IMES DISCUSSION PAPER SERIES

Inflation Targeting and Monetary Policy Activism

Toshitaka Sekine and Yuki Teranishi

Discussion Paper No. 2008-E-13

IMES

INSTITUTE FOR MONETARY AND ECONOMIC STUDIES

BANK OF JAPAN

Inflation Targeting and Monetary Policy Activism

Toshitaka Sekine* and Yuki Teranishi**

Abstract

We estimate monetary policy activism, defined as responsiveness of the policy interest rate to inflation, among five inflation-targeting countries (the UK, Canada, Sweden, Australia and New Zealand) plus the G3 (the US, Japan and Germany) by applying a time-varying parameter with a stochastic-volatility model. We find that activism of inflation-targeting countries tends to have increased before (not after) the adoption of the inflation-targeting policy framework and that these countries have experienced a decline in activism in recent years, albeit to different degrees. We further explore this result in terms of the constraint of an inflation target range by developing a formal theoretical model in a New Keynesian framework.

* Associate Director-General, Monetary Affairs Department, Bank of Japan (E-mail: toshitaka.sekine @boj.or.jp)
**Associate Director, Institute for Monetary and Economic Studies, Bank of Japan (E-mail: yuuki.teranishi @boj.or.jp)

1 Introduction

Since the early 1990s, an increasing number of central banks have adopted an inflation-targeting framework, in which explicit inflation objectives have been set up. A substantial body of existing literature has already investigated the macroeconomic effects of the inflation-targeting policy, both theoretically and empirically, and has documented that it has contributed to an array of favorable macroeconomic outcomes such as the emergence of the low and stable inflation environment in recent decades. See Svensson (1999, 2000), Bernanke et al. (1999), Mishkin and Schmidt-Hebbel (2001) and contributions in Bernanke and Woodford (2005), among others.

Yet it is not entirely clear how these favorable outcomes have been achieved. If the introduction of an explicit quantitative target, geared with a high degree of transparency and accountability, firmly anchors inflation expectations, the central bank can deliver low and stable inflation even without changing its interest rate setting.[1] On the other hand, if the adoption of the inflation-targeting framework reflects a change in the preference of the central bank, it may lead to greater responsiveness in the interest rate setting to inflation.

Some researchers have tried to tackle this question by estimating how the responsiveness of the interest rate to inflation changed in inflation-targeting countries. For example, Neumann and von Hagen (2002) and Kuttner and Posen (1999) estimate variants of Taylor rules for inflation-targeting countries that are covered in this paper. Their split sample estimations broadly suggest greater sensitivity of the interest rate to inflation after the adoption of inflation targeting. Cecchetti and Ehrmann (1999) identify the implied weight attached to inflation variability in a central bank's loss function. Most of the nine inflation-targeting central banks they examined exhibited increases in their revealed aversion to inflation variability after the adoption of inflation targeting.

In comparison with these existing studies, this paper makes the following contributions. First, we estimate monetary policy activism by applying a time-varying parameter with stochastic volatility (TVP-SV) model, which is used by Cogley and Sargent (2005) to uncover the evolution of the Fed policy stance. This enables us to see more precisely the timing of changes in the activism in-

---

[1]Johnson (2002, 2003), Levin et al. (2004) and Gürkayanak et al. (2006) show that inflation expectations have become more firmly anchored in inflation-targeting countries.

dicator, which may not necessarily be captured by the split sample estimation used in the existing literature. We find that, somewhat in line with the rolling regression results of Muscatelli et al. (2002), activism appears to have increased before (not after) the adoption of the inflation-targeting policy framework. Moreover, with the benefit of posttarget data, we also find that the activism indicator declined recently, although the extent of decline in the activism indicators varies across countries.

The second contribution of this paper is that, by developing a formal theoretical model within a New Keynesian framework, we show that the recent fall in activism can be seen as a less binding constraint of an inflation target range. The countries with superior inflation records were in a situation where they did not have to react to inflation very aggressively. On the other hand, countries with less favorable inflation records need to maintain high levels of activism to keep inflation within the desired range.

The structure of this paper is as follows. Section 2 defines monetary policy activism as the coefficients of a Taylor-type rule and shows how to estimate them within a TVP-SV model. Section 3 documents the estimation results. Section 4 develops a theoretical model of the optimal monetary policy with an inflation target range. Section 5 discusses possible reasons why activism in some countries declined more than in other countries. Section 6 concludes the paper. Two appendices outline a Markov chain Monte Carlo (MCMC) algorithm used for estimating the TVP-SV model and derivations of the optimal interest rate rules.

2 Analytical Framework

2.1 Monetary policy activism

To see the changing behaviors of central banks, we estimate the following hybrid Taylor rule with interest rate smoothing:

$$i_t = \beta_{0t} + \beta_{1t}E_t\pi_{t+1} + \beta_{2t}\pi_t + \beta_{3t}E_t x_{t+1} + \beta_{4t}x_t + \beta_{5t}i_{t-1} + \beta_{6t}i_{t-2} + \epsilon_t, \tag{1}$$

where i_t is the policy interest rate at time period t, π_t is the inflation rate, x_t is the output gap, and ϵ_t is an error term. $E_t\pi_{t+1}$ and $E_t x_{t+1}$ are the expected rate of inflation and the expected output gap, respectively. Monetary policy activism is gauged by the cumulative response to both expected and actual inflation rates, $(\beta_{1t} + \beta_{2t})/(1 - \beta_{5t} - \beta_{6t})$. It may also depend on the response to the output gap, β_{3t} and β_{4t}, but, following the existing literature, we focus on the response to inflation. Given the well-known difficulty of measuring the output gap, it would be more challenging to pin down the time variance of responsiveness to the output gap.

Equation (1) is a generalization of the policy reaction functions in the previous empirical literature. The central bank may react not only to expected inflation $E_t\pi_{t+1}$, but also to actual inflation π_t. In the literature, it is often the case that a reaction function includes either expected inflation (Clarida et al. (2000); Cogley and Sargent (2005)) or actual inflation (Primiceri (2005); Sims and Zha (2006)), but we retain both terms as there is no a priori reason to drop one of them.

Equation (1) can also be seen as an empirical correspondence of an optimal interest rate rule. It can be expressed as:

$$i_t = \theta_1 i_{t-1} + \theta_2 i_{t-2} + \sum_{j=0}^{\infty} \eta_3^j f_{t+j} + \sum_{j=0}^{\infty} \eta_3^j \psi^* \phi_{3t+j} - \sum_{j=0}^{\infty} \eta_3^j \psi^* \phi_{4t+j} + (1 - \eta_1)(1 - \eta_2)i^*, \quad (2)$$

where $f_t \equiv \kappa\lambda_\pi\psi\eta_3\pi_t + \lambda_x\psi\eta_3(-\beta\mu x_{t+1} + x_t - (1-\mu)x_{t-1})$, $\theta_1 = \eta_1 + \eta_2$, and $\theta_2 = -\eta_1\eta_2$. We defer details to the section below except for pointing out that in this optimal rule the interest rate is determined by its own lags and the current and future inflation rates as well as the lagged, current and future values of the output gap. Equation (1) covers all these ingredients except that the expectation terms are truncated at one-quarter ahead and the lagged output gap is not included specifically. In this setup, among other things, an increase in the weight on inflation in the central bank's loss function λ_π raises monetary policy activism.[2]

As emphasized by Clarida et al. (1998), considerable caution may be required for interpreting the behavior of non-G3 central banks especially before they introduced the inflation-targeting policy framework. It is rather unrealistic to assume that these central banks had followed the interest

---

[2]However, we cannot claim so in the following estimation, as unlike Cecchetti and Ehrmann (1999) and Assenmacher-Wesche (2006), we will not attempt to identify structural parameters.

rate rule specified by equation (2) at the time, as they used to use the exchange rate as a nominal anchor or follow policy decisions of the neighboring dominant central banks. Nonetheless, it is still interesting to gauge the policy activism in this setup, as this enables us to evaluate the past interest rate through the lens of the current policy regime, that is, if the central banks had adopted the current policy rule and had set the interest rate at historical values, what degree of monetary policy activism would have been implied.

2.2 Time-varying parameter with stochastic-volatility model

In equation (1), we assume all the coefficients are time varying as indicated by the time subscript of each coefficient. We allow permanent shifts in parameters such that $\beta_{i,t} = \beta_{i,t-1} + u_t$, where u_t is an iid error term. This, in principle, can capture both gradual and sudden shifts in parameters depending on the size of error u_t.[3] As we do not exclude the possibility that the central bank has gradually changed its behavior over time—as we will see below, before the central bank announced an inflation target, there might have been a transition period during which it gradually increased its focus on low and stable inflation—we prefer a time-varying parameter model to the regime-switching model used by Sims and Zha (2006) and Assenmacher-Wesche (2006), although we agree that it would be interesting to extend our analysis using their methodology for comparison.

In addition, we also assume time variance for the volatility of the error term ϵ_t such that $h_{t+1} = h_t + \vartheta_t$, where h_t is an unobserved log volatility and ϑ_t is another iid error term. Incorporation of time-variant stochastic volatility reflects the recent argument that inappropriate omission of heteroskedasticity can strongly bias statistical tests in favor of finding significant shifts in coefficients (see Sims (2001) and Cogley and Sargent (2005)). In this light, it is more prudent to retain stochastic volatility, especially when estimation points to its existence.[4] However, at the same time, this prevents us from using a more conventional classical approach, as we cannot derive an analytical form of the likelihood function in the presence of stochastic volatility. For this reason,

---

[3]Whether a TVP-SV model can identify a sudden structural break of a parameter remains to be confirmed by a careful Monte Carlo experiment. However, we are reasonably confident about this, as estimation below detects a sudden shift in the US Fed's activism in the early 1980s, which is often found in the literature using various methods.

[4]Although we do not show details below, this is exactly the case for our estimation.

we will rely on the Bayesian approach.

Combined with the transition processes of parameters and volatility, equation (1) can be represented by the following state space form of a time-varying parameter with stochastic volatility (TVP-SV) model:

$$i_t = Z_t \beta_t + \gamma e^{h_t/2} \varepsilon_t, \ \varepsilon_t \sim N(0,1), \tag{3}$$

$$\beta_t = \beta_{t-1} + u_t, \ u_t \sim N(0, B^{-1}), \tag{4}$$

$$h_t = h_{t-1} + \vartheta_t, \ \vartheta_t \sim N(0, H^{-1}), \tag{5}$$

and initial values of state variables are:

$$\beta_0 = 0 \text{ and } u_1 \sim N(0, B_0^{-1}), \tag{6}$$

$$h_0 = 0 \text{ and } \vartheta_1 \sim N(0, H_0^{-1}). \tag{7}$$

Z_t is a vector of explanatory variables $(E_t \pi_{t+1}, \pi_t, E_t x_{t+1}, x_t, ...)$. β_t is the corresponding vector of unobserved time-varying parameters and h_t is the unobserved log volatility. The model can be estimated by the MCMC using an efficient Gaussian smoother (de Jong and Shephard, 1995) combined with approximation of a mixture of normal density (Kim et al., 1998). Appendix A summarizes the main steps of the estimation procedure.

3 Empirical Findings

3.1 Baseline case

For empirical investigation, π_t is calculated as the annualized quarterly inflation rate $4\Delta p_t$, where p_t is the quarterly average of headline CPI (in logarithms), and the output gap x_t is derived from the difference between log real GDP and its HP-filtered trend. i_t is the money market interest rate. All the data come from the OECD Economic Outlook database. The sample period is 1970Q1–2005Q4

except for Germany (1970Q1–1998Q4)[5] and New Zealand (1975Q1–2005Q4).

Following Cogley and Sargent (2005), expected values of inflation and the output gap are obtained by preliminary running of a trivariate time-varying VAR comprising i_t, π_t and x_t. This VAR estimation corresponds to the first stage of two-stage least squares. The presumption is that the current and lagged inflation rates, the output gap and the nominal interest rate are a key information set for the central bank to make inflation projections, and time-varying coefficients (including that of a constant term) capture the effects of any important omitted variables.

Figure 1 shows development of the activism indicators of the sample countries. Prior to examining the changes in inflation-targeting countries, we briefly touch upon those of the G3. First, for the US, consistent with the findings of a number of existing studies (Clarida et al. (2000), Cogley and Sargent (2005), etc.), the activism indicator increased sharply toward 1980 when Chairman Volcker took office, and thereafter remained at a high level. However, contrary to Clarida et al. (2000), who claim that the cumulative response of the policy rate to inflation did not reach unity before 1980, our estimates of it remain above unity, albeit by a very small margin. This observation is consistent with Primiceri (2005), who also finds that this was the case even during the 1970s. For Japan, the activism indicator also increased toward 1980 and remained about unity until 1990.[6] The recent decline in activism seems to correspond to its running out of room to maneuver because of the constraint of the zero nominal interest rate floor. For Germany, the activism indicator remained at a relatively high level even in the 1970s. This finding is consistent with Cecchetti et al. (2002) and Assenmacher-Wesche (2006), who find a higher preference of the Bundesbank for inflation stabilization.

Turning to inflation-targeting countries, we find considerable diversity in the development of their activism indicators. This point is highlighted by Figure 2, where the corresponding activism indicators in Figure 1 are redrawn so that zero may correspond to the timing of the adoption of

---

[5]The responsibility of the monetary policy decision was passed to the European Central Bank from 1999Q1.

[6]The low level of activism in Japan is in line with Muscatelli et al. (2002), who estimate it to be 0.72 using data from 1970Q2 to 1999Q2. We suspect this may be related to the Bank of Japan's reliance on quantitative measures in the 1970s and 1980s including "window guidance" for direct lending by the central bank to private banks (Ito, 1992, Ch.5). However, given that Clarida et al. (1998) estimate it to be more than 2 using data from 1979 to 1994, there may be other reasons. Further investigation seems warranted, but is beyond the scope of this paper.

Figure 1: Activism indicator
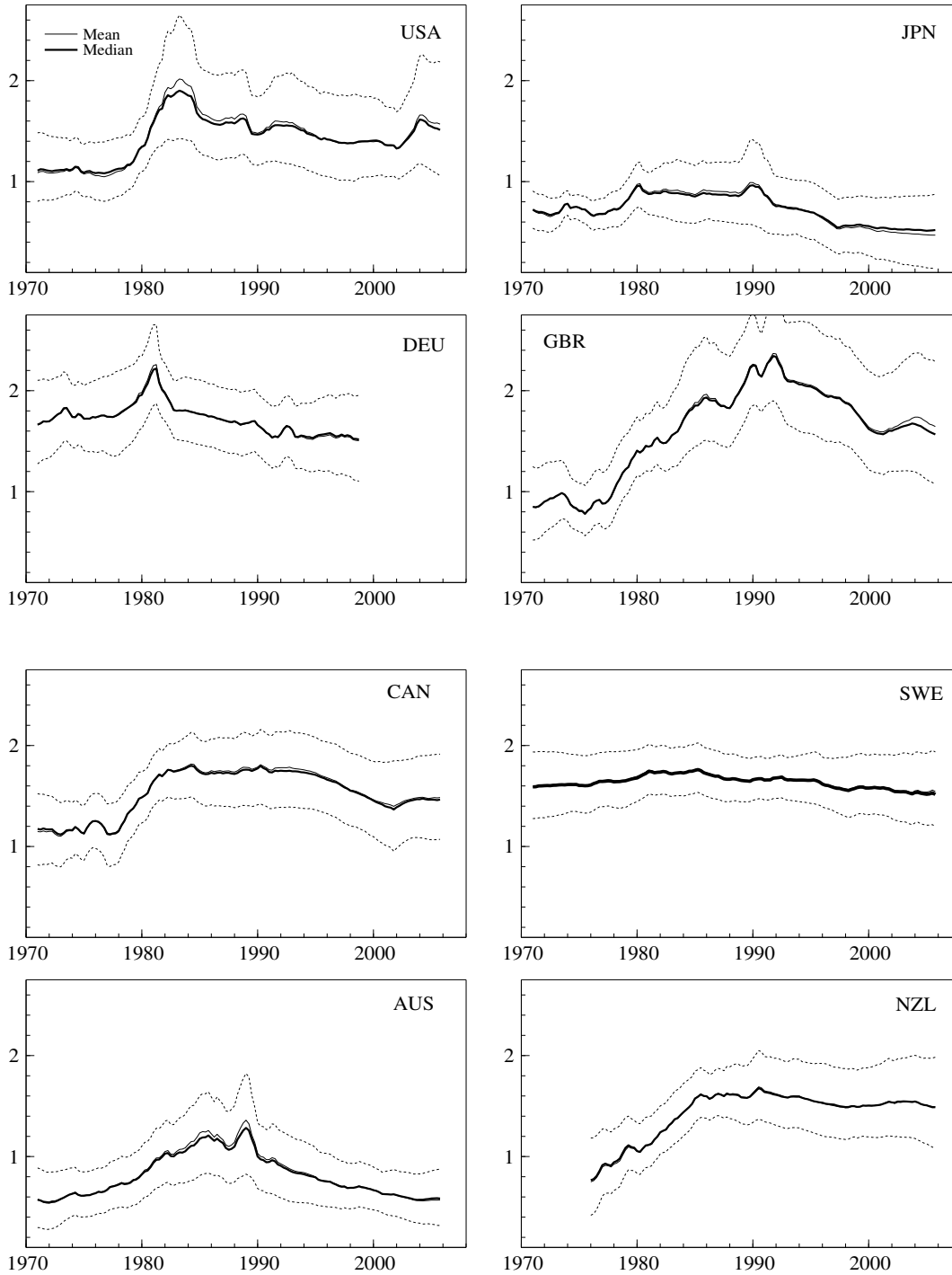
Note: Posterior means and medians of activism indicator $(\beta_{1t} + \beta_{2t})/(1 - \beta_{5t} - \beta_{6t})$ in equation (1). Dotted lines indicate posterior interquartile ranges. USA (the United States); JPN (Japan); DEU (Germany); GBR (the United Kingdom); CAN (Canada); SWE (Sweden); AUS (Australia); and NZL (New Zealand).

Figure 2: Activism indicator before and after the adoption of IT (Baseline)
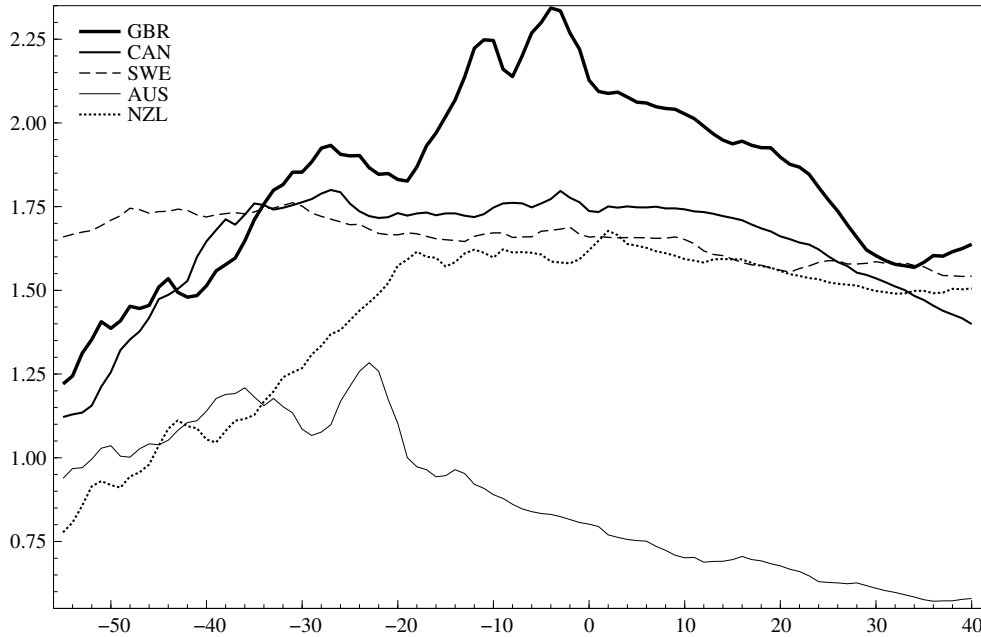
Note: Activism indicators of inflation-targeting countries based on forecasts by the trivariate VAR (corresponding to medians in Figure 1). Zero corresponds to the timing of the adoption of the inflation-targeting policy framework: i.e., 1992Q4 (GBR), 1991Q1 (CAN), 1993Q1 (SWE), 1994Q3 (AUS) and 1990Q1 (NZL).

the inflation-targeting policy framework. From this, we draw two observations.

First, *most countries experienced considerable increases in activism prior to the regime change.* These increases are particularly noticeable for the United Kingdom and New Zealand. Activism in Australia increased by the end of the 1980s.[7] An increase in Canada took place around 1980 when activism increased significantly in the United States. Sweden shows remarkable stability in activism at a relatively high level.

Second, *after the adoption of inflation targeting, activism declined.* Activism in the United Kingdom started its declining trend in the 1990s and that of Canada dropped toward the turn of the millennium. Australia's activism started to fall even before its adoption of an inflation-targeting

---

[7]Bernanke et al. (1999) note that the precise timing of the Australian move to inflation targeting is particularly difficult to pin down. Although an official announcement was first made in September 1994 (the timing used in Figure 2), the Reserve Bank of Australia's own view is that it has had an inflation target since early 1993.

Table 1: Mean activism

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
from:	1971Q1	1980Q1	*target*	2000Q1	Difference between samples		
to:	1979Q4	*target*$_{-1}$	1999Q4	2005Q4	(2) − (1)	(4) − (3)	
United States	1.13	1.63	1.44	1.46	0.50**	0.01	(0.9%)
Japan	0.73	0.88	0.65	0.53	0.16**	−0.12**	(−18.0%)
Germany	1.76	1.78	1.56	...	0.02	−0.22**	...
United Kingdom	0.96	1.85	1.95	1.62	0.89**	−0.33**	(−17.0%)
Canada	1.20	1.72	1.66	1.44	0.52**	−0.22**	(−13.3%)
Sweden	1.62	1.70	1.61	1.55	0.08**	−0.07**	(−4.1%)
Australia	0.64	1.03	0.73	0.60	0.38**	−0.12**	(−16.8%)
New Zealand	0.95	1.43	1.56	1.52	0.49**	−0.04**	(−2.4%)
IT5−G3 (G2)					0.24**	−0.10**	...

Notes:

a. For New Zealand, the sample period starts from 1976Q1 in column (1).

b. For Germany, the sample period ends at 1998Q4 in column (3).

c. *target* refers to the dates of adopting the inflation-targeting policy framework indicated in Figure 2. For the G3, *target* is defined as 1992Q4.

d. "**" in Columns (5) and (6) denotes statistical significance at the 1% level.

e. The figures in parentheses in column (7) are the rate of change from column (3) to (4).

policy. In contrast, the falls in activism in Sweden and New Zealand have been subdued.

Table 1 confirms the above points by calculating the average level of activism across different sample periods. These sample periods broadly correspond to (1) the 1970s, when inflation was at a high level in many countries; (2) the preinflation-target periods from the beginning of the 1980s, when most central banks raised their degree of activism; (3) the posttarget periods in the 1990s; for the G3 central banks (nontargeters), the posttargeting period is defined as starting at the mean of the start dates for sample targeters, which is 1992Q2; and (4) the periods after 2000. Compared with the 1970s, activism increased in the pretargeting periods as indicated in column (5). That these increases are statistically significantly different from zero indicates the time variance of activism. Activism declined after 2000 in all of the inflation-targeting countries (columns (6) and (7)). These declines are particularly noticeable in the United Kingdom, Canada and Australia compared with Sweden and New Zealand.

Table 2: Activism in pre- and posttargeting regimes (existing studies)

	Neumann & von Hagen pretarget → posttarget	Kuttner & Posen pretarget → posttarget
United Kingdom	$0.54 \rightarrow 1.09$	$1.64 \rightarrow 0.52$
Canada	$0.78 \rightarrow -0.56$	$1.29 \rightarrow -0.75$
Sweden	$0.49 \rightarrow 1.32$	...
Australia	$0.21 \rightarrow 0.55$	...
New Zealand	$0.79 \rightarrow 0.88$	$1.02 \rightarrow 1.55$

Note: Activism calculated from split sample OLS of $i_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2 x_t + \beta_3 x_{t-1} + \beta_4 i_{t-1} + u_t$, in Table 3 of Neumann and von Hagen (2002); and $i_t = \beta_0 + \beta_1 \pi_t + \beta_2 x_t + \beta_3 i_{t-1} + u_t$, in Tables 3, 5, 7 of Kuttner and Posen (1999).

The last row of Table 1 indicates the difference in changes in activism between the G3[8] and the inflation-targeting central banks. These figures plot coefficient a_1 in a difference-in-difference regression such as:

$$(\text{Changes in activism})_{it} = a_0 + a_1 D_i + u_{it},$$

where an inflation-targeting dummy D_i takes the value 1 if country i is a targeter, and 0 otherwise. With a caveat of a small number of nontargeters, the regression suggests that the inflation-targeting central banks increased activism more than the G3 central banks in the 1980s, while they reduced activism by a relatively large margin after 2000.

The observation of a greater degree of activism before the adoption of the new policy framework and declining activism thereafter cannot be seen in the split sample estimations of existing studies (Table 2). The TVP-SV model enables us to see changes in central banks' behaviors within pre- and posttarget periods. In addition, we also note that our estimates of activism are generally higher than those in the table. As these studies only use actual inflation rates, this may well be an indication of an error-in-variable problem in that actual rather than forecast inflation is likely to bias the coefficient downward (see Orphanides (2001) and Mishkin (2002)).

---

[8]The United States and Japan for column (6).

3.2 Robustness checks

The inference presented on policy responsiveness to inflation relies on the inference in the first step of the procedure: the estimation of the time-varying VAR to construct an expected inflation series $E_t\pi_{t+1}$ and the output gap series $E_t x_{t+1}$.[9] To check the robustness of the above findings, we use an alternative specification to obtain expected inflation.

Following Muscatelli et al. (2002), we use an unobserved component model as an alternative form of forecasting inflation. The inflation rate π_t is decomposed into the underlying level μ_t and a random white noise error term ξ_t as:

$$\pi_t = \mu_t + \xi_t, \quad \xi_t \sim \mathrm{NID}(0, \sigma_\xi^2)$$

$$\mu_t = \mu_{t-1} + \zeta_t. \quad \zeta_t \sim \mathrm{NID}(0, \sigma_\zeta^2)$$

The model is equivalent to an ARIMA(0,1,1), whose forecast performance dominates other models of the US consumer prices inflation rate (Stock and Watson, 2007). Expected inflation $E_t\pi_{t+1}$ is set as the latest estimate of the underlying inflation rate $\hat{\mu}_t$.[10]
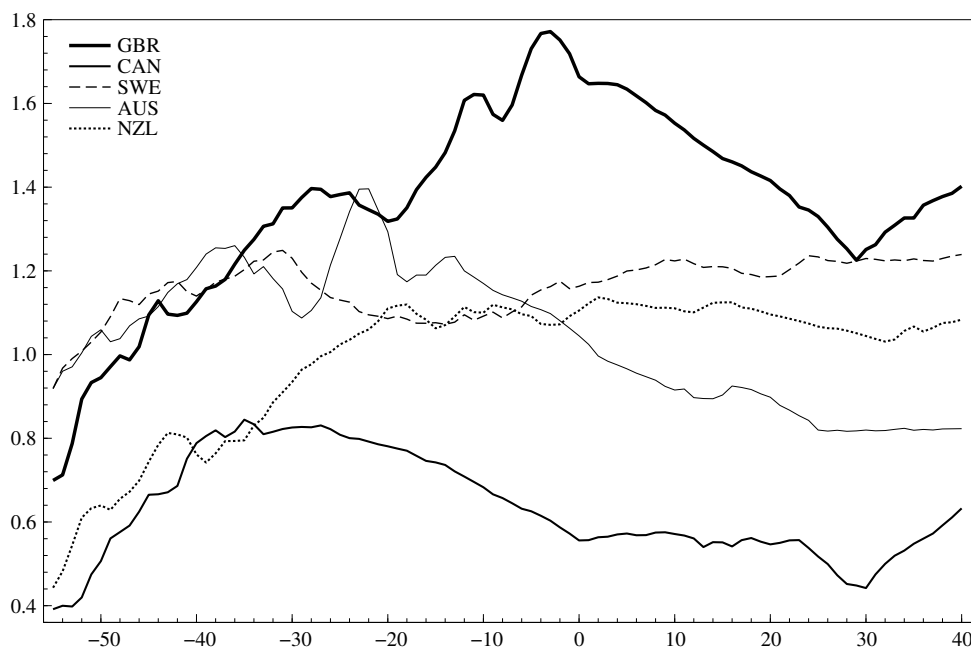
Figure 3 shows the activism indicators of inflation-targeting countries based on this alternative inflation expectation specification. Except for Canada, whose activism shifts downward and begins to decline earlier, the main points of the above findings remain reasonably intact. Namely, (i) the increases in activism took place before the adoption of the inflation-targeting policy framework; and (ii) activism declined somewhat after the adoption, while it has remained relatively high in some countries.

The finding that inflation-targeting central banks had changed their behaviors before their announcement of the regime changes accords closely with the historical account that "...most inflation-targeting countries have chosen to adopt the new regime only *after* having had some initial success in lowering inflation from previously high levels... [O]ne of the main benefits of inflation targets is that they may help to 'lock in' earlier disinflationary gains." (Bernanke et al. 1999, p. 288)

---

[9]The importance of the first step in the estimation is stressed as the weak instrument or the weak identification problem by Mavroeidis (2004) in the context of the GMM estimation.

[10]The unobserved component model is estimated by SsfPack 2.2 (Koopman et al., 1999).

Figure 3: Activism indicator before and after the adoption of IT (Alternative)

Note: Activism indicators of inflation-targeting countries based on forecasts by the unob-
served component model. Zero corresponds to the timing of the adoption of the
inflation-targeting policy framework: i.e., 1992Q4 (GBR), 1991Q1 (CAN), 1993Q1
(SWE), 1994Q3 (AUS) and 1990Q1 (NZL).

For example, the Bank of England (BOE) tightened its monetary policy very sharply in the early
1980s and the late 1980s to bring inflation in check. The Reserve Bank of New Zealand (RBNZ)
succeeded in bringing underlying inflation down from almost 17% at the beginning of 1985 to the
vicinity of 5% at the timing of the signing of the Policy Targeting Agreement and thus setting
up the inflation-targeting policy framework. The Reserve Bank of Australia (RBA) also raised
its interest rate considerably in the 1980s and the disinflation was largely complete by the end of
1991, although the RBA made no public commitment to a nominal target until 1994. The Bank
of Canada (BOC) raised the overnight rate to 20% in the early 1980s and halved the inflation rate
from its two-digit level.

In contrast, the finding that activism had declined (but not much in some countries) after the
regime changes has rarely been mentioned in the literature. The apparently difficult to interpret

negative values of Canadian activism aside, sample split estimations in Table 2 point to higher activism during the posttarget period except for the United Kingdom in Kuttner and Posen (1999).[11] Rolling regressions by Muscatelli et al. (2002) indicate that activism of all inflation-targeting countries examined in their paper increased toward the end of their sample period (1999Q2). We try to interpret why activism has declined (but not much in some countries) in terms of the constraints of an inflation target range in the following sections.

4   Roles of Inflation Target Range

Announcement of a numerical target of inflation is often associated with the corresponding target range. For instance, the BOE is required to keep inflation within one percentage point of either side of the target inflation, and if missed, the Governor must write an open letter to the Chancellor explaining the reasons behind it and the prospect of recovering the target range. In fact, all of the inflation-targeting central banks examined in this paper have set up inflation target ranges as their reference for monetary policy and their inflation reports often indicate, implicitly or explicitly, target ranges in order to evaluate actual and/or projected values of inflation.

However, with a few exceptions such as Mishkin and Westelius (2006), the roles of a target range have not been paid much attention in the existing literature (e.g., Svensson (1999, 2000) and Svensson and Woodford (2005)). In this section, we develop a formal theoretical model within the New Keynesian framework and derive the optimal interest rate rules with a target range. The model sheds light on the roles of an inflation target range, which turns out to be a key to understand the declining activism in some countries observed above.

4.1   The model

We use a family of the models developed by Woodford (2003). He proposes the aggregate-supply relation with inflation inertia by assuming that individual prices are indexed to an aggregate price index. Formally, the economy outside the central bank is represented by two equations: an "IS

---

[11]Kuttner and Posen (1999) attribute the smaller coefficient of the UK to either a move away from conservatism or an artifact of the reduction in inflation persistence.

curve" and a "hybrid Phillips curve":

$$x_t = E_t x_{t+1} - \sigma \left[(i_t - E_t \pi_{t+1}) - r_t^n \right], \tag{8}$$

$$\pi_t = \kappa x_t + \beta(1-\mu) E_t \pi_{t+1} + \mu \pi_{t-1} + u_t. \tag{9}$$

Equation (8) represents the forward-looking IS curve. This IS curve states that the output gap in period t, denoted by x_t, is determined by the expected value of the output gap in period $t+1$ and the deviation of the short-term real interest rate, the nominal interest rate i_t minus the expected rate of inflation $E_t \pi_{t+1}$, from the natural rate of interest in period t, denoted by r_t^n. Equation (9) is a hybrid Phillips curve. This Phillips curve states that inflation in period t depends on the expected rate of future inflation in period $t+1$, the past inflation rate in period $t-1$ and the output gap in period t. σ, κ, μ, and β are parameters, satisfying $\sigma > 0$, $\kappa > 0$, $0 \le \mu \le 1$, and $0 < \beta < 1$. When μ is zero, the model is purely forward-looking. The shocks to the economy occur from r_t^n and u_t. We assume that all shocks in this paper are deterministic shocks.[12]

We assume that the central bank's policy instrument is the short-term nominal interest rate. The central bank chooses the path of the short-term nominal interest rate, starting from period 0, $\{i_0, i_1, \cdots\}$ to minimize:

$$E_0 \sum_{t=0}^{\infty} \beta^t L_t,$$

where β is the discount factor and L is the loss function. We assume a period loss function given by:

$$L_t = \lambda_\pi \pi_t^2 + \lambda_x x_t^2 + \lambda_i (i_t - i^*)^2, \tag{10}$$

---

[12]This assumption is not trivial, but it does not change the qualitative results from the theoretical insights.

where λ_π, λ_x and λ_i are positive parameters.[13] The first term of the objective function can be interpreted as a restriction arising from the target inflation, which is assumed to be zero.[14]

4.2 Optimal interest rate rule with inflation target range

We derive the optimal interest rate rule on the assumption that the central bank is able to use commitment in a timeless perspective. Commitment implies that the conduct of monetary policy becomes forward-looking and the central bank takes account of the effects of its monetary policy decision on expected values of the future economic variables. We think that the inflation-targeting policy is characterized as a commitment rule rather than a discretionary policy in the light of its forward-looking nature. The publication of key macroeconomic conditions based on its interest rate projections currently done by the RBNZ, the Norwegian Central Bank and the Swedish Riksbank bodes well for our presumption.

To take into account the role of the inflation target range, we impose the following restriction:

$$\underline{\pi} \le \pi_t \le \bar{\pi}. \tag{11}$$

Modeling the inflation target range as a constraint on inflation in the central bank's optimization problems may be seen as omitting a sense of reality. No central banks commit themselves to a target range as strict as the above range. Some may take the range merely as an indicative band surrounding the target inflation rate. The time horizon of delivering inflation within the range may be too long for them to restrict their behaviors in the way implied by the inequality constraint.

---

[13]Woodford (2003, Ch.6) shows that a theoretical loss function in the presence of the hybrid Phillips curve becomes:

$$L_t = \lambda_\pi (\pi_t - \gamma \pi_{t-1})^2 + \lambda_x x_t^2 + \lambda_i (i_t - i^*)^2,$$

where γ is the degree of indexation to the lagged price index. For this derivation, instead of equation (9), he uses the following Phillips curve, which is an exact form corresponding to his microfounded setup:

$$\pi_t - \gamma \pi_{t-1} = \kappa x_t + \beta E_t(\pi_{t+1} - \gamma \pi_t) + \varepsilon_t.$$

However, neither using the quadratic deviation of inflation from the zero targeting π_t^2 instead of a change in inflation $(\pi_t - \gamma \pi_{t-1})^2$ nor using the above Phillips curve instead of (9) alters the theoretical implications of this paper, such as the choice of the terms included in the estimated Taylor rule (1).

[14]As shown in Giannoni and Woodford (2005), the objective function that includes other additional terms such as the output gap and the nominal interest rate can be defined as representing flexible inflation targeting. Giannoni (2000) and Woodford (2003) show that the last term is included in the objective function because of the monetary frictions. We use this term to derive an optimal monetary policy rule below.

However, even if we assume a softer range that permits some deviations from the target range, as long as the soft range has some restrictive effects on monetary policy at the time of deviation, the qualitative outcomes in a setting of a soft range are similar to those in a setting of a hard range.

Then we can derive the following optimal interest rate with commitment in a timeless perspective (Appendix B.1):

$$(1 - \eta_1 L)(1 - \eta_2 L)(1 - \eta_3 F)(i_t - i^*) =$$

$$\kappa \lambda_\pi \psi \eta_3 \pi_t + \lambda_x \psi \eta_3 (-\beta \mu x_{t+1} + x_t - (1 - \mu) x_{t-1}) + \psi^* \phi_{3t} - \psi^* \phi_{4t}, \tag{12}$$

where ϕ_3 and ϕ_4 represent the Lagrange multipliers associated with the upper and the lower bound on the inflation target range, respectively. L and F are the lag and the forward operators. $\psi^* = \kappa \psi > 0$. Transformation of equation (12) yields the following formula, which corresponds to equation (2) above:

$$i_t = \eta_1 i_{t-1} + (1 - \eta_2 L)^{-1} (1 - \eta_3 F)^{-1} f_t + (1 - \eta_2 L)^{-1} (1 - \eta_3 F)^{-1} \psi^* \phi_{3t}$$

$$-(1 - \eta_2 L)^{-1} (1 - \eta_3 F)^{-1} \psi^* \phi_{4t} + (1 - \eta_1) i^*, \tag{13}$$

where $f_t \equiv \kappa \lambda_\pi \psi \eta_3 \pi_t + \lambda_x \psi \eta_3 (-\beta \mu x_{t+1} + x_t - (1 - \mu) x_{t-1})$, which we call *the fundamental factor*. On top of that, equation (13) involves the Lagrange multipliers, ϕ_{3t} and ϕ_{4t}, which we call *the adjustment factor*. When inflation hits the target range, either of these terms becomes positive, which changes the elasticity of the interest rate to inflation.[15] Moreover, because the adjustment factor is multiplied by the forward operator, $(1 - \eta_3 F)^{-1}$, and the lag operator, $(1 - \eta_2 L)^{-1}$, the central bank is required to react to the binding constraint of the inflation target range both preemptively and history dependently. In other words, the central bank needs to continue to tighten or ease the monetary policy sometime before and after inflation hits the upper or lower bound. This implies that the observed interest rate elasticity to inflation is time varying, even if the coefficient on inflation in the fundamental factor f_t is constant: depending on the lead and lag structure of

---

[15]In this sense, the Lagrange multipliers express the elasticity of the interest rate to specific inflation, $\underline{\pi}$ and $\bar{\pi}$.

Figure 4: Activism and shocks
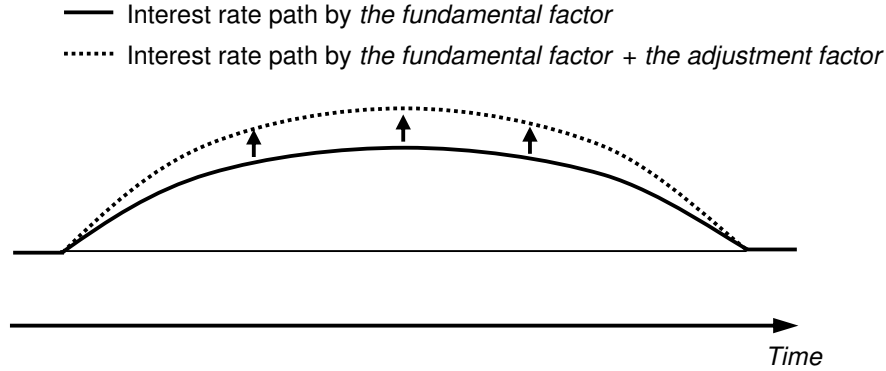
the adjustment factor and the timing when the constraint becomes binding (i.e., either ϕ_{3t} or ϕ_{4t} becomes positive), the observed elasticity may deviate from that implied by the fundamental factor. In the case that we do not assume the inflation target range, both ϕ_{3t} and ϕ_{4t} are always zero and thus the elasticity becomes time invariant, unless we assume a change in parameters such as the weight on inflation in the central bank's loss function λ_π.

The model suggests that the monetary policy activism takes the higher value as long as the central bank sees the possibility of the binding constraint of inflation. The situation is illustrated by Figure 4, where the simple positive inflationary shocks occur during the sequential T periods, which lead to hump-shaped dynamics of inflation hitting the upper bound of a target range (see Appendix B.2). In this case, the whole sequence of elasticity of the interest rate to inflation increases because of a positive value of the adjustment factor.[16]

Table 3: Activism when underlying inflation is outside/inside the range

	Outside	Inside	Difference
United Kingdom	NA	1.84	NA
	(0)	(49)	
Canada	1.73	1.56	0.18**
	(7)	(50)	
Sweden	1.59	1.60	−0.01
	(19)	(33)	
Australia	0.67	0.65	0.03
	(25)	(21)	
New Zealand	1.58	1.53	0.04**
	(25)	(39)	

Notes:

a. Average of activism when underlying inflation is outside/inside the target range.

b. Figures in parentheses are the number of quarters. "**" denotes statistical significance at the 1% level.

c. Underlying inflation is measured by the retail price index excluding mortgage interest payments (GBR); CPI excluding eight volatile components and the effect of changes in indirect taxes on the remaining components (CAN); CPI excluding household mortgage interest expenditure and the effects of changes in indirect taxes and subsidies (SWE); CPI excluding volatile items (fruit, vegetables and automobile fuel) (AUS); CPI excluding credit services (NZL).

5 Interpretation

5.1 Has the target range mattered?

To assess the empirical plausibility of the above theoretical model, Table 3 compares average values of the activism indicators when underlying inflation is within and outside the specified target range. When inflation falls outside the target range, activism tends to take statistically higher values in Canada and New Zealand, although the differences in activism are not significant in Sweden and Australia. These higher values of the activism indicators are consistent with the theoretical prediction in the case of simple shocks. At the same time, we agree that we cannot read too much into this result as the above comparison relies on a simple assumption that the central bank judges the risk of breaching the inflation target range solely by whether or not underlying inflation is within the range. As we will discuss below, the Riksbank may have kept activism high even when underlying inflation was inside the target range as it perceived the risk of breaching the target range was high. We will also discuss below the case of Australia.

Figure 5 cross plots activism and the underlying inflation rate, the latter of which is converted to the deviation from the midpoint of the range and scaled by the border of the target range. When the horizontal axis is below unity (i.e., underlying inflation is within the target range), there is no clear relationship between activism and inflation as most evident for the United Kingdom. The observation is in line with the theoretical model, which predicts no correlation between activism and inflation in the absence of the adjustment factor. When the horizontal axis exceeds unity, there is a clear indication that activism tends to take higher values, at least in Canada and New Zealand.

5.2 Why has activism declined?

The above theoretical model suggests that there exist at least two cases in which monetary policy activism declined after the adoption of the inflation-targeting policy framework.

---

[16]The model predicts that the elasticity of the interest rate to inflation may decline at some point in time if the economy is hit by a series of positive and negative shocks and inflation sequentially reaches the upper and the lower bounds of a target range. However, we do not pursue this case in the following analysis given the unlikelihood of this occurring. Reading their inflation reports, it is difficult to imagine that the inflation-targeting central banks foresee such complicated shocks.

Figure 5: Activism and inflation
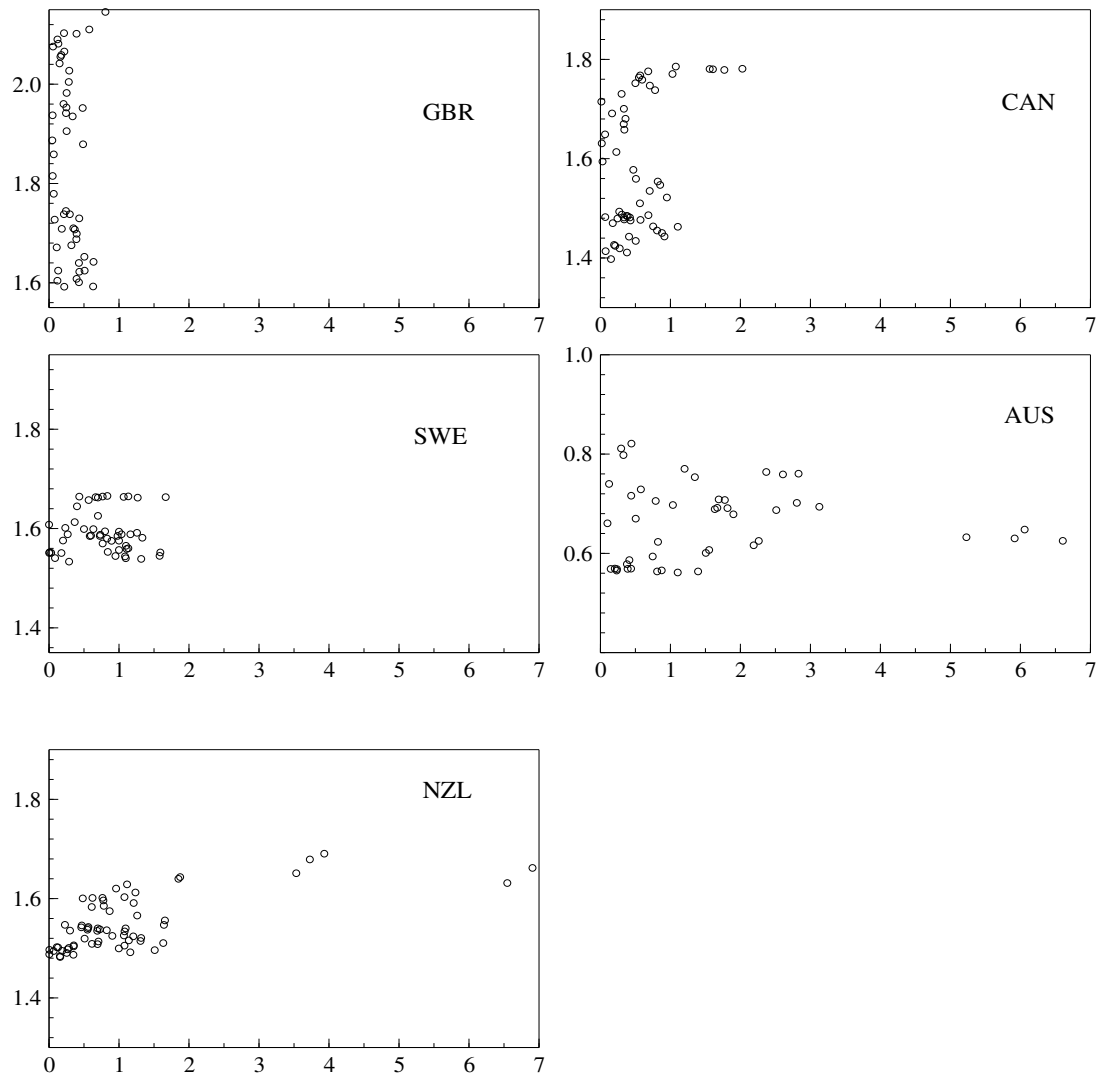
Note: The vertical axis is activism, while the horizontal axis is the underlying inflation rate. The underlying inflation is converted to the deviation from the middle of the target range and divided by one side of the target range so that it corresponds to the border: $\left(\pi - 0.5(\bar{\pi} + \underline{\pi})\right)/0.5(\bar{\pi} - \underline{\pi})$.

Case A: The central bank has reduced the relative weight attached to inflation variability in its loss function, λ_π in equation (10).

Case B: The central bank raised monetary policy activism on one occasion, because it foresees a great risk that inflation may fall outside the range (Figure 4). However, once inflation has become well contained, the central bank has reduced activism, as it has not faced the binding constraint.

Although we do not deny entirely its possibility, it is rather difficult to believe that inflation-targeting central banks reduce their preference for inflation stability (*Case A*). Therefore, we think *Case B* is the more compelling. A higher degree of accountability and transparency as well as independence in the conduct of monetary policy are likely to prevent a central bank from softening its policy stance. On the other hand, it is not hard to imagine that the inflation-targeting central banks foresaw a greater risk of breaching the target range and raised their monetary policy activism accordingly, given that inflation was still high around the time of the introduction of an inflation-targeting policy (Figure 6). After establishing successful records of inflation and containing inflation expectations, these central banks can gradually reduce their activism because of the lower probability of inflation falling outside the range. Their successful records may have been achieved through greater credibility of monetary policy stemming from a higher degree of activism even before the adoption of the inflation-targeting framework (the good policy hypothesis). At the same time, as extensively discussed in the literature (see Melick and Galati (2006) and White (2008)), factors attributable to good luck and those attributable to changes in the structure of the economy may also have worked.

Figure 6 also indicates why activism has declined in the United Kingdom and Canada, but not much in Sweden and New Zealand. Underlying inflation in the former two countries remained remarkably within the target ranges compared with the latter two. This left some room for the BOE and the BOC to reduce activism, while the Swedish Riksbank and the RBNZ had to remain vigilant. For example, the Riksbank eased monetary policy in 1997 in response to inflation that hit the lower band. The RBNZ, whose Governor may be subject to dismissal after any breach, raised the overnight cash interest rate from about 4% to 10% around the middle of the 1990s, when

Figure 6: Inflation target ranges
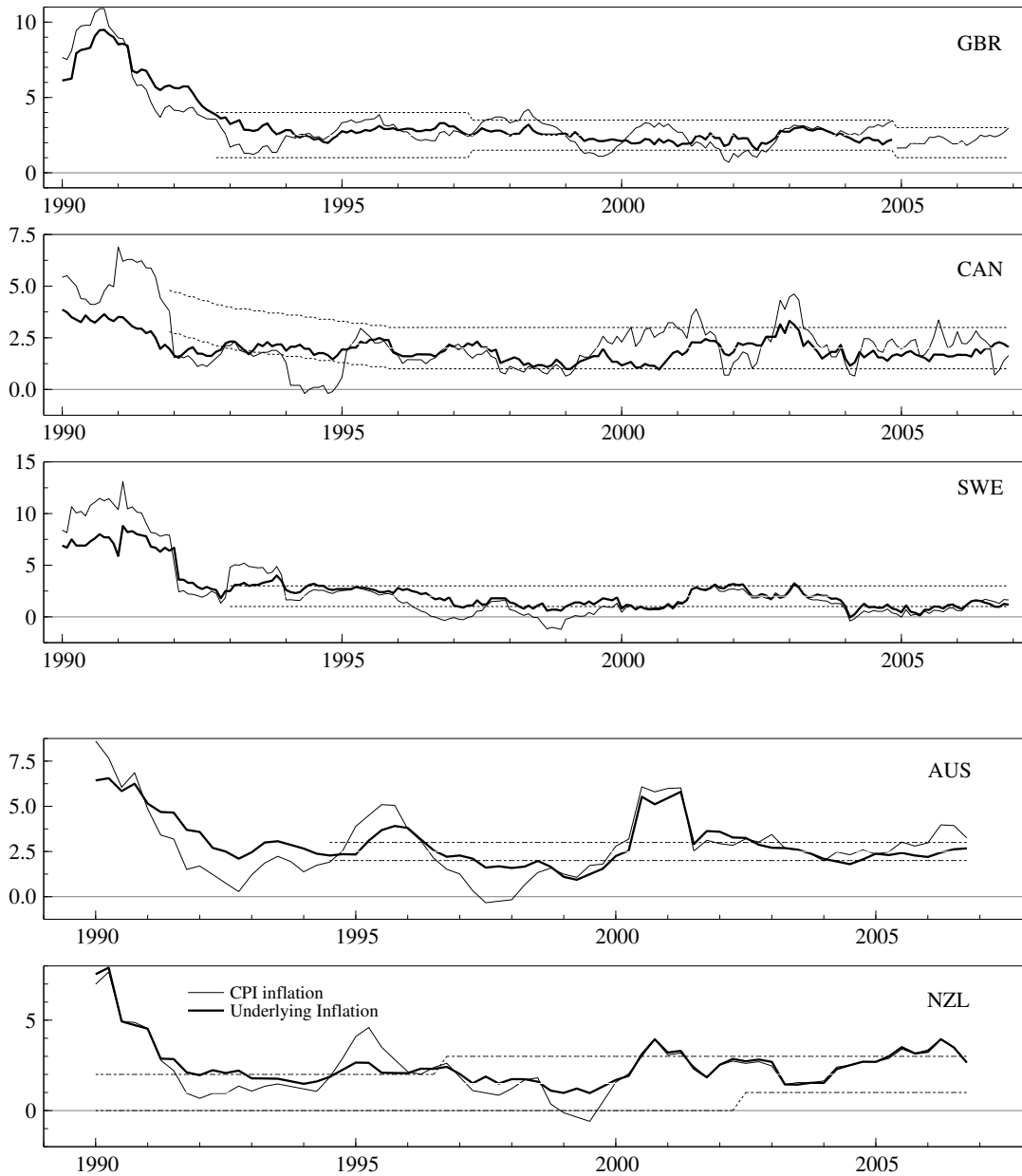
Note: Inflation rates measured as annual changes, in percentages. Dotted lines indicate inflation
target ranges. Underlying inflation is measured by the retail price index excluding mortgage
interest payments (GBR); CPI excluding eight volatile components and the effect of changes
in indirect taxes on the remaining components (CAN); CPI excluding household mortgage
interest expenditure and the effects of changes in indirect taxes and subsidies (SWE); CPI
excluding volatile items (fruit, vegetables and automobile fuel) (AUS); CPI excluding credit
services (NZL).

22

inflation overshot the target range.

Australia also breached the target range several times including at the time of the VAT rate hike in 2000. That activism in Australia has declined might be because the RBA has declared the upper and lower bounds to be an indicative "thick point" inflation target rather than a target range. In such an environment, the RBA does not have a strong incentive to keep the inflation rate within a target range.

6 Conclusion

When and how did inflation-targeting central banks change their behaviors? Evidence in this paper suggests that most of them had gone through a substantial change toward a higher response of the interest rate to inflation even before their announcement of numerical targets. Along with Muscatelli et al. (2002), this can be taken as a statistical complement to the careful historical investigation done by Bernanke et al. (1999), who highlight a tactical policy decision that these central banks prefer to adopt the new regime only after they can meet the initial inflation targets with high probability.

The paper also finds that, after the introduction of the inflation-targeting policy framework, responsiveness of the interest rate to inflation declined, while it has remained relatively high for some central banks. A theoretical model, which explicitly takes into account an inflation target range, suggests that the decline in monetary policy activism is in fact because of the successful inflation records of these central banks rather than a genuine change in their preference for inflation stability. The conjecture goes as follows: because of their success in keeping inflation within the target ranges, their credibility has improved and inflation expectations have become well contained. This in turn has reduced the need for high policy activism, as the probability of breaching target ranges has diminished.

We are tempted to call the recent decline in activism the "credibility gain" of these inflation-targeting central banks, but we admit that the evidence in this paper is a mere indicator of this story, as we have not estimated an identified structural model. Further analyses appear highly

warranted. These may include estimating nonlinear reactions of the interest rates depending on whether or not inflation is likely to hit a target range.

Appendix A: Algorithm for the TVP-SV model

Because a detailed description of the algorithm is already available elsewhere (Sekine, 2006), we only provide an outline in this appendix.

Our objective is to obtain a posterior density of an entire model represented by the state space form of (3)-(7):

$$p(\beta_1, \ldots, \beta_t, B, B_0, h_0, \ldots, h_t, H, H_0, c|i, Z).$$

This is achieved by running the following Gibbs sampler for 21,000 replications, with 1,000 burn-in replications discarded and 20,000 replications retained.[17]

1. Initialize B, B_0, h, H, H_0 and $c = \log \gamma^2$.

2. Sample β from $\beta|y, B, B_0, h$ using the simulation smoother of de Jong and Shephard (1995).

3. Sample B and B_0 from $B|\beta$ and $B_0|\beta$, respectively.

4. Sample h from $h|y, \beta, H, H_0, c$ using the method of Kim et al. (1998).

5. Sample H and H_0 from $H|h$ and $H_0|h$, respectively.

6. Sample c from $c|y, \beta, h$.

7. Go to 2.

We assume the following conjugate prior distributions (underline denotes prior parameters of these densities):

$B\|\beta$	Wishart: $p(\Lambda) = f_W(\Lambda\|\underline{\nu}_\Lambda, \underline{\Lambda})$ where $\underline{\nu}_\Lambda = 1$ and $\underline{\nu}_\Lambda = 10^{-5} \times I_p$
$B_0\|\beta$	Gamma: $p(\lambda_{0i}) = f_G(\lambda_{0i}\|\underline{s}_{\lambda 0i}^{-2}, \underline{\nu}_{\lambda 0i})$ where $\underline{s}_{\lambda 0i}^{-2} = 1$ and $\underline{\nu}_{\lambda 0i} = 1$
$H\|h$	Gamma: $p(\rho_i) = f_G(\rho_i\|\underline{s}_{\rho i}^{-2}, \underline{\nu}_{\rho i})$ where $\underline{s}_{\rho i}^{-2} = 1$ and $\underline{\nu}_{\rho i}) = 1$
$H_0\|h$	Gamma: $p(\rho_{0i}) = f_G(\rho_{0i}\|\underline{s}_{\rho 0i}^{-2}, \underline{\nu}_{\rho 0i})$ where $\underline{s}_{\rho 0i}^{-2} = 100$ and $\underline{\nu}_{\rho 0i} = 1$
$c\|y, \beta, h$	Normal: $p(c) = f_N(c\|\underline{c}, \underline{V})$ where $\underline{c} = 1$ and $\underline{V} = 1$

---

[17]All the codes are written in Ox (Doornik, 2006).

Appendix B: Optimization under commitment

B.1 Optimization with inflation target range

The optimal monetary policy with a restriction of an additionally specified permitted inflation range (equation (11)) is represented by the following Lagrangian form:

$$\mathcal{L} = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left\{ L_t - 2\phi_{1t} \left[x_{t+1} - \sigma(i_t - \pi_{t+1} - r_t^n) - x_t \right] - 2\phi_{2t} \left[\kappa x_t + \beta(1-\mu)\pi_{t+1} + \mu\pi_{t-1} - \pi_t, \right] \right\} \right\}$$

$$+ E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left\{ -2\phi_{3t} \left[\bar{\pi} - \pi_t \right] - 2\phi_{4t} \left[\pi_t - \underline{\pi} \right] \right\} \right\},$$

where ϕ_1, ϕ_2, ϕ_3 and ϕ_4 represent the Lagrange multipliers associated with the IS constraint, the Phillips curve constraint, the upper bound on the inflation target range and the lower bound on the inflation target range, respectively. We differentiate the Lagrangian with respect to π_t, x_t, and i_t under the restriction on the inflation target range, $\underline{\pi} \leq \pi_t \leq \bar{\pi}$, to obtain the first-order conditions:

$$\lambda_\pi \pi_t - \beta^{-1}\sigma\phi_{1t-1} - \beta\mu\phi_{2t+1} + \phi_{2t} - (1-\mu)\phi_{2t-1} + \phi_{3t} - \phi_{4t} = 0, \tag{B.1}$$

$$\lambda_x x_t + \phi_{1t} - \beta^{-1}\phi_{1t-1} - \kappa\phi_{2t} = 0, \tag{B.2}$$

$$\lambda_i(i_t - i^*) + \sigma\phi_{1t} = 0, \tag{B.3}$$

$$\phi_{3t}(\bar{\pi} - \pi_t) = 0, \tag{B.4}$$

$$\phi_{3t} \geq 0, \tag{B.5}$$

$$\bar{\pi} - \pi_t \geq 0, \tag{B.6}$$

$$\phi_{4t}(\pi_t - \underline{\pi}) = 0, \tag{B.7}$$

$$\phi_{4t} \geq 0, \tag{B.8}$$

26

$$\pi_t - \underline{\pi} \geq 0. \tag{B.9}$$

Equations (B.4) to (B.9) are conditions for the restriction on the inflation target range. The above nine conditions, together with the IS (equation (8)) and Phillips (equation (9)) equations, are the conditions governing the loss minimization. In other words, the sequence of interest rates determined by these conditions is the optimal interest rate setting at each time under the restriction on the inflation target range and the target inflation. When the constraints of the inflation target range are not binding (i.e., $\underline{\pi} < \pi_t < \bar{\pi}$), the Lagrange multiplier, ϕ_{3t} and ϕ_{4t}, becomes zero by the Kuhn–Tucker condition, and then the interest rate is determined by the conditions given by equations (8), (9), (B.1), (B.2) and (B.3) with $\phi_{3t} = 0$ and $\phi_{4t} = 0$. When the restriction on the inflation target range is binding (i.e., $\underline{\pi} = \pi_t$ or $\bar{\pi} = \pi_t$), the interest rate is adjusted according to the positive values of ϕ_{3t} and ϕ_{4t}. It should be noted that the expectation operator, E_t, does not appear in these equations because the future paths of shocks are perfectly foreseen thanks to the assumption of deterministic shocks.

To demonstrate the point mentioned above simply, we can show the optimal interest rate rule by the loss minimization conditions above:[18]

$$(1 - \eta_1 L)(1 - \eta_2 L)(1 - \eta_3 F)(i_t - i^*) =$$

$$\kappa \lambda_\pi \psi \eta_3 \pi_t + \lambda_x \psi \eta_3 (-\beta \mu x_{t+1} + x_t - (1 - \mu) x_{t-1}) + \psi^* \phi_{3t} - \psi^* \phi_{4t}, \tag{B.10}$$

where $\psi^* = \kappa \psi > 0$, $\eta_1 \eta_2 \eta_3^{-1} = \psi \lambda_i (1 - \mu)(\beta \sigma)^{-1}$, $\eta_1 \eta_2 + \eta_1 \eta_3^{-1} + \eta_2 \eta_3^{-1} = \psi \lambda_i (1 + \mu) \sigma^{-1}$, $\eta_1 + \eta_2 + \eta_3^{-1} = \psi \lambda_i (\beta \sigma)^{-1} (\sigma \kappa + 1 + (1 - \mu) \beta)$, and $\eta_3 = \eta_4^{-1}$ ($\eta_2 > 1 > \eta_1 > 0$ and $\eta_4 > 1 > \eta_3 > 0$). Thus we can confirm that when the restriction on the inflation target range is binding, the interest

---

[18]Here the optimal monetary policy is only valid under a deterministic shock process, because certainty equivalence does not hold when control variables are nonlinearly constrained. It is impossible to obtain optimal monetary policy in an analytical form under a stochastic environment.

rate, i_t, is adjusted according to the positive values of ϕ_{3t} and ϕ_{4t}. More specifically, when the upper inflation bound is binding, the optimal monetary policy rule holds a bias to set the interest rates higher according to the positive value of the upper inflation bound indicator, ϕ_{3t}. Instead of the positive value of ϕ_{3t}, $\pi_t = \bar{\pi}$ should hold. On the other hand, when the lower inflation bound is binding, the optimal monetary policy rule has a bias to set the interest rates lower according to the lower inflation bound indicator, ϕ_{4t}.

B.2 Activism

An impact of the inflation range on activism (i.e., elasticity of the interest rate to inflation) can be analytically derived as follows. As shown in Figure 4, in the case of the simple positive inflationary shocks, which lead to hump-shaped inflation dynamics hitting the upper or lower bound of a target range for the sequential T periods, the whole sequence of elasticities of the interest rate to inflation increases because of a positive value of the adjustment factor. We can demonstrate it by transforming equation (B.10) as:

$$(1 - \eta_1 L)(1 - \eta_2 L)(1 - \eta_3 F)(i_t - i^*) =$$

$$\kappa \lambda_\pi \psi \eta_3 (\pi_t + \psi^{**} \phi_{3t} - \psi^{**} \phi_{4t}) + \lambda_x \psi \eta_3 (-\beta \mu x_{t+1} + x_t - (1 - \mu)x_{t-1}), \qquad \text{(B.11)}$$

where we assume that inflation hits the upper bound ($\phi_{3t} > 0$ and $\phi_{4t} = 0$) and $\psi^{**} = \psi^*(\kappa \lambda_\pi \psi \eta_3)^{-1} >$ 0. In this case, positive ϕ_{3t} always raises the responsiveness of the interest rate, and so the whole sequence of elasticities of the interest rate to inflation increases.

References

Assenmacher-Wesche, Katrin. (2006). "Estimating Central Banks' Preferences from a Time-Varying Empirical Reaction Function." European Economic Review 50, 1951–1974.

Bernanke, Ben S., and Michael Woodford. (2005). The Inflation-Targeting Debate, Chicago, Illinois: University of Chicago Press.

Bernanke, Ben S., Thomas Laubach, Fredric S. Mishkin, and Adam S. Posen. (1999). Inflation Targeting: Lessons from the International Experience, Princeton, New Jersey: Princeton University Press.

Cecchetti, Stephan G., and Michael Ehrmann. (1999). "Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers' Preferences and Outcomes." NBER Working Paper, No. 7426.

Cecchetti, Stephen G., Margaret M. McConnell, and Gabriel Perez-Quiros. (2002). "Policymakers' Revealed Preferences and the Output-Inflation Variability Trade-Off: Implication for the European System of Central Banks." Manchester School 70, 596–618.

Clarida, Richard, Jordi Galí, and Mark Gertler. (1998). "Monetary Policy Rules in Practice: Some International Evidence." European Economic Review 42, 1033–1067.

Clarida, Richard, Jordi Galí, and Mark Gertler. (2000). "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." Quarterly Journal of Economics 115, 147–180.

Cogley, Timothy, and Thomas J. Sargent. (2005). "Drifts and Volatilities: Monetary Policies and Outcomes in the Post WWII U.S." Review of Economic Dynamics 8, 262–302.

de Jong, Piet, and Neil Shephard. (1995). "The Simulation Smoother for Time Series Models." Biometrika 82, 339–350.

Doornik, Jurgen A. (2006). Ox 4: An Object-Oriented Matrix Programming Language, London: Timberlake Consultants Press.

Giannoni, Marc P. (2000). "Optimal Interest-Rate Rules in a Forward-Looking Model, and Inflation Stabilization versus Price-Level Stabilization." mimeo.

Giannoni, Marc P., and Michael Woodford. (2005). "Optimal Inflation Targeting Rule." In The Inflation-Targeting Debate, edited by Ben S. Bernanke and Michael Woodford. pp. 93–162. Chicago, Illinois: University of Chicago Press.

Gürkayanak, Refet S., Andrew T. Levin, and Eric T. Swanson. (2006). "Does Inflation Targeting Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K. and Sweden." Federal Reserve Bank of San Francisco, Working Paper, 2006-09.

Ito, Takatoshi. (1992). The Japanese Economy. Cambridge, Massachusetts: MIT Press.

Johnson, David R. (2002). "The Effect of Inflation Targeting on the Behavior of Expected Inflation: Evidence from an 11 Countries Panel." Journal of Monetary Economics 49, 1521–1538.

Johnson, David R. (2003). "The Effect of Inflation Targets on the Level of Expected Inflation in Five Countries." Review of Economics and Statistics 85, 1076–1081.

Kim, Sangjoon, Neil Shephard, and Siddhartha Chib. (1998). "Stochastic Volatility: Likelihood Inference and Comparison with ARCH Models." Review of Economic Studies 65, 361–393.

Koopman, Siem Jan, Neil Shephard, and Jurgen A. Doornik. (1999). "Statistical Algorithms for Models in State Space Using SsfPack 2.2." Econometrics Journal 2, 113–166.

Kuttner, Kenneth N., and Adam S. Posen. (1999). "Does Talk Matter After All? Inflation Targeting and Central Bank Behavior." Federal Reserve Bank of New York Staff Reports, No. 88.

Levin, Andrew T., Fabi M. Natalucci, and Jeremy M. Piger. (2004). "Explicit Inflation Objectives and Macroeconomic Outcomes." ECB Working Paper, No. 383.

Mavroeidis, Sophocles. (2004). "Weak Identification of Forward-Looking Models in Monetary Economics." Oxford Bulletin of Economics and Statistics 66, 609–635. Supplement.

Melick, William, and Gabriele Galati (2006). "The Evolving Inflation Process: An Overview," BIS Working Paper, No. 196.

Mishkin, Frederic S. (2002). "Does Inflation Targeting Matter? Commentary." Federal Reserve Bank of St. Louis Review 84, 149–153. July/August.

Mishkin, Frederic S., and Klaus Schmidt-Hebbel. (2001). "One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?" NBER Working Paper, No. 8397.

Mishkin, Frederic S., and Niklas J. Westelius. (2006). "Inflation Band Targeting and Optimal Inflation Contracts." NBER Working Paper, No. 12384.

Muscatelli, V. Anton, Patrizio Tirelli, and Carmine Trecroci. (2002). "Does Institutional Change Really Matter? Inflation Targets, Central Bank Reform and Interest Rate Policy in the OECD Countries." Manchester School 70, 487–527.

Neumann, Mansfred J. M., and Jügen von Hagen. (2002). "Does Inflation Targeting Matter?" Federal Reserve Bank of St. Louis Review 84, 127–148. July/August.

Orphanides, Athanasios. (2001). "Monetary Policy Rules Based on Real-Time Data." American Economic Review 91, 964–985.

Primiceri, Giorgio E. (2005). "Time Varying Structural Vector Autoregressions and Monetary Policy." Review of Economic Studies 72, 821–852

Sekine, Toshitaka. (2006). "Time-Varying Exchange Rate Pass-Through: Experiences of Some Industrial Countries." BIS Working Paper, No. 202.

Sims, Christopher A. (2001). "Comment on Sargent and Cogley's 'Evolving Post World War II US Inflation Dynamics'." NBER Macroeconomics Annual 16, 373–379.

Sims, Christopher A., and Tao Zha. (2006). "Were There Regime Switches in US Monetary Policy?" American Economic Review 96, 54–81.

Stock, James H., and Mark W. Watson. (2007). "Why Has U.S. Inflation Become Harder to Forecast?" Journal of Money, Credit, and Banking 39, 3–33. Supplement.

Svensson, Lars E. O. (1999). "Inflation Targeting as a Monetary Policy Rule." Journal of Monetary Economics 43, 607–654.

Svensson, Lars E. O. (2000). "Open-Economy Inflation Targeting." Journal of International Economics 50, 155–183.

Svensson, Lars E. O., and Michael Woodford. (2005). "Implementing Optimal Policy Through Inflation-Forecasting Targeting." In The Inflation-Targeting Debate, edited by Ben S. Bernanke and Michael Woodford, pp. 19–83. Chicago, Illinois: University of Chicago Press.

White, William R. (2008). "Globalisation and the Determinants of Domestic Inflation." BIS Working Paper, No. 250.

Woodford, Michael. (2003). Interest and Prices: Foundations of a Theory of Monetary Policy. Princeton, New Jersey: Princeton University Press.