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The Choice of Monetary Policy Regime for Small Open Economies

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ABSTRACT. – Inflation targeting and exchange rate targeting, including monetary union, are analyzed in a simple, estimated macroeconomic model of a small open economy. Flexible inflation targeting produces lower nominal and real variability than exchange rate targeting, because the latter gives rise to persistent oscillations in the real interest rate and the real exchange rate due to the '*Walters' effect* '. We find, however, that with commitment to simple instrument rules, the performance of flexible inflation targeting can almost be matched

Le choix de régime politique monétaire pour une petite économie ouverte

RÉSUMÉ. – Les régimes de politique monétaire ayant pour objectif l'inflation ou le taux de change, y compris l'union monétaire, sont analysés dans un simple modèle macroéconométrique d'une petite économie ouverte. Un objectif d'inflation atteint d'une manière flexible produit moins de variabilité nominale et réelle qu'un objectif de taux de change, parce que celui-ci mène à des oscillations persistantes du taux de l'intérêt et du taux de change causées par l'effet suggéré par *Walters*. Pourtant, nous trouvons qu'en s'engageant à suivre une simple règle sur les instruments de politique monétaire, on obtient une performance de l'économie presque comparable à celle obtenue pour un objectif d'inflation.

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1 Introduction

There has been a tendency in recent years to abandon intermediate targets and steer monetary policy directly toward its ultimate goal of price stability, *ie,* low and stable inflation.[1] Since central banks have imperfect control over inflation, there is then a less direct relationship between monetary policy decisions and the target variable. This has triggered a renewed interest in monetary policy rules as guidelines 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 mainly affects inflation indirectly through its 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 price of imported goods.

This paper analyzes the stabilizing properties of alternative monetary policy regimes using a small, estimated open economy model. It may be argued that in practice there are only two alternative monetary policy regimes for small open economies. First, the country can peg its currency to another country's currency, either through exchange rate targeting, as in Denmark and Norway, or by abandoning its national currency and entering a monetary union, such as '*EMU*'. Second, the country can conduct some form of independent inflation targeting, as in Sweden, the United Kingdom and Switzerland. This paper considers both strict and flexible versions of the alternative regimes. Strict exchange rate targeting may be interpreted as being part of a monetary union, conducting monetary policy through a currency board, or having a target-zone regime with relatively narrow bands. Flexible exchange rate targeting may be interpreted as having a target zone with relatively broad bands (*eg*, '*EMU*' 1993-1999), or targeting the exchange rate in the medium run without formal tolerance bands (*eg*, NORWAY [1993-2001]).[3] In addition, we consider two simple policy rules, the TAYLOR [1993] rule and an MCI-based rule suggested by BALL [1999, 2000].

BALL [2000, p. 19] notes that many countries seem to stabilize exchange rates more than what is justified by models that focus on aggregate variables. One reason, he suggests, is that exchange rate fluctuations cause inefficient reallocations of resources across traded and non-traded sectors. He therefore concludes his paper by saying that "*Progress might be made by evaluating policy rules in models that disaggregate output into tradeables and non-tradeables*" (p. 20). To test this hypothesis, we distinguish between a traded and a non-traded sector in our model. The model may be viewed as an open economy extension of the models developed by SVENSSON [1997] and RUDEBUSCH and SVENSSON [1998].

1. See BERNANKE and MISHKIN [1997] for an overview.
2. *Eg*, SVENSSON [2000], BATINI and HALDANE [1999] and MCCALLUM and NELSON [1999].
3. Since March 29, 2001, the Central Bank of Norway has had an explicit inflation target.

In the growing literature on inflation targeting, we are aware of only a few papers that focus on traded and non-traded sectors. LEITEMO [2000a,b] studies the impact of simple, constant-interest-rate inflation targeting rules on the traded and non-traded sectors and argues that the length of the targeting horizon may have a strong effect on the relative stability of the two sectors. A long targeting horizon tends to destabilize the traded sector. The reason is that a longer targeting horizon implies stronger stabilization of interest rate movements and, hence, a weaker equilibrium-correcting monetary policy response to the state of the economy. A weak monetary policy response causes wages and domestic prices to fluctuate persistently which has a severe effect on the traded sector. 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 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 under inflation targeting than under exchange rate targeting, which is in contrast to the conventional wisdom. However, their model is kept overly simple, particularly 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 in a model with a traded and a non-traded sector. He focuses, however, on equilibrium unemployment and not on the alternative regimes' stabilizing 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 like ours. They find that monetary policy should be more active in response to exchange rate shocks under (flexible) aggregate inflation targeting than under (flexible) non-traded inflation targeting, whereas it should be more active in response to supply and demand shocks under non-traded inflation targeting. They focus, however, on stability in the non-traded sector and do not consider traded sector stability.

This paper is organized as follows. In Section 2, we present a theoretical open economy model with a traded and a non-traded sector and estimate the model using Norwegian data. In Section 3, we evaluate the performance of alternative regimes by considering the effects of the various regimes on the stability of inflation, output, real exchange rates and interest rates. We also consider how the performance of the regimes may be improved by a more active use of fiscal policy. Finally, we consider the implications of letting each sector enter the loss function separately and discuss the hypothesis put forward by *Ball*. Section 4 summarizes the results, and some technical issues regarding the solution procedure are described in an appendix.

2 Theoretical Framework

We consider a small open-economy that consists of two sectors, a traded and a non-traded sector. All variables (except the interest rate) are measured in logs as deviations from steady state. We assume for simplicity that labor is the only variable factor of production and that the wage rate is the same in each sector.[4] There is an equilibrium rate of unemployment, which is assumed to be independent of the monetary policy regime. However, unemployment can, due to nominal inertia, be temporarily increased or decreased by economic policy or by shocks. Firms in the traded sectors are price takers on the international markets. The way the traded sector is modelled, *ie*, as price takers, makes the model relevant for small commodity-exporting countries such as Norway, Iceland, Canada, Australia and New Zealand, but less relevant for larger countries with more specialized goods, such as Germany, France and the UK. Production in the traded sector is given by:

$$y_{t+1}^T = \rho_T(L) y_t^T + \kappa \left(p^T - w\right)_{t+1|t} + \varepsilon_{t+1}^T, \tag{1}$$

where y_t^T is traded sector output in period t, $\rho_T(L)$ is a polynomial of lag operators; p^T is the price of traded goods, measured in domestic currency; w_t is the nominal wage rate, and ε_{t+1}^T is a white noise supply shock. There is a planning horizon of one period, so that actual production in period $t+1$ is decided in period t based on the expected producer real wage in period $t+1$. The subscript $t+1|t$ denotes the (rational) expectation of a variable at period $t+1$ based on information available in period t. When estimating the model (see subsection 2.1), we will interpret a 'period' as a quarter. The degree of persistence in production, determined by $\rho_T(L)$, is motivated by cost of adjustment. Since firms in the traded sector face a perfectly elastic world demand, traded output is determined by the supply side.

The domestic currency producer price of traded goods is given by:

$$p_t^T = p_t^f + s_t, \tag{2}$$

where p_t^f is the foreign price and s_t is the price of the foreign currency in terms of domestic currency units. In line with empirical evidence, we allow a gradual pass-through from producer prices of traded goods to the corresponding consumer prices, which we denote by 'imported goods prices', p^i. Equalization of imported and traded goods prices is assumed to be an intermediate run phenomenon. Specifically, we assume, as in NAUG and NYMOEN [1996], that imported price inflation is given by an equilibrium correction mechanism (ECM):

4. It may be interpreted as centralized wage setting in a unionized economy.

(3) $$\Delta p_t^i = \tau(L)\Delta s_t + \upsilon(L)\Delta p_{t-1}^i - \mu(L)(p^i - s - p^f)_{t-1},$$

where s_t is the nominal exchange rate and Δ is the backward difference operator.

Firms in the non-traded sector face only domestic demand, and aggregate sector output is given by:

(4) $$y_{t+1}^N = \rho_N(L)y_t^N - \alpha(L)r_t + \beta(L)e_t + \varepsilon_{t+1}^N,$$

where r is the real interest rate, $e_t \equiv s_t + p_t^f - p_t$ is the real exchange rate, defined as the relative price of traded to non-traded goods, and ε_{t+1}^N is a shock to non-traded demand. The real interest rate is assumed to have a negative effect on non-traded sector demand due to intertemporal substitution effects,[5] while the real exchange rate is assumed to have a positive effect due to intra-temporal substitution effects between traded and non-traded goods.

There is monopolistic competition in the domestic economy, which implies that firms set prices as a mark-up on costs. We assume, for simplicity, that the mark-up is independent of the level of activity, *ie*,

(5) $$p_t = w_t,$$

where p_t is the price of non-traded goods.

Aggregate production is a weighted average of production in the two sectors, *ie*,

(6) $$y_t \equiv \eta y_t^T + (1-\eta)y_t^N,$$

where η is the share of traded production in steady state, $0 < \eta < 1$.[6]

Aggregate consumer price (CPI), p_t^c, is given by a weighted average of imported and non-traded goods prices:

(7) $$p_t^c = \theta p_t^i + (1-\theta)p_t,$$

Wages are set according to a standard wage curve relationship (see BLANCHARD and KATZ [1999]), specified as an equilibrium correcting model, as in BAARDSEN *et al.* [2000], *ie*,

(8) $$\Delta w_{t+1} = \rho_\pi(L)\pi_t^c + \gamma y_t - \lambda(L)(w_t - p_t^c) + \varepsilon_{t+1}^w,$$

5. We have, for the sake of simplicity, assumed that demand is affected by the short-term interest rate. In a more general model, one could also (or alternatively) include the long-term interest rate. This would introduce a new type of shock, namely to the interest rate risk premium. However, such 'shocks' would generally have the same effect as a demand shock, and we have therefore decided to disregard it.

6. The constancy of this share is indeed a simplification made for convenience. Factors influencing the equilibrium share may, however, be relatively unimportant from a stabilization policy perspective.

where $\pi_t^c \equiv p_t^c - p_{t-1}^c$ is quarterly consumer price inflation, and the equilibrium correcting mechanism is captured by the last term.

The exchange rate is determined by uncovered interest rate parity (UIP), *ie,*

$$s_t = s_{t+1|t} - .25(i_t - i_t^f) + u_t, \tag{9}$$

where i_t and i_t^f are the domestic and world nominal interest rates respectively, and u_t is a stochastic risk premium which follows the process $u_t = \phi u_{t-1} + \varepsilon_t^u$, where ε_t^u is white noise. The coefficient of 0.25 on the interest rate differential is due to quarterly annualization. Due to the assumption of a small open-economy, the world economy can be treated as exogenous to the domestic economy. World inflation is assumed to be given by the following *Phillips* curve relationship:

$$\Delta p_{t+1}^f = \rho_{pf}(L)\Delta p_t^f + \gamma y_t^f + \varepsilon_{t+1}^{pf}, \tag{10}$$

where Δp_{t+1}^f is world inflation, defined by the change in the foreign currency price of traded goods, $\rho_{pf}(L)$ is a polynomial of lag operators which represents inflation persistence; y_t^f is the world output gap, and ε_{t+1}^{pf} is a shock to world inflation. Aggregate world demand is negatively affected by the world real interest rate r^f, *ie,*

$$y_{t+1}^f = \rho_{yf}(L)y_t^f - a(L)r_t^f + \varepsilon_t^{yf}. \tag{11}$$

It is assumed that the world monetary policy is characterized by flexible inflation targeting. Specifically, the world interest rate, i_t^f, is found by solving the following minimization problem:[7]

$$\min_{i_t^f} E[(\Delta p_t^f)^2 + (y_t^f)^2 + .5(\Delta i_t^f)^2]. \tag{12}$$

subject to (10) and (11). The solution to the problem gives an implicit instrument rule where the interest rate depends on lagged interests rates, on current and lagged inflation rates and on current and lagged output, *ie,*

$$i_t^f = i(L)i_{t-1}^f + j(L)\Delta p_t^f + k(L)y_t^f. \tag{13}$$

2.1 The Transmission Process

The two-sector structure allows for a more detailed description of the monetary policy transmission mechanism than the standard one-sector open-

7. See the appendix for a description of the optimization procedure.

economy models. Monetary policy impulses are transmitted to inflation through four channels, one of them due to a change in the interest rate and three to a change in the exchange rate. First, there is a conventional real interest rate channel, working through non-traded output (and thereby aggregate output) and then onto wage and price inflation. Second, a change in the interest rate also affects the exchange rate. The exchange rate affects output in the traded sectors and, although to a lesser extent, output in the non-traded sector, which thereby affects wage and price inflation. Third, a change in the exchange rate has a direct effect on inflation through prices of imported goods. Monetary policy affects inflation most rapidly through this channel. Fourth, a change in the exchange rate also affects wage inflation in a more direct way than the first two channels. Nominal wage increases depend partly on realized CPI inflation, which is directly affected by the exchange rate through the third channel.

2.2 Estimation

The equations in the model are estimated using Norwegian data. We have used OLS if not otherwise stated.[8] Due to a large petroleum sector, Norway is somewhat different from most small openeconomies within the group of industrialized countries. However, one would expect that the mainland economy (*ie*, excluding the petroleum and shipping sectors) provides a reasonably representative example of a small open economy. The estimated model is shown in Table 1. All variables, except the interest rates, are log-transformed. Since variables are measured as deviations from their respective equilibria, variables are detrended using a *Hodrick-Prescott*-filter with a (standard) smoothing coefficient of 1600. This allows the equilibrium processes to have time-varying trends. We have followed a general-to-specific estimation strategy throughout, letting data determine the number of lags needed to produce a reasonable econometric specification of the different processes.

It is assumed in the model that there is a sharp distinction between the traded and non-traded sectors. In practice, there are various degrees of foreign competition in product markets. The distinction between traded and non-traded sectors thus relates to a continuum rather than a dichotomy. However, in order to operationalize the difference, we use manufacturing output as a proxy for the traded sector output and the rest of GDP (excl. the petroleum sector) as non-traded sector production.[9] The inverse of the producer real wage is proxied by the detrended series of the real exchange rate, defined as the effective exchange rate corrected for the CPI inflation differential between Norway and its trading partners. Production in the traded sector is based on the expected producer real wage one quarter ahead. The traded sector supply curve is estimated using the instrumental variable method with the real exchange rate instrumented by five lags of the seasonally adjusted unemployment rate,[10] five lags of the detrended real exchange rate and three (remaining) lags of the dependent variable.

8. Constants and seasonal dummies were included in the set of regressors, but not reported.
9. The equilibrium share of traded goods output to aggregate output were set at $\eta = 0.15$, which approximately reflects the manufacturing output average share during the 1990s.
10. The unemployment rate is used as one of the instruments because it serves as a proxy for the determinants of domestic inflation expectations, which affect the real exchange rate.

TABLE 1
Model Estimates

Traded Sector Output

$$y^T_{t+1} = \underset{(.12)}{.48}\, y^T_t + \underset{(.12)}{.23}\, y^T_{t-1} + \underset{(.11)}{.23}\left(p^T - w\right)_{t+1|t} + \varepsilon^T_{t+1}$$

$\sigma = 1.51\%$ $\quad AR\ 1-5\ F(5,65) = 0.40[.85] \quad Sample : 1980:2 - 1999:2$

Non-traded Sector Demand

$$y^N_{t+1} = \underset{(.09)}{.41}\, y^N_t - \underset{(.09)}{.18}\, y^N_{t-2} + \underset{(.09)}{.20}\, y^N_{t-3} - \underset{(.13)}{.26}\, \overline{r}_t + \underset{(.07)}{.16}\, e_{t-1} + \varepsilon^T_{t+1}$$

$\sigma = 1.09\%$ $\quad AR\ 1-5\ F(5,54) = 1.36[.25] \quad Sample : 1981:2 - 1999:2$

Wage Curve

$$\Delta w_{t+1} = \underset{(-)}{.59}\, \pi^c_t + \underset{(.12)}{.41}\, \pi^c_{t-1} + \underset{(.05)}{.125}\, y_t - \underset{(.03)}{.05}(w - p^c)_{t-1} + \varepsilon^w_{t+1}$$

$\sigma = 1.26\%$ $\quad AR\ 1-5\ F(5,106) = 2.14[.07] \quad Sample : 1966:4 - 1996:4$

Imported Price Inflation

$$\Delta p^i_t = \underset{(.16)}{.34}\, \Delta s_t + \underset{(.10)}{.18}\, \Delta p^i_{t-1} - \underset{(.06)}{.26}(p^i - s - p^f)_{t-1} + \varepsilon^{pi}_t$$

$\sigma = 2.67\%$ $\quad AR\ 1-5\ F(5,100) = 0.98[.43] \quad Sample : 1972:1 - 1998:3$

Foreign Inflation Process

$$\Delta p^f_{t+1} = \underset{(-)}{.627}\, \Delta p^f_t + \underset{(.12)}{.039}\, \Delta p^f_{t-1} + \underset{(.095)}{.281}\, \Delta p^f_{t-2} + \underset{(.028)}{.054}\, y^f_{t-2} + \varepsilon^{pf}_{t+1}$$

$\sigma = 0.23\%$ $\quad AR\ 1-5\ F(5,61) = .99[.43] \quad Sample : 1980:2 - 1999:1$

Foreign Output Process

$$y^f_{t+1} = \underset{(.052)}{.816}\, y^f_t - \underset{(.058)}{.238}\, \overline{r}^f_t + \varepsilon^{yf}_{t+1}$$

$\sigma = 0.39\%$ $\quad AR\ 1-5\ F(5,61) = 0.43[.83] \quad Sample : 1976:3 - 1998:4$

Risk Premium

$$u_{t+1} = (.13)\ .33 u_t + \varepsilon^u_{t+1}$$

$\sigma = 0.95\%$ $\quad AR\ 1-4\ F(4,54) = 1.72[.16] \quad Sample : 1981:2 - 1996:4$

Note: Standard errors in parentheses.
Constants, seasonal and other dummies are not reported in this table.

As a measure of the real interest rate, we use the detrended series of the four-quarter moving average of the difference between the 3-month NIBOR interest rate and the annualized quarterly change in the consumer price index, *ie,*

$$\bar{r}_t = \frac{1}{4}\sum_{j=0}^{3}(i_{t-j} - 4\pi^c_{t-j}).$$

Equation (4) is estimated using (mainland) GDP minus manufacturing production as the left-hand side variable.[11] The coefficient on the real exchange rate was somewhat higher than what one might expect. This may reflect the lack of a clear-cut distinction between traded and non-traded sectors, so that our proxy for the non-traded sector may include sectors that face some foreign competition.

In the estimation of the wage curve, we draw heavily on BÅRDSEN *et al.* [2000] for the precise functional form. Dynamic homogeneity in inflation was accepted by data with $\chi^2(1) = .23[.63]$ and hence imposed. The consumer real wage, $(w - p^c)$, is measured as deviations from the equilibrium real consumer wage, which is given by the level of productivity. As a measure for the (aggregate) output gap, we use the detrended series of aggregate mainland production.[12]

In the estimation of the import price equation (3), we impose complete long-run pass-through from foreign prices (trade-weighted export prices) in domestic currency units on to imported goods prices.[13] Our estimated coefficients suggest a pass-through from the exchange rate to import prices of about 88 percent after one year and a pass-through from foreign prices of about 78 percent.

In order to model the foreign sector, we use available data for Norway's trading partners. Foreign output is proxied by the trade-weighted GDP, foreign prices are measured by a trade-weighted consumer price index and the short-run interest rate is measured as the trade-weighted 3-month interest rate. The measure for the real interest rate was constructed as explained above. Dynamic homogeneity was accepted by data with $\chi^2(1) = 3.46[.06]$ in the CPI inflation regression.[14]

In order to construct a series of deviation from the uncovered interest rate parity condition[15] –defined here as the risk premium– we first regress the log of the effective nominal exchange rate on six lags of the foreign interest rate, the domestic interest rate, the output gap, the nominal effective exchange rate

11. Dummies were included for the following periods: 1982:1, 1985:4, 1986:2, 1987:4 and 1997:2.

12. The regression also included the series of employers' tax rate and the indirect (VAT) tax rate in order to take into account the effect of these taxes on wage growth. Since the study of these fiscal decision variables are not central to our study, the effects of these tax rates were not included in the subsequent model.

13. A Norwegian study by AKRAM [1999] finds support for a cointegrating relationship between imported manufacturing goods prices and foreign export prices in Norwegian data.

14. Dummies for the 1979:2 and 1980:2 quarters were included in the foreign output regression and for 1991:1 and 1985:2 in the foreign inflation regression.

15. We impose uncovered interest rate parity, adjusted for an autoregressive risk premium. We test these restrictions by regressing the effective nominal interest rate on the fitted values of the nominal exchange rate from the above regression (but excluding the one-period lagged nominal and real exchange rate as instruments in order to avoid simultaneity problems) and the domestic and foreign interest rates. We allow for an autoregressive error of order one and employ autoregressive least squares. The following estimates are obtained for the period 1983:1-1996:4,

$$s_t = \psi_s \hat{s}_{t+1} - \psi_i i_t + \psi_{if} i_t^f + .19\widehat{u}_{t-1} + \widehat{u}_t,$$

where $\psi_s = .97, \psi_i = .15$ and $\psi_{if} = .05$. The restrictions $\psi_s = 1; \psi_i = \psi_{if} = .25$ were accepted by data at $\chi^2(3) = 2.76[0.43]$.

and the detrended series of the real exchange rate.[16] The fitted values ($\widehat{s}_{t+1|t}$) from this regression are then assumed to be proxies for the expected nominal exchange rate given a one-period lagged information set. The risk premium is then calculated as:

$$u_t = 0.25(i_t - i_t^f) - (\widehat{s}_{t+1|t} - s_t).$$

We modelled the risk premium as an autoregressive disturbance process where no *a priori* restrictions were placed on the order of the process. We found that a simple AR(1) process fits the data reasonably well over the period 1981:2 to 1996:4, and additional lags had no significant effect.

The residuals from the regression equations were taken as the estimates of the structural shocks to the model. The residual covariance-variance matrix was computed over the period 1980:2 to 1996:4.

Although the choice of parameter values always may be questioned, we believe that our parameter estimates are not *a priori* unreasonable. In addition, the parameter estimates are broadly consistent with other comparable models.[17]

3 Monetary Policy Targeting Regimes

As argued in the introduction, there are in practice two alternative monetary policy regimes for small open economies: The country may either peg its currency to another currency (or basket of currencies) or it may steer monetary policy more directly towards its ultimate goal(s). Within the first group, there is a *continuum* of variants ranging from adopting another country's (or group of countries') currency, *via* traditional fixed exchange rate regimes to more flexible variants of exchange rate targeting. Within the second general group of regimes, there is a continuum of variants that differ with regard to the weights attached to variables other than inflation when setting the interest rate. We have chosen to consider two sub-groups of each group, a strict and a flexible version of the regimes. In the strict version of the regimes, the sole objective is to minimize variability of the primary target variable. Under flexible targeting there could be several other secondary variables that are targeted in addition to the primary variable. In principle, an infinite number of flexible regimes exist, depending on the weights attached to the variables in

16. A more sophisticated approach would be to use maximum likelihood techniques in combination with the *Kalman* filter to extract the unobservable risk premium component of domestic financial investments. Such a procedure, however, would likely be dependent on the specification and the estimation of the policy rule in effect throughout the estimation period. During this period, Norway maintained a policy whereby the exchange rate was stabilized to a changing basket of foreign currencies. The Norwegian krone was, however, devaluated several times in the 1980s. Specifying the target variables in the loss function of the regime would hence prove difficult. For such reasons, we adopted the current less ambitious, but possibly more robust strategy.

17. See, *eg*, Batini and Haldane [1999] and Leitemo [2000a, b].

the loss function. However, we only consider one type of flexibility, which has become standard in the literature, namely that the monetary authority attaches weight to aggregate output and nominal interest rate smoothing in addition to the main target variable. In section 3.5, we also consider loss functions in which output in each sector, instead of aggregate output, enters separately, in order to be able to discuss the importance of sector-specific stability.

We assume that the target(s) for monetary policy, whether ultimate or intermediate, is decided by the government. The central bank is assumed to be instrument independent, so that the bank sets the interest rate in order to achieve the target(s). Such a definition of a monetary policy regime applies to the institutional arrangements for monetary policy in many countries today, although some central banks, *eg*, the *European Central Bank* and the *Central Bank of Sweden* (*Sveriges Riksbank*), have 'narrow' goal independence, which means that they are free to specify the more general goals given by the political authorities. The distinction between goal independence and instrument independence becomes less important, however, when the central bank is given a mandate to hold the exchange rate fixed, since there is little room for maneuvering in the setting of the instrument.

The above definition of a monetary policy regime is consistent with what Svensson calls 'targeting rules' (see *eg*, SVENSSON [1999, 2000]). In addition to considering such 'targeting rules', we consider two 'instrument rules'; a *Taylor* rule (TAYLOR [1993]) and the MCI rule proposed by BALL [1999, 2000].

The model is estimated over a period with various forms of exchange rate targeting regimes. It is important to emphasize that economic behavior may not be exogenous to the choice of monetary policy regime. In particular, there is reason to believe that economic behavior will change if a country goes from independent inflation targeting to joining a monetary union. However, it is extremely difficult to specify and quantify exactly *how* economic behavior will depend on the monetary policy regimes. The approach in this paper is therefore suited for analyzing the costs and benefits of various monetary policy regimes, given that economic behavior remains the same.

3.1 Targeting Rules

A targeting rule can be defined by the following optimization problem:

$$\min_{i_t} E L_t, \tag{14}$$

where L_t is a function of the target variables and the nominal interest rate, i, is the monetary policy instrument. As is common in the literature, we assume that the loss function is linear-quadratic. Specifically, we consider the following loss function:

$$L_t = a_\pi (\bar{\pi}_t^c)^2 + a_s s_t^2 + a_y y_t^2 + a_{\Delta i} (\Delta i_t)^2, \tag{15}$$

where $\bar{\pi}_t^c = p_t^c - p_{t-4}^c$. Based on this loss function, we characterize the regimes as follows:

Strict inflation targeting:	$a_\pi = 1, a_s = 0, a_y = 0, a_{\Delta i} = 0$
Flexible inflation targeting:	$a_\pi = 1, a_s = 0, a_y = 1, a_{\Delta i} = .5$
Strict exchange rate targeting:	$a_\pi = 0, a_s = 1, a_y = 0, a_{\Delta i} = 0$
Flexible exchange rate targeting:	$a_\pi = 0, a_s = 1, a_y = 1, a_{\Delta i} = .5$

In the strict version of the regimes, only the primary target variable enters the loss function. Under strict inflation/exchange rate targeting, the interest rate is set so as to minimize the expected sum of deviations of the inflation/exchange rate from the target. In the flexible version of the regimes, the central bank also attaches weights to output and to the change in the interest rate. The weight attached to Δi_t represents 'interest rate smoothing', which seems to be an important feature of monetary policy in practice (FROYEN and WAUD [1995], GOODHART [1996]). In our model, it is not obvious that Δi_t should enter as a separate argument in the loss function. 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. Another reason for interest rate smoothing is that the central bank is uncertain about the true economic model. A cautionary strategy, implied by interest rate smoothing, may have attractive features, as shown by BRAINARD [1967]. It turns out that interest rate smoothing may also in some circumstances have a positive effect on the discretionary equilibrium, leading to lower variability of the targeted variables (see WOODFORD [1999], LEITEMO and RØISLAND [1999]). An additional reason for interest rate smoothing is that central banks may find it costly in terms of loss of public prestige if they reverse a change in the interest rate. Several small steps may therefore be preferable to one large step. In our analysis, the weights attached to Δi_t as well as to y_t are somewhat arbitrarily set to $.5$ and 1, respectively.

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. Because we have a forward-looking variable in the model, *ie*, the exchange rate, there is a difference between the discretionary solution and the commitment solution of the optimization procedure. We assume that the central bank does not possess the commitment technologies to make the commitment solution credible, and, therefore, we focus on the discretionary, time-consistent solution (see BACKUS and DRIFFILL [1986]).

The optimal time-consistent rule, that is, the rule that minimizes the loss given by (14), is in general a feedback rule where the instrument (the nominal interest rate) depends on all the state variables, *ie,*

$$i_t = F X_t, \tag{16}$$

where X_t is the vector of state variables and F is a vector of response coefficients. These specific, implicit rules associated with the alternative regimes are shown in Table 2.

3.2 Simple Instrument Rules

As illustrated by the table, implicit instrument rules like (16) are generally rather complex in models with reasonably rich dynamics. Moreover, optimal rules are model dependent, and one rule that is optimal within one specific model may give poor results in other models. For these reasons, there has been increased focus in the literature on simple instrument rules that are based on a small set of state variables. Particularly, the *Taylor* rule, where the interest rate is only a function of the inflation rate and the output gap, has received considerable attention (see *eg*, TAYLOR [1999]). It is therefore of interest to analyze the performance of the *Taylor* rule in this model of a small open-economy and to compare it with the monetary policy regimes specified above. Since the variables in our models are measured as deviations from their equilibria, the *Taylor* rule may be written as:

$$i_t = 1.5\bar{\pi}_t^c + .5y_t. \tag{17}$$

Note that neither of the right-hand side variables in the *Taylor* rule enter the optimal, implicit rule (16), see Table 2. This reflects that the sub-components in the aggregate variables π_t^c and y_t should in general enter separately in the optimal rule when the determination of prices and output in the two sectors is different.

It may be argued that since the *Taylor* rule does not include information about variables that are typically conceived as important in the open economy (*eg,* exchange rate, foreign demand), it is more suitable for a relatively closed economy than for small open economies. BALL [1999, 2000] has proposed a rule that is based on a 'Monetary Conditions Index' (MCI) rather than on the short-term interest rate alone. To allow for this, we extend the *Taylor* rule by including a term with the contemporaneous real exchange rate and a term with the lagged real exchange rate, *ie,*

$$i_t = 1.5\bar{\pi}_t^c + .5y_t + \omega_1 e_t + \omega_2 e_{t-1}. \tag{18}$$

By subtracting $\bar{\pi}_t^c - \omega_1 e_t$ from each side and dividing by $1 + \omega_1$, the rule may be written as:

$$\frac{1}{1+\omega_1} r_t - \frac{\omega_1}{1+\omega_1} e_t = \frac{.5}{1+\omega_1} y_t + \frac{.5}{1+\omega_1}\left[\bar{\pi}_t^c + 2\omega_2 e_{t-1}\right] \tag{19}$$

which has the same form as the rule proposed by *Ball*.[18] In order to numerically specify the rule, we find the optimal values[19] of ω_1 and ω_2 by minimizing the loss function corresponding to flexible inflation targeting. This yields:

$$i_t = 1.5\bar{\pi}_t^c + .5y_t - .03e_t - .23e_{t-1}. \tag{20}$$

18. See equation (7) on p. 6 in BALL [2000], but note that *Ball* measures the real exchange rate as the negative of our measure.

19. We used the BFGS numerical optimization procedure, included in the software package *Optimization for Gauss*, in computing the optimal coefficients.

TABLE 2
Implicit Interest Reaction Functions

State variables, X_t	Strict s-targeting	Flexible s- targeting	Strict $\bar{\pi}^c$-targeting	Flexible $\bar{\pi}^c$-targeting
y_t^f	.78	.43	.78	.29
y_{t-1}^f	.12	.07	.13	.03
y_{t-2}^f	.14	.08	.14	.03
π_t^f	3.02	1.58	-.03	.73
π_{t-1}^f	1.31	.69	1.38	.43
π_{t-2}^f	1.13	.56	1.19	.33
π_{t-3}^f	.20	.05	.26	.08
i_{t-1}^f	.34	–.05	.34	–.08
i_{t-2}^f	–.10	–.06	–.10	–.04
i_{t-3}^f	–.05	–.03	–.05	–.02
e_{t-1}	–	0.01	–.70	–.01
p_t	–	0.36	12.83	.83
p_{t-1}	–	–.12	–.33	–.29
p_{t-2}	–	–.10	5.60	–.24
p_{t-3}	–	–.03	14.02	–.09
p_{t-4}	–	–.02	–32.44	–.06
y_t^T	–	.02	–.33	.04
y_{t-1}^T	–	.01	–.00	.01
y_t^N	–	.07	–1.85	.12
y_{t-1}^N	–	–.01	–.01	–.01
y_{t-2}^N	–	.01	.01	.02
y_{t-3}^N	–	.03	–.01	.04
p_{t-1}^{IM}	–	.10	11.00	.24
p_{t-2}^{IM}	–	–.11	1.68	–.28
p_{t-3}^{IM}	–	–.02	9.35	–.06
p_{t-4}^{IM}	–	–.01	–21.62	–.04
u_t	4	.71	3.97	.35
i_{t-1}	–	.46	.01	.53
i_{t-2}	–	–.02	.00	–.03
i_{t-3}	–	–.01	.00	–.01
ε_t^{im}	–	.20	8.93	.50

Note: The reaction function under strict exchange rate targeting is equal to the foreign reaction function except for a response to the risk premium. Hence, $i_t = i_t^* + 4u_t$.

Since ω_1 and ω_2 are chosen optimally, the MCI rule must perform at least as well as the *Taylor* rule.[20] However, it is interesting to see how much is gained by extending the *Taylor* rule to include the exchange rate.

20. If the MCI rule gives a higher loss than the *Taylor* rule, the coefficients cannot be optimally chosen, since the values $\omega_1 = \omega_2 = 0$ gives the *Taylor* rule.

TABLE 3
Stabilization Properties %

$\bar{\pi}^c$	y^T	y^N	y	s	Δs	e	Δi	$Loss^a$	$Loss^b$
Strict inflation targeting									
0.0	6.1	8.3	7.2	∞	9.7	12.8	28.8	465.5	464.0
Flexible inflation targeting									
3.2	2.7	1.7	1.7	∞	1.9	4.0	1.7	14.9	14.3
Strict exchange rate targeting									
4.2	5.2	2.8	2.9	0.0	0.0	7.5	4.6	36.1	34.2
Flexible exchange rate targeting									
3.6	3.8	2.0	2.1	2.4	1.4	5.5	1.1	17.7	16.5
EMU									
4.1	5.0	2.6	2.7	0.0	0.0	7.2	0.6	24.2	22.3
Taylor rule									
3.1	2.7	1.7	1.7	∞	2.0	3.9	2.3	15.1	14.6
Ball MCI									
2.7	2.6	2.1	2.0	∞	2.5	4.5	2.7	15.0	14.0

Note: (a) aggregate loss, (b) disaggregate loss (see Section 3.5).

3.3 Performance of Alternative Regimes

In the literature on monetary policy rules, it is customary to consider welfare implications by using a (linear-quadratic) loss function where only inflation and aggregate output enter as arguments. By choosing such a loss function, we inevitably introduce a bias towards the flexible inflation targeting regime in terms of welfare ranking. Flexible inflation targeting may thus be interpreted as a more direct way of maximizing welfare. Although creating a bias in favor of flexible inflation targeting, minimizing the expected loss under discretion, which is done here and is most common in the literature, does not in general lead to the first-best solution when behavior is forward-looking. There is partly forward-looking behavior in our model, and it is therefore, in principle, possible that regimes other than flexible inflation targeting yield lower welfare loss. In any case, it is of interest to see how much is lost in welfare terms by choosing alternative monetary policy regimes.

The unconditional standard deviations of the variables under the alternative regimes[21] are summarized in Table 3.

Note that the unconditional standard deviation of the nominal exchange rate is infinite under inflation targeting and under the *Taylor* rule and MCI rule. The reason for this is that these regimes imply base drift in the differential between the domestic and foreign price level, so that the nominal exchange

21. The analytical method used in computing the unconditional standard deviations is described in the appendix.

rate becomes non-stationary. Hence, we have also computed the standard deviation of Δs in order to have a suitable measure of nominal exchange rate variability (see Table 3). It may, however, be argued that, if anything, it is the variability of the *real* exchange rate, as opposed to the nominal exchange rate, that may have a potential welfare cost in small open-economies.

As argued by BALL [2000], there might be reasons to include sectoral stability as well in the welfare loss function of small open economies. This will be considered in Section 3.5. In order to facilitate comparison with other studies, we choose a standard loss function as our baseline welfare loss function, but we also report in Table 3 the unconditional standard deviations of the variables under the alternative regimes.

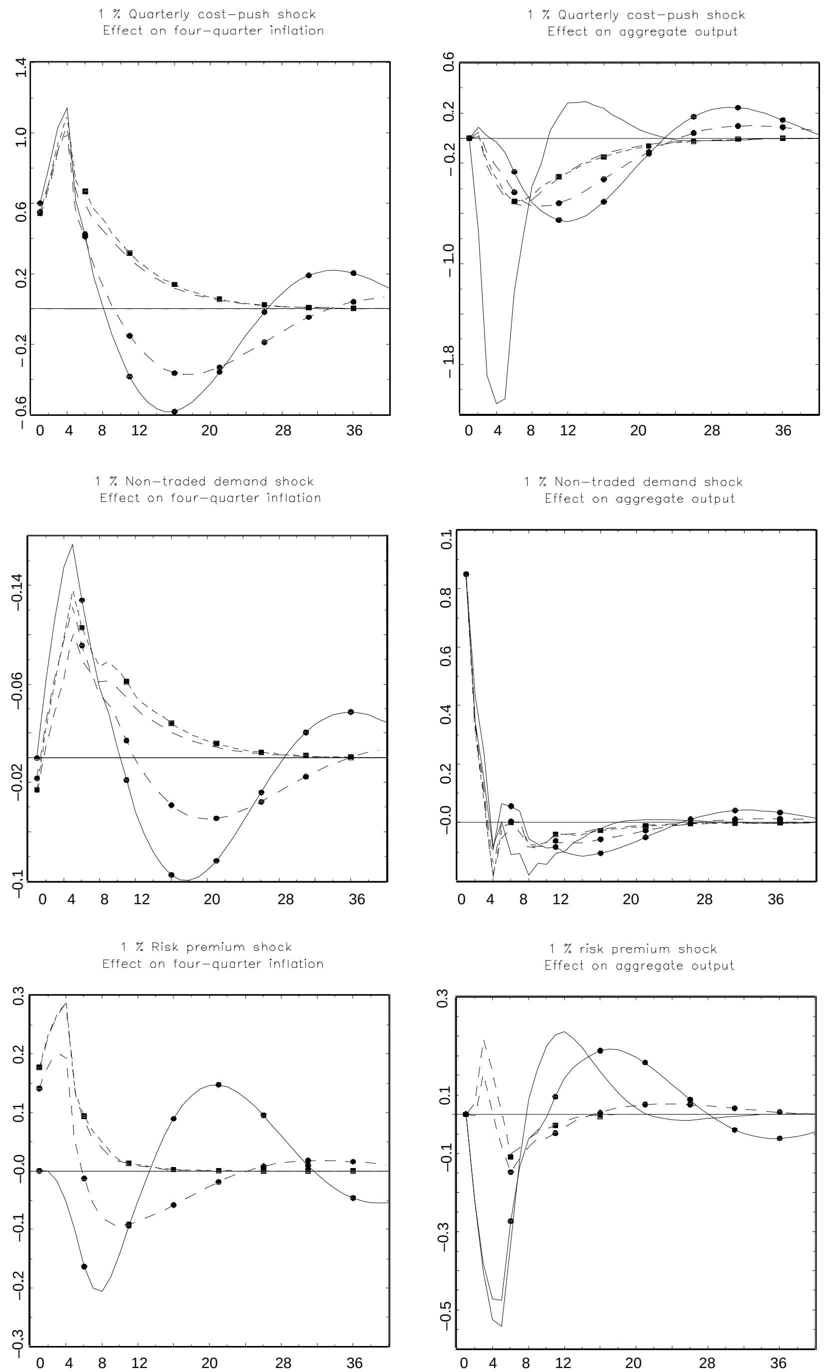
Targeting Rules

Not surprisingly, strict inflation targeting leads to the lowest CPI inflation variability of the alternative regimes. However, as illustrated in Figures 1-3, which show the effects on the key variables of a cost-push shock, a non-traded demand shock and a risk premium shock to several key variables, strict inflation targeting leads to large variability in all the other variables, and in particular the interest rate. The reason is that strict inflation targeting implies an aggressive monetary policy, where the direct exchange rate channel, which represents the shortest lag at which the policymaker can influence inflation, is used extensively in order to keep the inflation rate perfectly stable. Another reason is that inflation is highly persistent in the model, and inflation stabilization requires strong reactions to historic inflation, represented by large coefficients on the price-level terms in the reaction function.[22] This aggressive policy results in large fluctuations in the real variables. This result thus confirms the theoretical results of SVENSSON [2000] and BALL [1998].

Of all the targeting regimes considered, flexible inflation targeting provides the lowest variability in all the real variables, including the real exchange rate. In addition, its effect on inflation stability is only outperformed by strict inflation targeting. *Why does flexible inflation targeting provide a more stable real exchange rate than exchange rate targeting?* As indicated by the figures, exchange rate targeting generates more noticeable oscillations in the variables and slower convergence to equilibrium. The reason for this lies in the *Walters' effect* (WALTERS [1986]). In the case of strict exchange rate targeting, the domestic interest rate must follow the foreign interest rate, adjusted for risk premium shocks. A shock that affects domestic inflation thus affects the real interest rate and the real exchange rate. The mechanism may be explained as follows: Increased domestic inflation, due *eg*, to a cost-push shock or a positive non-traded demand shock, reduces the real interest rate, which reinforces the increase in inflation and thereby the decrease in the real interest rate. Since the nominal exchange rate is constant under strict exchange rate targeting, the increased inflation leads to a gradual real exchange rate appreciation. Eventually, the dampening effect of the real appreciation more than offsets the expansionary effect of a lower real interest rate, and the cycle turns. Inflation

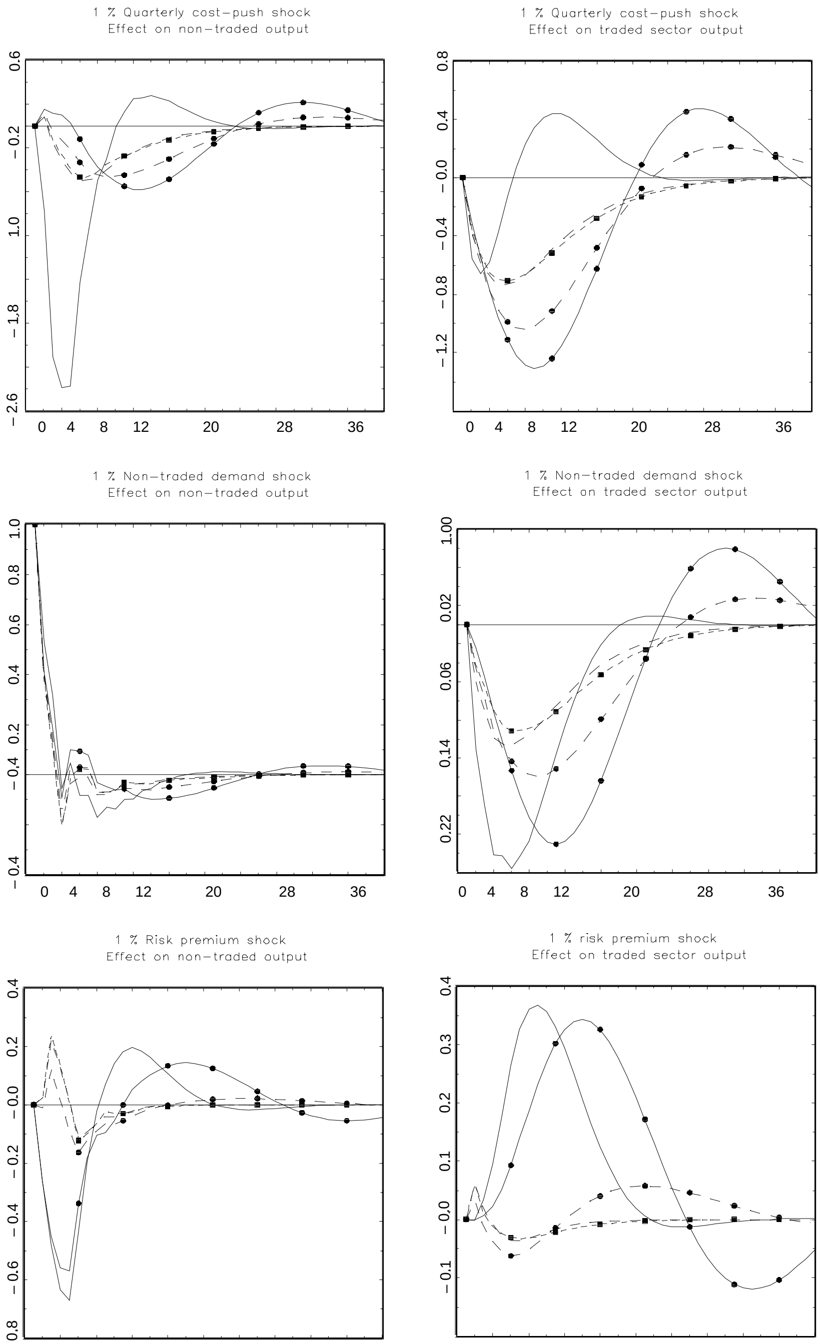
22. The reason that the level of prices is included in the reaction function is that the level affects future wage inflation through the equilibrium correction terms in equations (3) and (8). Actually, the *price level* and the *inflation rate* affect future inflation, so that the optimal interest rate is a function of both. However, we have rewritten the rule in terms of price levels.

FIGURE 1
Impulse Responses on Inflation and Aggregate Output



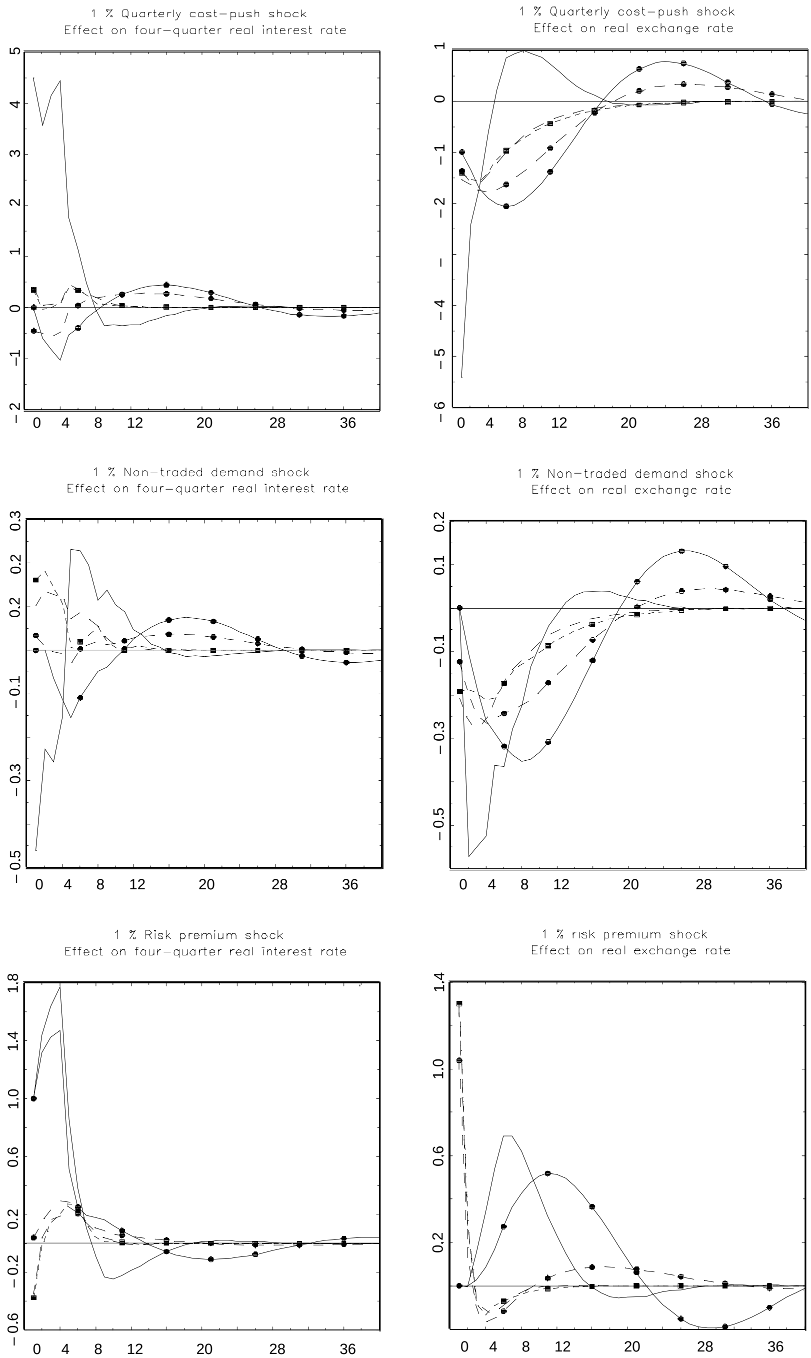
Note: A solid (dashed) line denotes a strict (flexible) targeting regime. Circles denote an exchange rate targeting regime, and squares the Taylor rule. The curves without symbols denote the inflation targeting regime.

FIGURE 2
Impulse Responses on Traded and Non-Traded Output



Note: A solid (dashed) line denotes a strict (flexible) targeting regime. Circles denote an exchange rate targeting regime, and squares the Taylor rule. The curves without symbols denote the inflation targeting regime.

FIGURE 3
Impulse Responses on Real Interest Rate and Real exchange Rate



Note: A solid (dashed) line denotes a strict (flexible) targeting regime. Circles denote an exchange rate targeting regime, and squares the Taylor rule. The curves without symbols denote the inflation targeting regime.

will then start to decrease, which increases the real interest rate, and the cycle will eventually turn again when the expansionary effect of a real exchange rate depreciation due to low inflation more than offsets the dampening effect of a higher real interest rate. Although, a shock will generate such oscillations in the key variables, the estimated coefficients in the model ensures stability, so that the oscillations diminish. Flexible exchange rate targeting will generate less pronounced responses, but the same type of oscillations. However, flexible exchange rate targeting gives lower variability in the nominal exchange rate, measured by the standard deviation of Δs, than flexible inflation targeting, as seen from Table 3.

Another reason for the relatively poor performance of exchange rate targeting compared with flexible inflation targeting, is related to the distinction between targeting the price level and targeting the inflation rate. A target for the nominal exchange rate level may be thought of as an implicit long-run price level target, where the relationship over time between the domestic price level and the foreign price level must be constant in order to achieve consistency between the equilibrium real exchange rate and the nominal exchange rate target. If domestic inflation increases, it is thus not sufficient to bring the inflation rate down to the same level as the world rate of inflation. A period with a lower inflation rate than the world rate is required to achieve the noted consistency. This requires a period with a negative output gap.

Although fluctuations in the real exchange rate are more persistent with exchange rate targeting than with the other regimes considered, it causes less high-frequency movements than the other regimes. The reason for this is that in the short run, the exchange rate is primarily affected by a volatile risk-premium component. This effect is, however, completely offset by monetary policy under the strict exchange rate targeting regime. The strong response to the risk premium is a third, although minor, reason why the exchange rate targeting regime is outperformed by inflation targeting in terms of inflation and output stability.

An alternative to keeping the domestic currency pegged to a foreign currency is adopting the foreign currency by joining a monetary union. One advantage of a monetary union compared to pegging the exchange rate is that the risk premium between the domestic and the union currency is removed. The average risk premium of the domestic currency relative to the trading partners' currencies is thus reduced. The larger the share of trade with the union, the more the trade-weighted risk premium is reduced. A full analysis of a monetary union would require a three-country framework with the home country, the union and the 'rest of the world'. A full specification would be particularly important if one analyzes game situations between the countries. This paper focuses, however, on the choice of monetary policy regime for a small open economy, and international game situations therefore have a limited role. The simplest way to discuss the alternative of joining a monetary union in our model is to consider strict exchange rate targeting with a lower risk premium.[23] '*EMU*' represents strict exchange rate targeting when there are no risk premium shocks.

23. A monetary union is likely to have other more fundamental effects than reflected in our analysis. It can be argued that the main reasons for joining a monetary union are of a microeconomic origin, *ie,* in the reduction of barriers to trade. These changes would most likely affect the economic structure and hence the propagation of policy behavior and structural shocks. Our results with regard to monetary union should therefore be interpreted with caution.

Comparing the '*EMU*' regime with the strict exchange rate targeting regime shows that the most noticeable difference is a reduction in the variability of the nominal interest rate. Since strict exchange rate targeting implies that the interest rate should fully offset a change in the risk premium, reducing the risk premium gives considerably lower variability in the interest rate. However, a reduction in the risk premium has a relatively modest effect on inflation and output variability. The modest effect is due to the low persistence of these shocks, which implies that they have a short-lived effect on the exchange rate and hence other variables. The relatively weak response to risk-premium shocks under flexible inflation targeting as opposed to strict targeting, as shown in Table 2, is also an indication that the risk premium component is a relatively unimportant shock if the policymaker cares about inflation and output stability. The removal of the risk-premium component may therefore be seen as relatively unimportant from a stabilization policy perspective. The degree of persistence in risk premium shocks may, however, be different for other currencies, which may affect the general validity of this result.

Instrument Rules

The *Taylor* rule and the MCI rule are within the family of 'simple rules', that is, rules where the instrument responds to only a sub-set of the state variables. Thus, the performance of simple rules is generally weaker than for the more complex optimal rules. The advantage of simple rules is that they are easier to monitor for the private agents of the economy. This may increase the central bank's ability to credibly commit to a strategy and thus be able to favorably influence private agents' expectations about the future. Moreover, simple rules seem to be more robust in the sense that they perform reasonably well in a variety of models (see TAYLOR [1999]).

By comparing expected losses in Table (2), we see that the simple rules outperform most of the targeting regimes considered and come very close to matching the performance of 'flexible inflation targeting' in terms of expected loss.

As explained above, the way we have constructed the MCI rule implies that it must give at least as low expected loss as the *Taylor* rule. We see from Table 3 that the reduction in loss from including the exchange rate in the rule is small. Although inflation becomes somewhat more stable, aggregate output becomes more volatile. Interest rate setting also becomes more volatile as the interest rate responds to an increasingly volatile real exchange rate. The strong performance of the *Taylor* rule in this model suggests that the set of state variables represented by the output gap and the four-quarter inflation rate are reasonably sufficient as indicators for monetary policy, and the additional reaction to shocks as represented by the forward-looking exchange rate does not greatly improve the performance of the rule. Improvements of the simple *Taylor* rule requires a commitment to a rule that includes more detailed response to the different shocks to the model. The insufficiency of the *Taylor* rule in BALL [1998], which requires an additional response to the exchange rate, may be a result of the particular model considered.

A further reason why adding the exchange rate information to the *Taylor* rule does not improve the outcome very much, is because the exchange rate is forward-looking. Forward-looking variables are determined by private agents that use the same information about the state of the economy as the monetary policymaker in our model. If the set of state variables represented by the output gap and the inflation rate provides a good summary of the state of the economy, the extra information imbedded in the exchange rate may not be important. Hence, the exchange rate is not necessarily an important indicator for monetary policy in the open economy.[24]

3.4 **Fiscal Policy**

In fixed exchange rate regimes, fiscal policy has traditionally been the main tool for macroeconomic stabilisation. If fiscal policy provides sufficient macroeconomic stability, the need for a flexible monetary policy becomes less important. It may, therefore, be argued that a comparison between exchange rate targeting and inflation targeting does not do justice to exchange rate targeting when it is assumed that fiscal policy is passive. However, the political and academic support for an activist fiscal policy has declined considerably during the last 20 years. The main reason for this is that many countries have experienced that activist fiscal policies tend to generate excessive government debt. Several countries have, therefore, adopted fiscal policy rules that are meant to provide fiscal discipline. In addition to the argument that an activist fiscal policy may generate excessive debt, several parts of the public budget can potentially lead to large welfare losses if they are changed on a cyclical basis, *eg*, health care and education. Other parts are easier to change, and some parts change automatically due to cyclical patterns, *eg*, tax revenues and unemployment benefits. Although there seems to be limited support for an activist fiscal policy in most countries, there is a broad consensus that as a minimum, automatic stabilisers in fiscal policy should be allowed to work.

In order to consider fiscal policy, we introduce an indicator of the fiscal policy stance, x, which is measured as a deviation from the natural policy stance. If fiscal policy were fully flexible, one could minimize the loss function and find the optimal fiscal policy rule. However, such flexibility in fiscal policy seems unrealistic, given fiscal policy decision lags, political negotiations, etc. We, therefore, adopt the following simple representation of fiscal policy:

$$x_{t+1} = \tau y_t. \tag{21}$$

Equation (21) may be thought of as an activist fiscal policy, where fiscal policy responds to the level of activity, represented by the aggregate output gap, by one period lag due to decision lags in fiscal policy. Alternatively, (21) may be thought of as a representation of a passive fiscal policy with automatic stabilization, where τ is the degree of automatic stabilization. Equation (4) is then replaced by:

$$y_{t+1}^N = \rho_N(L)y_t^N - \alpha(L)r_t + \beta(L)e_t + x_{t+1} + \varepsilon_{t+1}^N, \tag{22}$$

$$= \rho_N(L)y_t^N - \alpha(L)r_t + \beta(L)e_t + \tau y_t + \varepsilon_{t+1}^N. \tag{23}$$

24. See TAYLOR [2000] and LEITEMO and SÖDERSTRÖM [2001] and the references therein for similar results and further discussion.

TABLE 4
Fiscal Policy Stabilization. Unconditional Standard Deviations and Loss in Percent

(τ)	$\bar{\pi}^c$	y^T	y^N	y	s	Δs	e	Δi	$Loss^a$	$Loss^b$
Strict inflation targeting										
– 0.5	0.00	4.5	5.1	4.5	∞	9.9	10.6	25.50	440.1	439.4
– 0.2	0.00	5.2	6.6	5.8	∞	9.9	11.5	25.80	448.7	447.7
0.0	0.00	6.1	8.3	7.2	∞	9.7	12.8	28.70	465.5	464.1
0.2	0.00	8.1	11.5	10.0	∞	10.1	15.7	26.93	511.0	533.4
Strict exchange rate targeting										
– 0.5	3.8	4.9	1.6	1.8	0.0	0.0	6.9	4.60	28.2	27.5
– 0.2	4.0	5.0	2.1	2.3	0.0	0.0	7.1	4.60	31.2	29.9
0.0	4.2	5.2	2.8	2.9	0.0	0.0	7.5	4.60	36.1	34.2
0.2	4.9	6.2	4.5	4.4	0.0	0.0	9.3	4.60	53.3	49.4

Note: (a) aggregate loss, (b) disaggregate loss.

An activist fiscal policy that responds to the level of activity is particularly beneficial when monetary policy conducts either strict exchange rate targeting or strict inflation targeting. Although no central banks conduct strict inflation targeting in practice,[25] it is fruitful to consider an activist fiscal policy under strict interpretations of the regimes in order to focus on differences between an activist and a more passive fiscal policy. Moreover, by considering strict inflation targeting and an activist fiscal policy, we are able to analyze whether fiscal policy is a substitute for monetary policy in stabilizing the real economy, so that monetary policy can focus solely on controlling inflation.

Table 4 shows the effects of an activist fiscal policy on the unconditional standard deviations of the variables in the model. We consider three cases with different degrees of fiscal policy stabilization. First, a case where $\tau = -.5,$ which represents a case with a high degree of fiscal stabilization. Second, a case with more modest stabilization; $\tau = -.2$, and third $\tau = .2$, which represents a case where fiscal policy is pro-cyclical. The third case may be interpreted as a case with a strict budget rule, where reduced government revenues during recessions must be followed by reduced government spending.

We see that a counter-cyclical fiscal policy reduces the variability of output considerably, in particular under strict inflation targeting. This suggests that a fiscal policy that responds to the output gap in a rather mechanical way, as in (21), produces a considerably improved inflation variability/output variability trade-off. However, a regime with strict targeting and the highest counter-cyclical fiscal policy response considered here, *ie,* $\tau = -.5$, generates higher output variability than a regime with flexible inflation targeting and a passive

25. KING [1997] called central banks with strict inflation targets 'inflation nutters' and argued that such central banks are not observed in practice.

fiscal policy. Thus, for realistic degrees of fiscal policy stabilization, fiscal policy is not a perfect substitute for monetary policy in stabilizing output under inflation targeting. This result partly reflects that the fiscal policymaker is assumed to follow a simple rather than an optimal rule. Fiscal policy will necessarily improve the outcome if the fiscal policymaker is allowed to minimize a relevant loss function in a coordinated way with the monetary policymaker. Moreover, it is interesting to note that in the case of strict exchange rate targeting with $\tau = -.5$, aggregate output variability is the same as in the case of flexible inflation targeting with a passive fiscal policy. However, sectoral output variability is higher in the former case than in the latter.

The results show that fiscal policy stabilization, either in terms of an active fiscal policy or from automatic stabilization, reduces nominal and real variability under both exchange rate and inflation targeting. Thus, the trade-off between nominal variability and real variability can be improved by using fiscal policy. The results also suggest that there are greater advantages to an activist fiscal policy if the central bank conducts strict inflation targeting than if it conducts strict exchange rate targeting.

3.5 Stability in Traded and Non-Traded Sectors

If there are costs of adjustment in production or imperfect labor mobility between sectors, a measure of aggregate output variability might understate the cost of output variability. To see this, note that:

$$(24) \quad var(y_t) = \eta^2 var(y_t^T) + (1-\eta)^2 var(y_t^N) + 2\eta(1-\eta)cov(y_t^T, y_t^N)$$

If the covariance between the sectors is negative, aggregate output might in principle be stable, while output in each sector might be volatile. An alternative loss function to (15), where output variability is measured at a disaggregated level, is:

$$(25) \quad L_t^b = a_\pi(\bar{\pi}_t^c)^2 + a_s s_t^2 + a_y(\eta y_t^T)^2 + a_y((1-\eta)y_t^N)^2 + a_{\Delta i}(\Delta i_t)^2$$

which is identical to the loss function (15), except that the covariance term is disregarded. If output in the two sectors are uncorrelated, the expected loss is the same whether one applies loss function (24) or (15).

In order to investigate whether a concern about sector-specific variability has implications for optimal monetary policy, in particular the response to fluctuations in the exchange rate, we have considered flexible inflation targeting and flexible exchange rate targeting when the loss function (15) is replaced by (25). Table 5 summarizes the expected losses and the unconditional standard deviations for the two rules.[26]

26. The a-weights are identical to those in the flexible regimes, considered in Section 3.1.

TABLE 5
Stabilization Properties %

$\bar{\pi}^c$	y^T	y^N	y	s	Δs	e	Δi	$Loss^a$	$Loss^b$
Flexible disaggregate inflation targeting									
3.2	2.8	1.8	1.7	∞	1.9	4.1	1.7	14.6	14.0
Flexible disaggregate exchange rate targeting									
3.6	4.0	2.1	2.2	2.1	1.4	5.7	1.1	18.3	17.0

Note: (a) aggregate loss, (b) disaggregate loss.

We see from comparing Table 3 and 5 that a concern about sector-specific variability does not significantly alter the solutions for the variables. This suggests that if sector-specific stability is considered important for welfare, little is lost if the central bank cares about aggregate fluctuations instead of sector-specific fluctuations. This reflects that the covariance between the two sectors is small (in absolute value), and focussing on aggregate output, monetary policy does not achieve aggregate output stability by sacrificing sector-specific stability.

4 Summary and Final Remarks

This paper has analyzed alternative monetary policy regimes within a small open economy model with a traded and a non-traded sector. Two main types of regimes, or targeting rules, have been considered; inflation targeting and exchange rate targeting, where the latter regime includes either independent exchange rate targeting or entering a monetary union. These two general types of monetary policy regimes represent the realistic alternatives for monetary policy in small open-economies today. In addition, we have considered the *Taylor* rule, which has received considerable attention in the literature. Moreover, we have considered an open economy extension of the *Taylor* rule, where the exchange rate enters in addition to inflation and the output gap. The extended *Taylor* rule, which we refer to as an MCI rule, is proposed by BALL [1999, 2000].

Flexible inflation targeting leads to reasonably low variability in both nominal and real variables. Somewhat surprisingly, flexible inflation targeting gives a more stable real exchange rate than both strict and flexible exchange rate stabilization, and thereby a more stable traded sector. This is in contrast to the common view that a fixed exchange rate provides a more stable economic environment for the traded sector. Real exchange rate variability is higher under exchange rate targeting because a central bank that targets the nominal exchange rate responds less vigorously to domestic disturbances than it does under inflation targeting. Due to the *Walters' effect*, this generates persistent (although dampened) oscillations in the real interest rate and the real exchange rate. Even if the currency risk premium could be reduced or removed by entering a monetary union, flexible inflation targeting would still be preferable according to our model.

We find that the simple instrument rules, that is, the *Taylor* rule and the MCI rule, perform very well in comparison with the more complex targeting rules. This indicates that little is lost by considering these simple strategies, which imply a response to only a few key state variables in the model. Our results indicate, moreover, that the exchange rate is *not* necessarily an important variable to respond to, even in the open economy.

The rationale for modelling the traded and the non-traded sectors separately, and not just the economy as a whole, has been twofold. First, monetary policy affects traded and non-traded sectors differently, and an optimal policy should take into account all aspects of the transmission mechanism. Even if the central bank were only concerned about stabilizing inflation and aggregate output, it should respond to disturbances in each sector separately, and not just to aggregate disturbances. The optimal rules that are derived from minimizing alternative loss functions may, therefore, provide some guidance as to how monetary policy should respond to sector-specific disturbances. Second, there is reason to believe that sector-specific fluctuations have welfare effects that go beyond those of aggregate fluctuations. For example, the cost of adjustment in production might lead to welfare gains from stabilizing each sector if resources cannot be transferred between the sectors without cost. Hence, we have also considered the implications of allowing sector-specific output variability to enter the loss function. BALL [2000] suggests that concerns about sector stability may explain why central banks seem to place greater weight on exchange rate stability than what is indicated by existing models. Somewhat surprisingly, we do not find any strong support for the hypothesis. However, the lack of support for the hypothesis might be a result of the specific model chosen. Further work on this issue may therefore be required.

It should be noted that comparing the alternative regimes within the same numerical model makes our results subject to the *Lucas' critique*. There is no reason to believe that the economic structure is identical when the central bank conducts independent inflation targeting or the country is a member of a monetary union. However, until more research is conducted, it is difficult to specify exactly *how* the economic structure will differ among alternative monetary regimes. It has often been argued that countries entering the '*EMU*' will experience more synchronized business cycles. This would lead to a better adjustment of the common monetary policy to economic conditions in the small periphery countries. In that case, our comparison between inflation targeting and monetary union may not do justice to the latter. However, the exercise of comparing alternative regimes within the same model still has some attractive features. For example, the results provide answers to questions like: *Given that the economic structure remains the same, what are the potential costs and benefits for small open economies of abandoning an independent monetary policy and entering a monetary union?* Our results suggest that these costs are not insignificant. However, a monetary union provides gains in terms of policy credibility and lower transaction costs, which have been disregarded in this study. ▼

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APPENDIX

A. *The Discretionary Optimization Procedure*

The optimization procedure is described in BACKUS and DRIFFILL [1986]. SÖDERLIND [1999] provides an interesting empirical application. Here, we review this method with respect to our two-sectoral model. The model can be written conveniently in state space form:

$$X_{t+1} = AX_t + Di_t + U_{t+1}. \tag{A1}$$

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

Our objective function in (4) can be written in a more general form:

$$J_t = E_t \sum_{s=0}^{\infty} \begin{bmatrix} X'_{t+s} & i_{t+s} \end{bmatrix} \begin{bmatrix} Q & U \\ U' & R \end{bmatrix} \begin{bmatrix} X_{t+s} \\ i_{t+s} \end{bmatrix}, \tag{A2}$$

where,

$$Q = \begin{bmatrix} T_{\bar{\pi}^C} \\ T_y \\ T_s \\ T_{\Delta i} \end{bmatrix}' \begin{bmatrix} a_\pi & 0 & 0 & 0 \\ 0 & a_y & 0 & 0 \\ 0 & 0 & a_s & 0 \\ 0 & 0 & 0 & a_{\Delta i} \end{bmatrix} \begin{bmatrix} T_{\bar{\pi}^C} \\ T_y \\ T_s \\ T_{\Delta i} \end{bmatrix}, \tag{A3}$$

where T_x defines the relationships between the target variables and the state vector X, *eg*, $\bar{\pi}^c_t = T_{\bar{\pi}^c} X_t$.

The problem now is to minimize (A2) subject to (A1). 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:

$$\begin{aligned} J_t &= \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix}' \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ e_t \end{bmatrix} + 2x'_{1t} U_1 i_t + i'_t R i_t \\ &+ E_t \left[x'_{1t} V_{t+1} x_{1t} + v_{t+1} \right], \end{aligned} \tag{A4}$$

where V_{t+1} and v_{t+1} – the parameters in the value function – so far are unspecified. The Q matrix is given by (A3) and U_1 is a vector that has zero elements except at the position that corresponds to the position of the lagged interest rate in the state vector, where the element is $-a_{\Delta i}$.

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 (A1), we get

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

After expressing the non-predetermined variables as explicit functions of the predetermined and instrument variables, we get:

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

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

$$\text{(A5)} \quad \begin{aligned} e_t &= (A_{22} - C_{t+1}A_{12})^{-1}(C_{t+1}A_{11} - A_{21})x_{1t} + \\ &\qquad (A_{22} - C_{t+1}A_{12})^{-1}(C_{t+1}D_1 - D_2)i_t \\ &= H_{1t}x_{1t} + K_{1t}i_t, \end{aligned}$$

where H_{1t} and K_{1t} are defined accordingly. Now using (A5) in (A1), we can extract an expression for the backward-looking variables:

$$\text{(A6)} \quad \begin{aligned} x_{1t+1} &= (A_{11} + A_{12}H_{1t})x_{1t} + (D_1 + A_{12}K_{1t})i_t + u_{1t+1} \\ &= H_{2t}x_{1t} + K_{2t}i_t + u_{1t+1}. \end{aligned}$$

By using (A5) in the instantaneous period t loss of (A4) and denoting this by j_t, it becomes:

$$\begin{aligned} j_t &= \begin{bmatrix} x_{1t} \\ H_{1t}x_{1t} + K_{1t}i_t \end{bmatrix}' \begin{bmatrix} Q_{11} & Q_{12} \\ Q_{21} & Q_{22} \end{bmatrix} \begin{bmatrix} x_{1t} \\ H_{1t}x_{1t} + K_{1t}i_t \end{bmatrix} \\ &+ 2x'_{1t}U_1 i_t + i'_t R i_t \\ &= x'_{1t}\left[Q_{11} + H'_{1t}Q_{21} + Q_{12}H_{1t} + H'_{1t}Q_{22}H_{1t}\right] x_{1t} \\ &+ x'_{12}\left[Q_{12}K_{1t} + H'_{1t}Q_{22}K_{1t} + U_1\right] \\ &+ i'_t\left[K'_{1t}Q_{21} + K'_{1t}Q_{22}H_{1t} + U'_1\right] x_{1t} \\ &+ i_t\left[R + K'_{1t}Q_{22}K_{1t}\right] i_t \\ &= x'_{1t}Q^* x_{1t} + 2x'_{1t}O^* i_t + i'_t R^* i_t. \end{aligned}$$

By substituting this expression into (A4) and using (A6) you eventually get:

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

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:

$$\text{(A7)} \qquad \begin{aligned} i_t &= -(R^* + \beta K_{2t}' V_{t+1} K_{2t})^{-1} (O_t^{*\prime} + \beta K_{2t}' V_{t+1} H_{2t}) x_{1t} \\ &= -F_t x_{1t} \end{aligned}$$

where F is defined accordingly.

We can now use (A7) in (A5) 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}:

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

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:

$$\text{(A8)} \qquad \begin{bmatrix} i_t \\ e_t \end{bmatrix} = \begin{bmatrix} -F \\ C \end{bmatrix} x_{1t}.$$

From (A1) the path for the predetermined variables can also be calculated accordingly:

$$\text{(A9)} \qquad \begin{aligned} x_{1t+1} &= (A_{11} + A_{12} C - B_1 F) x_{1t} + U_{t+1}, \\ &= \tilde{A} x_{1t} + U_{t+1.} \end{aligned}$$

Computing the Unconditional Moments

First, define $\Sigma_{x1} \equiv E\left[x_{1t} x_{1t}^{'}\right]$ and $\Sigma_U \equiv E\left[U_t U_t^{'}\right]$ as the unconditional variances. Considering the state-space form (A9), Σ_{x1} is given by the formulae:

$$\Sigma_{x1} = \left[I - \tilde{A} \otimes \tilde{A} \right]^{-1} \Sigma_U.$$

Given that G_t is the vector containing the variables of which we want to compute the unconditional variances, which relates to the vector (using equation (A8)):

$$\begin{bmatrix} x_{1t} \\ x_{2t} \\ i_t \end{bmatrix} = \begin{bmatrix} I \\ C \\ -F \end{bmatrix} x_{1t} \equiv W x_{1t}$$

by the matrix T in the following way:

$$G_t = TWx_{1t}.$$

The unconditional variances are then given by:

$$\begin{aligned} \Sigma_{G_t} &= TWE\left[x_{1t}x_{1t}^{'}\right]W'T' \\ &= TW\Sigma_{x1}W'T'. \end{aligned}$$

The unconditional standard deviations of the variables can be computed by taking the roots of the diagonal elements of Σ_{G_t}.