensson (1997) denotes this monetary policy as flexible inflation targeting.

Given the model in (2.1) and (2.2), the policy problem under discretion can be solved analytically by finding the first-order conditions to the Lagrangian function given by

$$L_{t_0} = E_{t_0}\sum_{t=t_0}^{\infty}\delta^{t-t_0}\left[\begin{array}{c}\pi_t^2+\lambda x_t^2-\mu_{t+j}\left(\pi_{t+j|t}-\delta\pi_{t+j+1|t}-\gamma x_{t+j|t}-\varepsilon_{t+j|t}\right)-\\ \upsilon_{t+m}\left(x_{t+m}-x_{t+m+1|t}+\sigma\left(i_{t+m|t}-\pi_{t+m+1|t}-r^n_{t+m|t}\right)\right)\end{array}\right]. \tag{2.5}$$

The first-order conditions are given by

$$\frac{\partial L}{\partial \pi_{t+j|t}} = (1-\delta)E_{t_0}\delta^{t-t_0}\left(\delta^j 2\pi_{t+j|t}-\mu_{t+j}\right)=0, \tag{2.6}$$

$$\frac{\partial L}{\partial x_{t+m|t}} = (1-\delta)E_{t_0}\delta^{t-t_0}\left(\delta^m 2\lambda x_{t+m|t}-\upsilon_{t+m}\right)=0, \text{ for } j>m, \tag{2.7}$$

$$\frac{\partial L}{\partial x_{t+m|t}} = (1-\delta)E_{t_0}\delta^{t-t_0}\left(\delta^m 2\lambda x_{t+m|t}+\gamma\mu_{t+m}-\upsilon_{t+m}\right)=0, \text{ for } j=m, \text{ and} \tag{2.8}$$

$$\frac{\partial L}{\partial i_{t+m|t}} = (1-\delta)E_{t_0}\delta^{t-t_0}\left(\delta^m\upsilon_{t+m}\right)=0. \tag{2.9}$$

[5] The welfare-theoretic loss function applies to the model with implementation lags, see Woodford (2003, ch. 8, p. 570).

The first-order conditions (2.6)–(2.9) imply that for every period $t \geq t_0$,

$$\begin{aligned} x_{t+m|t} &= 0, \text{ for } j > m, \text{ and} \\ x_{t+m|t} &= -\tfrac{\gamma}{\lambda}\pi_{t+m|t}, \text{ for } j = m. \end{aligned} \tag{2.10}$$

Equations (2.1) and (2.10) determine the path for inflation and (expected) output. The policy rule for the (expected) interest rate can be derived using equations (2.2) and (2.10):

$$\begin{aligned} i_{t+m|t} &= \pi_{t+m|t} + r^n_{t+m|t}, \text{ for } j > m, \text{and} \\ i_{t+m|t} &= \left(1 + \tfrac{\gamma}{\sigma\lambda}\right)\pi_{t+m|t} - \tfrac{\gamma}{\sigma\lambda}\pi_{t+m+1|t} + r^n_{t+m|t}, \text{ for } j = m. \end{aligned} \tag{2.11}$$

The equations in (2.11) determine the optimal policy 'announcements' m period in advance of policy implementation. As noted by Svensson and Woodford (2005), however, the unforecastable component of the interest rate $(i_{t+m} - i_{t+m|t})$ influence neither of the targeting variables. Nor has the policymaker any incentives to deviate from the announcement and to produce surprises. Correspondingly, we assume that the policymaker sets the unforecastable part of interest rate to zero. The policymaker implements the interest rate policy therefore by setting $i_{t+m} = i_{t+m|t}$.

The optimality conditions in (2.10) show that the optimal monetary policy in the discretionary equilibrium depends on the relative length of the implementation lags. When inflation is predetermined for a longer time that output, the interest rate is set with the intention of keeping output equal to its natural rate. The reason for this is that at the time policy is being announced, inflation is predetermined, and the central bank has no incentives to pay attention to inflation determination within the period. The policymaker does not trade-off any output variability with inflation variability and there are no stabilization of cost-push shocks. In the case with implementation lags of equal length, however, the central bank influences output and inflation in the same period. Thus the monetary authority trades off inflation expectations with output gap expectations without having to commit to future policies.

The credibility problem of monetary policy can be alleviated by delegating monetary policy to a central bank with a modified loss function. Svensson and Woodford (2005) show that if the implementation lags of inflation and output both are equal to one, including the revision of the (one period ahead) inflation forecast in the social loss function with a weight corresponding to the loss caused by a marginal increase in the inflation forecasts (in optimum), produces a solution that replicates the timeless commitment solution. Although we do not argue against the possibility that there may be a modified extension to the loss function that can reduce the discretionary bias in the case of differing implementation lags too, the extension would however be highly model dependent. Furthermore, as Svensson and Woodford (2005) also note, such a solution to the discretionary problem involves 'a somewhat abstract consideration for the purposes of practical policymaking'. Since we view implementability of the solution as essential, we do not explore this venue any further and restrict the analysis by only considering regimes that seem realistic alternatives to inflation targeting.

The benefits of price-level targeting versus inflation targeting have been discussed by Vestin (2006). He shows that price-level targeting under discretion can produce an outcome that replicates inflation targeting under commitment. Price level targeting in many respects represents an improvement over inflation targeting, not only because it can reduce the credibility problem of the central bank, but also because it is an easily implementable and practical alternative to inflation targeting. It does not, however, alleviate the credibility problems caused by implementation lags for the same reason as above: prices are predetermined at the horizon the policymaker can affect output.

2.2 Monetary policy under money growth targeting

Given that price-level targeting does not alleviate the credibility problem associated with implementation lags, the closest alternative to the welfare-maximizing inflation targeting policy is arguably money growth targeting. Interestingly, money growth targeting was originally promoted by Friedman (1960) partly due to the perceived problems associated with transmission lags and discretionary policy of trying to control prices directly. Friedman warned against trying to stabilize inflation directly in a discretionary manner due to long and variable lags in the transmission mechanism of monetary policy.

> [...] the link between price changes and monetary changes over short periods is too loose and too imperfectly known to make price level stability an objective and reasonably unambiguous guide to policy. [...] [T]here is much evidence that monetary changes have their effect only after a considerable lag and over a long period and that the lag is rather variable. (p. 87)

He instead promoted the well-known $k - \%$ money growth rule:

> [...] The stock of money [should be] increased at a fixed rate year-in and year-out without any variation in the rate of increase to meet cyclical needs. (p. 90)

Friedman argued that discretionary policymaking aiming to stabilize inflation could potentially be destabilizing due to imperfect knowledge about the transmission mechanism of monetary policy, including the lag structure. Although imperfect knowledge is not the reason why transmission lags of monetary policy creates credibility problems analysed in this paper, the money growth targeting strategy does offer some robustness to different lag specifications since it is independent of the lag structure of the economy.[6] Furthermore, and relevant for our current perspective, money growth targeting (or the 'Friedman $k - \%$ rule') does not involve the potential temptation to deviate from the announced policy as is the case under inflation targeting.

[6] In Kilponen and Leitemo (2007) we discuss the advantages of money growth targeting in providing robustness against model uncertainty when there are implementation lags in price setting.

Söderström (2005) discusses some of the benefits of money growth targeting in the New Keynesian framework as a solution to the credibility problem. For these reasons, we investigate how the solution to the credibility problem offered by money growth targeting changes as a result of implementation lags.

The interest rate implication of money growth targeting can be derived in the following way. The period loss function is

$$L_t = m_t^2. \tag{2.12}$$

We assume that the demand for money is given by a conventional money demand function[7]

$$m_t - p_t = x_t - \kappa i_t + v_t. \tag{2.13}$$

By subtracting real money balances $\hat{m}_{t-1} \equiv m_{t-1} - p_{t-1}$ on both sides, the growth rate of money supply is given by

$$\Delta m_t = \pi_t + \Delta x_t - \kappa i_t - \hat{m}_{t-1} + v_t. \tag{2.14}$$

In the intertemporal minimization of equation (2.12), the central bank chooses $\Delta m_t = 0$. The interest rate then follows from (2.14) and is given by

$$i_t = \frac{1}{\kappa}\left[\pi_t + \Delta x_t - \hat{m}_{t-1} + v_t\right]. \tag{2.15}$$

Although the strategy of money growth targeting stated in terms of interest rate is model dependent, we note that it is independent of the length of the transmission lags in the model under conventional assumptions about money demand, ie, it is robust to different assumptions about implementation lags.

3 Equilibrium responses under inflation targeting

In this section we study the effect of transmission lags on inflation and output and how the cost-push shock influences these variables in the optimal discretionary equilibrium. We focus on the case where inflation reacts to changes in monetary policy with a greater lag than output, and contrasts this case where $j = 1$ and $m = 0$ with the case of no implementation lags.

For the case with implementation lags, the solution for the output gap is given from equation (2.10) as $x_t = 0$. The first-order difference equation for inflation can then be found by using (2.10) in equation (2.1). This results in

$$\pi_{t+1} = \delta\pi_{t+2|t} + \varepsilon_{t+1} \text{ for } j = 1, \text{ and} \tag{3.1}$$

$$\pi_t = \delta\left(\frac{\lambda}{\lambda+\gamma^2}\right)\pi_{t+1|t} + \left(\frac{\lambda}{\lambda+\gamma^2}\right)\varepsilon_t \text{ for } j = 0. \tag{3.2}$$

Under the assumption that the cost-push shock follows the AR(1) process,

$$\varepsilon_{t+1} = \rho_\varepsilon\varepsilon_t + \hat{\varepsilon}_{t+1}, \tag{3.3}$$

[7] See for instance Walsh (2003), ch 2 for the derivation of money demand equation in the context of dynamic money-in-the-utility function model.

the forward solution for inflation can be found by noting that $\pi_{t+1} = \pi_{t+1|t} + \varepsilon_{t+1} - \varepsilon_{t+1|t}$ and solving forward for $\pi_{t+1|t}$. This yields

$$\begin{aligned}\pi_{t+1} &= \varepsilon_{t+1} - \varepsilon_{t+1|t} + \sum_{i=0}^{\infty} \delta^i \varepsilon_{t+i+1|t} \\ &= \hat{\varepsilon}_{t+1} + \frac{\rho_\varepsilon}{1-\delta\rho_\varepsilon}\varepsilon_t, \end{aligned} \tag{3.4}$$

where $\hat{\varepsilon}_{t+1} \equiv \varepsilon_{t+1} - \varepsilon_{t+1|t}$.

In the the standard case where $j = m = 0$, the solution for output is found from equations (2.1), (2.10) and (3.3) and it is given by

$$x_t = -\frac{\gamma}{\gamma^2 + \lambda(1-\delta\rho_\varepsilon)}\varepsilon_t. \tag{3.5}$$

The forward solution for inflation is found by combining equations (2.1) and (3.5), and equation with AR(1) specification of cost-push shock yielding

$$\begin{aligned}\pi_{t+1} &= \sum_{i=0}^{\infty} \frac{\lambda}{\lambda+\gamma^2}\left(\frac{\delta\lambda}{\lambda+\gamma^2}\right)^i \varepsilon_{t+i+1|t+1}, \\ &= \sum_{i=0}^{\infty} \frac{\lambda}{\lambda+\gamma^2}\left(\frac{\delta\lambda\rho_\varepsilon}{\lambda+\gamma^2}\right)^i \varepsilon_{t+1}, \qquad (3.6) \\ &= \frac{\lambda}{\gamma^2+\lambda(1-\delta\rho_\varepsilon)}\varepsilon_{t+1} \\ &= \frac{1}{1-\delta\rho_\varepsilon}\varepsilon_{t+1} - \frac{1}{1-\delta\rho_\varepsilon}\left(\frac{1}{1+\frac{\lambda}{\gamma^2}(1-\delta\rho_\varepsilon)}\right)\varepsilon_{t+1} \\ &= \hat{\varepsilon}_{t+1} + \frac{\rho_\varepsilon}{1-\delta\rho_\varepsilon}\varepsilon_t + \\ &\frac{\delta\rho_\varepsilon}{1-\delta\rho_\varepsilon}\hat{\varepsilon}_{t+1} - \frac{1}{1-\delta\rho_\varepsilon}\left(\frac{1}{1+\frac{\lambda}{\gamma^2}(1-\delta\rho_\varepsilon)}\right)\varepsilon_{t+1}, \qquad (3.7)\end{aligned}$$

The equilibrium behaviour of the models with and without the implementation lag differs in two important respects. The first difference is related to the expectations channel. In the model with the implementation lag, the only immediate effect is a one-to-one reaction of inflation to the surprise component of the cost-push shock $\hat{\varepsilon}_{t+1}$, ref. the first term in equation (3.4). Thus, inflation does not respond immediately to the expected future effect of the surprise as it does in the model without implementation lags (see equation (3.6)). In the model with implementation lags, the remaining effect is delayed by one period, ref. the second term in (3.4). However, only a part ρ_ε of the surprise shock survives until the second period and then affects the inflation path through the expectations channel as firms reoptimize prices given new information about the future path of marginal costs. This delayed effect reduces inflation variability in the model with implementation lag. The reduction is particularly large when the cost-push shocks has little persistence, ie ρ_ε is small. The expectation channel is then relatively unimportant for inflation determination.

The second type of difference regards optimal policy under the two models. As noted above, the monetary policymaker does not respond by adjusting output in the case with the implementation lag and hence inflation is not insulated from the cost-push shock. In the absence of implementation lag, the monetary policymaker is able to trade-off some of the inflation variability with output variability in response to the cost-push shock.

The monetary policy channel has a stronger impact on inflation if the persistence of the cost-push shock (ρ_ε) is large. If cost-push shocks are persistent and monetary policymaker does not stabilize the cost-push shock, the price setters expect marginal costs to be high for a long time and they increase todays prices at a faster rate. Hence, current inflation reacts strongly to the cost-push shock.

The effects on inflation are summarized by equation (3.7). It shows that inflation is a function of four terms in the model without implementation lags. The first two terms correspond to inflation in the model with the implementation lag. The third term represents the additional effect on inflation through the expectation channel and the fourth term represents the effect of a policy that insulates inflation from the cost-push shock.

4 Welfare and the discretionary bias

In this section we study the effects on social loss of implementation lags in pricing decisions and compare it to the standard model with no implementation lag.

We let the disturbances to the output and money demand equations follow the AR(1) processes such that

$$r_{t+1}^n = \rho_r r_t^n + \hat{r}_{t+1}^n, \tag{4.1}$$

$$v_{t+1} = \rho_v v_t + \hat{v}_{t+1}. \tag{4.2}$$

As noted above, ε_t is a cost-push shock, r_t^n is a shock to the natural rate of interest and v_t is a money demand shock. We calibrate the model according to Giannoni and Woodford (2005) by setting $\beta = 0.99$, $\gamma = 0.024$, $\sigma = 6$, $\rho_r = 0.35$, and $\sigma_{\hat{r}} = 0.0372$. Since Giannoni and Woodford (2005) do not produce calibrated values for the parameters in the cost-push shock process, we set $\sigma_\varepsilon = 0.01$ and $\rho_\varepsilon = 0.5$. We also consider higher degree of persistence in the cost push shock below. For the parameters in the money demand equation (2.13), we have used the estimates from Kilponen and Leitemo (2007). Using the US data[8] over the period $1980q1 - 2004q4$, we obtained an estimate of $\kappa = 0.43$ with a coefficient standard error of 0.11.[9] Moreover, the estimated parameter values of the disturbance processes are $\rho_v = 0.77$ and $\sigma_{\hat{v}} = 0.0116$.

[8]The estimation was carried out with ordinary least square allowing for serial correlation of the residual of order one. We used HP-filtered data on log monetary base, log GDP deflator, log GDP and the federal funds rate. The detrending was carried out with a smoothing parameter of 1600 over the period 1960q1–2005q4 to reduce the endpoint problem associated with the filter.

[9]Varying the endpoint of the estimation period between 1990q1 and 2005q4, produced estimates between 0.35 and 0.45, well within the range suggested by the standard error of the estimate for the shorter period. The estimate also stabilized very close to our point estimate after year 2000.

Finally, the elasticity of substitution between alternative differentiated goods (ψ) in is parameterized as $\psi^{-1} = 0.13$ as in Woodford (2003). This implies that inflation is the component of the welfare loss that dominates, and social loss can be studied primarily by the impact on inflation.

Given the parameterization, we compute the welfare loss under the discretionary and commitment equilibria. Furthermore, we illustrate the importance of the persistence of cost push shocks by analyzing the two models with two alternative assumptions on the persistence of cost push shock. Results as regards welfare loss[10] is presented in Table 1. Figures 1–4 in appendix show the equilibrium responses of the model under different policies and assumptions about the persistence of cost-push shocks.

Table 1: Comparison of welfare losses under different models and policies

Equilibrium	No lag ($j = 0$)	Price lag ($j = 1$)
Commitment	0.142	0.109
Discretion	0.246	0.170
	(+73%)	(+55%)
Money growth targeting	0.216	0.122
	(+52%)	(+12%)

As observed from Table 1, there are substantial benefits in having access to commitment technology if the central bank is maximizing welfare directly through inflation targeting. The welfare loss is 73 per cent higher with discretion in the standard model. The gains from committing are slightly lower under the model with the implementation lag. Discretion produces a loss that is 52 per cent higher than under commitment. Commitment is more important in the setting without implementation lag since the expectations channel has a stronger influence on the outcome, as discussed in Section 3.

The central bank can improve significantly on the outcome with money growth targeting. This is in particular evident in the model with the implementation lag, where loss is only 12 per cent above the optimal commitment equilibrium as opposed to 52 per cent in the model without lags. The model supports the claim by Friedman that money growth targeting is welfare improving in particular if there are transmission lags in monetary policy, but for a different reason: Money growth targeting alleviates the problem caused by a lack of credibility with discretionary inflation-targeting policy.

As noted in the previous section, the persistence of the cost-push shock influences whether or not lags in the model improve on the relative performance of the discretionary policy. With the baseline assumption of $\rho_\varepsilon = 0.5$, a lag will in fact improve on the relative performance of discretion. This is a result of firms not accounting for the future effect of the shock in the period in which the shock occurs which has a moderating effect on inflation. This effect outweighs the effect of a missing monetary policy channel on inflation under the baseline calibration.

[10] Welfare losses in the table are scaled up by a factor 10^3.

However, this result is overturned if the cost-push shock becomes sufficiently persistent. In Table 2, we consider the case where $\rho_\epsilon = 0.7$. This higher degree of persistence suggests a half-life of inflation of about 2 quarters, which does not seem unreasonably high considering the high degree of persistence in observed inflation. The presence of an implementation lag now worsens the discretionary equilibrium substantially. Discretion produces welfare losses that is 123 per cent and 258 per cent higher than under commitment in the model with and without the implementation lag respectively. Since the shock is expected to have a more persistent effect on costs, the control of expectations channel via the appropriate design of monetary policy is vital to the outcome. Such a control is not available to the policymaker in the discretionary equilibrium.

Table 2: Comparison of welfare losses under different models and policies.

Equilibrium	No lag ($j = 0$)	Price lag ($j = 1$)
Commitment	0.216	0.155
Discretion	0.481	0.555
	(+123%)	(+258%)
Money growth targeting	0.382	0.216
	(+77%)	(+39%)

The table considers the case with $\rho_\varepsilon = 0.7$ and the standard deviation of the cost-push shock (σ_ε) unchanged at 0.01.

Although the performance of money growth targeting deteriorates relative to the optimal commitment policy with increased cost-push persistence, it improves relative to the discretionary inflation targeting equilibrium. With increased persistence and the implementation lag, money growth targeting reduces the loss (relative to inflation targeting under discretion) by 61 per cent compared to 28 per cent in the case with baseline persistence. The corresponding numbers are 21 per cent and 12 per cent in the model without the implementation lag.

The benefits of money growth targeting is due to its ability to induce history dependence in policymaking. As can be seens from the implied interest rate rule in (2.15), money growth targeting features history dependence through the terms Δx_t and $\hat{m}_{t-1}$.[11] Such a history dependent policy affects people's expectations about the future. This can improve the equilibrium substantially in a model where these expectations play a major role. Figures 1–4 in the appendix show the impulse responses of the model to a cost-push shock. The response under money growth targeting bears relatively close resemblance to that of the optimal commitment policy. It produces hump-shaped output and inflation responses that reflect the history-dependence of the policy under both the commitment and money growth rule. Why does history dependence contribute to an improved outcome? Under both money growth targeting and the commitment equilibrium, the price level is (trend) stationary. Under

[11] This is extensively discussed in Söderström (2005).

money growth targeting prices will over time return to the money growth path. A cost-push shock that raises inflation today will lead to people expecting future inflation to be relatively low as to get prices in line with money. Expectations of lower inflation tomorrow has a moderating effect on inflation today, since inflation is a function of expected future inflation.

Money growth targeting does not exactly replicate the commitment solution, however, and is furthermore inefficiently affected by money demand shocks that induce variability in the interest rate. The variability in the interest rate induces inefficient movements in output which again affects inflation. In the case with implementation lags on prices, however, the initial shock to money demand has no impact on inflation since prices are predetermined. This reduces the inefficient impact of the money demand shock since only a part of the money demand shock survives into the future and can affect inflation. This is the reason why the efficiency of money growth targeting increases with the implementation lag.

5 Conclusions

It is well established that monetary policy is subject to transmission lags. These lags can be the results of delayed responses of the private sector to economic shocks. We show under the reasonable assumption that if inflation reacts with a longer lag than output to changes in monetary policy, the optimal discretionary equilibrium implies no policy-induced stabilization of cost-push shocks. Since inflation is predetermined at the time when monetary policy can influence output, the discretionary optimizing policymaker stabilize the output gap perfectly and does not stabilize inflation.

Implementation lags in prices increase the discretionary stabilization bias severely if cost-push shocks are sufficiently persistent. Money growth targeting reduces the bias substantially, since it features history dependence, similarly to the policy under commitment equilibrium. Although we admit that money growth targeting is currently out of fashion, it provides a practical and implementable solution to the credibility problems of monetary policy when there are implementation lags and commitment technology is not available.

References

Barro, R J – Gordon, D B (1983) **Rules, discretion and reputation in a model of monetary policy.** Journal of Monetary Economics 12(1), 101–121.

Calvo, G A (1983) **Staggered prices in a utility-maximizing framework.** Journal of Monetary Economics 12(3), 383–398.

Christiano, L J – Eichenbaum, M – Evans, C (2005) **Nominal rigidities and the dynamic effects of a shock to monetary policy.** Journal of Political Economy 113(1), 1–45.

Clarida, R – Galí, J – Gertler, M (1999) **The science of monetary policy: A new Keynesian perspective.** Journal of Economic Literature 37:4, 1661–1707.

Friedman, M (1960) **A Program for Monetary Stability.** Fordham University Press, New York City.

Giannoni, M P – Woodford, M (2005) **Optimal inflation targeting rules.** In Bernanke, B S and Woodford, M (eds.), The Inflation-Targeting Debate. University of Chicago Press, Chicago.

Goodfriend, M – King, R G (1997) **The new neoclassical synthesis and the role of monetary policy.** In Bernanke, B S and Rotemberg, J J (eds.), NBER Macroeconomics Annual. MIT Press, Cambridge and London, 231–283.

Kilponen, J – Leitemo, K (2007) **Delegation and model uncertainty: A case for the friedman k-% rule?** Forthcoming in Journal of Money, Credit, and Banking.

Kydland, F E – Prescott, E C (1977) **Rules rather than discretion: The inconsistency of optimal plans.** Journal of Political Economy 85(3), 473–491.

McCallum, B T – Nelson, E (1999) **An optimizing IS-LM specification for monetary policy and business cycle analysis.** Journal of Money, Credit and Banking 31(3), 296–316, NBER Working Paper No. W5875.

Roberts, J M (1995) **New Keynesian economics and the Phillips curve.** Journal of Money, Credit and Banking 27:4, Part 1, 975–984.

Rotemberg, J J – Woodford, M (1997) **An optimizing-basec econometric model for the evaluation of monetary policy.** In Rotemberg, J J and Bernanke, B S (eds.), NBER Macroeconomics Annual. MIT Press, Cambridge, MA, 297–346.

Rudebusch, G (2002a) **Term structure evidence on interest rate smoothing and monetary policy inertia.** Journal of Monetary Economics 49, 1161–1187.

Rudebusch, G D (2002b) **Assessing nominal income rules for monetary policy with model and data uncertainty.** Economic Journal 112, 1–31.

Söderström, U (2005) **Targeting inflation with a promiment role for money.** Forthcoming. Economica. Earlier version published as Sveriges Riksbank Working Paper No. 123.

Svensson, L E (1997) **Inflation forecast targeting: Implementing and monitoring inflation targets.** European Economic Review 41, 1111–1146.

Svensson, L E – Woodford, M (2005) **Implementing optimal policy through inflation-forecast targeting.** In Bernanke, B S and Woodford, M (eds.), The Inflation-Targeting Debate. University of Chicago, Chicago, 19–92.

Vestin, D (2006) **Price-level versus inflation targeting.** Journal of Monetary Economics 53, 1361–1376.

Walsh, C E (2003) **Monetary Theory and Policy.**The MIT Press, Cambridge, MA.

Woodford, M (2003) **Interest and Prices: Foundations of a Theory of Monetary Policy.** Princeton University Press, Princeton

Appendix

Equilibrium responses to cost-push shocks

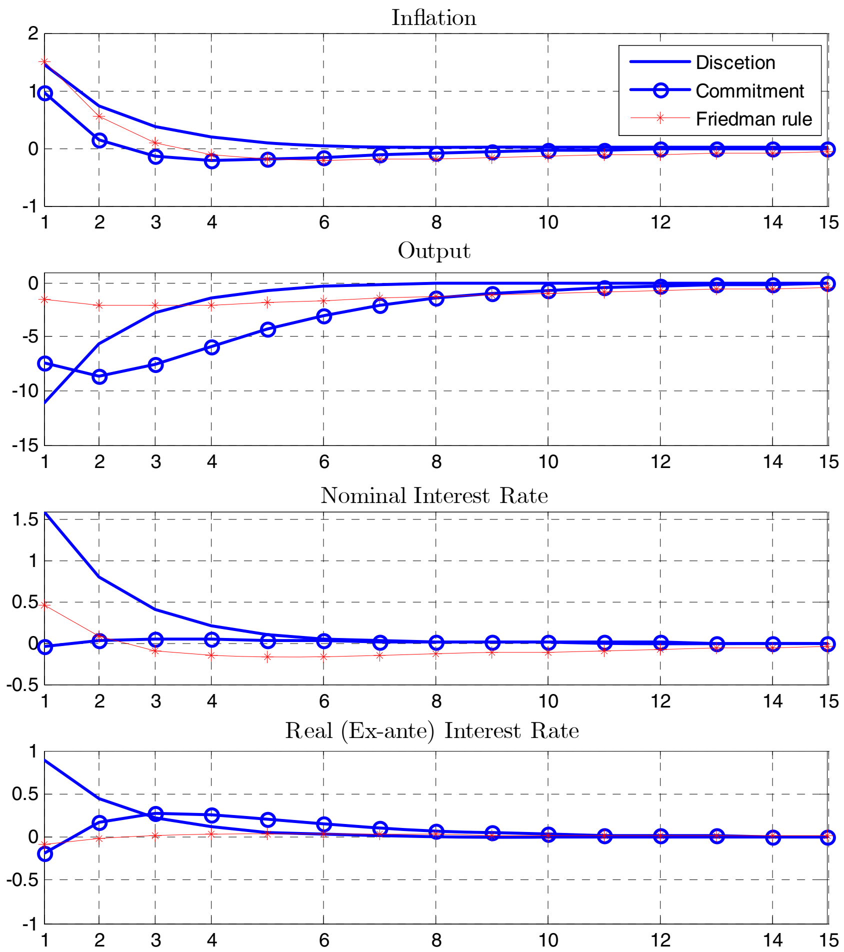

Figure 1: Equilibrium responses to cost-push shock in the standard New Keynesian model.

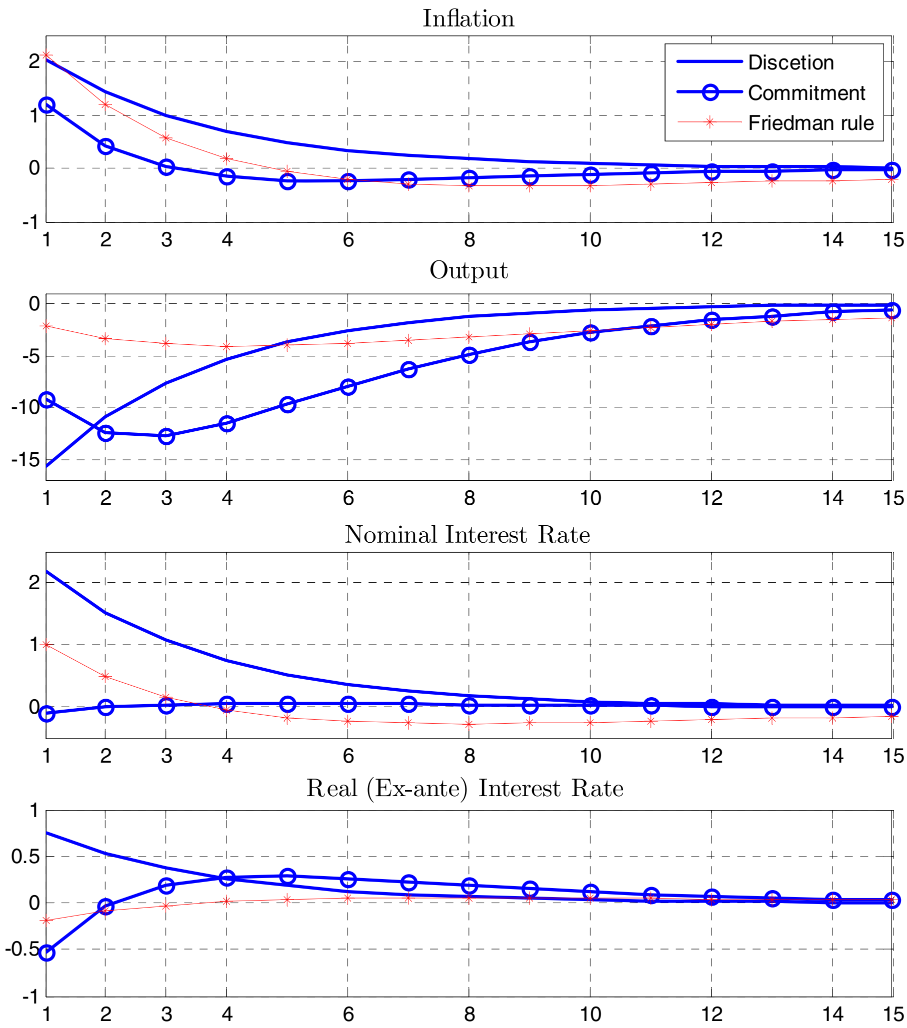

Figure 2: Equilibrium responses to persistent cost-push shocks in the standard New Keynesian model under alternative policies.

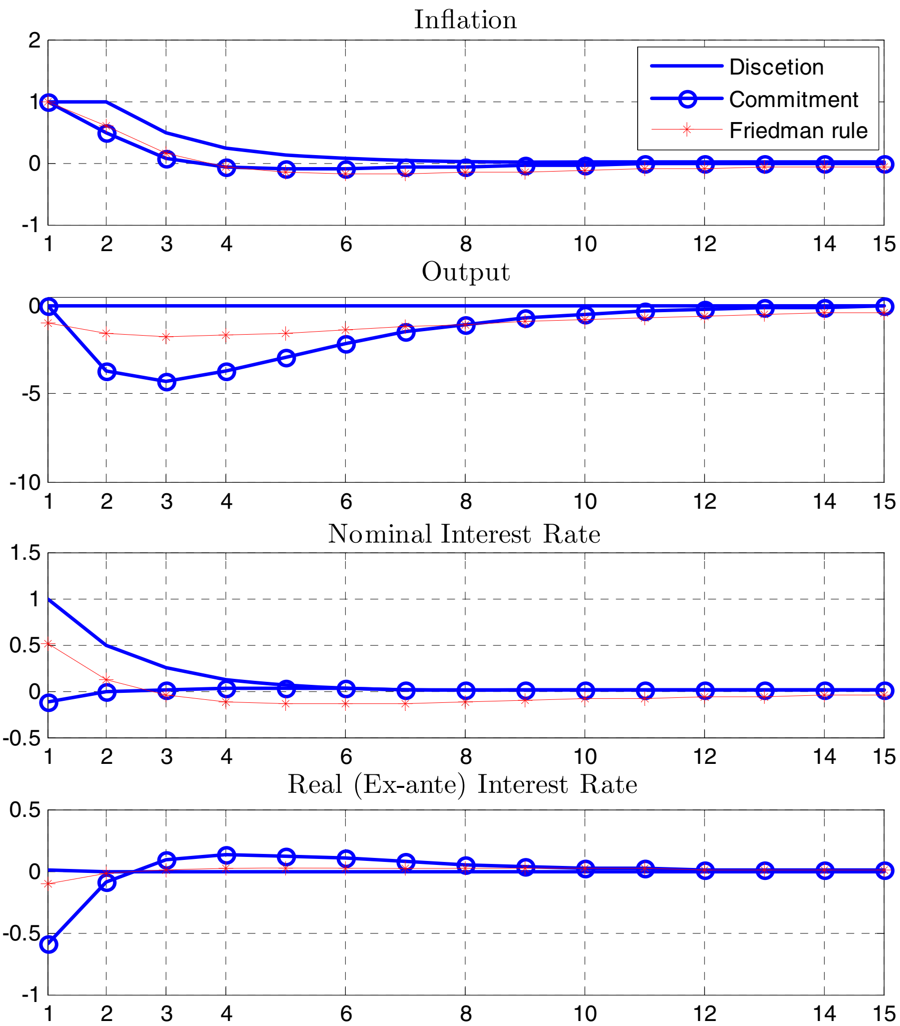

Figure 3: Equilibrium responses to cost-push shocks in the model with one period implementation lag under alternative policies. Standard parameterisation of the model.

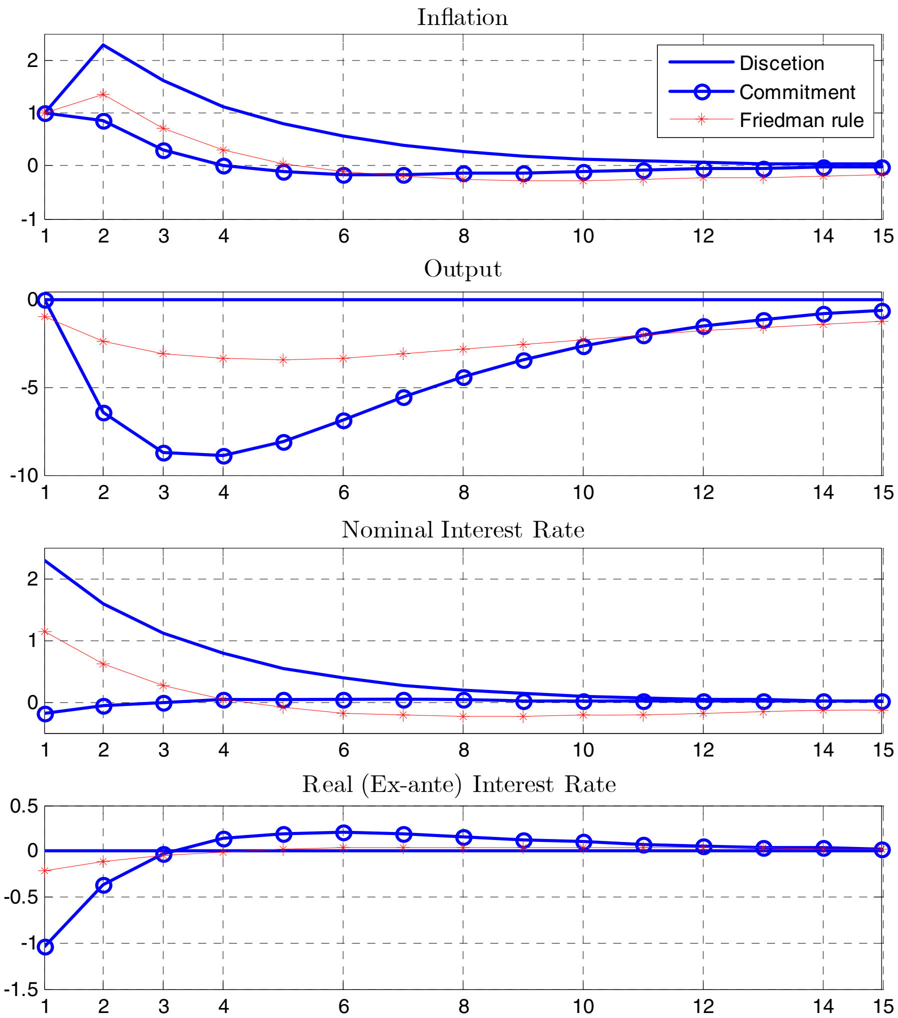

Figure 4: Equilibrium responses to persistent cost-push shocks in the model with one period implementation lag under alternative policies.

BANK OF FINLAND RESEARCH
DISCUSSION PAPERS

ISSN 0785-3572, print; ISSN 1456-6184, online

1/2007 Timo Korkeamäki – Yrjö Koskinen – Tuomas Takalo **Phoenix rising: Legal reforms and changes in valuations in Finland during the economic crisis.** 2007. 39 p. ISBN 978-952-462-346-9, print; ISBN 978-952-462-347-6, online.

2/2007 Aaron Mehrotra **A note on the national contributions to euro area M3.** 2007. 25 p. ISBN 978-952-462-348-3, print; ISBN 978-952-462-349-0, online.

3/2007 Ilmo Pyyhtiä **Why is Europe lagging behind?** 2007. 41 p. ISBN 978-952-462-350-6, print; ISBN 978-952-462-351-3, online.

4/2007 Benedikt Goderis – Ian W Marsh – Judit Vall Castello – Wolf Wagner **Bank behaviour with access to credit risk transfer markets.** 2007. 28 p. ISBN 978-952-462-352-0, print; ISBN 978-952-462-353-7, online.

5/2007 Risto Herrala – Karlo Kauko **Household loan loss risk in Finland – estimations and simulations with micro data.** 2007. 44 p. ISBN 978-952-462-354-4, print; ISBN 978-952-462-355-1, online.

6/2007 Mikael Bask – Carina Selander **Robust Taylor rules in an open economy with heterogeneous expectations and least squares learning.** 2007. 54 p. ISBN 978-952-462-356-8, print; ISBN 978-952-462-357-5, online.

7/2007 David G Mayes – Maria J Nieto – Larry Wall **Multiple safety net regulators and agency problems in the EU: is Prompt Corrective Action a partial solution?** 2007. 39 p. ISBN 978-952-462-358-2, print; ISBN 978-952-462-359-9, online.

8/2007 Juha Kilponen – Kai Leitemo **Discretion and the transmission lags of monetary policy.** 2007. 24 p. ISBN 978-952-462-362-9, print; ISBN 978-952-462-363-6, online.

Suomen Pankki
Bank of Finland
P.O.Box 160
FI-00101 HELSINKI
Finland

. 2343