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Choosing a Monetary Policy Regime: Effects on the Traded and Non-Traded Sectors*

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Abstract

The paper considers alternative monetary policy regimes within a calibrated macroeconomic model with a traded and a non-traded sector. Two classes of regimes are considered; inflation targeting and exchange rate targeting. When the target variable is completely stabilized, both rules have poor stabilizing properties for all real variables - nominal exchange rate targeting is even dynamically unstable. When the monetary authority places some weight on output stabilization in addition to the primary target variable, inflation targeting outperforms exchange rate targeting in terms of output stability in both the traded and the non-traded sectors.

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1 Introduction

There has been a tendency in recent years to abandon intermediate targets and steer monetary policy directly to the ultimate goal of monetary policy; price stability, in the meaning of low and stable inflation[1]. Since central banks have imperfect control over inflation, there is a less direct relationship between the monetary policy decisions and the target variable. This has triggered a renewed interest in monetary policy rules as guides for monetary policy. A small, but growing, part of the literature considers open-economy models.[2] There are important differences between the monetary policy transmission mechanism in closed and open economies. In closed economies, monetary policy affects inflation in the short run mainly indirectly through the effect on aggregate demand. In open economies, however, there is an additional direct channel through which monetary policy affects inflation, namely through its effect on the exchange rate and thereby on the prices of imported goods. Moreover, prices of imported goods might also affect the growth of nominal wages and thereby domestic inflation through the aggregate supply channel.

The paper analyzes the stabilization properties of alternative monetary policy rules by the use of a small calibrated open-economy model with a traded and a non-traded sector. The reason for choosing a two-sectoral model instead of an aggregate one may be motivated by the following stylized example: Suppose there exist two policy rules which has the same stabilizing properties on aggregate output, but where one of the rules stabilizes both traded and non-traded output separately whereas the other produces large fluctuations in the two sectors. Most economists would agree that the former rule is preferable to the latter. There are reasons to believe that monetary policy may affect the sectors differently since the traded sector output is considered more sensitive to changes in the real exchange rate, whereas the non-traded sector output is more affected by the real interest rate through domestic demand. Monetary policy therefore has a potential for causing sectoral fluctuations. Stable aggregate production therefore does not necessarily mean that adjustment costs are low if aggregate stability relies on large sectoral fluctuations. A second rationale for distinguishing between sectors is that the costs of transferring resources may be higher between than within each sector. Eventually, adjustment costs may differ across sectors. Adjustment in the traded sector may be more costly than adjustment in the non-traded sector. Then, sectoral output stability might be considered important in addition to aggregate output stability. There is thus a case for studying disaggregated models when analyzing alternative monetary policy regimes.

[1] See Bernanke and Mishkin (1997) for an overview.

[2] E.g. Svensson (1998), Batini and Haldane (1998) and McCallum and Nelson (1998).

In the growing literature on inflation targeting, we are aware of only a few papers that focus on traded and non-traded sectors. Røisland and Torvik (1999) compare exchange rate targeting and inflation targeting within a simple theoretical model with a traded and a non-traded sector. They find, among other things, that some earlier results from aggregated models are turned around in a two-sectoral model. For instance, a demand shock may induce higher aggregate output fluctuations with inflation targeting than with exchange rate targeting, which is in contrast to the conventional wisdom. However, their model is kept overly simple, in particular in its dynamic structure, in order to focus on the new mechanism brought about by the two-sectoral structure. Holden (1998) also compares exchange rate targeting and inflation targeting within a model with a traded and a non-traded sector. He focuses, however, on the equilibrium unemployment and not on the alternative regimes' stabilization properties. Chapple (1994) focuses solely on output stability in the traded sector and discusses the optimal weights attached to traded and non-traded goods in the target price index. He finds that targeting traded goods prices provides the highest output stability in the traded sector when the economy faces shocks to demand. Bharucha and Kent (1998) compare aggregate inflation targeting and non-traded inflation targeting within a calibrated dynamic two-sectoral model, much in line with ours. They find that monetary policy should be more activist in response to exchange rate shocks for a (flexible) aggregate inflation target than for a (flexible) non-traded inflation target, while it should be more activist in response to supply and demand shocks under non-traded inflation targeting. They focus, however, on stability in the non-traded sector and leaves out traded sector stability considerations.

The paper is organized as follows: In section 2, we present the two-sectoral rational expectations model which we will use when evaluating the different monetary policy rules. Section 3 considers two classes of targeting regimes; inflation targeting and exchange rate targeting. In a *targeting regime*, the monetary authority conducts policy so as to minimize the deviations of the target variable from the targeting level. Both strict and flexible targeting are considered. By flexible targeting we mean that additional (secondary) variables are also being targeted. Given a model of the economy, a targeting regime implies a specific instrument rule for monetary policy. The rules are derived under the assumption that the monetary authorities lacks commitment technology, so that there is nothing that prevents them from reoptimizing in later periods. The resulting rule is a perfect Stackelberg rational expectations equilibrium strategy (Backus and Driffill (1986), Cohen and Michel (1988), Blake (1992)) that minimizes the loss-function of the monetary authorities. Section 4 concludes, while some technical issues regarding the solution procedure is left to an appendix.

2 The model

The model is kept as simple as possible to identify the various effects of shocks, but still capturing some important stylized facts. It is carefully modelled to reflect the different lags in the monetary policy transmission mechanism. The interest rate influences output with a one year lag and domestic inflation after another year. Furthermore, the additional exchange rate channels work more quickly by immediately influencing CPI inflation through import prices and, within a year, influencing domestic inflation. Reflecting an assumption that the real (long run) equilibrium of the model is independent of the monetary policy regime[3], all variables are measured as deviations from their unconditional expectations (steady state).

The price of traded goods is determined in the world market and is exogenous to the domestic producer. The law of one price applies, such that the price of traded goods is given by

$$p_t^T = s_t + p_t^*,$$

where s_t is the log of nominal exchange rate and p_t^* is the log of the foreign currency price of traded goods.

Planned production in the traded sector in period $t+1$ depends on the expected producer real wage in period $t+1$, where expectations are rationally based on information in period t. Thus, there is a one period lag after the production decision has been taken until production is realized[4]. The supply function is thus represented by

$$y_{t+1}^T = \rho_T y_t^T - \alpha(w_{t+1|t} - p_{t+1|t}^T) + u_{t+1,}^T \tag{1}$$

where y_{t+1}^T is the log of output in the traded sector, $w_{t+1|t}$ is the expected log of the nominal wage, which is the same in both sectors and $p_{t+1|t}^T$ is the expected log of the traded sector product price. A high sunk cost capital intensity in the production of tradeable goods will typically generate a higher degree of persistence. We model persistence by the inclusion of the lagged production term.

There is a downward sloping demand curve that determines output in the non-traded sector. We conventionally assume that the real interest rate affects consumption through intertemporal substitution

[3]This assumption has recently been questioned by Holden (1998) and Lawler (1998).

[4]If producers reduce income volatility by hedging behaviour in the foreign exchange market, they would be more interested in the future development of real prices. The investment decision is also believed to be forward looking, which can give an additional argument for our supply function.

effects and investment through the user cost of capital. Demand is also affected by the relative price of tradeables to non-tradeables through intratemporal substitution effects:

$$y_{t+1}^N = \rho_s y_t^N - \beta_1 r_t + \beta_2(p_t^T - p_t) + u_{t+1}^N \tag{2}$$

y_{t+1}^N is the log of output in the sheltered sector, r_t is the sheltered sector real interest rate, which is defined by

$$r_t \equiv i_t - \pi_{t+1|t}$$

$\pi_{t+1|t}$ is the rational expectations value of next period domestic inflation rate formed today. e_t is the real exchange rate, which is defined by

$$e_t \equiv p_t^T - p_t \tag{3}$$

The price of non-traded goods is determined by a constant mark-up over wages, i.e.

$$p_t = w_t \tag{4}$$

Since y_t^T and y_t^N are measured in logs as deviations from steady state, aggregate production is a weighted average of production in the two sectors, i.e.

$$y_t \equiv \eta y_t^T + (1-\eta) y_t^N \tag{5}$$

where η is the share of traded production in steady state, $0 < \eta < 1$. p^c is the consumer price index (CPI), and its rate of change, $\pi_t^c = p_t^c - p_{t-1}^c$, is given by:

$$\begin{aligned} \pi_t^c &= (1-\theta)\pi_t + \theta\left(\Delta s_t + \pi_t^*\right) \\ &= \pi_t + \theta(e_t - e_{t-1}) \end{aligned} \tag{6}$$

where Δs_t is the change in the nominal exchange rate and where we have used (11).

There is perfect capital mobility in the foreign exchange market, and its agents have rational expectations, which implies that the following real interest rate parity condition holds[5][6]:

$$e_t = e_{t+1|t} - r_t + r_t^* \tag{7}$$

where r_t^* is the foreign real interest rate, which is defined by

$$r_t^* \equiv i_t^* - \pi_{t+1|t}^* \tag{8}$$

Due to our small economy assumption, the foreign disturbances are modelled in the simplest way possible. Both the foreign inflation and the foreign interest rate processes are assumed to be AR(1):

$$r_{t+1}^* = \rho_r^* r_t^* + u_{t+1}^{r^*} \tag{9}$$

$$\pi_{t+1}^* = \rho_w^* \pi_t^* + u_{t+1}^{\pi^*} \tag{10}$$

By using (8) at the appropriate period and taking expectations in (10), substituting for the real interest rate in (9), we get the following expression for the foreign nominal interest rate:

$$i_{t+1}^* = \rho_r^* i_t^* + \rho_w^* (\rho_w^* - \rho_r^*) \pi_t^* + \rho_w^* u_{t+1}^{\pi^*} + u_{t+1}^{r^*}$$

The change in the nominal exchange rate is then given by:

$$\Delta s_t \equiv \Delta e_t - \pi_t^* + \pi_t \tag{11}$$

The labour market is represented by the following wage curve:

$$\Delta w_{t+1} = \pi_t^C + \gamma y_t - \lambda (w - p^C)_t + u_{t+1}^w \tag{12}$$

[5] The real uncovered interest parity follows directly from the nominal uncovered interest parity:

$$s_t = s_{t+1|t} - i_t + i_t^*$$

By adding $\pi_{t+1|t} = p_{t+1|t} - p_t$ and subtracting $\pi_{t+1|t}^* = p_{t+1|t}^* - p_t^*$ on each side, we get:

$$s_t - (p_{t+1|t}^* - p_t^*) + (p_{t+1|t} - p_t) = s_{t+1|t} - i_t + i_t^* - \pi_{t+1|t}^* + \pi_{t+1|t}$$

and then rearranging:

$$(s + p^* - p)_t = (s + p^* - p)_{t+1|t} - (i_t - \pi_{t+1|t}) + (i_t^* - \pi_{t+1|t}^*)$$

which is the real uncovered interest parity.

[6] We could explicitly have allowed for a risk premium term in this setup. However, nothing is lost by considering r^* the *premium corrected* foreign real interest rate - the domestic real interest rate level needed to keep expected changes in the real exchange rate equal to zero.

Workers are assumed to be fully compensated for CPI inflation with a lag. Alternatively, the wage equation can be interpreted as adaptive and non-rational expectations formation in the labour market, where expected CPI inflation tomorrow is equal to CPI inflation today. Wage inflation is assumed to be related to the degree of pressure in the labour market, as represented by y_t. Finally, wage inflation responds to the real consumption wage disequilibrium, which is represented by the third term in (12). Arguably, we could have included a more forward looking wage process, as suggested by Fuhrer and Moore (1995). However, (12) has received rather good empirical support in several countries[7] and it is easy to interpret.

By using (3), (4), (12) and (6), we can write domestic inflation as

$$\pi_{t+1} = \pi_t + \gamma y_t + \lambda \theta e_t + \theta \Delta e_t + u_{t+1}^w \tag{13}$$

We see that the real exchange rate affects inflation in the non-traded sector through the wage response to consumer prices. In addition, it affects π_t through its effect on the level of activity, y_t.

The monetary policy instrument is assumed to be the short-term nominal interest rate, i_t. The model is calibrated to represent a small open economy, and estimated models of the Norwegian economy are used as benchmarks[8]. The benchmark parameter values are: $\rho_T = .85$, $\rho_s = .7$, $\rho_w = 1$, $\rho_i^* = .65$, $\rho_w^* = .85$, $\alpha = .3$, $\beta_1 = .5$, $\beta_2 = .05$, $\gamma = 0.325$, $\lambda = .35$, $\theta = .4$ and $\eta = .2$. The standard deviations of the shocks are $\sigma_{u^T} = 0.025$, $\sigma_{u^N} = 0.021$, $\sigma_{u^w} = 0.010$, $\sigma_{u^{r*}} = 0.024$ and $\sigma_{u^{\pi*}} = 0.017$.

2.1 The transmission mechanisms

The model has four transmission channels in which monetary policy may affect the economy. Three of these channels work through the exchange rate and the fourth works through the real interest rate.

The first of these channels is the *direct effect* of a change in the nominal exchange rate, which has the most immediate effect on inflation. This channel affects the price of tradeables directly and thus the prices of imported goods. The larger the share of tradeables in the CPI, as measured by θ, the stronger the impact of a given change in the nominal exchange rate on inflation. In the above model, the direct effect from exchange rate movements onto inflation is instantaneous. This is obviously a simplification[9].

[7] See Holden and Nymoen (1998).

[8] The coefficients of the model is chosen from inspection of the impulse responses in the KVARTS empirical macromodel of Statistics Norway and confirmed by some regression analysis using instrument variables for future expected values. Estimates of the variances of the shocks are taken from Evjen and Nymoen (1997) for the wage equation. For all other equations, the variances have been calculated based upon regression analysis on Norwegian and international data.

[9] Naug and Nymoen (1995) estimate an import price relationship for manufacturing goods. They show that the pass-

However, there seems to be a wide spread view[10] among economists that this is the fastest monetary policy channel through which monetary policy affects inflation in an open economy.

The second channel, which is often denoted the *indirect effect* of a change in the nominal exchange rate, is operational to the extent that the nominal exchange rate influences the (expected) real exchange rate. The real exchange rate influences production in the tradeable sector. One-period-in-advance *expected* changes in the real exchange rate influence the production decision in the tradeable sector. However, *un*expected changes have no immediate effect in this model, since the production decision in this sector is made one period in advance based upon the expected producer real wage in the coming period. It will, however, have effects later on, unless the process is reversed. Furthermore, the real exchange rate affects the non-traded sector due to substitution effects between the sectors.

The third transmission mechanism works directly through wages. The rate of change of nominal wages depends on CPI inflation and deviation of the consumption real wage from its steady state. The real exchange rate affects both CPI inflation and the consumption real wage, and thereby the domestic inflation rate with a one period lag.

The fourth channel is the interest rate channel. Due to nominal rigidities, the nominal interest rate influences the real interest rate, which affects domestic inflation through its effect on demand for non-traded goods.

3 Monetary policy rules

There is a relatively large literature on how to conduct monetary policy with the use of rules[11]. A large part of the literature evaluates rules that are designed to give guidance on how to set the instrument of monetary policy, the short interest rate or the monetary base. The literature on how to optimally conduct monetary policy and set interest rates in open economies when the central bank has been delegated a *specific* macroeconomic objective or target such as keeping inflation low or the exchange rate stable, is considerably smaller[12].

through into import prices is very fast and almost all changes has taken place within a year of the change in the exchange rate.

[10] See for instance Svensson (1998) and Ball (1998).

[11] See McCallum (1997) for an overview.

[12] However, the literature is growing rapidly. See for instance Svensson (1998) and Ball (1998).

3.1 Policy optimization and targeting regimes

A targeting regime is defined by the following optimization problem:

$$\min_{i_t} E_0 \sum_{t=0}^{\infty} L_t \tag{14}$$

where

$$\begin{aligned} L_t &= a_{\pi^C}(\pi_t^c)^2 + a_\pi(\pi_t)^2 + a_{\Delta s}(\Delta s_t)^2 + \\ & \quad a_s s_t^2 + a_y y_t^2 + a_{y^T}\left(y_t^T\right)^2 + a_{y^N}\left(y_t^N\right)^2 + a_{\Delta i}(\Delta i_t)^2 \end{aligned} \tag{15}$$

given the model in equations (1)-(13). The optimization problem is linear quadratic and therefore certainty equivalent (see Currie and Levine (1993)), which means that the solution to the problem is independent of the distribution of the u's.

Alternative regimes can be represented by alternative choices of the a-parameters. Svensson (1997) specifies the characteristics of a (*strict*) *targeting regime (rule)*[13] as the solution to the above optimization problem with a unit coefficient of a_x, where x is the targeted variable and zero restrictions on all other a's. A targeting regime is optimal in the sense that no other discretionary strategy gives a lower expected value of the monetary policy authorities loss function.

A formal treatment of the optimization procedure is given in appendix A. The procedure calculates the rational expectations solution for a given policy rule and iterates on the policy rule to produce the minimum loss of policy. This can be seen as a game between the policy maker and the market. Because we have forward looking variables in the model, there is a difference between the discretionary and the commitment outcome of the optimization procedure. We assume that the monetary policy authorities do not possess the commitment technologies to make the commitment solution credible. As we want policy to be time-consistent, we do optimization under the assumption of discretion in monetary policy following Backus and Driffill (1986). In other words, we do not allow strategies of the monetary authority which there will be benefits in deviating from at a later stage in the game. Furthermore, we assume that the policy goals are understood and believed by the private markets and hence the central bank enjoys full goal credibility within the discretionary framework.

[13]Svensson uses the term "targeting rule" instead of our "targeting regime". We believe that our term is more appropriate as a rule could be misperceived in this discretionary framework. The terms, however, are interchangeable.

The nominal interest rate is assumed to be the policy instrument, and the optimal time-consistent rule, that is, the rule that minimizes the loss given by (15), is in general a feedback rule where the interest rate depends on all the state-variables, i.e.

$$i_t = b_1 y_t^T + b_2 y_t^N + b_3 \pi_t + b_4 i_t^* + b_5 \pi_t^* + b_6 e_{t-1} + b_7 i_{t-1} + b_8 s_{t-1} \tag{16}$$

In this paper, we consider two main targets for monetary policy: CPI inflation targeting and nominal exchange rate targeting. Both of these regimes provide a nominal anchor for the economy. Within each of these regimes, we distinguish between *strict* and *flexible* targeting. In the strict versions of these regimes, the sole objective of the authorities is to minimize variability of the primary target. Under flexible targeting there could be several other secondary variables that is targeted in addition to the primary variable denoted by the regime name. There is in principle an infinite number of flexible regimes, depending on the weights attached to a linear combination of the targeted variables. However, we only consider one type of flexibility, namely that the monetary authority attaches weight to aggregate output in addition to the main target variable. We have chosen to attach a unit weight to each variable in the criterion function. This means that in the flexible regime the authorities target both the primary and secondary variable (output) to the same degree. Arguably, the secondary variables could instead have been given a smaller weight since they are in fact secondary. However, a smaller weight to the secondary variable gives a reaction function of the form (16) with the b-coefficients being somewhere in between the strict and (our chosen) flexible regime.

We also study the consequences of extended interest smoothing in all regimes by attaching a unit weight to changes in the nominal interest rate in the loss function ($a_{\Delta i} = 1$). In our model, there are no economic reasons for disliking changes in the interest rate per se. However, it can be argued that in a larger model with a financial sector explicitly modelled, interest volatility may have significant costs and should therefore be included in the criterion function. Another reason is the central banks' apparent reluctance to change the interest rate when the monetary authority is uncertain about the true economic model. This cautionary strategy may have attractive properties, as shown by Brainard (1967). It turns of that interest smoothing may also in some circumstances have a positive effect on the discretionary equilibrium leading to lower variability of the targeted variables.

There is also a technical reason for allowing some degree of interest smoothing in every regime. Under nominal exchange rate targeting, there exists a strategy which will completely stabilize the nominal exchange rate. This strategy requires that the domestic nominal interest rate is set equal to

Regimes (abbreviations)		High degree of interest smoothing ($a_{\Delta i} = 1$)	Low degree of interest smoothing ($a_{\Delta i} = 0.01$)
CPI inflation targeting	Strict ($a_{\pi^C} = 1$)	*SITis*	*SIT*
	Flexible ($a_{\pi^C} = 1, a_y = 1$)	*FITis*	*FIT*
Nominal exchange rate targeting	Strict ($a_s = 1$)	*SETis*	*SET*
	Flexible ($a_s = 1, a_y = 1$)	*FETis*	*FET*

Table 1: Parameter values in the objective function (17) under different regimes

the foreign nominal interest rate at every point of time. This requires a completely flexible interest rate in order to keep the interest differential always at zero. However, such a strategy leads to model instability, as will be explained in the next section. This is a central feature of many models of monetary policy (Hall and Nixon (1997)), and a feature that is obviously an unattractive feature to the authorities which delegated the exchange rate stabilizing objective to the central bank. By including some costs of changing the interest rate, it is possible to avoid such a strategy by forcing the monetary policy authority to rely on other strategies for reducing nominal exchange rate volatility. Since we will be comparing the different regimes, we have included some costs of changing the interest rate in every regime. Table 1 gives an overview of the 8 targeting cases with their respective abbreviations.

3.2 Nominal exchange rate targeting

Under strict nominal exchange rate targeting, the interest rate is set so that the exchange rate is always at target, i.e.

$$s_t = 0 \tag{17}$$

If strict exchange rate targeting is credible, the domestic interest rate cannot deviate from the foreign interest rate: $i_t = i_t^*$. However, such a rule is incompatible with stationarity of the real variables in our model, as output, the real interest rate and the real exchange rate then will show exploding oscillatory patterns[14]. The reason for this is that monetary policy is pro-cyclical when prevented from responding to disequilibrium conditions. This can be shown from equation (13). When $i_t = i_t^*$, the real interest

[14]In appendix B we explore the results of letting the long run real interest rate instead of its short run counterpart enter the demand function. One of the key results is that it will be possible to have a completely fixed nominal exchange rate and still produce model stability. This equilibrium, however, produces large fluctuations in output and CPI inflation.

rate is

$$
\begin{aligned}
r_t &= i_t - \pi_{t+1|t} \\
&= i_t^* - \rho_w(1-\theta)\pi_t - \gamma y_t - \rho_w \theta \pi_t^* - \theta\lambda(p_t^* - p_t^N)
\end{aligned}
\tag{18}
$$

where we have used that $e_t = p_t^* - p_t^N$ when $s_t = 0$.

Now, suppose that a positive demand shock to the non-traded sector occurs. Higher output increases expected domestic inflation, which reduces the real interest rate. The decline in the real interest rate increases output further, and an expansionary spiral starts. This is the so-called Walter's effect (Walters (1986)). Higher domestic inflation produces a real appreciation, which eventually will dominate the Walter's effect, and the cycle turns into a self-enforcing recession. The stabilizing effect of the real exchange rate is not large enough to dominate the de-stabilizing Walter's effect. We therefore need to have some degree of flexibility in the exchange rate target in order to ensure stability. By attaching a small weight to the change in the interest rate in the loss function, we eliminate the $i = i^*$ strategy, since this strategy requires a completely flexible interest rate. The exchange rate targeting central bank would now have to set the instrument in such a way that the exchange rate would "hover" as close as possible around the target level. This requires that the central bank uses the transmission channels in the best possible way to induce nominal exchange rate stability. Model stability is then a requirement for a rational expectations equilibrium in the model.

Would then a monetary union be unstable? It is important to point that our model not possibly can account for all of the elements in a monetary union like that of EMU. Our model focuses on some important aspects of monetary policy in a small, open economy with economic processes that not necessarily are similar to those in the target currency area. Increased factor mobility, an increased traded sector due to reduction in transaction and transport costs, convergence of wage processes, a more coordinated fiscal policy and integration, in general, may all contribute to stability beyond our narrow definition of monetary policy. We, however, believe that our model may illuminate some problems that may occur in a monetary union, especially at the start of one, when the degree of integration may be low. Recognizing that there may be elements in the economy that may induce stronger stabilization than our baseline model can account for, we return to consider combined fiscal and monetary policies later in this section.

There are two opposing considerations when stabilizing the nominal exchange rate. First, short term stability in the nominal exchange rate requires that the domestic nominal interest rate follows the foreign interest rate tightly. Second, long term nominal exchange rate stability requires that the

Regime	y^T	y^N	π	i^*	π^*	i_{t-1}	e_{t-1}	s_{t-1}
SET	-0.004	0.326	1.445	1.569	-1.952	0.014	-0.633	0.092
SETis	-0.011	0.061	0.402	0.758	-0.524	0.305	-0.194	0.055
FET	0.027	0.458	1.434	1.560	-1.901	0.011	-0.629	0.093
FETis	0.004	0.173	0.622	0.872	-0.794	0.273	-0.284	0.059

Table 2: Nominal exchange rate targeting: Parameter values in the reaction function (19)

domestic price level is equal to the foreign level, so that a fixed nominal exchange rate is consistent with the long run equilibrium real exchange rate. This might require that the domestic interest rate must, at times, deviate from the foreign interest rate in order to secure that the domestic price level returns to the foreign price level in the long-run.

Table 2 shows the implied interest rate rules for the nominal exchange rate targeting regimes. In all these regimes policy responds mildly to disequilibrium conditions in the traded sector - with a coefficient close to zero. This sector is relatively small (20 percent of equilibrium aggregated output) and accordingly has a small effect on the wage pressure in the labour market. Hence, it has only a small effect on domestic prices and the real exchange rate.

The interest rate rules exhibit a stronger response to deviations in the non-traded sector than in the traded sector because (i) this sector is the larger one and thus influences wages to a greater extent and (ii) it is more responsive to the interest rate. The interest rate responses to domestic and foreign inflation shocks are both very strong. A shock to domestic inflation produces a real exchange rate appreciation, and a policy of reducing the persistent, domestic inflation is required in order for the domestic price level to return to level that is consistent with the exchange rate target. A foreign inflation shock, however, produces the need for a rise in domestic prices.

Monetary policy becomes very dependent on foreign monetary policy, as the foreign interest rate plays an important part of the reaction functions in all regimes. In the *SET* and *FET* regimes, the reaction coefficients are both above unity. As foreign interest rate shocks exhibit a relatively high degree of persistence in our model, the domestic interest rate will have to be raised for a rather long time in order not to induce larger changes in the exchange rate. A high domestic interest rate will, however, produce a domestic recession which eventually calls for a lowering of the interest rate. Since the interest rate differential will "hover" around zero in order to produce nominal exchange rate stability, this eventual lowering of the interest rate will contribute to exchange rate stability if the interest rate was initially set sufficiently high.

As can be seen from table 2, targeting output in addition to the nominal exchange rate in regimes

FET and *FETis,* produces surprisingly few changes to policy. A somewhat stronger response to output deviation is the most important change. Interest rate smoothing, on the other hand, has a more pronounced effect on policy. The interest rate responses are then less aggressive with respect to nearly every state variables, but more dependent on the interest rate in the period before.

3.2.1 Stabilization properties

The unconditional standard deviations are displayed in table 3.

Regime	y^T	y^N	y	π^c	π	i	e	s
SET	5.59	4.36	3.31	3.09	3.16	4.98	5.27	12.95
SETis	6.48	4.52	3.82	3.25	3.59	3.72	6.06	7.02
FET	5.40	4.08	3.09	3.13	3.20	4.93	4.99	13.42
FETis	5.56	3.98	3.24	3.20	3.38	3.98	5.00	9.39

Table 3: Nominal exchange rate targeting: Unconditional standard deviations in percent.

Perhaps the most striking result in table 3 is the similarity between the *SET* and *FET* regimes. Allowing the monetary authorities to target output in addition to the exchange rate has only a minor effect on the standard deviations of the variables. The standard deviations of output in both sectors drop slightly, but nominal exchange rate volatility increases approximately by the same magnitude. One interpretation of this is that a policy of targeting the nominal exchange rate requires output stability in order to bring the domestic price level in line with the foreign level. Thus, the scope for a trade-off between output stability and exchange rate stability is limited. Evidently, a rather high degree of volatility in the targeted variable is unavoidable with this strategy, as the nominal exchange rate channels are important parts of the monetary transmission mechanism.

One contra intuitive feature is that nominal exchange rate volatility is smaller in the interest smoothing regimes than when nominal exchange rate targeting is the single objective of monetary policy. The discretionary equilibrium thus gives a better outcome for nominal exchange rate targeting if the policy maker is reluctant to change the interest rate. The loss due to interest rate changes works as a commitment mechanism for the central bank in achieving a lower variance of the nominal exchange rate - a solution that is closer to the optimal commitment solution. To understand this it is important to remember that the nominal exchange rate is forward looking. It depends on the expected future interest rate differentials in the model. As the central bank reoptimizes in every period, it can only to some extent influence these expectations in a favorable manner. The central bank uses the interest rate actively to set the domestic price level in line with the foreign level. It will prioritize the long run goal of exchange rate stability. However, if interest rate changes is punished, the financial market will know that the central bank would be less likely to create large interest differentials that would produce exchange rate movements, and hence the central bank is getting a more favorable trade-off between long and short term exchange rate stabilization. This might be an additional argument for the well known fact that the central banks indeed show smoothing behavior of its instrument (Walsh (1990)). The ability of the central bank to be successful in reaching its goals in a nominal exchange rate targeting regime will increase if the central bank can signal a reluctance in changing the interest rate. However, variability in key variables increases. Comparing the *SET/SETis* regimes shows that increased interest smoothing behavior gives higher output variability, particularly in the traded sector.

In the flexible output targeting regime, interest rate smoothing has less effect on stability in the model. However, it still has markedly positive effect on the central bank's ability to stabilize the exchange rate.

In all four regimes, aggregate output stability is partly achieved at the expense of higher sectoral fluctuations. As argued in the introduction, there are reasons to consider sectoral stability as well as aggregate stability. However, it is not obvious how sectoral stability should be measured. We have chosen to measure sectoral output variability (SOV) by the square root of a weighted sum of the variances of each sector, where the weights reflects the sectors relative sizes:

$$SOV = \sqrt{\eta \; var(y^T) + (1-\eta) \; var(y^N)} \tag{19}$$

We can also get a measure of how much the regimes relies upon sectoral fluctuations to achieve aggregate stability by considering the unconditional correlation coefficient between traded and non-traded production. Both these measures are considered in the following table:

Regime	SET	SETis	FET	FETis
SOV (%)	4.63	4.97	4.38	4.34
$corr(y^T, y^N)$	-0.32	-0.014	-0.318	-0.122

Table 4: Nominal exchange rate targeting: Measures of adjustment cost

Output in both sectors tends to move in opposite directions in all regimes. This shows that there are important asymmetrical effects of monetary policy on the economy. This implies that aggregate output variability underestimates sectoral output variability and hence adjustment costs in the economy.

We also see that interest rate smoothing reduces the negative correlation between output in the two sectors. This means that interest smoothing is a way of reducing total adjustment cost to the economy by having a variance reducing effect on output in each sector. This may be another reason to consider interest smoothing.

Specific shocks It may be interesting to consider the effects of different shocks to the model in isolation. We consider four types of transitory shock to our model:

- *a domestic shock to non-tradeable production,*
- *a domestic cost-push shock*,
- a *shock to the foreign real interest rate* and
- *a shock to foreign inflation.*

The magnitude of the shocks are: 1 percent for non-traded output, and 1 percentage point shock to nominal wage inflation, the foreign real interest rate and foreign inflation rate respectively. Figures at the end of the paper show the impulse responses in different regimes to the four types of shocks. In each figure we have also reproduced the impulse responses for the strict nominal exchange rate targeting regime, which can be viewed as the benchline case. To get a measure of the impact of these shocks, we calculate the root mean square deviations (from their unconditional expectations) of key variables according to the formula:

$$RMSD = \sqrt{\sum (x_t)^2}$$

where x denotes the variable in question. These measures are displayed in table 5.

Regime	**Nominal exchange rate targeting**			
RMSD	*SET*	*SETis*	*FET*	*FETis*
y^T	$(0.35, 0.49, 1.53, 2.51)$	$(0.96, 1.52, 1.52, 3.18)$	$(0.27, 0.40, 1.41, 2.26)$	$(0.59, 1.01, 1.23, 2.41)$
y^N	$(1.05, 1.61, 1.31, 2.39)$	$(1.25, 1.35, 1.28, 2.43)$	$(1.03, 1.48, 1.22, 2.18)$	$(1.12, 1.25, 1.13, 2.07)$
s	$(1.58, 4.38, 3.55, 8.53)$	$(1.22, 2.33, 1.92, 4.31)$	$(1.56, 4.66, 3.76, 8.84)$	$(1.38, 3.22, 2.65, 5.98)$
π^c	$(0.47, 0.82, 0.59, 1.57)$	$(0.34, 0.66, 0.42, 1.84)$	$(0.49, 0.86, 0.62, 1.57)$	$(0.42, 0.74, 0.51, 1.72)$
e	$(1.19, 2.18, 1.37, 2.21)$	$(1.14, 2.58, 1.37, 2.99)$	$(1.21, 2.02, 1.32, 1.88)$	$(1.09, 2.16, 1.13, 1.97)$
π	$(0.36, 1.10, 0.52, 1.52)$	$(0.19, 1.14, 0.45, 1.99)$	$(0.39, 1.12, 0.58, 1.52)$	$(0.27, 1.09, 0.51, 1.76)$
i	$(0.45, 1.72, 1.92, 2.57)$	$(0.33, 0.89, 1.31, 1.65)$	$(0.53, 1.68, 1.89, 2.48)$	$(0.37, 1.11, 1.44, 1.85)$
y	$(0.84, 1.31, 0.84, 1.73)$	$(0.99, 1.32, 0.96, 2.04)$	$(0.82, 1.22, 0.78, 1.57)$	$(0.89, 1.17, 0.79, 1.64)$

Table 5: Responses to specific shocks. There is a vector of four elements associated with every combination of regime and variable. In each vector, the elements represent the RMSD for each variable sorted by type of shock: demand shock, cost-push shock, foreign real interest rate shock and foreign inflation shock.

There are a number of interesting conclusions that can be drawn from table 5. Output variability in the traded sector is low for both types of domestic shocks for the *SET* and *FET* regimes. However, interest rate smoothing changes this conclusion markedly and strongly exasperates these shocks. Interest rate smoothing also exasperates foreign inflation shocks - although to a lesser extent in the *FETis*-regime.

In the non-traded sector, interest rate smoothing increases variability caused by demand shocks, but reduces variability due to cost-push shocks. The impact of foreign shocks in this sector is slightly reduced in the *FET*-regime and even more in the *FETis*-regime.

The nominal exchange rate responds most strongly to foreign inflation shocks in every regime. Interest rate smoothing has the effect of reducing nominal exchange rate variability for every type of shock. CPI inflation reacts strongly to foreign inflation shocks, as domestic prices follow foreign prices in order to stabilize the nominal exchange rate at the equilibrium real exchange rate level. Aggregate output stability is only to a small extent affected by output targeting and interest rate smoothing.

3.2.2 Active fiscal policy

As discussed above, when monetary policy is the sole stabilizing element of economic policy, nominal exchange rates can not be perfectly stabilized, since the rule $i = i^*$ does not induce stability. Stability can, however, be ensured by other elements of policy, e.g. by active fiscal policy. In this section, we ask how strong the stabilizing effort of fiscal policy has to be in order to induce stability and so that the nominal exchange rate can be kept completely fixed by letting the central bank eliminate interest rate differentials.

If this degree of activism is considered too strong and therefore unrealistic, we can ask the opposite question - what degree of exchange rate variability must be allowed if the economy is to be kept stable? To capture active fiscal policy in a simple way, we assume that fiscal policy is represented by the following reaction function:

$$d_t = \tau(y_{t-1} + \pi_{t-1}^C) \tag{20}$$

where d_t is a measure of fiscal stance, e.g. the fiscal budget deficit[15] (measured as a proportion of total non-traded output). τ is a response coefficient reflecting partly the degree of automatic stabilization and partly the degree of fiscal activism of the fiscal authorities, normalized in such a way that a unit of d_t corresponds to a unit of non-traded good. Thus, fiscal policy reacts linearly to both the output and

[15]Any effects of Ricardean equivalence would obviously render this example less appropriate. Then fiscal expenditure may be a somewhat better description of fiscal stance.

CPI inflation gap. One might also consider optimal fiscal policy, which minimizes a given loss function. However, given the rigidity in fiscal budget decisions, such a policy seems unrealistic.

We assume fiscal policy has an immediate impact on non-traded demand. There is, however, a one-period decision lag. Equation (2) is then replaced by a demand equation that includes the fiscal demand component:

$$\begin{aligned} y_{t+1}^N &= \rho_s y_t^N + d_{t+1} - \beta_1 r_t + \beta_2 e_t + u_{t+1}^N \\ &= \rho_s y_t^N + \tau(y_t + \pi_t^C) - \beta_1 r_t + \beta_2 e_t + u_{t+1}^N \\ &= (\rho_s + \tau\eta) y_t^N + \tau(1-\eta) y_t^T + \tau\pi_t + \tau\theta(e_t - e_{t-1}) \\ &\quad -\beta_1 r_t + \beta_2 e_t + u_{t+1}^N \end{aligned} \tag{21}$$

where we have used equation (5) and (6).

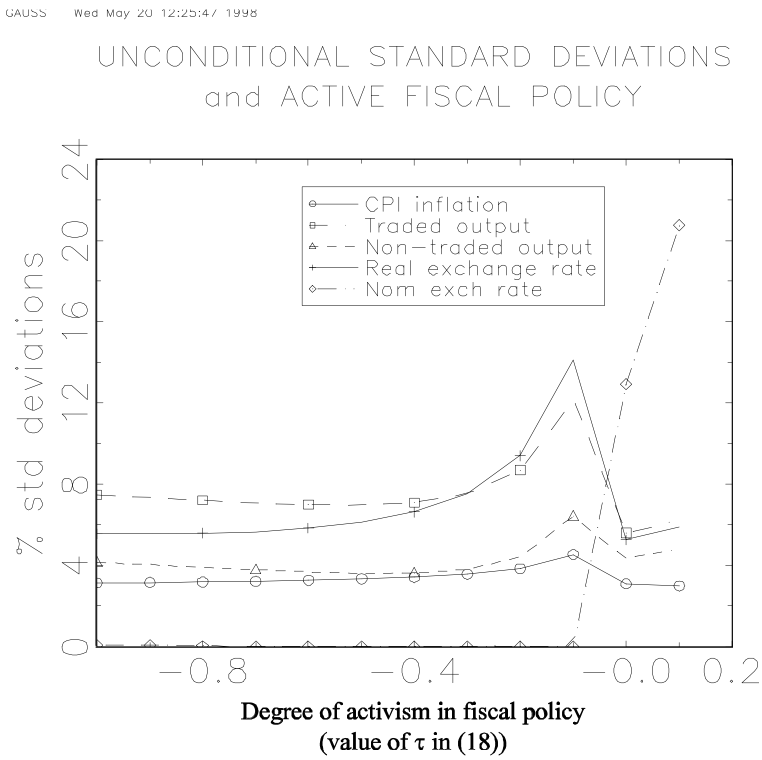

Figure 1: Standard deviations of key macroeconomic variables under different levels of fiscal policy activism

Figure 1 shows standard deviations in key macroeconomic variables for different values of τ along the horizontal axis. We assume that the relevant values of τ are in the interval $\tau \in [-1, .1]$. The lower limit in this interval represents a very active fiscal policy. Even if the limit is arbitrarily chosen, it seems unrealistic to assume lower values of τ. An example should illustrate this: If $\tau = -1$ and fiscal expenditure is 50 percent of non-traded output, a total output increase of 1 percent would mean that the fiscal deficit should be reduced by 1 percentage point of total non-traded output. This is equivalent to a 2 percentage reduction in fiscal expenditures.

There are several conclusions to be drawn from this experiment. First note that the nominal exchange rate is completely stabilized if the fiscal policy maker is committed to follow a policy that is slightly countercyclical. If fiscal policy is neutral or even slightly procyclical, the nominal exchange rate becomes volatile as a results of leaving the necessary stabilization policy to the monetary policy maker in order to avoid exploding paths.

Volatility of other variables than the nominal exchange rate increases when the fiscal policy moves from a neutral to a slightly active stance. Now, the central bank does not have to produce model stability and it can achieve its objective completely by setting $i_t = i_t^*$. The fiscal effort now brings about stability, but to a much smaller degree compared to the situation when fiscal policy was neutral and monetary policy allowed to contribute to stabilization. This indicates that there can be considerable gains in allowing the nominal exchange rate to fluctuate somewhat and use this flexibility to stabilize the economy.

A more activist stabilizing fiscal policy, in the form of an decreased τ, reduces real exchange rate volatility and traded output variability markedly. Minimum variability in the traded sector is achieved at moderate levels of fiscal policy activism. Volatility reductions are also achieved for other variables, but to a lesser extent. Our model predicts that there are few advantages of committing to a very active fiscal policy ($\tau < -0.5$) in a nominal exchange rate targeting regime.

There are considerable gains in allowing monetary policy to play a part in stabilizing the economy. Allowing some degree of nominal exchange rate volatility can thus produce a more efficient outcome. As figure 1 indicates, there is a significant cost, in terms of increased volatility of real variables, of stabilizing the exchange rate completely. This cost, however, is smaller the more active fiscal policy stabilization is.

3.3 CPI Inflation targeting

During the 1990s, explicit inflation targeting regimes have been implemented in several countries. The inflation rate cannot be considered a traditional intermediate target variable, since the central bank can only influence, and not control, the inflation rate. However, Svensson (1997) argues that the central banks' conditional inflation forecast can be treated as an intermediate target variable. By definition, the inflation forecast is the measure that, in expectational sense, is most highly correlated with future inflation and is influenced (at some horizon) by the central bank - and thus satisfies the condition for being a good intermediate target.

The undesirability of a completely fixed inflation rate One can, in principle, constantly keep inflation on target by use of the direct exchange rate channel. However, such a strategy does not produce a good outcome in our model. As with a completely fixed exchange rate, monetary policy is procyclical when the target is achieved exclusively by use of the direct exchange rate channel. To see this, note that $\pi_t^c = 0$ implies from (6) that

$$e_t - e_{t-1} = -\frac{1}{\theta}\pi_t \tag{22}$$

Leading (22) one period, taking the expectation at period t and utilizing the uncovered interest rate relationship yields

$$\begin{aligned} e_{t+1|t} - e_t &= -\frac{1}{\theta}\pi_{t+1|t} \\ &= r_t - r_t^* = -\frac{1}{\theta}[\rho_w \pi_t + \gamma y_t + \lambda\theta(e_{t-1} - \frac{1}{\theta}\pi_t)] \end{aligned}$$

By taking expectation in (13) and substitute for $\pi_{t+1|t}$, exploiting (7) and finally using (22) to substitute for e_t, we get:

$$r_t - r_t^* = -\frac{1}{\theta}[\rho_w \pi_t + \gamma y_t + \theta(\rho_w + \lambda)(-\frac{1}{\theta}\pi_t + e_{t-1}) - \theta\rho_w e_{t-1})]$$

The real interest rate is thus given by

$$r_t = r_t^* - \frac{1}{\theta}\left(\rho_w - \theta(\rho_w + \lambda)\right)\pi_t - \frac{\gamma}{\theta}y_t - \lambda e_{t-1} \tag{23}$$

If a positive demand shock occurs, the real interest rate decreases as a result of higher expected inflation and a lowering of the nominal interest rate. The reason why the interest rate must be lowered is that a positive demand shock leads to higher expected domestic inflation. In order to keep the CPI inflation on target, an offsetting expected exchange rate appreciation is required, which, according to the UIP condition, implies a lower interest rate. Thus, monetary policy is even more pro-cyclical than with a completely fixed exchange rate, since under the latter, the nominal interest rate remains unchanged.

The higher domestic inflation must be offset by a continuous appreciation of the real exchange rate in order to reach the CPI inflation target. Eventually, the effect of a stronger real exchange rate starts to dominate the effect of the lower real interest rate, and a recession arises. The result is stable, but strongly oscillating paths for the real variables.

As evident in table 1, we have included some interest rate smoothing even in the strict targeting cases. Some degree of interest rate smoothing does not change the strict inflation targeting equilibrium significantly and is included in order to make the regime comparable to the nominal exchange rate regime.

3.3.1 Strict and flexible inflation targeting

As for the nominal exchange rate regimes, we distinguish between strict and flexible regimes in accordance with the definitions earlier in table 1. The reaction functions are shown in table 2.

Regime	y^T	y^N	π	i^*	π^*	i_{t-1}	e_{t-1}
SIT	-0.094	-0.370	0.516	0.960	-0.814	0.037	-0.206
SITis	-0.027	-0.048	0.380	0.482	-0.409	0.457	-0.152
FIT	0.067	0.507	1.047	1.297	-1.103	0.024	-0.419
FITis	0.014	0.185	0.578	0.709	-0.602	0.334	-0.231

Table 6: Inflation targeting: Parameter values in the reaction function (14)

The *SIT* regime requires a reaction function for the nominal exchange rate that is very close to the rule which exploits the direct exchange rate channel extensively in order to provide complete CPI inflation stability (23). In such a regime, the real interest rate differential is adjusted in order to achieve real exchange rate changes that off-set inflationary pressure. As seen from the table 6, this strategy requires the interest rate to respond negatively to output in both sectors. This requirement, in addition to the low response coefficient in front of the domestic inflation term, is the source of the large oscillations in this regime. The negative coefficient for the lagged real exchange rate is the sole component that eventually brings about stability. By introducing extensive interest rate smoothing, the *SITis* regime cannot rely only on the direct exchange rate channel in order to produce CPI inflation stability, as this would have required a very flexible interest rate. Policy is much softer and responds less aggressively to all the state variables (except past interest rate).

When the monetary authorities explicitly stabilizes aggregate production in addition to the CPI inflation rate in the *FIT* regime, policy responds to disequilibrium in the state variables in a stronger and more intuitive way. The interest rate now reacts positively to the output gap in both sectors in order to prevent increased domestic inflation and reduce output fluctuations. Interest rate smoothing continues to reduce the aggressiveness of policy.

3.3.2 Stabilization properties

In table 7 the standard deviations for key variables in each of the inflation targeting regimes are displayed.

Regime	y^T	y^N	y	π^c	π	i	e	s
SIT	8.52	6.59	5.45	0.20	1.92	3.80	9.28	NS
SITis	5.15	3.74	3.13	1.50	1.86	2.62	5.1	NS
FIT	4.73	2.76	2.08	2.58	2.67	4.11	4.24	NS
FITis	4.49	2.74	2.20	2.61	2.77	3.48	4.27	NS

Table 7: CPI Inflation targeting: Unconditional standard deviations in percent

The *SIT* regime exhibits large fluctuations in the level of production, as the direct exchange rate channel is used strongly to stabilize CPI inflation, which produces large real exchange rate fluctuations. Even though there is some degree of interest smoothing in this regime, the solution is close to the solution that would be realized if the interest rate were completely free to move in order to keep CPI inflation constant at its target level. By introducing extensive interest rate smoothing behavior, the *SITis* regime reduces output variability markedly in both sectors and at the aggregate level. Real exchange rate variability drops as the policy of almost exclusively using the direct exchange rate channel is abandoned and thus other transmission channels of monetary policy are used to stabilize CPI inflation. CPI inflation variability increases somewhat and is now at the same level as domestic inflation variability.

By comparing the two flexible inflation targeting regimes, *FIT* and *FITis*, we see that the outcomes are not very different. Thus, interest rate smoothing does not seem to change the results significantly in this regime. However, compared with the strict *SIT/SITis* regimes, output variability drops markedly at the expense of higher CPI inflation variability.

Table 8 shows that production in the two sectors are negatively correlated, which is the same result that was found for nominal exchange rate targeting. The sectoral output variability measure in (19) deviates from aggregate output variability, as aggregate stability is achieved at the expense of stronger sectoral fluctuations.

We find that aggregate output variability underestimates the adjustment costs under inflation targeting as it did for nominal exchange rate targeting. However, compared to nominal exchange rate

Regime	SIT	SITis	FIT	FITis
SOV (%)	7.01	4.05	3.25	3.17
$corr(y^T, y^N)$	-0.055	-0.031	-0.352	-0.203

Table 8: CPI Inflation targeting: Measures of adjustment cost

targeting, the strict regime seem to rely less on intersectoral resource transfers as the correlation coefficient is closer to zero. The flexible regimes are more comparable. Interest smoothing does seem to have a positive effect on sectoral output variability as in the nominal exchange rate targeting case.

3.3.3 Specific shocks

The RMSD measures for the CPI inflation targeting regime for specific shocks are displayed in table 9.

Regime	**CPI inflation targeting**			
RMSD	*SIT*	*SITis*	*FIT*	*FITis*
y^T	$(2.29, 2.64, 2.69, 2.32)$	$(1.10, 1.32, 0.98, 0.85)$	$(0.23, 0.57, 0.98, 0.81)$	$(0.49, 0.93, 0.45, 0.38)$
y^N	$(2.06, 2.66, 2.09, 1.81)$	$(1.33, 1.36, 1.04, 0.90)$	$(1.02, 0.72, 0.75, 0.66)$	$(1.10, 0.59, 0.64, 0.55)$
π^c	$(0.01, 0.01, 0.2, 0.11)$	$(0.28, 0.58, 0.62, 0.53)$	$(0.49, 0.86, 0.62, 1.57)$	$(0.42, 0.74, 0.51, 1.72)$
e	$(2.67, 4.58, 2.79, 2.41)$	$(1.32, 2.52, 1.67, 1.41)$	$(1.23, 1.17, 1.50, 1.24)$	$(1.14, 1.28, 1.59, 1.32)$
π	$(0.48, 1.32, 0.44, 0.40)$	$(0.09, 1.03, 0.77, 0.65)$	$(0.40, 1.44, 1.02, 0.87)$	$(0.31, 1.42, 1.14, 0.96)$
i	$(0.73, 1.32, 1.62, 1.37)$	$(0.32, 0.95, 1.18, 1.00)$	$(0.57, 1.55, 1.83, 1.55)$	$(0.39, 1.32, 1.58, 1.33)$
y	$(1.69, 2.33, 1.64, 1.42)$	$(1.06, 1.28, 0.84, 0.73)$	$(0.82, 0.67, 0.41, 0.37)$	$(0.87, 0.65, 0.44, 0.38)$

Table 9: Responses to specific shocks. There is a vector of four elements associated with every combination of regime and variable. In each vector, the elements represent the RMSD for each variable sorted by type of shock: demand shock, cost-push shock, foreign real interest rate shock and foreign inflation shock.

In the *SIT* regime, the strong reliance upon the direct exchange rate channel produces extensive fluctuations in both the traded and non-traded sectors for all kind of disturbances. The traded sector, which relies upon a stable real exchange rate, is, however, mostly affected by foreign disturbances. Interest rate smoothing reduces output variability for all shocks and has in particular a good influence on the traded sector stability.

The *FIT* regime protects the traded sector well from domestic disturbances compared with the *SIT* regime. Non-traded sector output is also to some degree insulated from all types of shocks. As total output volatility is relatively low compared to sectoral output variability with respect to foreign disturbances, the outcome seems to rely on extensive transfer of resources between the sectors in order to provide aggregate output stability. Interest rate smoothing increases variability in the traded sector for domestic shocks and decreases variability for foreign shocks. Interest smoothing will have much of the same effect in the non-traded sector, but will here also reduce volatility with respect to domestic

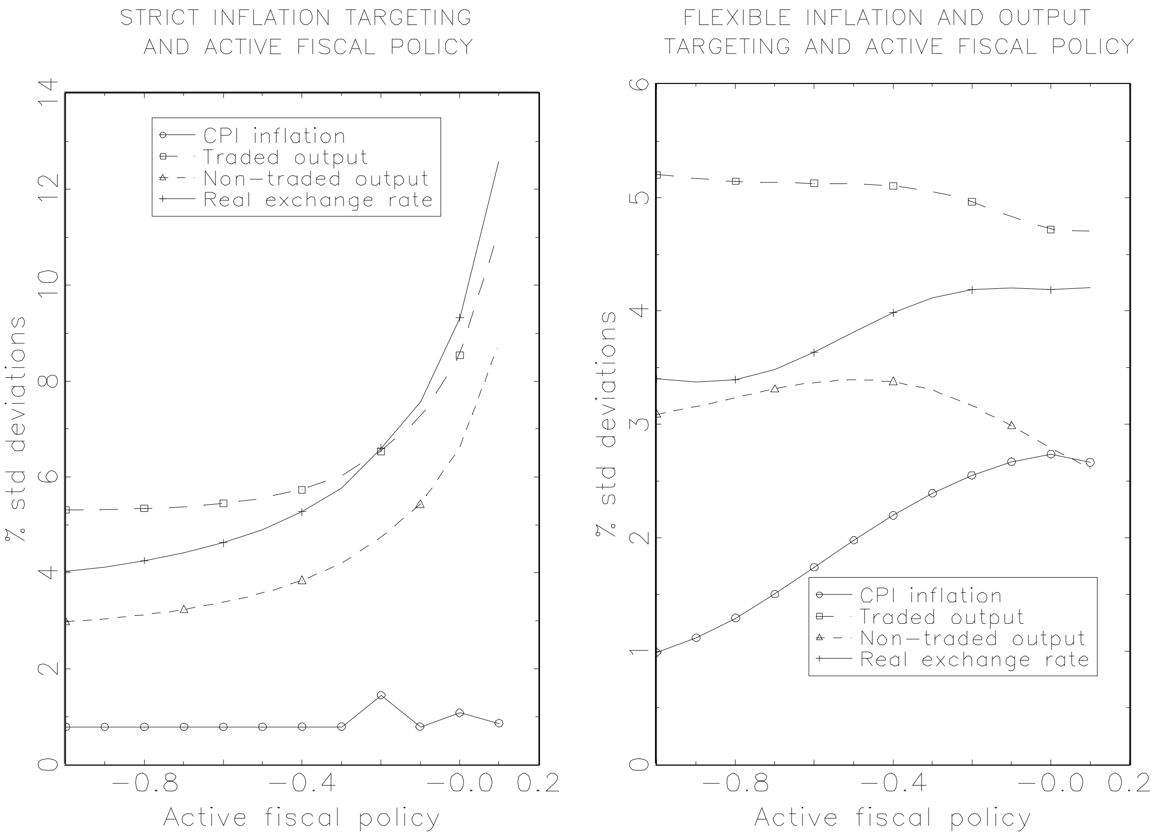

Figure 2: The impact of the degree of fiscal policy activism: τ in (19). (Note: The scale is different among the panels)

supply shocks. Aggregate output is much less affected by interest smoothing, which means that the positive effects from interest smoothing is based upon inter-sectoral resource transfers.

3.3.4 Active fiscal policy

In section 3.2.2, we saw that the outcome of nominal exchange rate targeting is heavily influenced by the degree of fiscal policy stabilization. We now go on to evaluate the effects from fiscal policy under CPI inflation targeting.

As described earlier, we continue to represent fiscal policy by the simple fiscal rule (20). Fiscal policy reacts to disequilibrium in aggregate output and CPI inflation with a one-period lag, but has an instantaneous effect on the non-traded sector production. We vary the coefficient τ in the interval $\tau \in [-1.0, .1]$, where the lower limit represents the most active countercyclical fiscal policy and the higher limit a slightly procyclical policy.

Figure 2 illustrates the effects from systematic fiscal policy in a regime of strict inflation targeting (left) - *SIT* - and in a flexible inflation and aggregate output targeting regime - *FIT*. A number of conclusions can be drawn from these figures. First note that in the *SIT* regime, CPI inflation is stable for all degrees of fiscal activism. Furthermore, an increasing fiscal stabilizing effort has a monotonic variance reducing effect on all the real variables. The results suggest, however, that fiscal activism should be very high in order to provide a reasonably good outcome in terms of stability in real variables.

A comparison of panels a and b in figure 2 shows that the flexible inflation targeting regime response to fiscal activism produces a much more mixed outcome. However, one striking feature is that the *SIT* regime requires a fairly strong fiscal policy activism in order to have an outcome that is comparable to the outcome in the *FIT* regime under neutral fiscal policy. CPI inflation variability decreases with a more active fiscal policy, but traded sector output shows a slightly increasing variability as fiscal policy becomes more active. Non-traded output variability increases with stronger countercyclical fiscal policy up to a certain point, and thereafter variability is moderately reduced. However, except for CPI inflation variability, most variables are only moderately affected by fiscal policy.

4 Conclusions

The paper has analyzed alternative monetary policy rules within a model with a traded and a non-traded sector. Two main types of rules have been considered; CPI inflation targeting and nominal exchange rate targeting. The rationale for considering the traded and the non-traded sectors separately, and not just the economy as a whole, is that there are reasons to believe that sector-specific fluctuations have welfare effects beyond those of aggregate fluctuations. For example, adjustment costs in production might lead to welfare gains from stabilizing each sector if resources cannot be transferred between the sectors free of costs. Our results seem to indicate that the choice of monetary policy target affects the two sectors rather differently. Our view that the two sectors should be treated separately when evaluating policy rules, is therefore supported by the results.

If the main policy objectives are to stabilize output and CPI inflation, there seems to be a clear case for choosing a form of CPI inflation targeting in our model. However, the results also indicate that one should avoid a policy of keeping either CPI inflation or the nominal exchange rate fixed, as this would mean strong output volatility. In the nominal exchange rate targeting regime, a fixed exchange rate would even produce explosive oscillations. Output stability is more successfully achieved in both the traded and the non-traded sector under flexible CPI inflation targeting compared with the equivalent nominal exchange rate targeting rule. An important conclusion in our model is also that traded sector output is, in general, less stable than non-traded sector output - irrespective of the choice of regime.

As would be expected, active fiscal countercyclical policy helps stabilizing the economy in all the regimes. The strict regimes benefits in particular when there is a high degree of fiscal countercyclical policy. For strict nominal exchange rate targeting, stabilizing fiscal policy induces asymptotic stability, and the monetary authorities are able to stabilize the nominal exchange rate completely. However, a completely fixed nominal exchange rate creates a need for (unrealistically?) strong fiscal activism in order to replace the stabilizing effects from monetary policy. Even with a very strong countercyclical fiscal policy, it cannot replace the stabilizing effects of allowing some degree of nominal exchange rate fluctuations in order to stabilize output in both sectors. We are left with the conclusion that even in a nominal exchange rate targeting regime, one should allow the nominal exchange rate to fluctuate within large bands if output stability is considered important.[16].

A strong form of fiscal policy activism is also needed for stabilizing the economy in the strict CPI inflation targeting (SIT) regime. As fiscal policy activism is increased, most real variables are stabilized more quickly in this regime than in the SET-regime, and CPI inflation variability is kept very low.

The most stable regime is the flexible CPI inflation targeting regime. In this regime, monetary policy provides the highest degree of output stability, and CPI inflation variability is lower than in any of the nominal exchange rate targeting regimes. When fiscal policy participates in stabilizing the economy, real stability is not much affected, but CPI inflation variability is reduced considerably.

With our dynamic model, we do not find that cost-push shocks in general favor nominal exchange rate targeting and demand shocks favor inflation targeting, as found in e.g. the more static models of Rødseth (1996) and Røisland and Torvik (1999). This suggests that the dynamic stabilization properties of inflation targeting may be superior to the dynamic properties of exchange rate targeting.

If inter-sectoral resource transfers involve costs, as suggested in the introduction, CPI inflation targeting seems preferable to nominal exchange rate targeting. However, if there are large costs of changing the interest rate so that the central bank smooth their interest rate setting, the choice of targeting regime becomes less important for stabilization considerations.

[16]The European Exchange Rate Mechanism allowed for exchange rate volatility by having large tolerance bands around their target exchange rate. These bands could allow the national central bank to have some influence on domestic monetary policy by allowing some fluctuation. However, it can also be argued that these bands were mainly there as a shock absorber for policy non-credibility effects and varying risk premia.

A The discretionary optimization procedure

The optimization procedure is described in Backus and Driffill (1986) and Søderlind (1999)[17] . Here we review this method with respect to our two-sectoral model. The model can be written conveniently on the following form:

$$X_{t+1} = AX_t + Di_t + U_{t+1} \tag{24}$$

where

$$\begin{aligned}
A &= \begin{bmatrix} \rho_T - \alpha\gamma\eta & -\alpha\gamma(1-\eta) & -\alpha & -\alpha & \alpha\rho_w^* & 0 & \alpha\theta & 0 & \alpha(1-\theta(1+\lambda)) \\ \beta_1\gamma\eta & \rho_N + \beta\gamma(1-\eta) & \beta_1 & 0 & 0 & 0 & -\beta_1\theta & 0 & \beta_1\theta(1+\lambda)+\beta_2 \\ \gamma\eta & \gamma(1-\eta) & 1 & 0 & 0 & 0 & -\theta & 0 & \theta(1+\lambda) \\ 0 & 0 & 0 & \rho_r^* & \rho_w^*(\rho_w^* - \rho_i^*) & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho_w^* & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 & -1 & 0 & -1 & 1 & 1 \\ -\gamma\eta & -\gamma(1-\eta) & -1 & -1 & \rho_w^* & 0 & \theta & 0 & 1-\theta(1+\lambda) \end{bmatrix} \\
X_{t+1} &= \begin{bmatrix} y_{t+1}^T & y_{t+1}^N & \pi_{t+1} & i_{t+1}^* & \pi_{t+1}^* & i_t & e_t & s_t & e_{t+1|t} \end{bmatrix}' \\
X_t &= \begin{bmatrix} y_t^T & y_t^N & \pi_t & i_t^* & \pi_t^* & i_{t-1} & e_{t-1} & s_{t-1} & e_t \end{bmatrix}' \\
D &= \begin{bmatrix} \alpha & -\beta_1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}' \text{ and} \\
U_{t+1} &= \begin{bmatrix} u_{t+1}^T & u_{t+1}^N & u_{t+1}^w & u_{t+1}^{r^*} + \rho_w^* u_{t+1}^{\pi^*} & u_{t+1}^{\pi^*} & 0 & 0 & 0 & 0 \end{bmatrix}'
\end{aligned}$$

Note that the X matrix is ordered in such a way that the forward looking variable, e_t, is the last variable.

Our objective function in (14) can be written in a more general form:

$$J_t = E_t \sum_{s=0}^{\infty} \begin{bmatrix} X_{t+s}' & i_{t+s} \end{bmatrix} \begin{bmatrix} Q_{9x9} & U_{9x1} \\ U_{1x9}' & R_{1x1} \end{bmatrix} \begin{bmatrix} X_{t+s} \\ i_{t+s} \end{bmatrix} \tag{25}$$

where

$$Q_{9x9} = \begin{bmatrix} T_{\pi^C} \\ T_\pi \\ T_{\Delta S} \\ T_S \\ T_y \\ T_{i-} \end{bmatrix}' \begin{bmatrix} a_1 & 0 & 0 & 0 & 0 & 0 \\ 0 & a_2 & 0 & 0 & 0 & 0 \\ 0 & 0 & a_3 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_4 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_5 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_6 \end{bmatrix} \begin{bmatrix} T_{\pi^C} \\ T_\pi \\ T_{\Delta S} \\ T_S \\ T_y \\ T_{i-} \end{bmatrix} \tag{26}$$

where T_x defines the relationships between the target variables x and the state-variable vector X. These matrixes are in our case:

$$\begin{aligned}
\pi^C &= T_{\pi^C} X = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & -\Theta & 0 & \Theta \end{bmatrix} X \\
\pi^S &= T_{\pi^S} X = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} X \\
\Delta s &= T_{\Delta S} X = \begin{bmatrix} 0 & 0 & 1 & 0 & -1 & 0 & -1 & 0 & 1 \end{bmatrix} X \\
s &= T_S X = \begin{bmatrix} 0 & 0 & 1 & 0 & -1 & 0 & -1 & 1 & 1 \end{bmatrix} X \\
y &= T_y X = \begin{bmatrix} \eta & 1-\eta & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} X \\
\Delta i &= i_t + T_{i-} X = i_t + \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{bmatrix} X
\end{aligned}$$

[17]We are very indebted to Paul Söderlind for presenting this solution method to us.

and $U_{9x1} = T'_{i-}a_6$ and $R_{1x1} = a_6$.

Our problem is now to minimize (25) given (24). We go on to partition the X matrix: $X_t = \begin{bmatrix} x_{1t} & e_t \end{bmatrix}'$. Since our loss function is quadratic, the value function is quadratic and the Bellman equation can then be written accordingly:

$$\begin{aligned} J_t &= \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix}' \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix} + 2x'_{1t}U_1 i_t + i'_t R i_t + \\ &\quad \beta E_t \left[x'_{1t} V_{t+1} x_{1t} + v_{t+1} \right] \end{aligned} \tag{27}$$

where V_{t+1} and v_{t+1} - the parameters in the value function - so far are unspecified. The Q matrixes are given by (26) and $U_1 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -a_6 & 0 & 0 \end{bmatrix}'$.

The expectation of the forward looking variable can be written as a linear function of the expectation of the predetermined variables:

$$e_{t+1|t} = C_{t+1} x_{t+1|t}$$

where C_{t+1} is a known vector of parameters that remains to be solved for. By using this relationship and taking expectations in (24), we get[18]

$$\begin{aligned} \begin{bmatrix} x_{1t+1|t} \\ e_{t+1|t} \end{bmatrix} &= \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix} + \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} i_t \\ &\Rightarrow \\ \begin{bmatrix} I \\ C_{t+1} \end{bmatrix} x_{1t+1|t} &= \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix} + \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} i_t \end{aligned}$$

and after expressing the non-predetermined variables as explicit functions of the predetermined and instrument variables, you get:

$$\begin{aligned} \begin{bmatrix} I & -A_{12} \\ C_{t+1} & -A_{22} \end{bmatrix} \begin{bmatrix} x_{1t+1|t} \\ e_t \end{bmatrix} &= \begin{bmatrix} A_{11} \\ A_{21} \end{bmatrix} x_{1t} + \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} i_t \\ &\Rightarrow \\ \begin{bmatrix} x_{1t+1|t} \\ e_t \end{bmatrix} &= \begin{bmatrix} I & -A_{12} \\ C_{t+1} & -A_{22} \end{bmatrix}^{-1} \left(\begin{bmatrix} A_{11} \\ A_{21} \end{bmatrix} x_{1t} + \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} i_t \right) \end{aligned}$$

The real exchange rate can be extracted from the above system of equations:

$$\begin{aligned} e_t &= (A_{22} - C_{t+1}A_{12})^{-1}(C_{t+1}A_{11} - A_{21})x_{1t} + \\ &\quad (A_{22} - C_{t+1}A_{12})^{-1}(C_{t+1}D_1 - D_2)i_t \\ &= H_{1t}x_{1t} + K_{1t}i_t \end{aligned} \tag{28}$$

where H_{1t} and K_{1t} is defined accordingly. Now using (28) in (24) we can extract an expression for the backward looking variables:

$$\begin{aligned} x_{1t+1} &= (A_{11} + A_{12}H_{1t})x_{1t} + (D_1 + A_{12}K_{1t})i_t + u_{1t+1} \\ &= H_{2t}x_{1t} + K_{2t}i_t + u_{1t+1} \end{aligned} \tag{29}$$

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[18] $A_{11} = \begin{bmatrix} \rho_T & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta\gamma\eta & \rho_S + \beta\gamma(1-\eta) & \beta\rho_w & 0 & 0 & 0 & 0 & 0 \\ \gamma\eta & \gamma(1-\eta) & \rho_w & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_{i^*} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho_{w^*} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & -1 & 0 & -1 & 1 \end{bmatrix}$

$A_{12} = \begin{bmatrix} 0 & 0 & \lambda\theta & 0 & 0 & 0 & 0 & 1 \end{bmatrix}'$

$A_{21} = \begin{bmatrix} \alpha\gamma\eta & \alpha\gamma(1-\eta) & \alpha\rho_w & \alpha & -\alpha\rho_{w^*} & 0 & 0 & 0 \end{bmatrix}$

$A_{22} = -\alpha$

By using (28) in the instantaneous period t loss of (27) and denoting this by j_t, it becomes:

$$\begin{aligned} j_t &= \begin{bmatrix} x_{1t} \\ H_{1t}x_{1t} + K_{1t}i_t \end{bmatrix}' \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ H_{1t}x_{1t} + K_{1t}i_t \end{bmatrix} + 2x_{1t}'U_1 i_t + i_t' R i_t \\ &= x_{1t}' \left[Q_{11} + H_{1t}'Q_{21} + Q_{12}H_{1t} + H_{1t}'Q_{22}H_{1t} \right] x_{1t} + \\ &\quad x_{12}' \left[Q_{12}K_{1t} + H_{1t}'Q_{22}K_{1t} + U_1 \right] + \\ &\quad i_t' \left[K_{1t}'Q_{21} + K_{1t}'Q_{22}H_{1t} + U_1' \right] x_{1t} + \\ &\quad i_t \left[R + K_{1t}'Q_{22}K_{1t} \right] i_t \\ &= x_{1t}'Q^* x_{1t} + 2x_{1t}'O^* i_t + i_t' R^* i_t \end{aligned}$$

By substituting this expression into (27) and using (29) you eventually get:

$$\begin{aligned} J_t &= x_{1t}'Q^* x_{1t} + 2x_{1t}'O^* i_t + i_t' R^* i_t + \\ &\quad \beta E_t \left[(H_{2t}x_{1t} + K_{2t}i_t + u_{1t+1})' V_{t+1} (H_{2t}x_{1t} + K_{2t}i_t + u_{1t+1}) + v_{t+1} \right] \end{aligned}$$

which should be minimized with respect to i_t. The first order condition is:

$$2(R^* + \beta K_{2t}' V_{t+1} K_{2t}) i_t + 2(O_t^{*\prime} + \beta K_{2t}' V_{t+1} H_{2t}) x_{1t} = 0$$

which means that the optimal rule for the interest rate is:

$$\begin{aligned} i_t &= -(R^* + \beta K_{2t}' V_{t+1} K_{2t})^{-1} (O_t^{*\prime} + \beta K_{2t}' V_{t+1} H_{2t}) x_{1t} \\ &= -F_t x_{1t} \end{aligned} \tag{30}$$

where F is defined accordingly.

We can now use (30) in (28) in order to get:

$$\begin{aligned} e_t &= H_{1t}x_{1t} + K_{1t}i_t \\ &= (H_{1t} - K_{1t}F_t) x_{1t} \end{aligned}$$

which means that $C_{t+1} = (H_{1t} - K_{1t}F_t)$. The optimal value function can now be written in terms of the predetermined state variables only, x_{1t} :

$$\begin{aligned} J_t^* &= x_{1t}'Q^* x_{1t} - 2x_{1t}'O^* F_t x_{1t} + x_{1t}'F'R^* F x_{1t} + \\ &\quad \beta E_t \left[((H_{2t} - K_{2t}F_t)x_{1t} + u_{1t+1})' V_{t+1} ((H_{2t} - K_{2t}F_t)x_{1t} + u_{1t+1}) + v_{t+1} \right] \\ &= x_{1t}' \left[Q_t^* - O_t^* F_t - F_t' O_t^{*\prime} + F_t' R_t^* F_t + \beta (H_{2t} - K_{2t}F_t)' V_{t+1} (H_{2t} - K_{2t}F_t) \right] x_{1t} + \\ &\quad E_t u_{1t+1}' \beta V_{t+1} u_{1t+1} + \beta E_t v_{t+1} \end{aligned}$$

which gives an equation for $V_{t+1} = \left[Q_t^* - O_t^* F_t - F_t' O_t^{*\prime} + F_t' R_t^* F_t + \beta (H_{2t} - K_{2t}F_t)' V_{t+1} (H_{2t} - K_{2t}F_t) \right]$.

The above procedure is recursive and describes an iterative process. When the process converges, we have found the path for the interest rate as well as the non-exploding path for the exchange rate:

$$\begin{bmatrix} i_t \\ e_t \end{bmatrix} = \begin{bmatrix} -F \\ C \end{bmatrix} x_{1t}$$

From (24) the path for the predetermined variables can also be calculated accordingly:

$$x_{1t+1} = (A_{11} + A_{12}C - B_1 F) x_{1t} + U_{t+1}$$

B The long interest rate

In this section we describe the changes to some of the conclusion in our papers when the long interest rate affects aggregate demand instead of the short one. We assume that the long interest rate is formed according to the expectational hypothesis. The T-year real interest rate is thus:

$$R_t = \frac{1}{T}\sum_{s=0}^{T} r_{t+s|t} \tag{31}$$

By iterating on the real uncovered interest parity (7), you get that:

$$e_t = e_{T+1|t} - \sum_{s=t}^{T} r_{s|t} + \sum_{s=t}^{T} r^*_{s|t}$$

and assuming that $\lim_{T\to\infty} e_{T+1|t} = 0$ then

$$e_t = -\sum_{s=t}^{\infty} r_{s|t} + \sum_{s=t}^{\infty} r^*_{s|t} \tag{32}$$

Assuming that the short real interest rate converges quickly, the long real interest rate in (31) can be approximated by

$$R_t \approx \frac{1}{T}\sum_{s=0}^{\infty} r_{t+s|t} \tag{33}$$

and by similar arguments, the foreign long interest rate can be approximated keeping in mind that the foreign short interest rate follows an AR(1) process

$$\begin{aligned} R^*_t &\approx \frac{1}{T}\sum_{s=0}^{\infty} r^*_{t+s|t} \\ &= \frac{1}{(1-\rho_{r^*})}\frac{r^*_t}{T} \end{aligned} \tag{34}$$

Using (33) and (34) in combination with (32) yields:

$$e_t \approx -TR_t + T\frac{1}{1-\rho^*_r} r^*_t$$

By rearranging, we get:

$$R_t \approx \frac{1}{T}\left[\frac{1}{1-\rho^*_r} r^*_t - e_t\right] \tag{35}$$

the long real interest rate is determined by the average time to maturity, the short foreign interest rate and the real exchange rate. We have rather arbitrarily set $T = 7$ to represent the average time to maturity.

If we assume that both the short and the long interest rate equally contribute to demand for non-traded goods, then we can replace the equation (2) by:

$$y^N_{t+1} = \rho_s y^N_t - \frac{1}{2}\beta(r_t + R_t) + \beta_2 e_t + u^N_{t+1}$$

Regime	y^T	y^N	y	π^c	π	i	e	s
SIT	6.44	4.42	3.67	0.19	1.56	3.28	6.51	∞
FIT	4.60	2.92	2.29	1.93	1.98	3.58	4.29	∞
SET	13.02	6.81	6.86	4.79	6.84	3.71	15.44	0.03
FET	6.59	4.02	3.56	3.29	3.74	3.87	6.33	4.57

Table 10: Unconditional standard deviations in percent

where R_t is given by (35).

This setup gives the following unconditional standard deviations in percent

Table 10 shows the unconditional standard deviations of key variables in our model. If we compare these results with the results in our original model, there are some features that are worth mentioning.

Strict inflation targeting now produces a better equilibrium in terms of lower output variability in both sectors - and is much more viable than in the original model. The trade-off between inflation and output variability is not as steep as before since manipulation of the real exchange rate that is required to stabilize CPI inflation has a greater impact on production. A real appreciation that comes about because of a need to reduce CPI inflation, reduces domestic demand to a greater extent through a rising long real interest rate - which has an impact on the underlying domestic inflation.

A fixed nominal exchange rate is a stable policy alternative in the above model, and hence, strict nominal exchange rate targeting produces this outcome. The outcome in terms of output and inflation variability is however much worse than in the original model. Since domestic demand now relies much less upon the short real interest rate, the Walters effect does not cause an unstable model. However, due to the possibility of completely fixing the exchange, exasperate the remaining Walters effects features in our model and output becomes more volatile.

There is now a bigger difference between the strict and flexible nominal exchange rate regimes since the latter strategy deals more effectively with the Walters effect.

Flexible inflation targeting still remains the best regime in terms of output variability and compare to our original model, CPI inflation variability is markedly reduced.

C Tables and figures

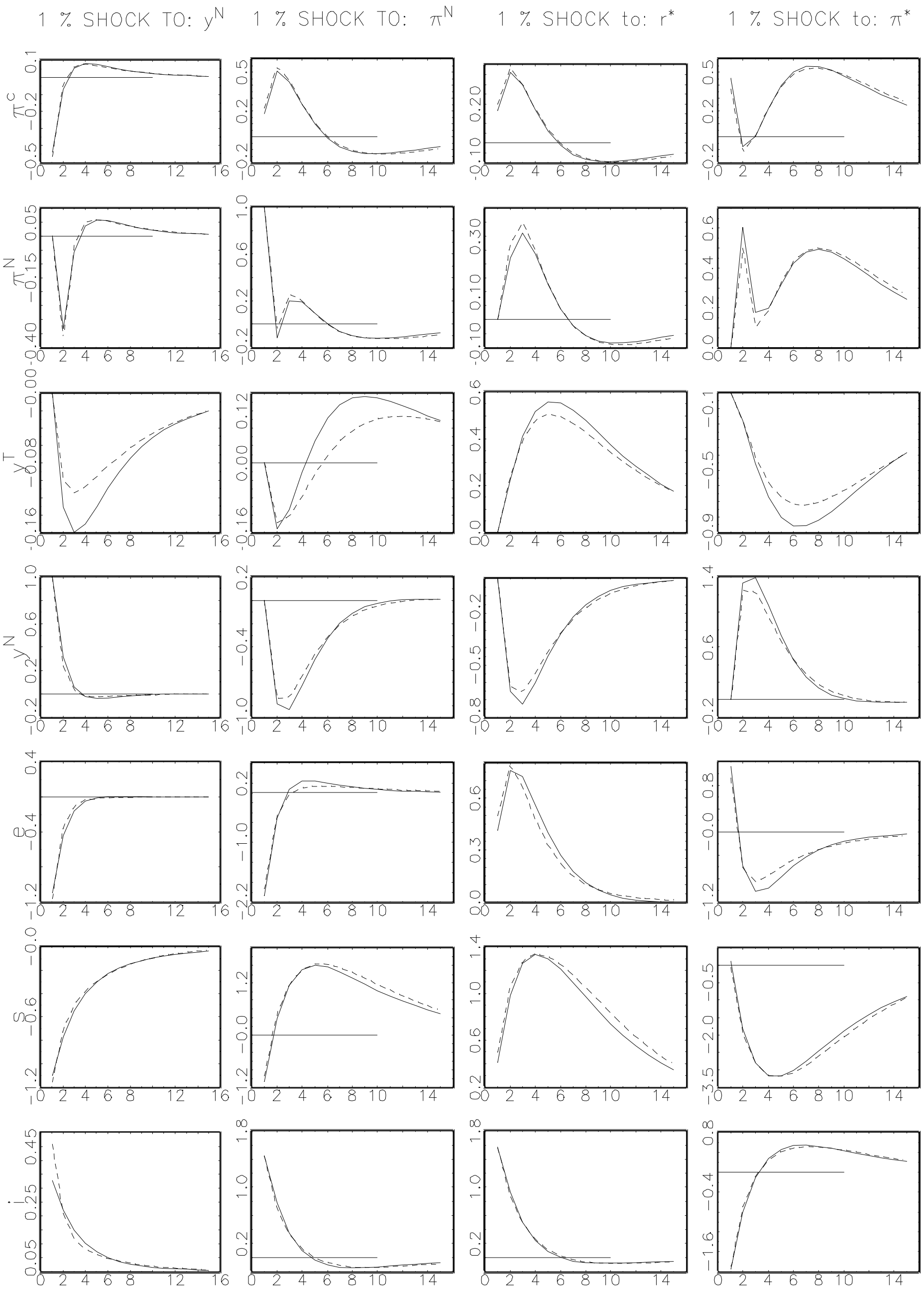

Figure 3: Strict (Solid line) and flexible nominal exchange rate targeting

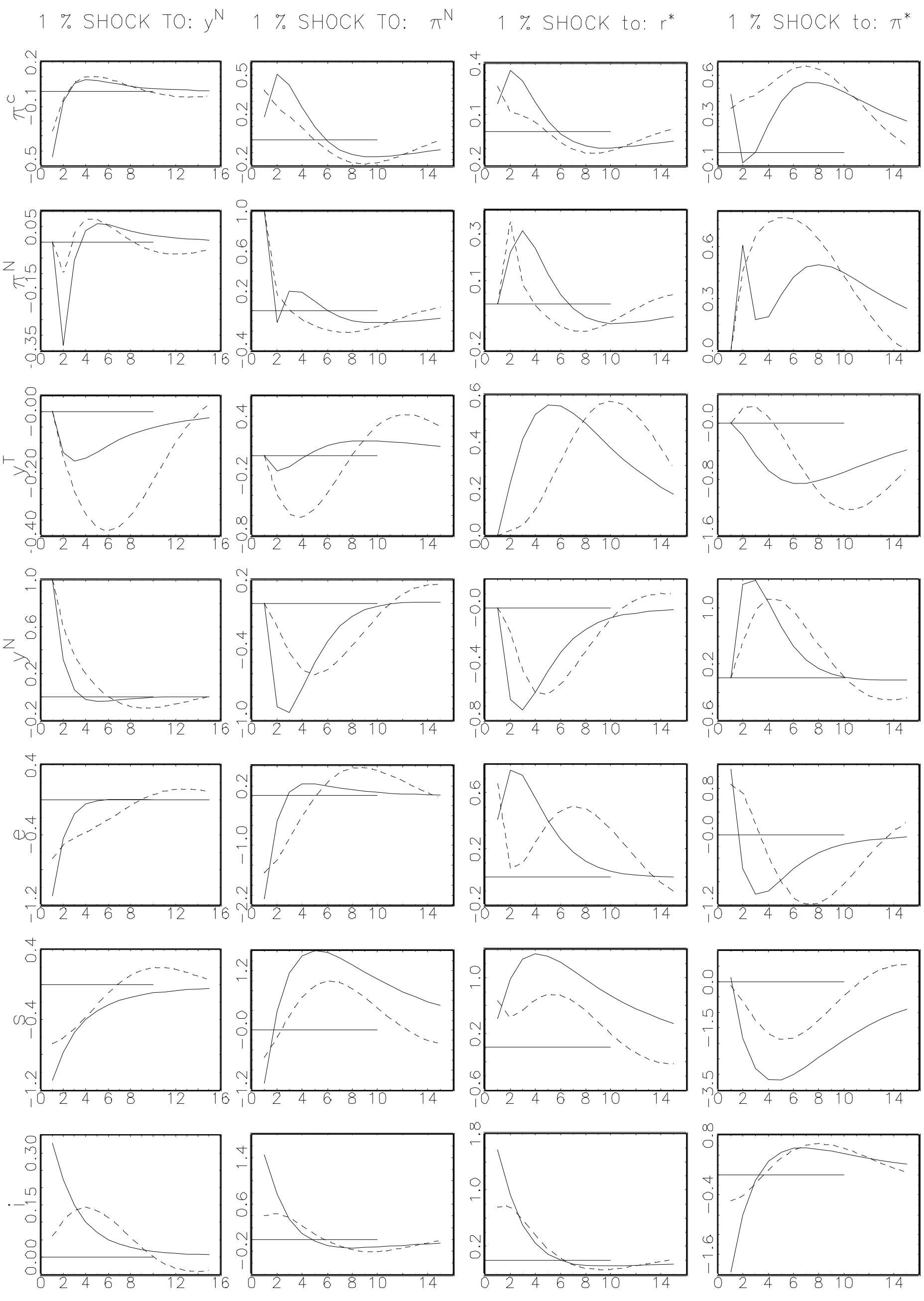

Figure 4: Impulse responses: Nominal exchange rate targeting with (SETIS - solid line) and without (SET) interest rate smoothing.

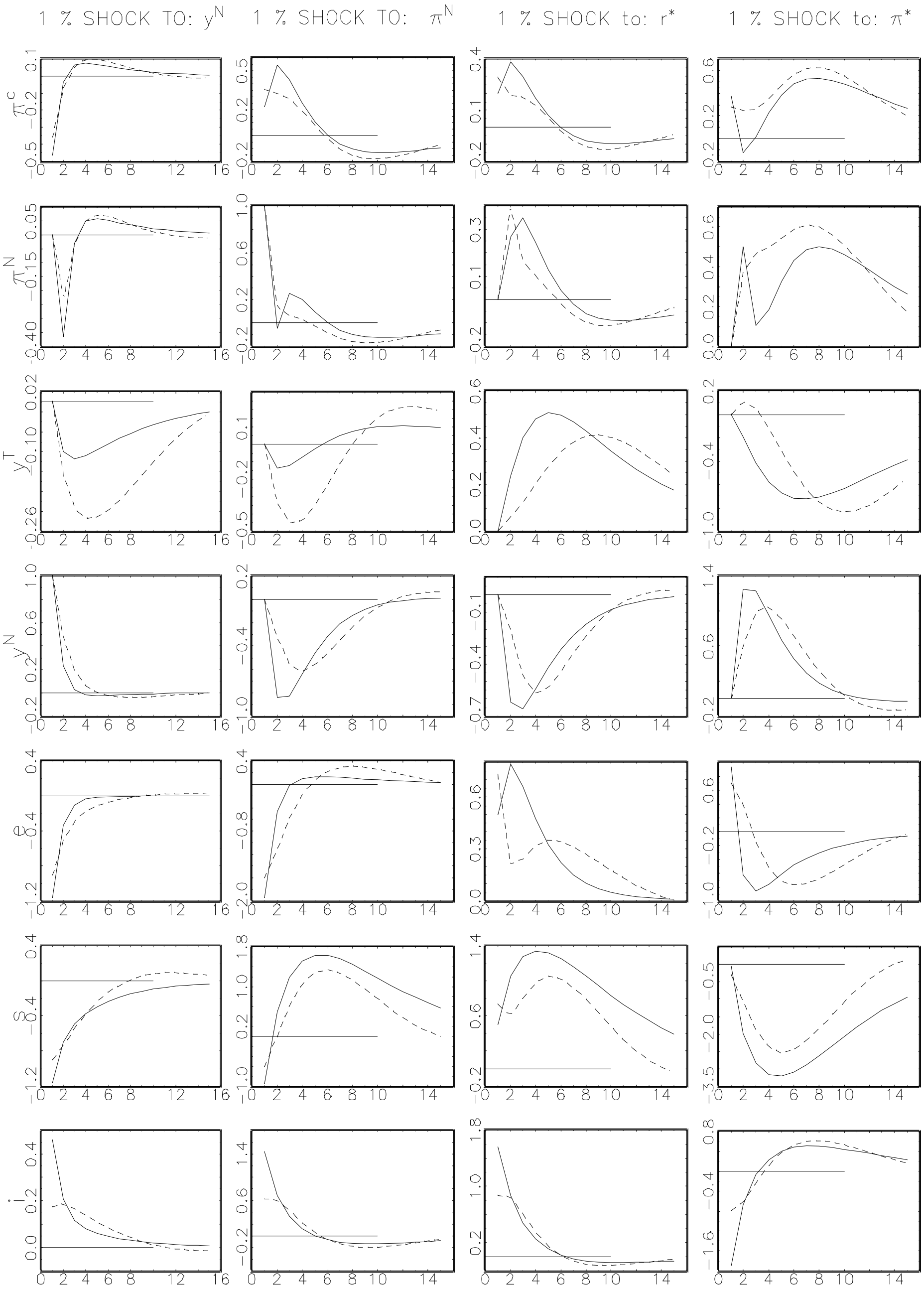

Figure 5: Impulse responses: Flexible nominal exchange rate targeting with (FETIS - solid line) and without (FET) interest rate smoothing.

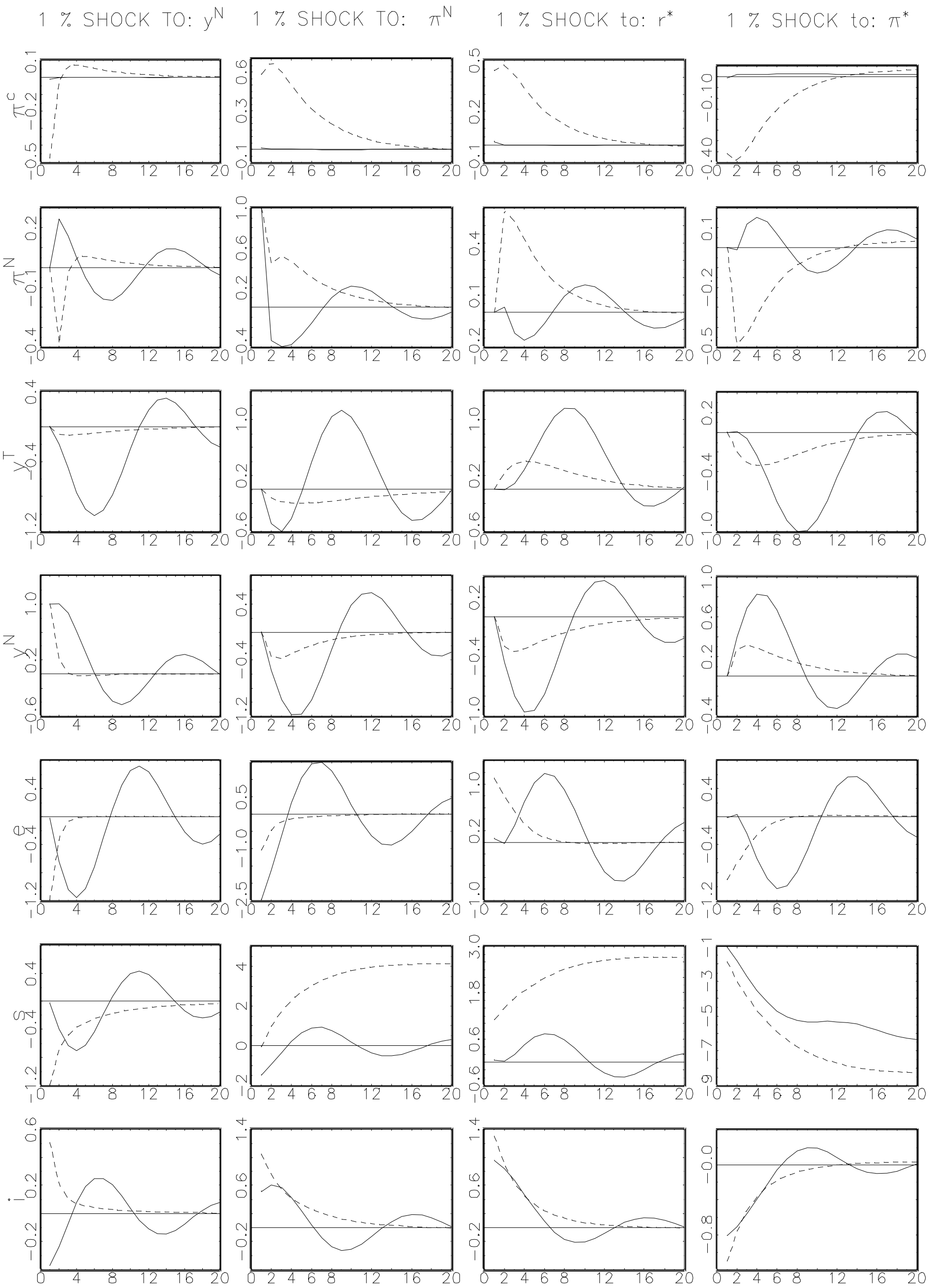

Figure 6: CPI inflation targeting with (FIT- solid line) and without (SIT) output targeting

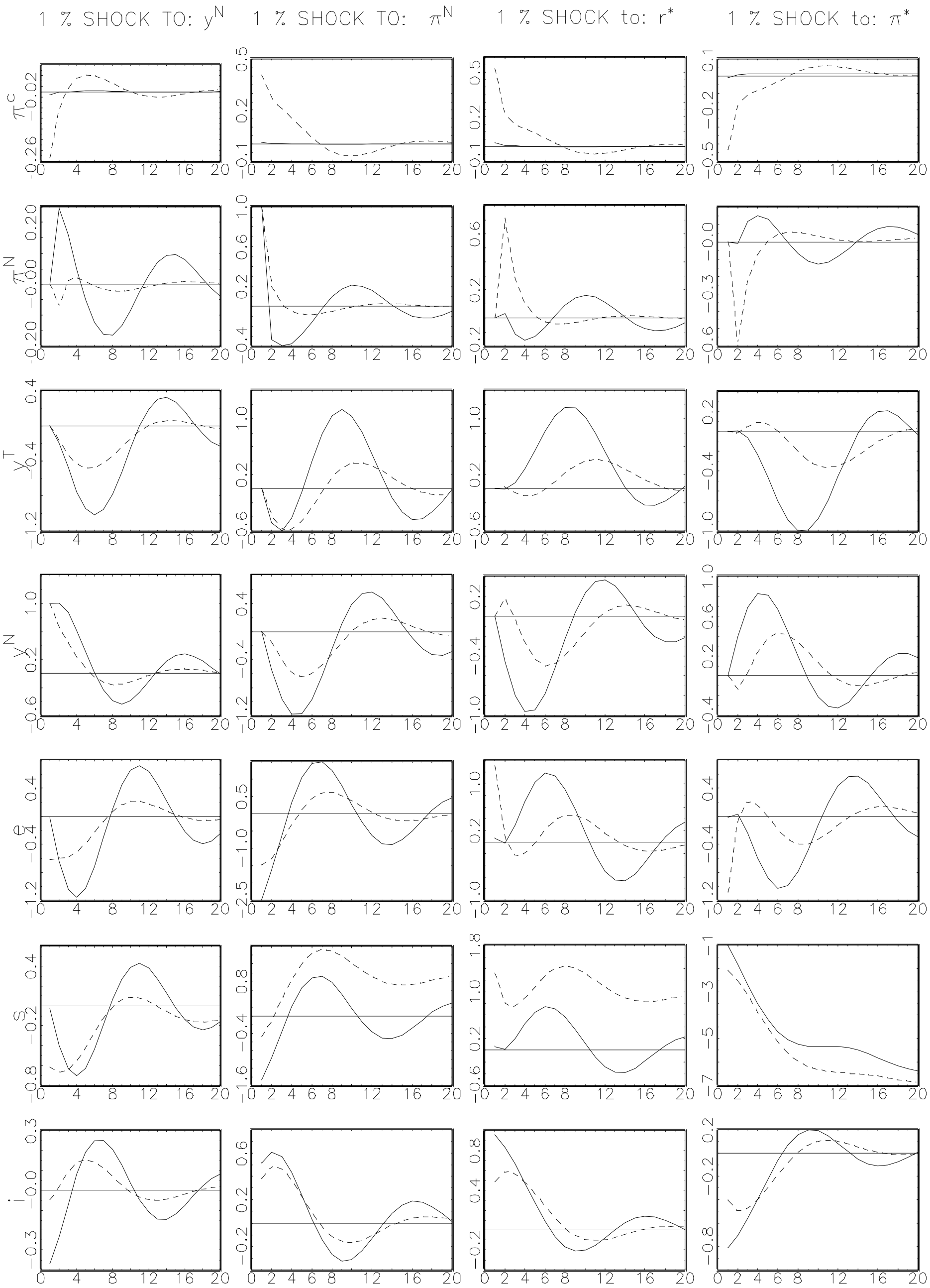

Figure 7: Strict CPI inflation targeting with (SITIS) and without (SIT - solid line) interest rate smoothing

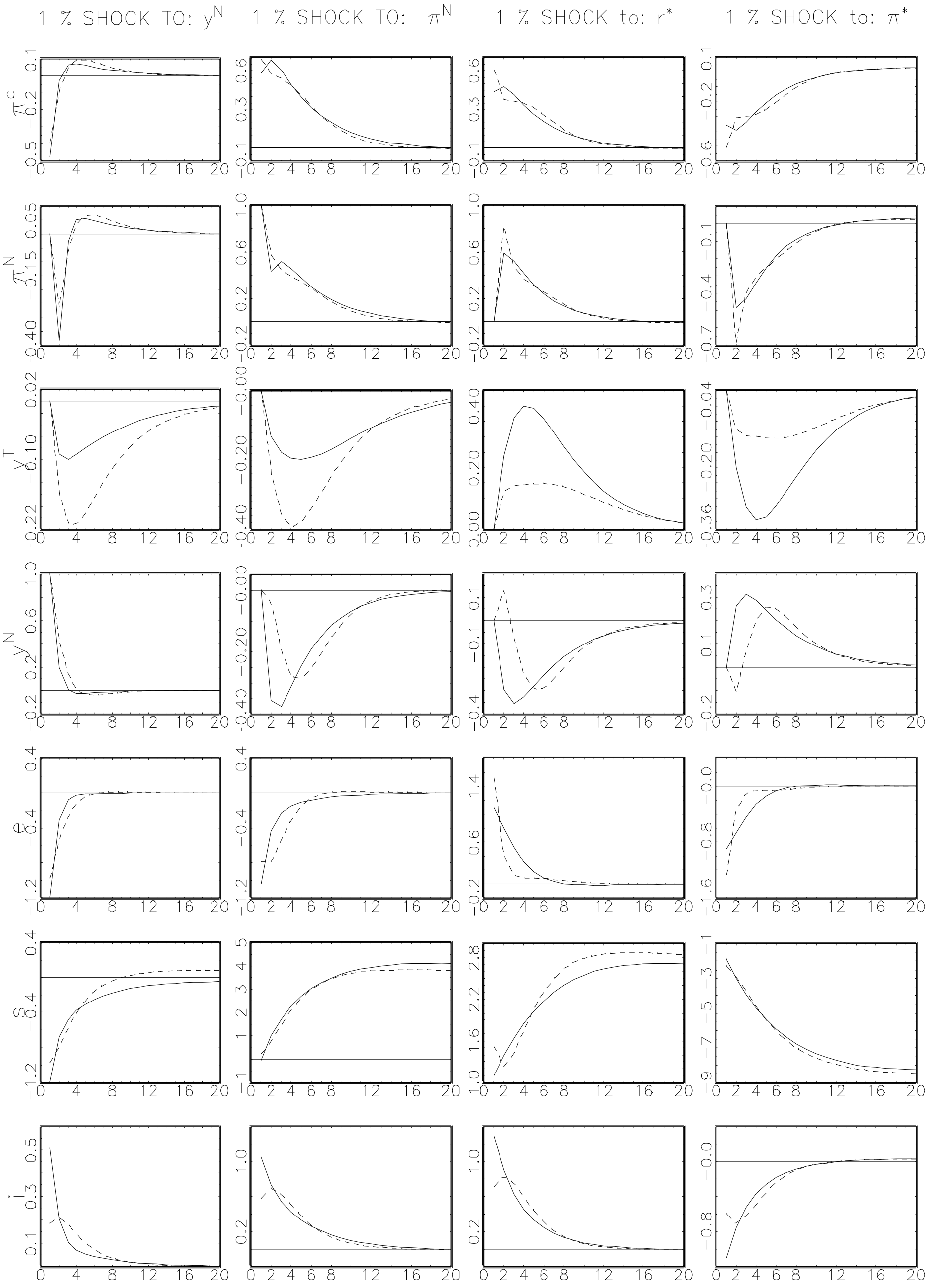

Figure 8: Flexible CPI inflation and output targeting with (FITIS - solid line) and without (FIT) interest rate smoothing.

References

Backus, David and John Driffill (1986). "The Consistency of Optimal Policy in Stochastic Rational Expectations Models." CEPR Discussion Paper No. 124.

Ball, Laurence (1998). "Policy Rules for Open Economies." NBER Working Paper No. 6760.

Batini, Nicoletta and Andrew Haldane (1998). "Forward-Looking Rules for Monetary Policy." NBER Working Paper No. W6543.

Bernanke, Ben S. and Frederic S. Mishkin (1997). "Inflation Targeting: A New Framework for Monetary Policy?" *Journal of Economic Perspectives*, 9:27–48.

Bharucha, Nargis and Christopher Kent (1998). "Inflation Targeting in a Small Open Economy." Reserve Bank of Australia Discussion Paper No. 9807.

Blake, Andrew P. (1992). "Time Consistent Mixed Precommitment Macropolicy." National Institute of Economic and Social Research Discussion Paper no. 7.

Brainard, William (1967). "Uncertainty and the Effectiveness of Policy." *American Economic Review*, 57:411–425.

Chapple, S. (1994). "Inflation Targeting and the Impact on the Tradeable Sector." Working paper no 94/7, New Zealand Institute of Economic Research.

Cohen, Michael and Philippe Michel (1988). "How Should Control Theory Be Used to Calculate a Time-Consistent Government Policy." *Review of Economic Studies*, 55:263–74.

Currie, David and Paul Levine (1993). *The Design of Feedback Rules in Linear Stochastic Rational Expectations Models*. Cambridge University Press.

Evjen, Snorre and Ragnar Nymoen (1997). "Har Solidaritetsalternativet Bidratt Til Lav Lønnsvekst I Industrien?" *Sosialøkonomen*, 2:10–19.

Fuhrer, Jeffrey C. and George R. Moore (1995). "Inflation Persistence." *Quarterly Journal of Economics*, 110:127–59.

Hall, Stephan and Jamex Nixon (1997). *Controlling Inflation: Modelling Monetary Policy in the 1990s*, chap. 10.

Holden, Steinar (1998). "Wage Setting under Different Monetary Regimes." Mimeo University of Oslo.

Holden, Steinar and Ragnar Nymoen (1998). "Measuring Structural Unemployment: Is There a Rough and Ready Answer?" Working paper, University of Oslo.

Lawler, Phillip (1998). "Union Wage Setting and Exchange Rate Policy." Working paper, University of Wales Swansea.

McCallum, Bennett T. (1997). "Issues in the Design of Monetary Policy Rules." NBER Working Paper No. 6016.

McCallum, Bennett T. and Edward Nelson (1998). "Nominal Income Targeting in an Open-Economy Optimizing Model." Paper presented at the Sveriges Riksbank and IIES Conference on Monetary Policy Rules in Stockholm, 12-13 June.

Naug, Bjørn and Ragnar Nymoen (1995). "Pricing to Market in a Small Open Economy." *Scandinavian Journal of Economics*, 98(3):329–50.

Rødseth, Asbjørn (1996). "Exchange Rate versus Price Level Targets and Output Stability." *The Scandinavian Journal of Economics*, 98.

Røisland, Øistein and Ragnar Torvik (1999). "Exchange Rate Targeting versus Inflation Targeting: A Theory of Output Fluctuations in Traded and Non-Traded Sectors." In Norges Bank Working Paper series 1/99.

Søderlind, Paul (1999). "Algorithms for RE Macromodels with Optimal Policy." Lecture notes, Stockholm School of Economics.

Svensson, Lars E.O. (1997). "Inflation Targeting: Some Extensions." NBER Working Paper No. 5962.

— (1998). "Open-Economy Inflation Targeting." NBER Working Paper No. 6545.

Walsh, Carl E. (1990). *Issues in the Choice of Monetary Policy Operation Procedures*, chap. 2, pp. 8–37. The AEI Press.

Walters, Alan (1986). *Britain's Economic Renaissance*. Oxford University Press.