Exploring the potential conflict between monetary stability and financial stability in a small open economy*

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Abstract

We investigate empirically the possible role of asset prices in interest rate setting and the potential conflict between monetary policy and financial stability. We provide empirical evidence by evaluating rules within a small econometric model of the Norwegian economy. The model allows for interdependence between the real economy, credit and three classes of assets prices: housing prices, domestic equity prices and nominal exchange rate. The performance of rules that allow for response to significant misalignment of asset prices are compared to more standard monetary policy rules. We find that additional response to asset price misalignment may improve macroeconomic performance in terms of both nominal and real economic stability.

Keywords
Monetary policy, asset prices, econometric model, simulations

JEL Classification *C51, C52, C53, E47, E52*

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1 Introduction

It is often argued that an inflation targeting central bank should set interest rates in response to (forecasts of) inflation and the output gap, and not react directly to misalignments in asset prices. Such a policy is justified by the argument that asset price misalignments are not easily identifiable. Moreover, they are quite volatile, which may result in an overactive monetary policy that may prove to be destabilizing. Thus, it suffices that a central bank reacts indirectly to asset prices by responding to their effects on inflation and output, see e.g. Bernanke and Gertler (2001) and Bean (2003). For example, exchange rates may have direct effects on inflation through imported inflation, while housing and equity prices may affect inflation and output through their effects on, credit growth, aggregate consumption and investment.

The opposing view is that central banks can improve macroeconomic performance (defined in terms of minimizing the variability of output and inflation) by additionally reacting to asset prices themselves, relative to the case where they respond just to the effects of asset prices, see e.g. Cecchetti et al. (2000). Notwithstanding the conceptual and definitional problems with respect to how to characterize asset price misalignments, it is argued that e.g. an asset price bubble may lead to excessive investment and consumption, which may be corrected rather abruptly when the bubble bursts. Thus, both output and inflation may undergo excessive variability due to the evolution of a bubble in asset prices, see e.g. Cecchetti et al. (2000), Borio and Lowe (2002), Bordo and Jeanne (2002). Accordingly, a modest tightening or easening of monetary policy when asset prices rise above or below levels that are supposed to be sustainable may help to smooth fluctuations in output and inflation. This may even reduce the possibility of an asset price bubble forming in the first place. Thus several authors argue that monetary policy makers should use asset prices and exchange rates not only as a part of their information to assess future inflation, but also to let interest rates partly offset deviations of asset prices from their sustainable or equilibrium levels, see e.g. Chadha et al. (2003).

The two positions on the role of asset prices in monetary policy have mostly been framed and analyzed within the framework of calibrated or stylized models with strong theoretical properties, see e.g. Ball (1999), Batini and Haldane (1999), Svensson (2000), Walsh (1999), and Woodford (2000). One may argue that such models are not necessarily well-suited for the problem at hand. First, such models do not seem readily able to analyze effects of state dependent or large shocks caused by e.g. asset price bubbles. Second, the impact of asset price volatility on the economy remains largely, by its very nature, economy-specific and empirical, and is therefore more appropriately investigated within an empirical framework.

We develop a small macroeconometric model of the Norwegian economy where three classes of asset prices, housing prices, domestic equity prices and the exchange rate, are modelled. The empirical evidence embedded in the model shows that these assets prices have substantial influences on the real economy and vice versa. The model is therefore well suited to evaluate the performance of interest rate rules that allows for direct response to misalignments in asset prices relative to standard rules for closed and open economies as in Taylor (1993). The latter type of rules allows only indirect response to assets prices through their effects on inflation and output.

We evaluate and compare the performance of interest rate rules by counterfactual simulations of the model. The performance of a rule is summarised by a loss function based on the variability in inflation, output and implied interest rate volatility. Furthermore, its performance is also evaluated by a new measure "mean squared target errors" (MSTE), which takes into account two properties of a given interest rate rule: the implied variability in target variables (inflation and output) and the bias, i.e., the average deviation from the target(s) implied by the rule. In order to investigate whether the performance of a rule depends on the nature of a shock, we re-examine the performance of the rule under both supply and demand shocks.

The paper is organized as follows. The next section presents a stylized version of the macroeconometric model, emphasizing the role of asset prices. Section 3 lays out dynamic properties of the model. It also traces out effects on the economy of the build up and rapid decline in housing prices. Section 4 performs counterfactual simulations and compares the performance of different interest rate rules. Section 5 evaluates the performance of the different interest rate rules in response to supply and demand shocks. Section 6 explores particularly their contribution to promote financial stability. Section 7 concludes.

2 Asset prices in a small open economy

We develop a small macroeconometric model of the Norwegian economy that accounts for interdependencies between the real economy, inflation, credit growth and asset prices. The model is an extension of the model developed in Bårdsen et al. (2003) and Bårdsen and Nymoen (2001). It contains an econometrically well specified representation of wage and price inflation as well of the determination of output, unemployment, credit, and three classes of asset prices: housing prices, domestic equity prices and the nominal exchange rate.

Thus, the model takes explicitly into account several channels of interplay between credit, output and asset prices, see e.g. Kiyotaki and Moore (1997). Moreover, it captures features that are considered essential for the propagation of shocks such as unemployment persistence, and implicitly the dynamic adjustment in the household savings ratio and the debt service and debt capital ratios. The complete model is reported in the Appendix.

In the following, we first present a stylized version of the model which highlights the role of assets prices in a small open economy, particularly the transmission of changes in asset prices and monetary policy to the rest of the economy. The stylized version is based on the static long-run solution of the estimated model. Thereafter, we present a dynamic version of the stylized model, which further substantiates the importance of asset prices in the economy. In order to focus on the channels through which asset prices can affect the economy, we ignore forcing variables, or common trends, that enters the static and or the dynamic solutions of the model but play no role for the argument. In the models, all variables except interest rates are in logarithms, while foreign variables are denoted with starred superscripts.

The stylized version of the model highlights the interdependence between domestic output, real credit and real house prices. More specifically, aggregate demand y is influenced by real house prices $(ph-p)$, capturing changes in collateral effects —see Kiyotaki and Moore (1997), in addition to the real exchange rate $(e+p^{*}-p)$ and the real interest rate $(r-\Delta p)$:

$$y = -(r-\Delta p) + 0.5\,(e+p^{*}-p) + 0.1\,(ph-p)\,. \tag{2.1}$$

Real house prices affect demand for real credit $(l-p)$, for example like

$$(l-p) = 0.5y - 3r + (ph-p)\,,$$

while real house prices are mainly determined by aggregate demand and real credit demand, in addition to the real interest rate:

$$(ph-p) = 0.5y + 0.25\,(l-p) - 4\,(r-\Delta p)\,.$$

The real exchange rate is a function of the interest rate differentials:

$$(e+p^{*}-p) = -(r-r^{*}),$$

where a constant interest rate differential in the long run implies a constant real exchange rate, i.e. relative purchasing power parity (PPP).

Similarly, a simplified, stylized, version of this dynamic core model can be given as:

$$\begin{aligned}
\Delta y_t &= 0.05\Delta\,(s-p)_t + 0.7\Delta\,(e+p^{*}-p)_t && (2.2)\\
&\quad - 0.1\,[y - \{-(r-\Delta p) + 0.5\,(e+p^{*}-p) + 0.1\,(ph-p)\}]_{t-1}\,, \\
\Delta\,(l-p)_t &= 0.1\Delta y_t + 0.05\Delta\,(ph-p)_t + 0.02\Delta\,(s-p)_t && (2.3)\\
&\quad - 0.05\,[(l-p) - \{0.5y - 3r + (ph-p)\}]_{t-1}\,, \\
\Delta ph_t &= 1.3\Delta p_t + 0.2\Delta y_t + 1\Delta\,(l-p)_t - 1.2\Delta r_t && (2.4)\\
&\quad - 0.1\,[(ph-p) - \{0.5y + 0.25\,(l-p) - 4\,(r-\Delta p)\}]_{t-1}\,, \\
\Delta e_t &= -0.5\Delta r_t - 0.1\{e-(p-p^{*})\}_{t-1} - 0.1(r-r^{*})_t. && (2.5)
\end{aligned}$$

Here we simplify both in terms of the dynamics and abstract from additional explanatory variables. The dynamic version of the model is in equilibrium correction form, so the growth rates of the endogenous variables are affected negatively by positive deviations from the steady-state levels.

It appears that asset price volatility affects the economy through several additional channels in the short run. For example, growth of aggregate demand Δy_t is affected by real stock-price inflation $\Delta\,(s-p)_t$, in addition to changes in the real exchange rate $\Delta\,(e+p^{*}-p)_t$ and deviations from steady-state, which also depends on real housing prices and the real exchange rate. Growth in real credit demand $\Delta\,(l-p)_t$ also reacts positively to growth in real stock prices, as well as to increases in real housing prices $\Delta\,(ph-p)_t$.

The growth rate of nominal house prices Δph_t in the short run is ascribed to growth in aggregate demand, credit, consumer prices Δp_t, shifts in the interest rate and deviations from steady state. The exchange rate equation Δe_t captures the appreciation effect of positive changes in the interest rate, the interest rate differential as well as from deviations from PPP.

Nominal stock prices are modelled according to the Capital Asset Pricing Model (CAPM) by treating the national stock market portfolio as a "single" asset and the international stock market portfolio as the "market portfolio". The obtained relationship shows that excess return on the Norwegian stock market portfolio ($\Delta s_t - r_t$) reflects its exposure to the international market portfolio (0.8) and the risk premium on the international market portfolio ($\Delta s_t^* - r_t$). In addition, there is a strong negative relationship between changes in interest rates and excess return on the domestic stock market.

$$\Delta s_t - r_t = 0.8(\Delta s_t^* - r_t) - 5\Delta r_t.$$

Consumer price inflation Δp and wage inflation Δw depend on each other, labour productivity (pr) and changes in the activity level:

$$\begin{aligned} \Delta p_t &= 0.2\Delta w_t + 0.1\Delta y_t - 0.1\left[p - 0.7\left(w - pr\right) - 0.3\left(e + p^*\right)\right]_{t-1}, \\ \Delta w_t &= 0.7\Delta p_t - 0.1\left(w - p - pr + 0.1u\right)_{t-1}. \end{aligned}$$

Unemployment u also fluctuates together with the activity level, as suggested by Okun's law. In addition, it exhibits weak reversion towards its equilibrium rate:

$$\Delta u_t = -0.1u_{t-1} - 2\Delta y_t. \tag{2.6}$$

Inflation Δp_t has a long-run elasticity with respect to import prices of 0.3 (the term with $e + p^*$ in brackets), while the short-run elasticity is a tenth of this. In the full econometric model productivity pr is also an endogenous variable that depends on real wages $w - p$, unemployment (u) and a deterministic trend.

In the context of asset price volatility and potential bubbles, stability and steady-state properties of a model becomes particularly important. A couple of the steady state properties of our model are worth pointing out: First, the steady-state solution implies that domestic and foreign inflation rates are equilibrated:

$$\Delta p = \Delta e + \Delta p^*.$$

Moreover, given that $\Delta e = 0$ in steady state, the real exchange rate ($e + p^* - p$) is linked to a potentially non-zero interest rate spread $r - r^*$. And second, the model implies that equilibrium unemployment is a function of the steady-state growth rate of the economy:

$$u = \text{constant} + f(\text{factors determining steady state growth of } y).$$

That is, the model implies no long-run trade off between inflation and unemployment, even though we have not imposed a long-run Phillips curve. This property of the model is discussed in more details in Bårdsen and Nymoen (2003).

3 Model properties

The complete model is econometrically well specified and characterizes the actual behaviour of all endogenous variables quite well. This is demonstrated in Figure 3.1, which displays tracking properties of the model for key variables. These are based on dynamic simulations of the full model conditional on historical values of the exogenous variables: foreign GDP growth, oil prices and domestic and foreign money market rates. We note that the tracking properties do not deteriorate over the relatively long simulation period of 18 years: 1984:1–2001:1.

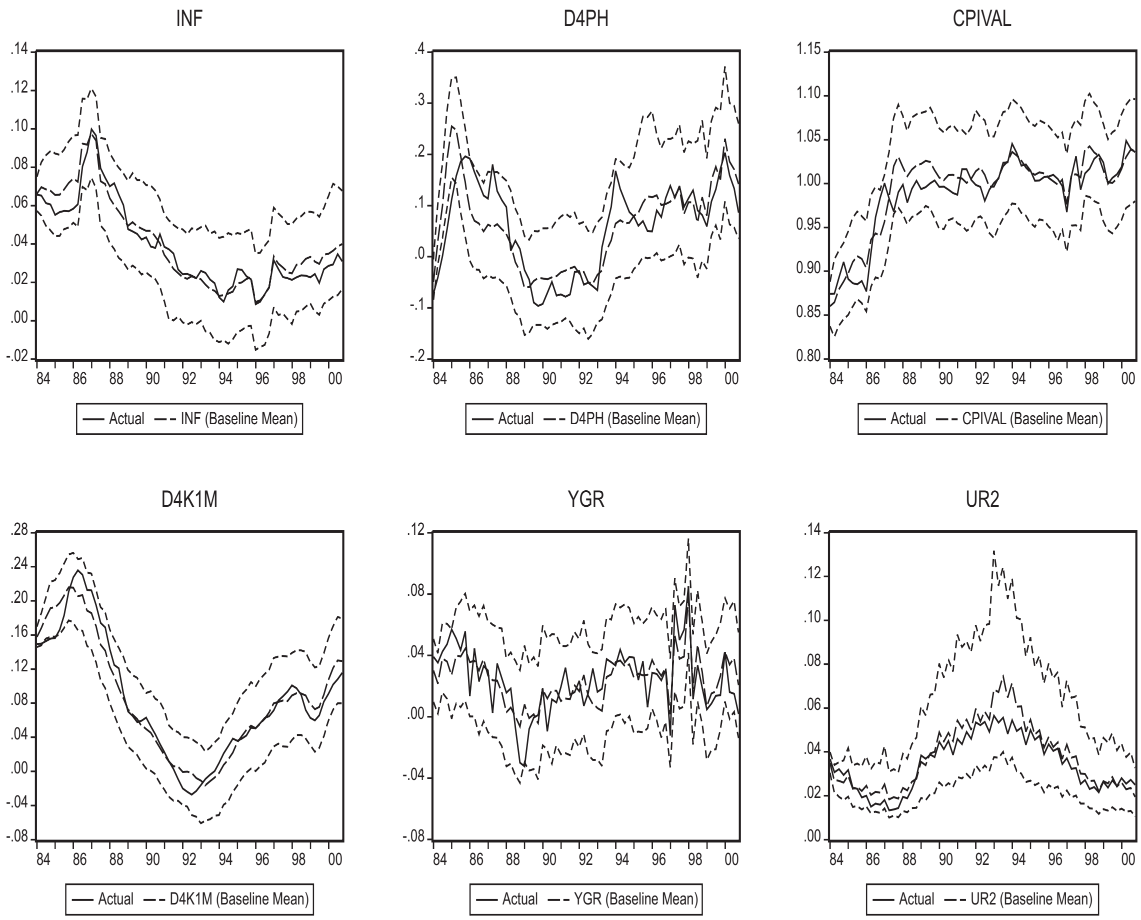

Figure 3.1: *Dynamic baseline simulation of the model over the period 1984:1–2001:1.*

Figure 3.2 displays the responses of key variable to a permanent rise in money market rates of 1 percentage point from 1990:1 and onwards. We note that e.g. responses of inflation and GDP to a monetary policy shock are comparable to those reported in other studies. Three other observations from the figure are also worth pointing out:

First, importance of asset price volatility is evident: while the maximum response of inflation is on average of the magnitude of a fourth of a percentage point, the reaction of house prices is seven times as high. There is also a permanent appre-

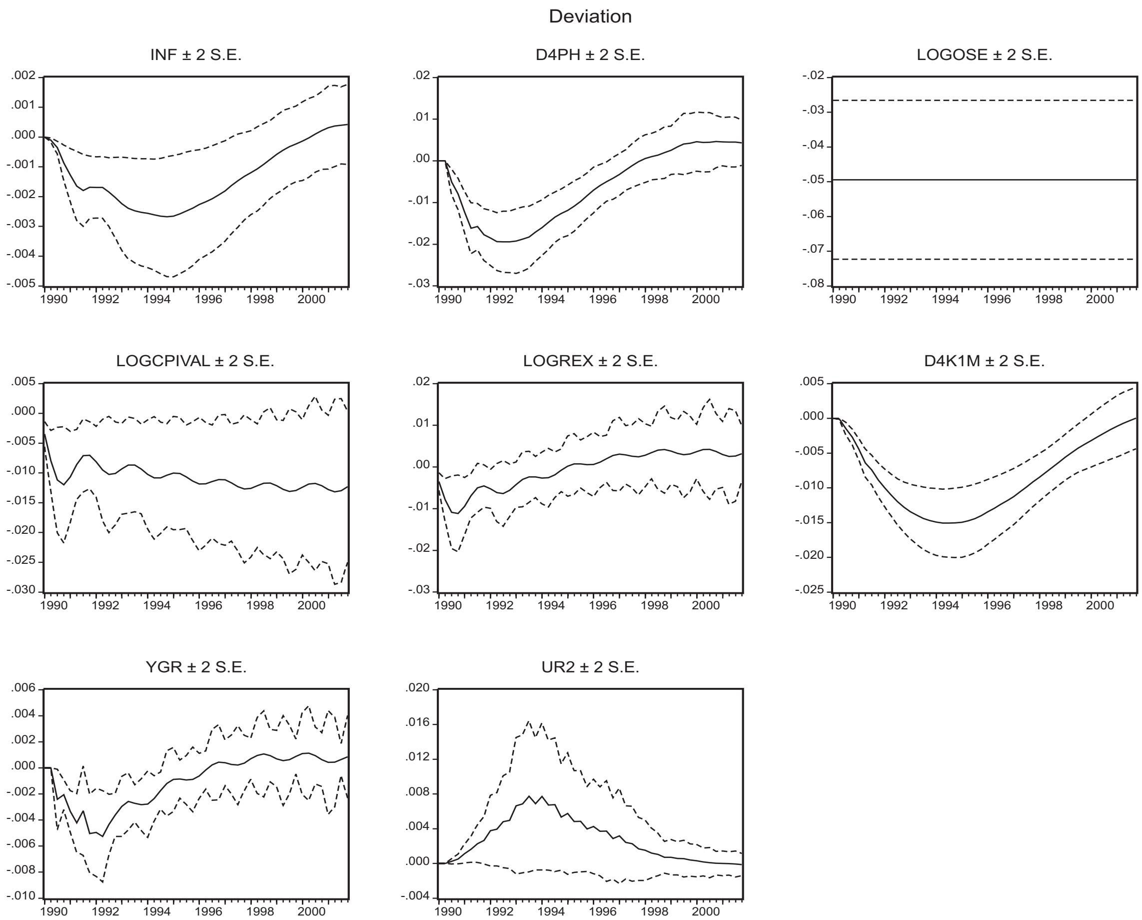

Figure 3.2: *Responses to a percentage point permanent rise in short-term interest rates. Solid lines represents deviations from corresponding baseline simulations, while dashed line depicts the corresponding 95% confidence intervals.*

ciation of the nominal exchange rate of one percentage point, while nominal credit falls at the annual rate of 1 1/2 percentage point at maximum.

Second, the response of aggregate demand and the unemployment rate is faster than that of inflation. This suggests that supply-side shocks may lead to a conflict between nominal stability and economic activity, which may also lead to financial instability. For example, monetary policy tightening in the face of supply shocks may incur substantial reduction in economic activity before inflation is brought back to the desired rate. Concurrently, high interest rates combined with high unemployment may increase the default ratio of households and businesses and thereby the fragility of the financial sector. In the case of a demand shock, however, high interest rates are likely to be raised in a state of relatively low unemployment. Hence, financial stability will not be threatened to the same extent as in the case of a supply shock.

Finally, monetary policy is neutral in the long run. The deviations of the real exchange, GDP growth and unemployment from their base values become zero in the long run.

3.1 Excess growth in housing prices

Housing prices have larger effect than the other asset prices on economic activity directly and indirectly through their effects on credit growth. This section examines their behaviour more closely and investigates the model's sensitivity with respect to changes in housing prices.

The leftmost panel of Figure 3.3 shows a measure of excess growth in housing prices, defined as annual nominal growth in housing prices relative to the after tax nominal interest rate $r(1-\tau)$, which is used a measure of the opportunity or funding costs of investing in the housing market. Interestingly, growth in excess of about 10% tend to be followed by corrections towards zero excess return, i.e., where the returns in the housing and the bond markets equalize. There is one obvious exception from this pattern. In the period 1988–1993 housing prices fall by about 10% per annum. This fall coincided with increases in the after tax interest rate. Thus excess growth, $\Delta ph - r(1-\tau)$, was around -15% percentage points during 1988–1993. The rightmost panel of Figure 3.3 also offers other examples of a negative relationship between interest rates and growth in housing prices.

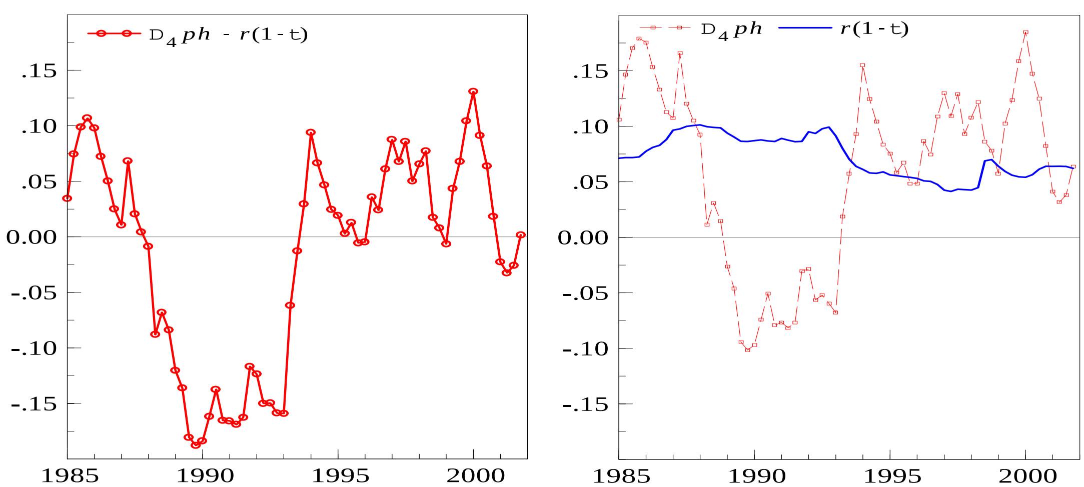

Figure 3.3: *Excess return in the housing market: Annual nominal growth in housing prices relative to the after tax nominal interest rate.*

Figure 3.4 (a) shows another measure of excess growth in the housing market, defined as annual growth in real housing prices relative to annual GDP growth. This measure also shows a similar pattern in the evolution of housing prices as the one observed in Figure 3.3. That is, growth in excess of about 10% tend to be followed by corrections towards the zero rate, except in the period 1988–1993. Figures 3.4 (b)–(c) indicate that GDP growth tend to coincide with growth in real and nominal housing prices.

Figure 3.5 shows the dynamic response of key macroeconomic variables to excess growth of housing prices which is followed by a sudden fall. More specifically, housing prices are assumed to rise an extra 2.5 percentage points per quarter for two years

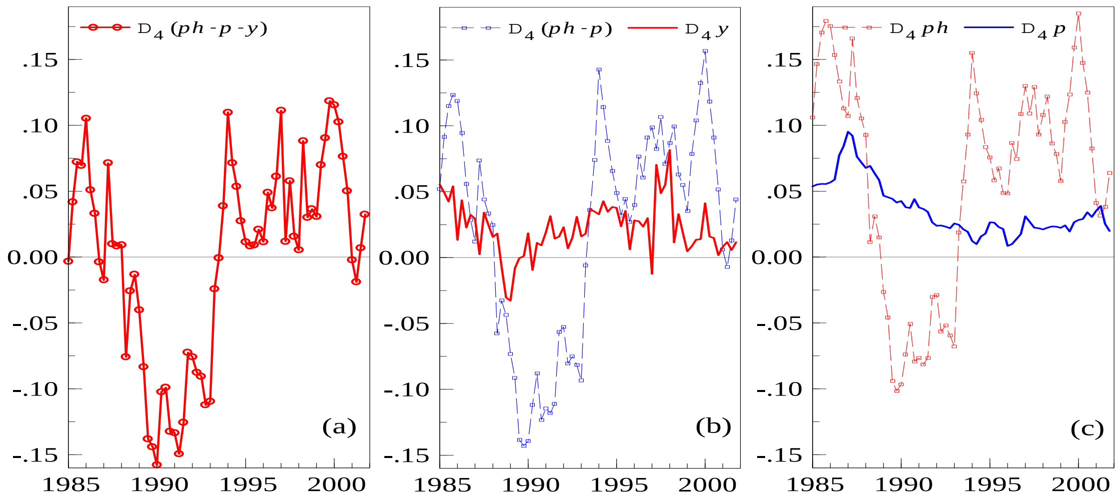

Figure 3.4: *Annual growth in real housing prices relative to annual gdp growth.*

(1984–1985) before this additional impulse suddenly disappears. Figure 3.5 shows that inflation, nominal credit growth and the activity rate rise with the (exogenous) increase in housing prices. The responses of inflation and nominal exchange rate are however slower than those of the other variables, which tend to move more closely with the growth in housing prices. Consequently, when the additional growth in housing prices disappears, inflation continues to rise and is at its maximum 2 years after the burst—when output growth has already declined and unemployment has started climbing upward. The only variable that is mainly unaffected by the bubble is the exchange rate.

To summarize, housing price volatility seem to have quite strong effects on the rest of the economy. It also appears that, when consumer price inflation is slower in response relative to the real economy, strict inflation targeting in response to a bubble in asset prices can increase variability in the real economy. It seems that in such cases, allowing the monetary policy response to be guided by the evolution of asset prices and or output might be more stabilizing relative to the case of strict inflation targeting.

4 Macroeconomic performance of different interest rate rules

We now specify the interest rate rules considered in this paper, presents criteria for their evaluation and examines their performance in terms of these criteria.

4.1 Specification

Several extensions of the simple three-parameter family of interest rate rules (inflation, output gap, smoothing) have been proposed in the literature. Open economy

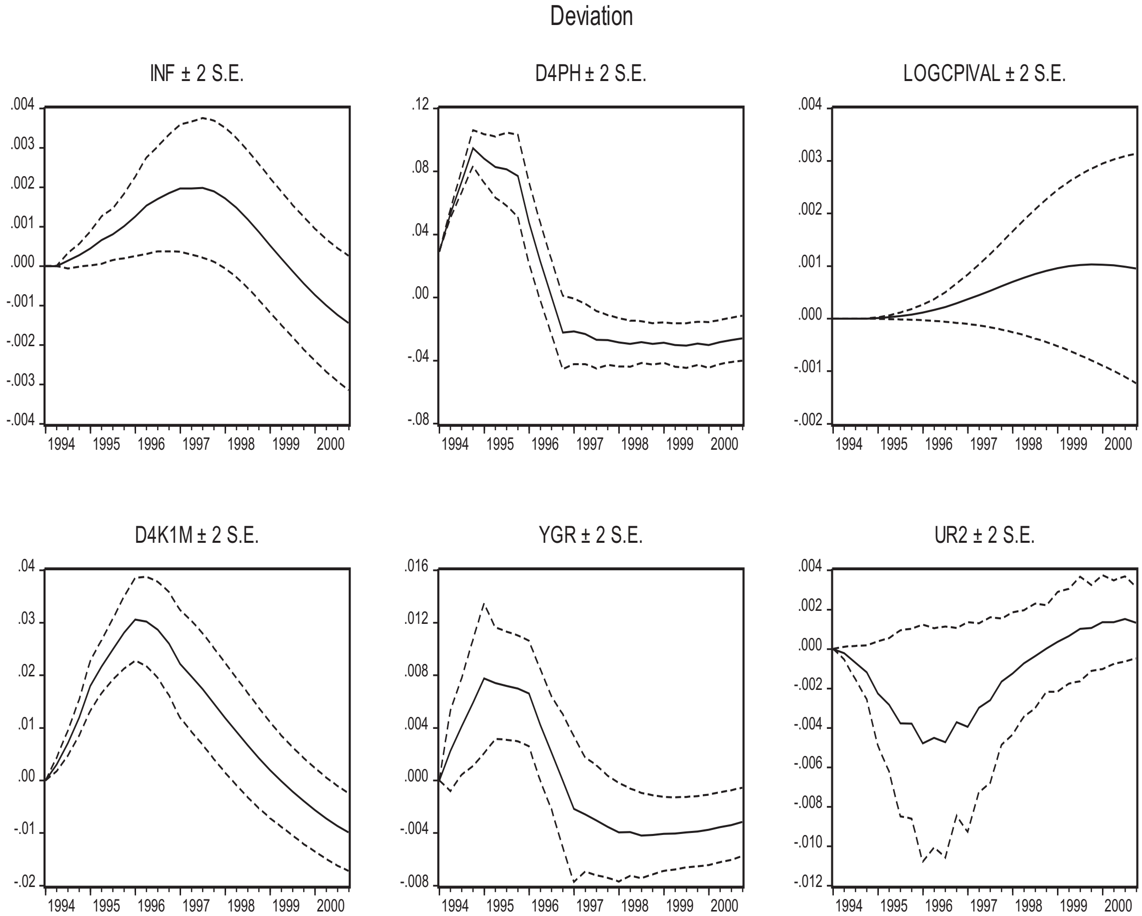

Figure 3.5: *Responses to a bubble in housing prices.*

extensions have been proposed by *inter alia* Ball (1999) and Batini et al. (2001), where they let the interest rate also respond to real exchange rate misalignments. While several authors have argued for the inclusion of asset prices such as real estate and equity prices in addition to exchange rates, cf. e.g., Cecchetti et al. (2000), Bernanke and Gertler (2001) and Bean (2003).

In the following, we examine the merits of some of the proposed rules within the context of our econometric model. They can all be classified as simple interest rate rules, in contrast to so called optimized rules where weights on the preferred arguments in central banks response functions are chosen such that they minimize deviations from the target variables within a given model. Given, the model dependency of such rules, their performance may deteriorate substantially across models. In contrast, the performance of simple rules does not tend to suffer that much across models. For example, a number of studies suggest that the standard Taylor rule performs remarkably well across different types of models for different economies. Thus, even though a derivation of the optimal response to e.g. asset prices would be of interest, this paper employs simple rules and leaves it to future studies to derive and employ optimal rules to investigate the robustness of our findings.

Consider the following general specification for the interest rate rule:

$$rs_t = \omega_r rs_{t-1} + (1-\omega_r)(\pi^* + rr^*) + \omega_\pi(\Delta_4 pu_t - \pi^*) + \omega_y(\Delta_4 y_t - g_y^*) \quad (4.1)$$
$$+ \omega_{q0}(q_t - q^*) + \omega_{q1}(q_{t-1} - q^*)$$
$$+ \omega_p h(\Delta_4 ph_t - g_{ph}^*) + \omega_o se(\Delta_4 ose_t - g_{ose}^*)$$

All the interest rate rules considered can be written as a special case of equation (4.1). We use output growth instead of output gap in the interest rate rules considered in this paper.[1] The different interest rate rules are explained in detail in Table 4.1. The first line notes the different variables, their associated target parameters and the assumptions about the target parameter's trigger values. Each rule corresponds to a line in Table 4.1 and the weights attached to the different variables are shown in the columns.

Table 4.1: Interest rate rules used in the counterfactual simulations
$rs_t = \omega_r rs_{t-1} + (1-\omega_r)(\pi^* + rr^*) + \omega_\pi(\Delta_4 pu_t - \pi^*) + \omega_y(\Delta_4 y_t - g_y^*) + \omega_{q0}(q_t - q^*) + \omega_{q1}(q_{t-1} - q^*) + \omega_{ph}(\Delta_4 ph_t - g_{ph}^*) + \omega_{ose}(\Delta_4 ose_t - g_{ose}^*)$

Variables:		rs_{t-1}	$\Delta_4 pu_t$	$\Delta_4 y_t$	q_t	q_{t-1}	$\Delta_4 ph$	$\Delta_4 ose$
Target/trigger:		$\pi^* + rr^*$	π^*	g_y^*	q^*	q^*	g_{ph}^*	g_{ose}^*
Trigger value:		0.06	0.025	0.025	0	0	0.10	0.10
Weights:		ω_r	ω_π	ω_y	ω_{q0}	ω_{q1}	ω_{ph}	ω_{ose}
Flexible	FLX		1.5	0.5				
Smoothing	SM	0.75	1.5	0.5				
Real exchange rate	MCI		1.5	0.5	0.33			
Housing prices	PH		1.5	0.5			0.20	
Stock prices	OSE		1.5	0.5				0.20
Composite rule	CMP	0.25	1.5	0.5	0.25	-0.25	0.05	0.05

The rules in Table 4.1 fall in four categories. The first rule (FLX) is a variant of the standard Taylor-rule for a closed economy ("flexible "rule) where interest rates respond to inflation and output. The next rule introduce interest rate smoothing (SM) ("smoothing"rule), where we also include the lagged interest rate, and the third group contains three rules which can be labelled as "asset price"rules. This group includes a rule with response to the real exchange rate, q_t, which has previously been used in the open economy models proposed by *inter alia* Ball (1999) and Batini et al. (2001). This rule is termed MCI. The second rule in this group includes a response to domestic housing prices while the third allows monetary policy to respond to

[1]There are several arguments for looking at output growth rather than the output gap. In addition to the inherent possibility of measurement error in the output gap, as emphasized by Orphanides (2000), there are also theoretical reasons why output growth might be a sensible objective. Walsh (2003) argues that changes in the output gap—growth in demand relative to growth in potential output—can lead to better outcomes of monetary policy than using the output gap. He demonstrates that such a "speed limit policy" can induce inertia that dominates monetary policy based on inflation targeting and the output gap—except when inflation expectations are primarily backward-looking.

domestic equity prices. These rules are denoted as PH and OSE, respectively. Some motivation for incorporating several different asset prices are given in e.g., Chadha et al. (2003). Finally, we consider a "composite" rule (CMP) in which we incorporate effects from several of the different variables at the same time.

In order to facilitate the comparison between the different interest rate rules we have maintained the weights on inflation ($\omega_\pi = 1.5$) and output growth ($\omega_y = 0.5$) in all rules in Table 4.1. Note that these values alone define the interest rate rule denoted FLX. The FLX rule serves as a benchmark for comparison with all other rules in Table 4.1.

4.2 Evaluation

The performance of the different rules is examined by measuring their performance in counterfactual simulations of the model over the period 1995:1–2000:4. In line with the common practice, when undertaking counterfactual simulations, we assume that the model's parameters are invariant to the specified changes in the interest rate rules. This assumption may be innocuous if the Lucas critique is quantitatively not that important, see e.g. Rudebusch (2003).

Rather then deriving optimal rules, simple rules have been chosen to facilitate comparison across specifications.

The performance of a rule can be summarised by monetary authorities supposed loss function:

$$\pounds(\lambda, \phi) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta rs_t] \tag{4.2}$$

where λ and ϕ express monetary authorities' aversion to variation $V[.]$ in output growth ($\Delta_4 y_t$) and interest rate volatility (Δrs_t), relative to that in underlying (core) inflation ($\Delta_4 pu_t$). The performance of a rule will be examined under different choices of these weights.

The monetary authorities may also care about the ability of an interest rate rule to achieve their targets in the short run, i.e. to what extent a rule is biased relative to the targets. Such bias and variation in a target variable x can be measured by MSTE (Mean Squared Target Error) measure:

$$\mathsf{MSTE}(x) = \frac{1}{T}\sum_{t=1}^{T}(x_t - x^*)^2 = V[x] + (\bar{x} - x^*)^2.$$

where x^* denotes the target value of x, while $\bar{x}$ is the sample mean of x over the simulation period. It represents an estimate of the expected level of x, $E[x]$. When evaluating the rules, we calculate values of the loss function using estimated values of MSTE as arguments.[2]

[2] The target levels has been chosen in the light of the Norwegian inflation target of 2.5% and the presumed long run values of the other variables. Accordingly, headline and core inflation rates are set equal to 2.5%, which is in line with the official target since Mars 2001. Target rates for output growth, unemployment and credit growth has been set to 2.5%, 4% and 5%, respectively. Growth target in nominal housing and equity prices has been set equal to 10% per annum, while

4.3 Performance of the rules relative to the actual policy

Figure 4.1 displays counterfactual simulations under different interest rate rules for some of the key variables: short-term interest rates RSH, underlying inflation INFJAE, output growth YGR and unemployment UR2. The solid line is the No Rule scenario with (exogenous) short-term interest rates at their actual values. In this case, the model reproduces actual values of the data when simulated.[3]

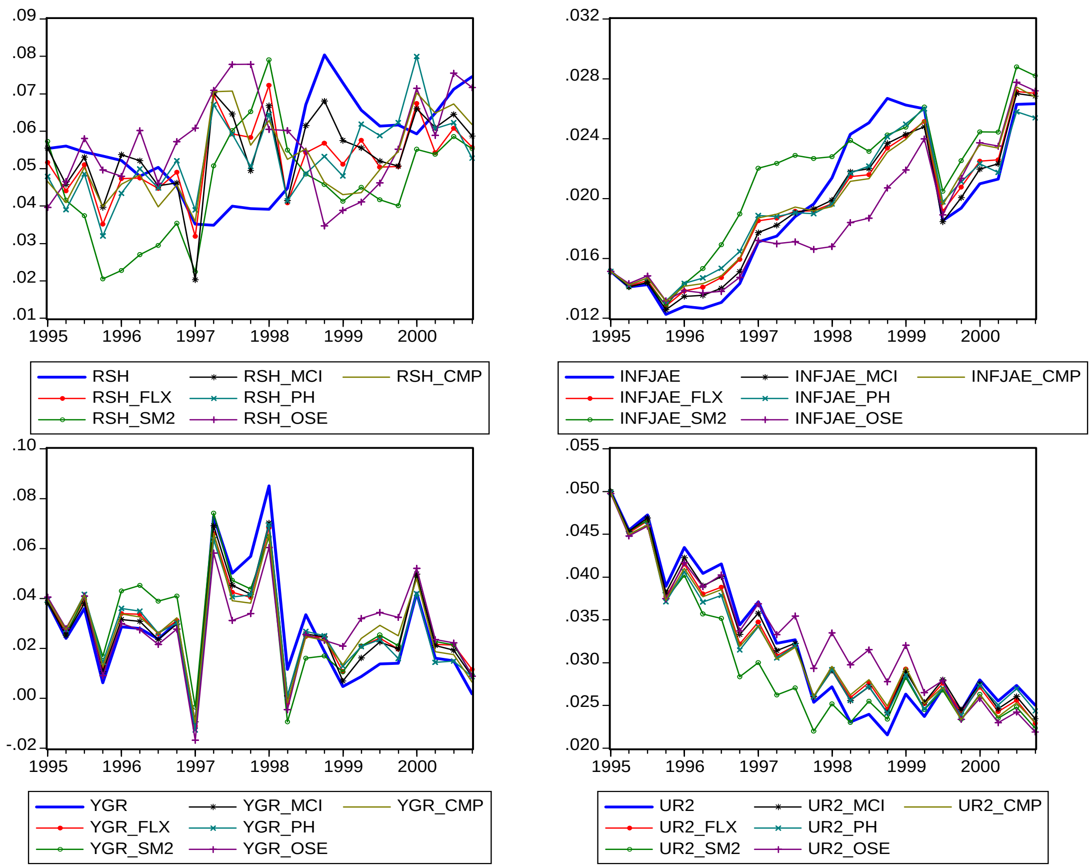

Figure 4.1: *Counterfactual simulations 1995:1 to 2000:4 for each of the interest rate rules in Table 4.1. The solid line denote the No Rule scenario. Short-term interest rate (upper left), underlying inflation (upper right), output growth (lower left), unemployment (lower right).*

Figure 4.1 shows that the different interest rate rules imply considerably different stances of monetary policy over time and hence different paths for the endogenous variables. One common feature, however, is that most of the rules lead to a more

changes in nominal exchange rates and interest rates has been set equal to zero.

[3]This is achieved by calibrating model residuals such that actual values of the data are reproduced exactly when we simulate the model with historical values for the short run interest rate, rs_t. For each of the different interest rate rules we maintain these add factors at their historical values. Thus, we isolate the partial effect from changing the interest rate rule while maintaining a meaningful comparison with the historical sample values.

expansive monetary policy with lower interest rates in the first two years of the simulation period, compared with the No Rule scenario. This contributes to e.g. GDP growth in excess of 2.5%. Consequently, the expansionary policy is followed by a tightening of monetary policy during 1997 with interest rates rising towards a peak level of 8%. Monetary policy is relaxed again in 1998 as e.g. GDP growth declines. In contrast, monetary policy is tightened in the No Rule scenario (i.e. in the data) in this period. This occurs mainly as a response to speculative attacks at the Norwegian krone when monetary policy was aimed at exchange rate stabilization.

Figure 4.2 displays deviations from the actual development under each monetary policy rule. Behaviour of the individual rules is rather difficult to grasp from figure. It seems however that responses to the smoothing rule SM and the rule with additional response to stock price changes, OSE, form the boundaries of a corridor for the relative responses for each rule compared with the data. The SM rule gives rise to the most expansionary monetary policy over the simulation period, while the OSE rule seems to give rise to the largest swings in interest rates. Consequently, the OSE scenario is the most contractive scenario until early 1997 and thereafter the most expansionary scenario compared with all other rules. For inflation the width of this corridor is about plus/minus 0.5 pp relative to actual inflation. Output growth deviate from actual growth with about plus/minus 2 pp, and unemployment deviate from actual with about plus/minus 0.7 pp.

Table 4.2 shows quantified measures of the performance of the different interest rate rules. For each interest rate rule, it records the bias, standard deviation and the "root mean squared target error" (RMSTE) measured relative to the sample values.

Table 4.2 suggests that the benchmark rule FLX rule gives a slightly more expansive monetary policy compared with the sample average over the period 1995:1 to 2000:4. A lower interest rate and weaker exchange rate give rise to somewhat higher output growth (relative bias greater than 1) and higher inflation growth (relative bias less than 1). The explanation is that while average output growth in the sample is higher than the target growth of 2.5%, average headline and underlying inflation is lower then the inflation target of 2.5%. Thus the relative bias from a more expansionary monetary policy becomes larger than 1 for output (moving output growth further away from the target) and smaller than 1 for inflation (moving inflation closer to the target). The relative variability of underlying inflation and output growth is 15% lower than in the sample, while interest rates, exchange rates and housing prices show greater variability.

The smoothing rule SM, which is (partly) defined by a positive weight $\omega_r = 0.75$ on the lagged interest rate, gives rise to an even more expansionary monetary policy relative to FLX rule. Thus it reduces the bias for underlying inflation and gives a negative bias for headline inflation. Consequently, we obtain inflation (on average) above the target of 2.5% in the SM scenario. On the other hand, the "smoothed" interest rate changes turns out to minimize the variance of interest rate changes, Δrs_t, compared with all the other rules in Table 4.2.

The MCI rule puts weight on the real exchange rate, q_t, such that a weaker real exchange rate leads to a tightening of monetary policy. In addition to its

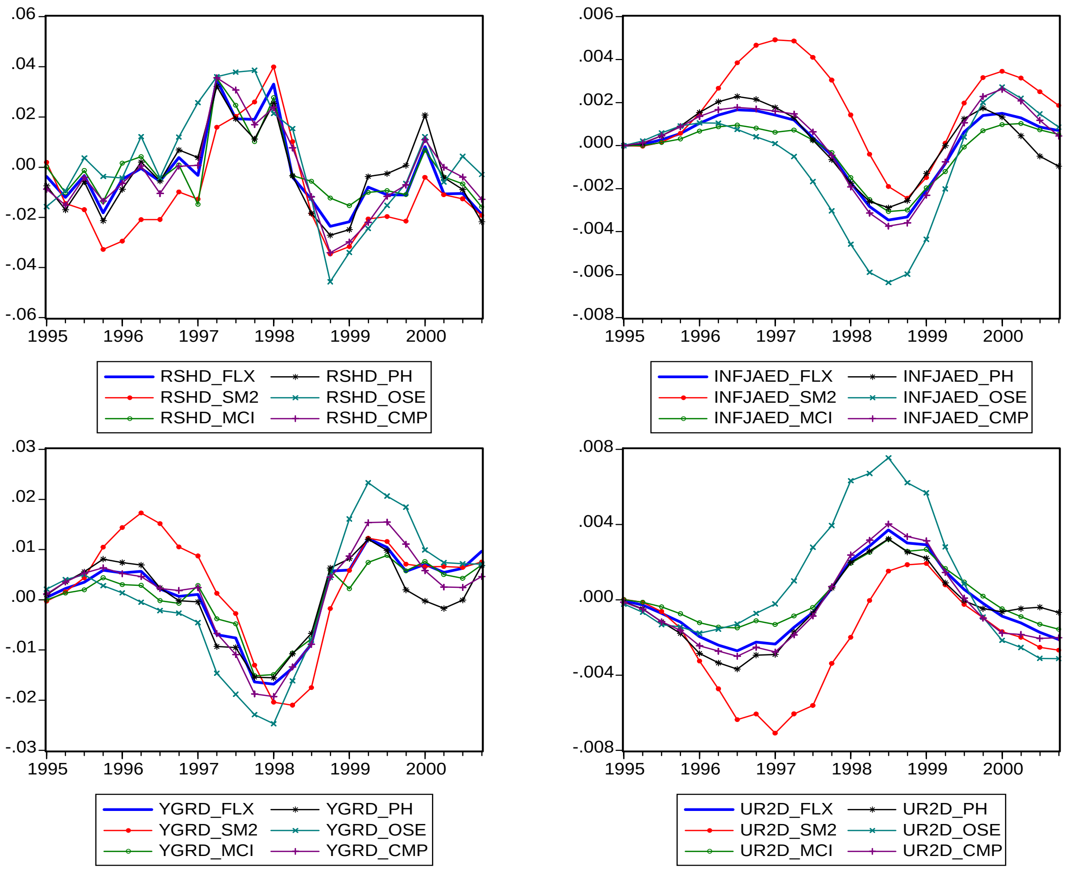

Figure 4.2: *Counterfactual simulations 1995:1 to 2000:4 for each of the interest rate rules in Table 4.1. The variables are measured as deviations from the No Rule scenario. Short-term interest rate (upper left), underlying inflation (upper right), output growth (lower left), unemployment (lower right).*

direct contractionary effect, the increase in interest rates also partly counteracts the weakening of the exchange rate and dampen the expansionary effects working through the exchange rate channel. In our simulation the MCI scenario leads to a less expansionary monetary policy compared with the sample average, which results in an increased bias in headline and underlying inflation. We obtain on the other hand a more stable exchange rate (less variability in v_t), but at the cost of higher variability in interest rate changes.

When specifying interest rate rules with (additional) response to domestic asset price inflation in either the housing market or the stock market, we consider a "leaning against the wind" strategy and let interest rates react to asset prices only in the case of double digit asset price inflation. In the PH scenario, we obtain a more expansionary monetary policy, which eventually leads to a smaller inflation bias compared with the sample. But, relatively high housing price growth in the sample implies higher interest rates and thereby provide a more balanced scenario of economic growth, compared with the FLX scenario. For example, we find lower

Table 4.2: *Counterfactual simulations 1995:1 to 2000:4. RMSTE and its decomposition in bias, standard deviations and root mean squared target errors (RMSTE) of the different interest rate rules, relative to the sample average.*

		Simstart 1995:1, evaluation over 1995:1-2000:4:								
		$\Delta_4 p_t$	$\Delta_4 pu_t$	$\Delta_4 y_t$	u_t	$\Delta_4 cr_t$	v_t	$\Delta_4 ph$	$\Delta_4 ose$	Δrs_t
Policy rule	Target/trigger	0.025	0.025	0.025	0.040	0.050	0	0.100	0.100	0
Sample	Mean	0.023	0.019	0.027	0.032	0.074	0.013	0.106	0.163	0.000
No Shift	bias	-0.002	-0.006	0.002	-0.008	0.024	0.013	0.006	0.063	0.000
1995:1-2000:4	sdev	0.006	0.005	0.023	0.009	0.023	0.017	0.040	0.232	0.007
	RMSTE	0.007	0.008	0.023	0.012	0.033	0.022	0.040	0.240	0.007
	Mean	0.023	0.019	0.028	0.032	0.075	0.016	0.109	0.163	-0.001
Flexible rule	Rel. bias	0.96	0.99	1.53	1.03	1.02	1.18	1.53	0.95	-1.97
FLX	Rel. sdev	1.04	0.85	0.81	0.90	1.00	1.36	1.19	0.77	1.92
	Rel. RMSTE	1.03	0.93	0.82	0.96	1.01	1.29	1.20	0.78	1.92
	Mean	0.025	0.021	0.030	0.030	0.086	0.024	0.121	0.161	-0.001
Smoothing rule	Rel. bias	-0.17	0.69	2.47	1.27	1.46	1.82	3.46	0.97	-1.93
SM	Rel. sdev	1.09	0.92	0.88	0.95	1.20	1.51	1.24	0.68	1.53
	Rel. RMSTE	1.05	0.80	0.90	1.11	1.34	1.63	1.34	0.70	1.53
	Mean	0.023	0.019	0.028	0.032	0.073	0.014	0.107	0.161	0.000
Real exchange rate	Rel. bias	1.11	1.03	1.26	0.98	0.95	1.05	1.12	0.97	-1.41
MCI	Rel. sdev	1.03	0.87	0.84	0.92	0.99	1.19	1.18	0.87	2.18
	Rel. RMSTE	1.04	0.96	0.84	0.95	0.97	1.14	1.17	0.88	2.18
	Mean	0.023	0.020	0.027	0.032	0.076	0.015	0.108	0.156	-0.001
Housing price	Rel. bias	0.88	0.97	1.22	1.06	1.05	1.14	1.30	0.89	-2.31
PH	Rel. sdev	0.96	0.80	0.81	0.88	0.89	1.32	0.98	0.77	1.78
	Rel. RMSTE	0.95	0.90	0.81	0.96	0.97	1.26	0.99	0.78	1.78
	Mean	0.022	0.019	0.028	0.033	0.069	0.011	0.105	0.140	0.000
Stock price	Rel. bias	1.53	1.14	1.31	0.88	0.78	0.85	0.83	0.63	0.55
OSE	Rel. sdev	1.16	0.85	0.77	0.88	1.06	1.71	1.53	0.36	1.61
	Rel. RMSTE	1.19	1.03	0.78	0.88	0.92	1.45	1.51	0.38	1.61
	Mean	0.024	0.020	0.028	0.032	0.076	0.016	0.110	0.148	0.000
Composite rule	Rel. bias	0.84	0.96	1.53	1.05	1.06	1.19	1.66	0.77	-0.95
CMP	Rel. sdev	1.06	0.85	0.80	0.90	1.01	1.38	1.22	0.60	1.53
	Rel. RMSTE	1.05	0.91	0.80	0.97	1.03	1.31	1.23	0.62	1.53

output growth bias, and less variability in housing growth and credit growth in the PH scenario compared with all the other scenarios in Table 4.2. Thus, it seems as a "leaning against the wind" strategy where we partly offset double digit asset price inflation, leads to less output volatility, and we would also expect to see a dampening of the accumulation of financial imbalances since housing price volatility and credit volatility is decreased.

The OSE scenario, in contrast with the PH scenario, gives rise to a quite contractive monetary policy, with higher interest rates and less weakening of the exchange rate. This gives rise to a greater bias in headline and underlying inflation and a lower bias in housing price growth, credit growth and currency depreciation. Since the variability of output is minimized for the OSE rule, and the only variables which affects stock prices are domestic interest rates and international stock market returns, we would expect to see relatively low interest rate volatility as well. This is corroborated by the fact that the interest rate volatility is lower than all other scenarios but the SM scenario. However, the greater stability in interest rates, seems to come at the cost of higher exchange rate volatility which achieves its maximum in the OSE case.

Table 4.3 lays out calculated values of the loss function using variability in out-

Table 4.3: Loss function evaluation based on relative variances (to the No Rule and FLX rule)
$\pounds(\lambda, \theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative variances						
λ	ϕ	FLX/NoR	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
0	0	0.849	1	1.086	1.027	0.946	1.005	0.996
0	0.1	1.113	1	0.946	1.084	0.937	0.922	0.899
0	0.5	1.498	1	0.847	1.119	0.932	0.866	0.833
0	1.0	1.653	1	0.824	1.126	0.930	0.854	0.818
0.5	0	0.813	1	1.087	1.037	0.995	0.956	0.981
0.5	0.1	0.848	1	1.062	1.047	0.989	0.945	0.965
0.5	0.5	0.964	1	0.995	1.072	0.972	0.916	0.921
0.5	1.0	1.074	1	0.947	1.089	0.961	0.897	0.891
1	0	0.811	1	1.087	1.038	0.997	0.953	0.980
1	0.1	0.830	1	1.074	1.043	0.994	0.947	0.971
1	0.5	0.897	1	1.030	1.060	0.983	0.929	0.943
1	1.0	0.964	1	0.991	1.074	0.973	0.913	0.919
2	0	0.810	1	1.087	1.038	0.999	0.952	0.979
2	0.1	0.820	1	1.080	1.041	0.997	0.949	0.975
2	0.5	0.857	1	1.055	1.051	0.990	0.938	0.958
2	1.0	0.898	1	1.029	1.061	0.983	0.927	0.942

put, inflation and interest rates as arguments, cf. equation (4.2), for different values of central bank preference parameters (λ, ϕ). The first column in the table show the results from the flexible rule FLX relative to the No Rule scenario, while the remaining columns in Table 4.3 evaluate the different interest rate rules relative to the FLX scenario, see the next section.

We note that the FLX scenario leads to a gain of 15%–19% relative to the No Rule scenario. This is because both underlying inflation and output growth show less variability under the FLX rule (cf. column two and 'three in Table 4.2). As we increase λ (the weight on output) from 0 to 2, we find corresponding loss reductions from 15% to 19% since the relative reduction in variability is greater for output than inflation[4]. As we increase the weight ϕ on interest rate variability from 0 to 1 we find that when $\lambda = 0$ relative losses increase from 0.85 to 1.65 since the variability in interest rates is 92% higher under the FLX rule. As more weight is put on the variability of output, the partial effect from interest rate variability counts less and we find that when $\lambda = 2$ relative losses only increase from 0.81 to 0.90 as we increase ϕ from 0 to 1.

The loss calculations reported so far are calculated on the basis of pure measures of volatility (variances). Table 4.4 reports similar loss calculations based on the "mean squared target errors" (MSTEs). We find qualitatively similar results when we apply MSTEs. However, given that bias for inflation is generally larger than the bias for output growth, the inflation moment $m(\Delta_4 pu_t)$ gets a larger weight in the loss calculations when we use MSTE instead of variances.

To summarise, a central bank that prefers relatively high output stability (high λ) may be impressed by the performance of the FLX rule relative to the actual policy in the simulation period. The performance of the FLX rule would, however, be

[4]Note that in the discussion of relative losses reference to inflation is short hand for underlying inflation which enters the loss function.

Table 4.4: Loss function evaluation based on relative MSTE (M) ((relative to No Rule and FLX rule))
$\pounds(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative MSTE						
		FLX/NoR	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
λ	ϕ							
0	0	0.930	1	0.864	1.036	0.965	1.102	0.979
0	0.1	1.053	1	0.845	1.065	0.955	1.033	0.931
0	0.5	1.330	1	0.819	1.103	0.941	0.934	0.863
0	1.0	1.495	1	0.809	1.116	0.936	0.987	0.838
0.5	0	0.839	1	1.056	1.034	0.989	0.985	0.980
0.5	0.1	0.869	1	1.037	1.042	0.984	0.973	0.966
0.5	0.5	0.971	1	0.982	1.066	0.970	0.941	0.927
0.5	1.0	1.070	1	0.941	1.083	0.961	0.918	0.898
1	0	0.830	1	1.078	1.033	0.991	0.969	0.980
1	0.1	0.847	1	1.066	1.038	0.989	0.963	0.972
1	0.5	0.908	1	1.027	1.055	0.979	0.944	0.946
1	1.0	0.974	1	0.991	1.069	0.971	0.927	0.923
2	0	0.824	1	1.091	1.033	0.993	0.959	0.980
2	0.1	0.833	1	1.084	1.036	0.992	0.956	0.975
2	0.5	0.867	1	1.060	1.046	0.986	0.945	0.960
2	1.0	0.907	1	1.035	1.056	0.980	0.934	0.944

considered less impressive if the central bank additionally prefers a stable monetary policy characterised by low interest rate volatility, i.e. it has a high ϕ. Actually, for a central bank that has strong preferences for a stable monetary policy and is mainly concerned about its inflation target (low λ), the FLX rule performs poorly relative to the actual policy, in our experiment.

4.4 Performance of the rules relative to the standard Taylor rule (FLX)

In the following we investigate value added of responding to additional information relative to that from the primary targets inflation and output. That is, we evaluate the different interest rate rules relative the FLX rule. We undertake the evaluation for different values of a central bank's preference parameters λ and ϕ. We also rank the performances of the different interest rates rules against each other.

We focus on three main questions. First, does additional response to asset prices improves the performance of a rule relative to the FLX rule, in the view of a central bank that primarily cares about nominal stability (i.e. strict inflation targeting and low interest rate volatility)? Second, to what extent would such (perceived) improvement in relative performance (in terms of nominal stability) arise at the expense of higher output fluctuation? In other words, should a central bank that cares about both monetary and real economic stability also respond to misalignment in asset prices? And third, is there a rule which would be preferred by a central bank irrespective of its preferences and macroeconomic conditions?

Figure 4.4 summarises the performance of different rules relative to the FLX rule for different values of preference-parameters (λ and ϕ). This figure is based on loss calculations using both the volatility and the bias criteria (MSTE). In the figure, values below 1 on the vertical axe suggest that the rule would be perceived

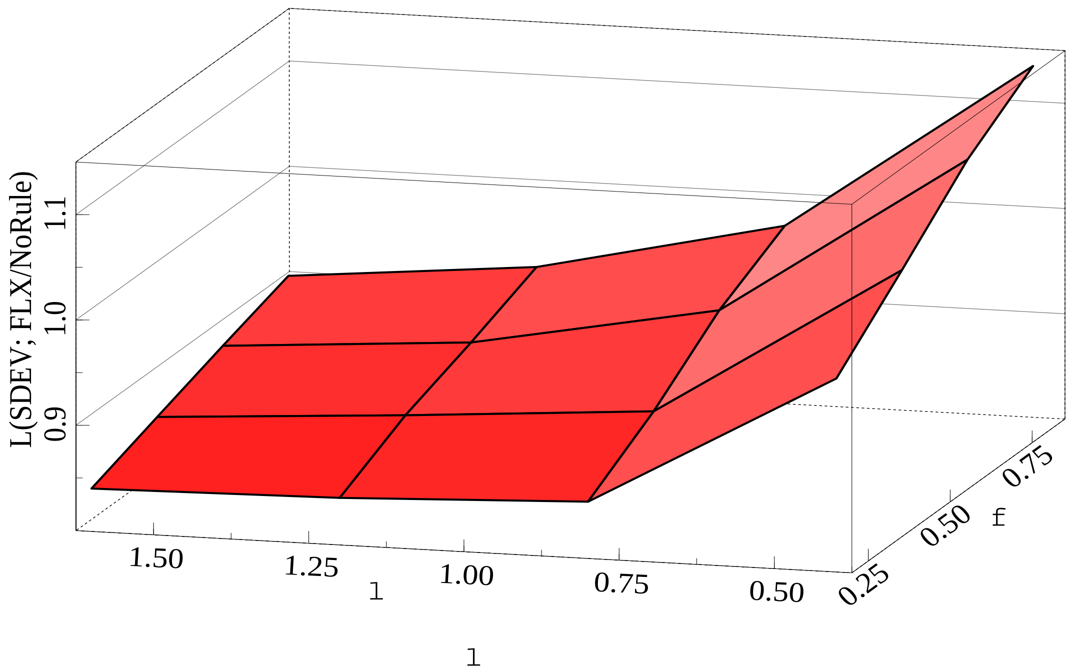

Figure 4.3: Loss function evaluation of the FLX relative to the No Rule. The loss function depends on relative variances.
$\pounds(\lambda,\theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

to outperform the FLX rule at the given values of the preference-parameters. A detailed account of the performances is presented in Tables 4.3 and 4.4 using both the volatility criterion (variances) and the volatility and bias criteria (MSTE). The tables suggest that the relative performance a rule is largely unaffected by the way the loss function is measured.

Figure 4.4 shows that the addition of gradualism in monetary policy making (SM) increases nominal stability, but at considerable expense of output stability. This makes the SM rule preferable to the FLX rule to a central bank preoccupied with nominal stability, but not to one that also cares about real economic stability.

More specifically, the smoothing rule SM gives rise to a slightly more expansive monetary policy, with higher output growth and inflation. This entails an increase in the bias of output growth and a decrease in the bias for inflation. For $\lambda = 0$, the smoothing rule SM seems to give about 13% to 19% lower losses relative to the FLX rule. As we increase ϕ the relative losses decrease due to the relatively high weight on the smoothing term ($\omega_r = 0.75$). The differences in the relative loss based on variances and MSTEs is also largest in this case ($\lambda = 0$). For $\lambda = 2$, the smoothing rule SM gives higher loss relative to FLX based on both variances and MSTEs.

Additional response to the real exchange rate (MCI), however, leads to a generally inferior performance relative to the FLX rule. In particular, it raises monetary instability relative to the FLX rule. Interestingly, the MCI rule has been proposed as an alternative to the FLX rule in an open economy context. Our results, however,

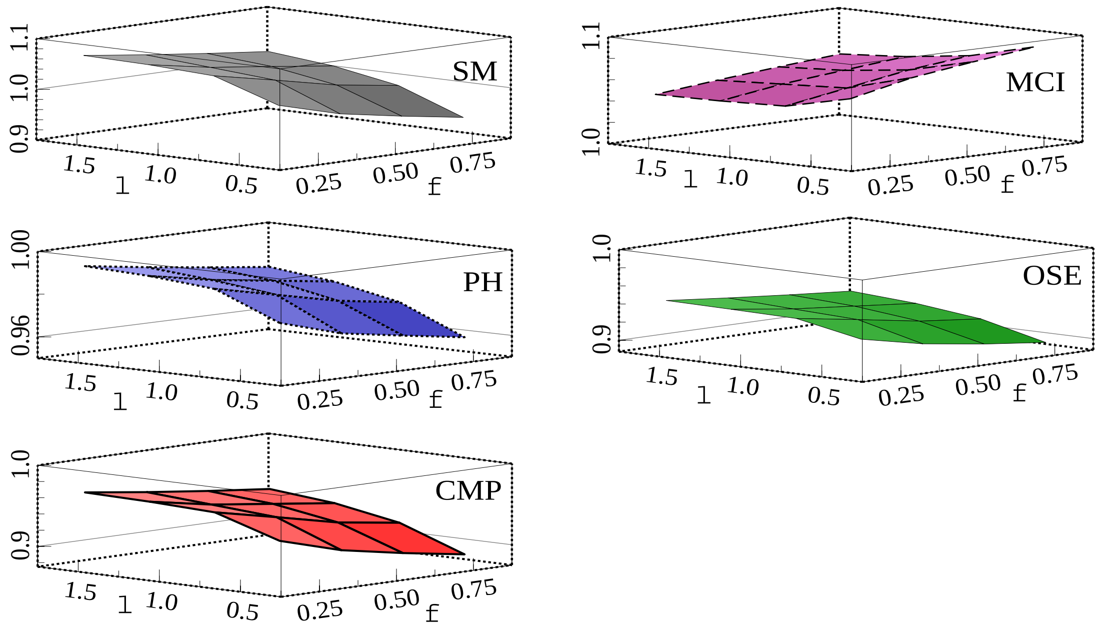

Figure 4.4: Loss function evaluation based on relative variances (to the FLX rule) $\mathcal{L}(\lambda,\theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

suggests that this rule would not be preferred to the FLX rule in this context, irrespective of a central bank's preferences.

In details, the exchange rate based MCI rule raises interest rate volatility. Thus the relative loss compared with the FLX rule increases with the weight ϕ. The MCI rule gives a slightly more contractive monetary policy compared with FLX, and the relative loss increases for all values of λ (on both variance- and MSTE-based losses). The increase in the relative loss seems to be within the range of 3% to 13%.

However, additional response to housing prices (PH) or equity prices (OSE) improves the performance of a rule relative to the FLX rule, irrespective of the preference parameters. The improvement is especially notable for a central bank preoccupied with nominal stability. It also appears that preferences for output stabilization reduces the attractiveness of these rules, but they would still be preferable to the FLX rule for a central bank that cares about both monetary and real economic stability.

Specifically, the PH rule performs well in the relative loss calculations based on both variances and MSTEs. This reflects the more balanced growth scenario relative to the FLX rule with lower output growth bias and less variability in housing prices and credit growth, see Table 4.2 for details. Since the PH rule implies more expansionary monetary policy than the FLX rule, both the inflation bias and variability seem to decrease. The relative loss reduction is therefore larger for small values of λ. The reduction in losses range from 0.5% to 7% relative to the FLX rule.

Details on the performance of the OSE are as follows. This rule was shown to be more contractionary in the previous section, in particular during the first two years due to the strong development in stock market prices in this period. However, due to a rapid fall in growth of stock prices in 1997 which was followed by fall in stock prices in 1998, the OSE rule leads to a rapid cut in interest rates. Overall, the relative loss evaluation of the OSE rule come out favourably compared with the FLX rule. Interestingly, variability of output is minimized for the OSE rule. Moreover, although the inflation bias increases somewhat due to the more contractionary monetary policy, the inflation variability remains at the same level as in the case of the FLX rule. Thus, lower output variability ensures that the relative loss declines with increases in λ. It is also interesting to note that the interest rate volatility remains small despite the rather large and quite abrupt swings in interest rates under the OSE rule. The interest rate volatility seems to be comparable to the case of the SM rule.

Finally, it appears that the composite rule (CMP) which embeds some gradualism and response to asset prices leads to an outcome preferable to the FLX rule, both in terms of monetary and real economic stability. This finding may be contributed to the combined effects of factors that each contributes to lower the relative loss compared with the rule. These factors are the two domestic asset prices, which enters with weights $\omega_{ph} = \omega_{ose} = 0.05$ and some degree of interest rate smoothing where we have set $\omega_r = 0.25$. Response to the real exchange rate may contribute to deteriorate its relative performance. It should however be noted that this rule responds to volatility in the real exchange rate rather than its level as in the case of the MCI rule.

Figures 4.5 and 4.6 rank the performance of the different interest rate rules relative to the FLX rule, conditional on the different preference parameters.

Both figures suggest that the CMP and the OSE rules are generally preferable to the PH rule. The CMP rule is particularly favourable to nominal stability. Moreover, its performance is nearly the same as the OSE rule in terms of real economic activity. The SM rule seems to be preferred to the PH and the OSE rules on the account of nominal stability. However, the CMP rules which embeds some interest smoothing combined with attention to asset price misalignments delivers the most preferable outcome in terms of nominal stability.

To summarize, our evidence suggests value added of responding to asset prices in terms of improved monetary and real economic stability relative to the standard Taylor rule (FLX). The next section investigates whether this conclusion is invariant to macroeconomic conditions, i.e. whether it is invariant to the nature of economic shocks.

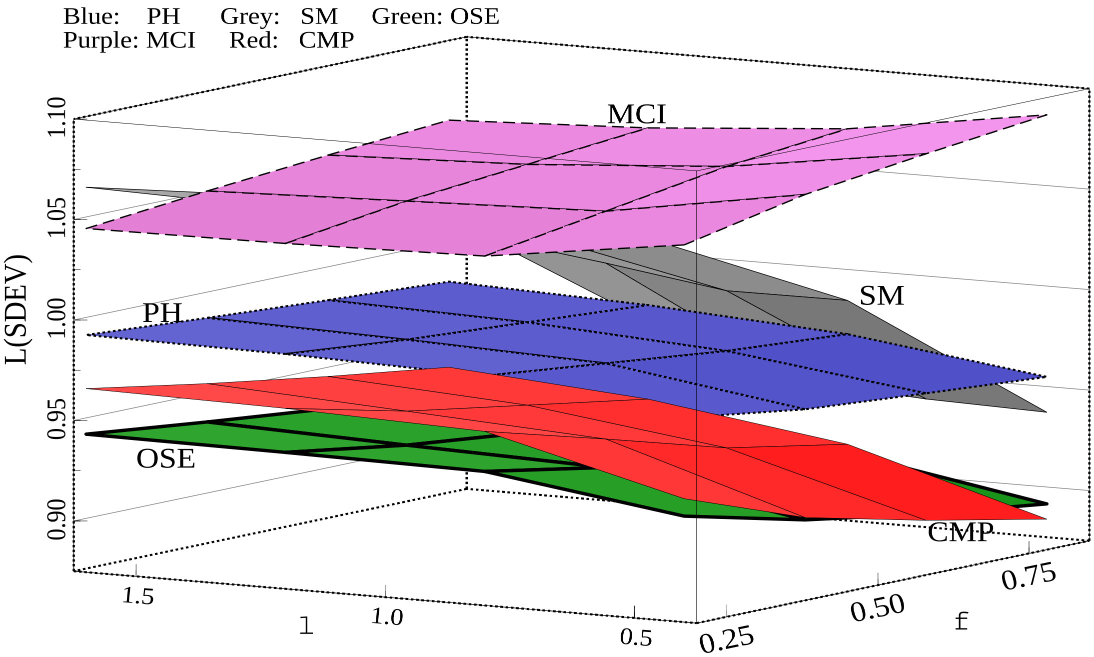

Figure 4.5: Loss function evaluation based on relative variances (to the FLX rule) $\mathcal{L}(\lambda, \theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

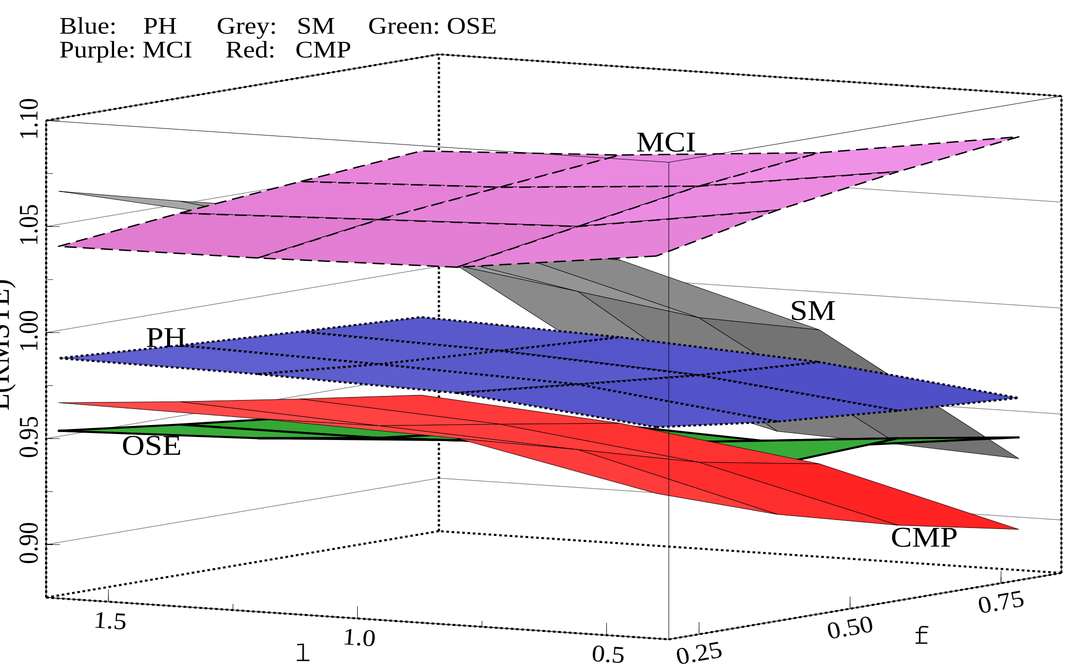

Figure 4.6: Loss function evaluation based on relative MSTE (M) (to the FLX rule) $\mathcal{L}(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

5 Performance under supply and demand shocks

This section examines the performance of the different interest rate rules under a supply and demand shock to the model. Section 5.1 considers the case of a supply shock, while section 5.2 considers the case of an adverse demand shock. For each shock we simulate the model under all the different interest rate rules in Table 4.1 and compare the outcome with the FLX scenario. The simulations start in 1996:1 and we end the simulations two years after the last exogenous shock to the model to allow some of the propagation mechanisms to unwind.

5.1 Adverse supply shock

This section considers the performance of the interest rate rules in the face of an adverse supply shock. More specifically, effects of a positive cost-push shock to the wage equation. This shock is specified by an exogenous increase in the quarterly wage inflation by one percentage point over the period 1996:1 to 1998:4.

A cost-push shock increases inflation quite fast in the model, but there may be trade-off between inflation and output stabilization. Although a positive wage shock may have positive effects on aggregate demand, the negative effects on output and labour demand dominate and the shock raises the unemployment rate. Thus both inflation and unemployment rise. If interest rates are raised in order to stabilize inflation, unemployment may increase further (and thereby place additional burden on the financial system).

Figure 5.1 illustrates the performance of the different interest rate rules in the face the positive wage shock, relative to the FLX scenario. Clearly, different interest rate rules have considerably different implications for monetary and real economic stability. Figure 5.2 summarizes the evaluation of the relative performance of the rules. Detailed accounts of this evaluation are presented in Tables B.2 and B.1 (Appendix B).

Figure 5.2 does not alter the conclusions raised above on the merits of the different interest rate rules. In particular, this figure also shows value added of additional response to housing and equity prices (PH and OSE). As above, the performance of the composite rule (CMP) rule may be considered remarkably well. For instance, the perceived reduction in the losses relative to the FLX rule in the case of both the OSE and the CMP rules are about 20% when $\lambda = 0$ and $\phi = 1$, see Table B.1 for details (Appendix B).

Figure 5.3 ranks the different rules at different values of the preferences. We note that the ranking of these rules is also largely unchanged relative to the one illustrated in Figure 4.6. However, the performance of the OSE rule may be judged slightly better than that of the CMP rule, see the details in Table B.1.

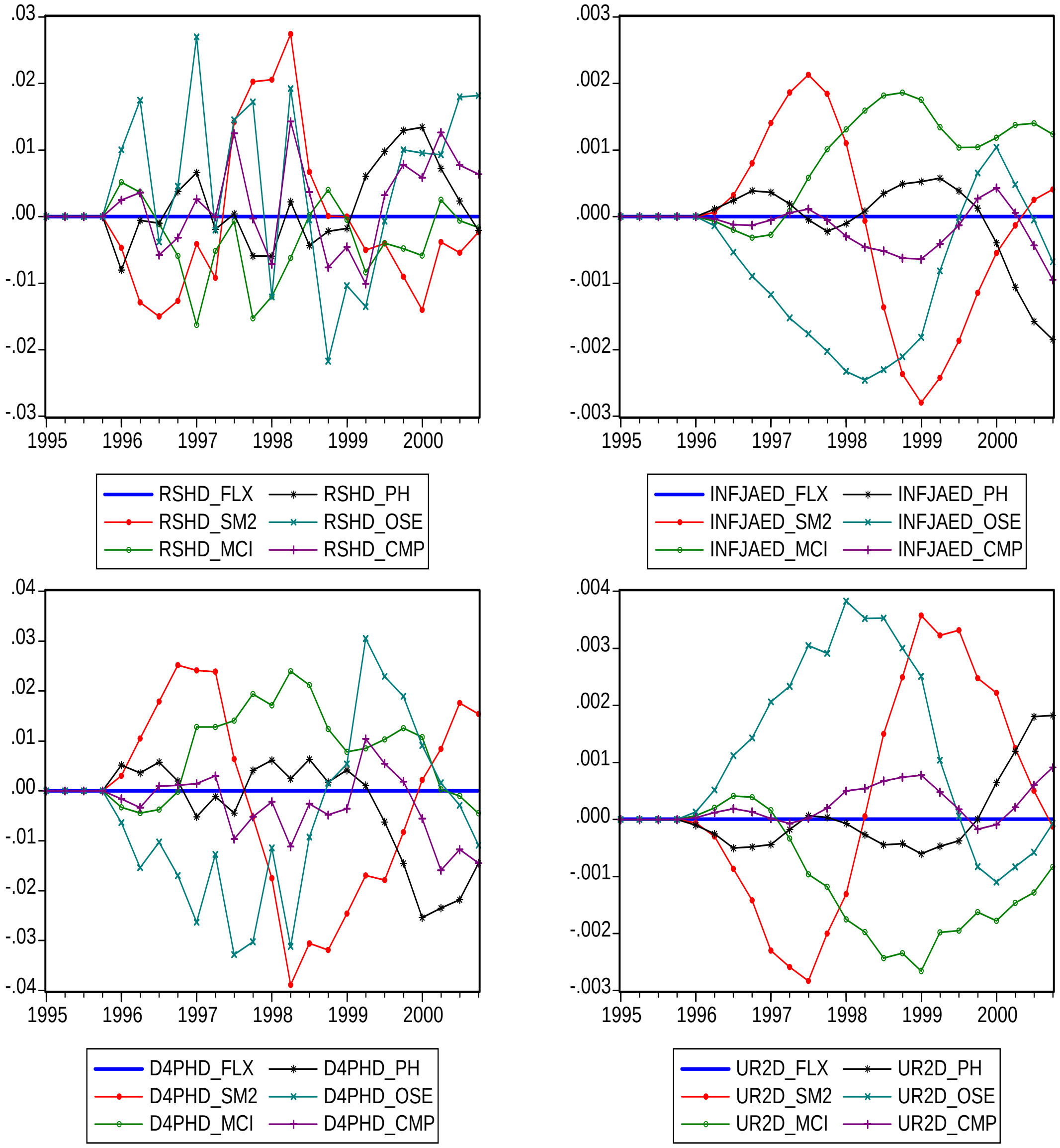

Figure 5.1: *Supply shock. The variables are measured as deviations from the FLX Rule scenario. Underlying inflation (upper left), housing price growth (upper right), unemployment (lower left), financial fragility indicator (lower right).*

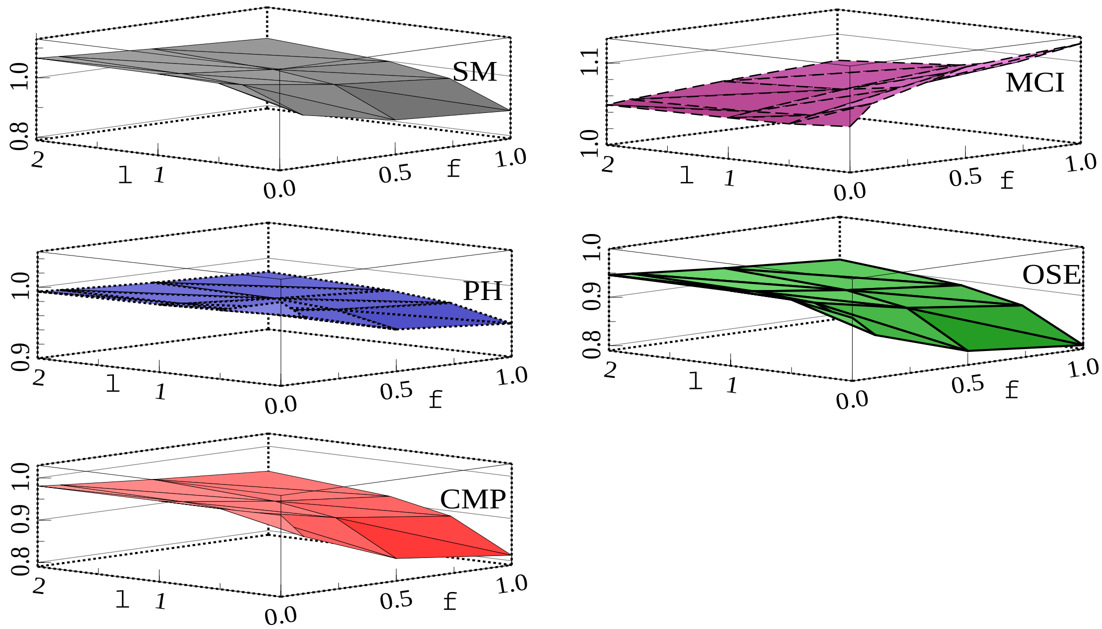

Figure 5.2: *Supply shock. Loss function evaluation of the rules relative to the FLX rule. The loss function depends on MSTE (M).*
$\mathcal{L}(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ *for* $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

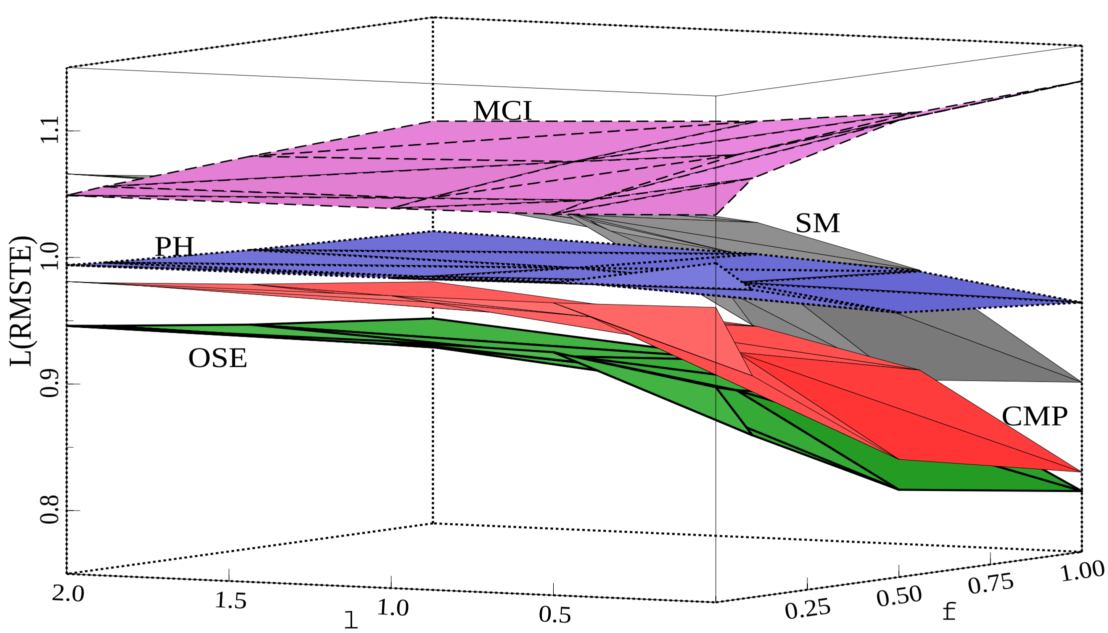

Figure 5.3: *Supply shock. Loss function evaluation of the rules relative to the FLX rule. The loss function depends on MSTE (M).*
$\mathcal{L}(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ *for* $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$

5.2 Adverse demand shock

This section examines the robustness of the above conclusions in the face of a demand shock. The negative demand shock is specified as an exogenous decline in public expenditure of six per cent each quarter over the three years 1996:1 to 1998:4. In addition, housing prices decline by 10 per cent in each of the two first years.

The negative demand shocks yields substantial negative impulses to both inflation and aggregate output, and the unemployment rate increase rapidly due to the Okun's law effect. Figure 5.4 illustrates response of different interest rate rules and their effects on the key variables.

Figure 5.5 illustrates the performance of the different interest rate rules relative to the FLX rule in the case of the demand shock. Tables B.3 and B.4 in Appendix B report calculated values of the loss functions using variability and MSTEs as arguments, respectively. The figure is based on Table B.3, but the results are qualitatively the same.

Figure 5.5 shows that, as above, both the OSE and the CMP rules outperform the FLX rule in the terms of nominal stability. However, this seems to be at the expense of real economic stability, as both of them are perceived to perform worse than the FLX rule.

In contrast, the PH rule seems to deliver the opposite outcome. It improves on the FLX rule in terms of real stability, but performs relatively poor on the account of nominal stability. The latter is mainly due to higher interest rate volatility, as the PH rule outperforms the FLX rule in terms of inflation variability. The higher interest rate volatility is likely to be an artifact of the way the demand shock is specified. One needs to be examine the performance of the PH rule (and the other rules) for alternative specification of shocks. Yet, this demand shock illustrates nicely the point made in the literature that response to asset price misalignment may lead to an overreacting monetary policy. However, it also illustrates that an overreacting monetary policy is not necessarily destabilizing.

However, the performance of the CMP rule suggests that modest smoothing combined with some weight on asset price misalignments may contribute to a favourable monetary environment compared to the FLX rule. Furthermore, the loss in terms of increased output variability may not be perceived large by some central banks, see Table B.3 for details.

Figure 5.5 also indicates a ranking of the different rules. It shows that the ranking becomes more dependent on the preferences of a central bank. In particular, a central bank that is preoccupied with nominal stability will choose the CMP rule relative to the FLX rule. On the other hand, a central bank that only cares about the behaviour of output and inflation would prefer the PH rule.

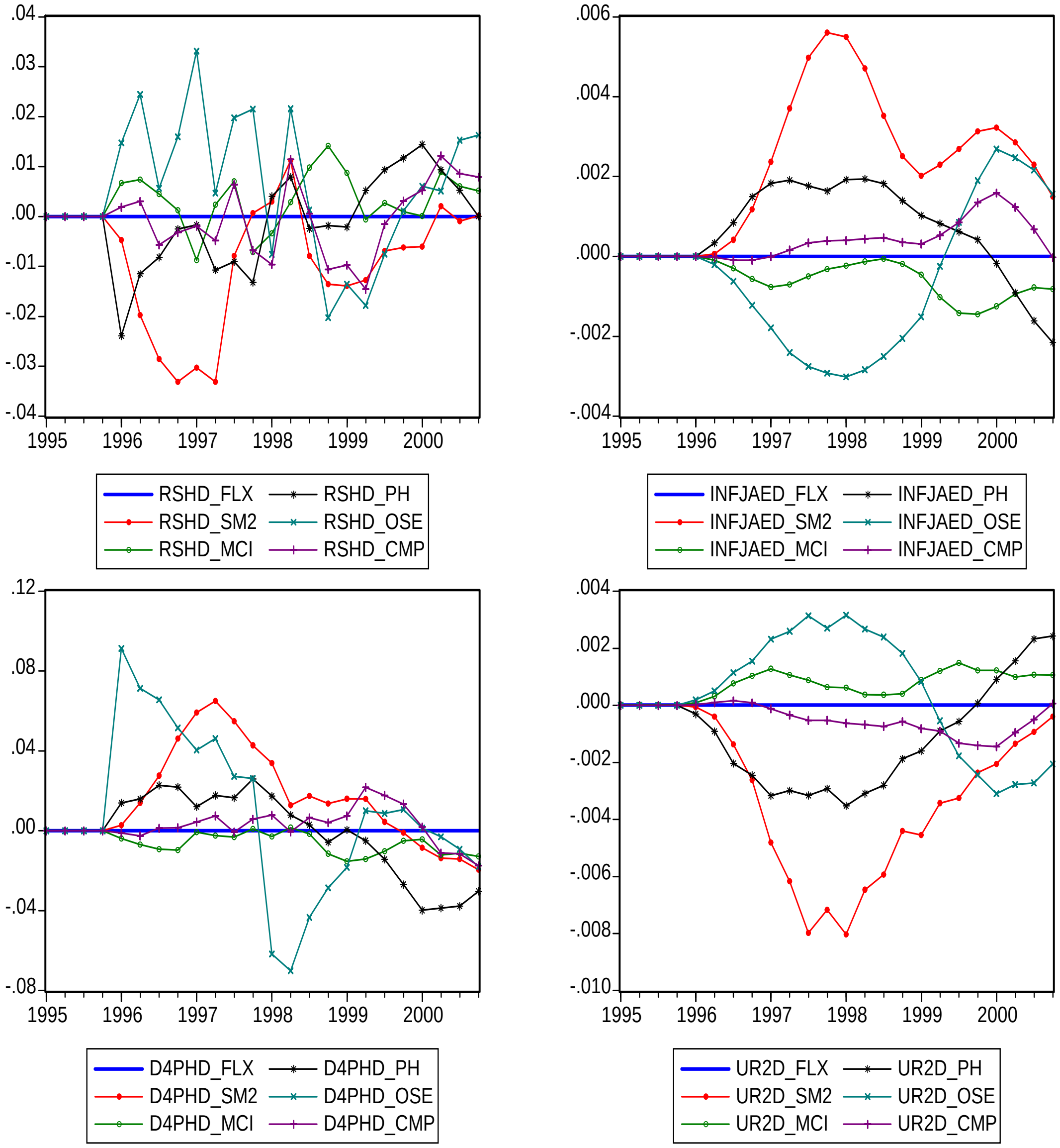

Figure 5.4: *Negative demand shock. The variables are measured as deviations from the FLX Rule scenario. Underlying inflation (upper left), housing price growth (upper right), unemployment (lower left), financial fragility indicator (lower right).*

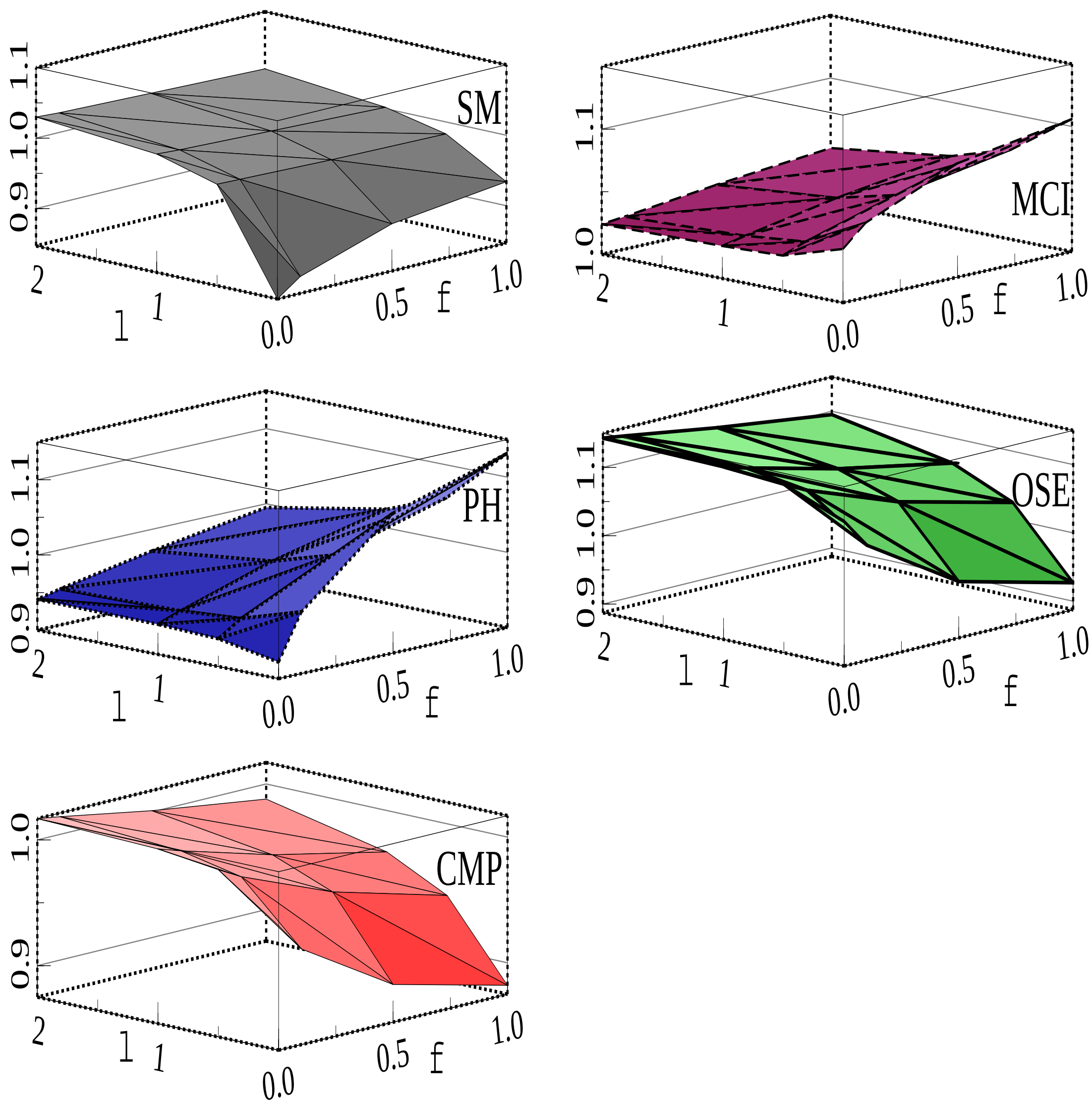

Figure 5.5: *Demand shock. Loss function evaluation of the rules relative to the FLX rule. The loss function depends on MSTE (M).*
$\pounds(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ *for* $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$

6 Monetary policy and financial stability

So far, performance of the interest rules have been examined in terms of real and nominal variability. The findings suggest gains in terms of both nominal and real stability from admitting asset prices into interest rate rules. Furthermore, almost all of the rules suggest a trade off between nominal and real variability. The exception is the MCI rule, which contributes to raise both nominal and real variability, relative to the standard Taylor rule. Moreover, it does not indicate any obvious tradeoff between nominal and real variability.

This section examines performance of the interest rate rules in terms of their implications for financial stability, which is commonly another concern of monetary policy. One might expect that rules that improve on both real and nominal stability would also promote financial stability. Hence, interest rate rules that admit response to asset prices, except the MCI rule, would be expected to additionally benefit financial stability. Evidence presented in this section does not conform fully with these expectations, however.

We proceed by constructing a financial fragility indicator similar to the one employed in Eitrheim and Gulbrandsen (2001) and investigate how this behaves under the different interest rate rules, in the face of the adverse supply and demand shocks. Improvement in financial stability is measured relative to that implied by the standard Taylor rule (FLX).

The financial fragility indicator, FS, is a function of a number of variables in the model that may be considered of direct relevance for financial stability. These are the debt service ratio, real interest rate, the unemployment rate, and the three real asset prices in the model, i.e., the real exchange rate, the real housing price and real stock prices. The (aggregated) debt service ratio is defined as $RL \times K1M/P \times Y$, where RL is the bank lending rate for households, $K1M$ is the stock of nominal credit, while $P \times Y$ is the nominal GDP, which is defined by the CPI (P). Specifically, the financial fragility indicator is defined as the percentage of accrued losses in the financial sector (mainly banks) that are accounted for by the aforementioned variables. A simple model of FS is reported in the appendix.

However, when measuring a rule's contribution to financial stability, we use the indicator of financial fragility net of the direct interest rate effects: FS2. This is because of the relatively large direct effects of changes in real interest rate on the primary financial fragility indicator FS. Thus movements in FS2 reflects the effects of unemployment and asset prices, as well as the indirect interest rate effects that are reflected through these variables.

6.1 Financial stability under the supply shock

When the economy faces a cost shock, and the monetary authority responds to rising inflationary pressure by tightening monetary policy, financial fragility can increase due to e.g. higher unemployment, lower housing and equity prices and a stronger exchange rate, see Figure 5.1. In such cases, response to these asset prices contributes to reverse the tightening of the monetary policy. The degree of such reversion may, however, differ across the rules and hence the outcome in terms of financial stability.

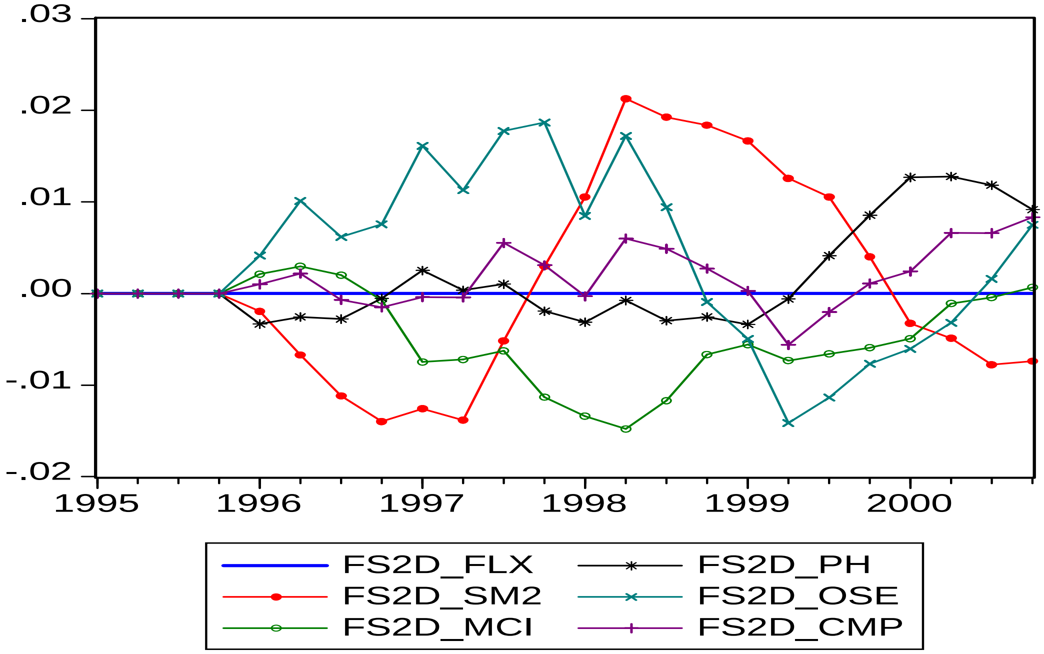

Figure 6.1: *Supply shock. Financial stability indicator (FS2) for different interest rate rules relative to the FLX rule.*

Figure 6.1 displays the effect of different interest rate rules on the financial fragility indicator FS2. Notably, in contrast to the other rules, the MCI contributes to a systematically lower value of FS2 over the whole simulation period. One explanation is that higher interest rates in response to the cost push inflation appreciates the exchange rate. In the MCI rule, such appreciation contributes to reverse the (initial) rise in interest rates. Consequently, the inflation stays relatively higher while the unemployment becomes lower than in the case of the FLX rule. Thus, FS2 also remains lower than in the case of the FLX rule.

Furthermore, the higher domestic inflation leads to higher growth in (nominal) housing prices, which also contribute to reduce the value of FS2. In the case of the other rules, however, similar reversion of the monetary tightening does not take place. Thus, both consumer price and housing price inflation are subdued, while unemployment tends to increase. Thereby, FS2 tends to display similar behaviour to the FLX rule on average, despite large differences in its behaviour across the rules.

6.2 Financial stability under the demand shock

In the case of the adverse demand shock, however, an initial relaxation of the monetary policy tends to depreciate the exchange rate. In the case of the MCI rule, such depreciation commands higher interest rates, which amplifies the adverse demand shock. Consequently, unemployment remains higher than in the case of e.g. the

FLX rule. Thus the initial increase in the financial fragility (high FS2) owing to lower housing price tends to persist over the simulation horizon, see Figure 5.4.

In the case of the other asset price rules, particularly the PH and the CMP rules, the initial relaxation of the monetary policy is supported, leading to higher consumer price and housing price inflation than the FLX rule, but lower unemployment rate, which reduces financial fragility (lower FS2). None of these rules tends to systematically outperform the FLX rule, however. The SM rule seems to be most beneficial to financial stability, by contributing to persistently low interest rates relative to the FLX rule.

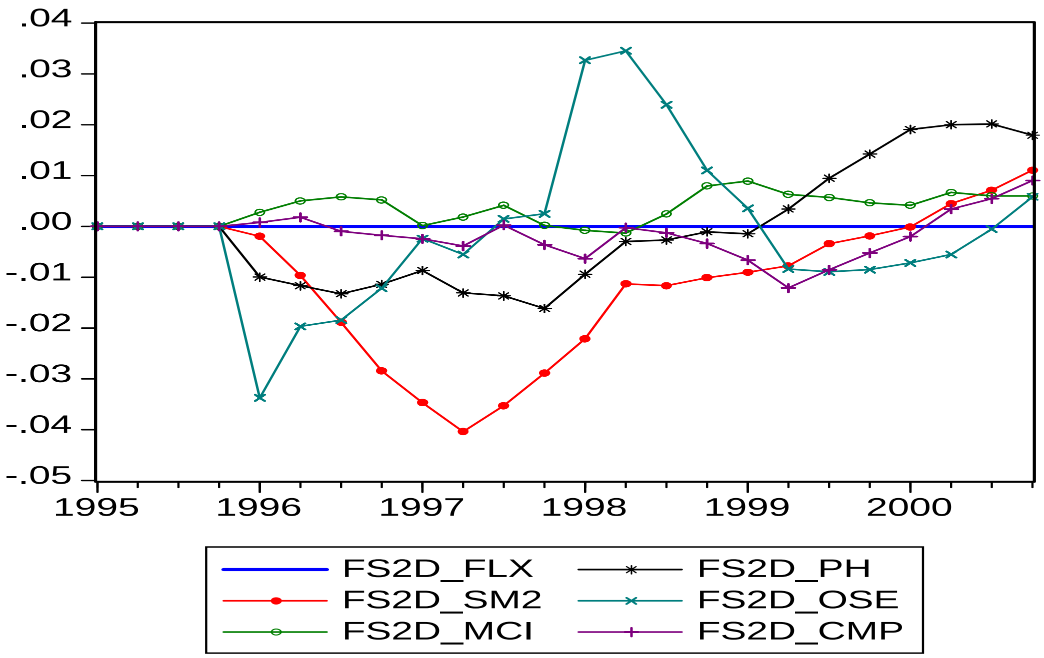

Figure 6.2: *Demand shock. Financial stability indicator (FS2) for different interest rate rules relative to the FLX rule.*

7 Concluding remarks

This paper is a contribution to the recent debate on the role of asset prices in the conduct of monetary policy within an inflation targeting regime. In contrast with a majority of the other contributions, we employ an econometrically well specified model. The evidence embedded in this model suggest that there are significant interdependencies between asset prices, aggregate demand and credit growth.

Furthermore, evaluation of standard simple rules proposed for closed and open economies against those that allow for additional response to housing and equity prices, suggest that there seems to be some scope for improving macroeconomic performance in terms of both monetary and real economic stability if monetary authorities (in addition) respond to misalignments in asset prices. This finding has emerged under different types of shocks. In contrast, it remains yet unclear whether there are gains in terms of financial stability by additionally responding to asset prices.

However, our conclusions are conditional on a number of simplifying assumptions. Firstly, this paper only considers simple rules and not optimized rules. Secondly, we have only made comparison against simple rules already proposed in the literature. The results can potentially change if we had compared against alternative simple rules. Thirdly, we have not touched upon the difficulties in identifying asset price misalignments. Moreover, the degree of response to a given misalignment has been chosen rather arbitrarily. Even though we have not differed much from a number of existing studies in this regard, this is clearly an issue that needs to be addressed in future research. Fourthly, our results are based on counterfactual simulations for a particular time period. Thus, given the empirical nature of our inquiry, the results can be potentially economy dependent. Notwithstanding the robustness of our findings under demand and supply shocks, the result could also depend on macroeconomic conditions. Finally, we would like to add that given the considerable model uncertainty, other models might yield different conclusions.

Further research is therefore needed to investigate the validity of our conclusions under alternative assumptions and models.

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A Documentation of the econometric model

A.1 Data definitions

Unless another source is given, all data are taken from RIMINI, the quarterly macroeconometric model used in Norges Bank (The Central Bank of Norway). The data are seasonally unadjusted. For each RIMINI-variable, the corresponding name in the RIMINI-database is given by an entry [RIMINI: variable name] at the end of the description. (The RIMINI identifier is from Rikmodnotat 140, Norges Bank, Research department, 19th April 1999.) Several of the variables refer to the *mainland economy*, defined as total economy minus oil and gas production and international shipping.

CO Public consumption expenditure, fixed 1991 prices. Mill. NOK. [RIMINI: CO].

CR Real credit volume. Mill. NOK. [RIMINI: K1M/CPI].

H Normal working hours per week (for blue and white colour workers). [RIMINI: NH]

OIL USD oil price, per barrel Brent-Blend. [RIMINI: SPOILUSD].

$OILST$ Smooth transition function (see Teräsvirta (1998)) of North-Sea oil price:

$$\Delta oilST_t = \frac{\Delta oil_t}{1 + exp(4(OIL - 14.21))}$$

P Consumer price index. [RIMINI: CPI].

P^* Consumer prices abroad in foreign currency. [RIMINI: PCKONK].

PB Deflator of total imports. 1991=1. [RIMINI: PB].

Y Total value added at market prices in the mainland economy. Fixed baseyear (1991) prices. Mill. NOK. [RIMINI: YF].

PR Mainland economy value added per man hour at factor costs, fixed baseyear (1991) prices. Mill. NOK. [RIMINI: ZYF].

RS 3 month Euro-krone interest rate. [RIMINI: RS].

$RSECU$ ECU interest rate. For the period 1967(1)-1986(3): Effective interest rate on foreign bonds, NOK-basket weighted. [RIMINI: R.BKUR] For the period 1986(4)-1996(4): ECU weighted effective rate on foreign bonds. [RIMINI: R.BECU].

$\tau 1$ Employers tax rate. [RIMINI: T1F].

$\tau 3$ Indirect tax rate. [RIMINI: T3].

U Rate of unemployment. Registered unemployed plus persons on active labour market programmes as a percentage of the labour force, calculated as employed wage earners plus unemployment. [RIMINI: UR2].

V Effective import weighted value of the NOK. 1991=1. [RIMINI: PBVAL].

W Nominal mainland hourly wages. This variable is constructed from RIMINI-database series as a weighted average of hourly wages in manufactures and construction and hourly wages in private and public service production, with total number of man-hours (corrected for vacations, sick hours, etc) as weights:

$$W = [WIBA \cdot TWIBA + WOTVJ \cdot (TWTV + TWO + TWJ)] / TWF$$

WC Nominal mainland hourly wage costs. [RIMINI: WCF].

YF Weighted average of GDP of trading countries, using share of Norwegian exports in 1985 as weights. 1991=1. [RIMINI: UEI].

A.2 The model

Aggregate demand, 1986:4-2001:4

$$\Delta\hat{y}_t = -\underset{(0.092)}{0.39}\Delta y_{t-1} + \underset{(0.013)}{0.024}\Delta(s-p)_{t-2} + \underset{(0.06)}{0.27}\Delta g_t + \underset{(0.11)}{0.46}cap_t\Delta\left(e+p^*-p\right)_t$$
$$-\underset{(0.076)}{0.3}\left[(y-0.5g-0.3y^* + (rl\,(1-\tau_2)-\Delta_4 p) - 0.1(ph-p)_{t-1} - 0.5\left(e+p^*-p\right)_{t-3}\right]$$

$$OLS,\ T = 61,\ \hat{\sigma} = 0.0097$$

$\mathsf{F}_{\mathsf{Chow}(1994:2)}(31,21)$	$= 1.215\ [0.3250]$	$\mathsf{F}_{\mathsf{ar}(1-4)}(4,48)$	$= 1.165\ [0.3380]$
$\mathsf{F}_{\mathsf{Chow}(2000:2)}(7,45)$	$= 1.574\ [0.1677]$	$\mathsf{F}_{\mathsf{arch}(1-4)}(4,53)$	$= 0.430\ [0.7861]$
$\chi^2_{\mathsf{nd}}(2)$	$= 2.502\ [0.2862]$	$\mathsf{F}_{\mathsf{het}}(13,47)$	$= 2.094\ [0.0327]$

Real credit demand, 1986:4–2001:4

$$\Delta\widehat{(l-p)}_t = \underset{(0.023)}{0.074}\Delta y_t + \underset{(0.024)}{0.06}\Delta(ph-p)_t + \underset{(0.0064)}{0.012}\Delta(s-p)_{t-2}$$
$$-\underset{(0.0046)}{0.058}\left[(l-p) - 0.5y - (ph-p) + 3\,(rl-rb)\right]_{t-1}$$

$$OLS,\ T = 61,\ \hat{\sigma} = 0.0049$$

$\mathsf{F}_{\mathsf{Chow}(1994:2)}(31,24)$	$= 0.845\ [0.6739]$	$\mathsf{F}_{\mathsf{ar}(1-4)}(4,51)$	$= 0.821\ [0.5178]$
$\mathsf{F}_{\mathsf{Chow}(2000:2)}(7,48)$	$= 0.978\ [0.4584]$	$\mathsf{F}_{\mathsf{arch}(1-4)}(4,53)$	$= 0.800\ [0.5308]$
$\chi^2_{\mathsf{nd}}(2)$	$= 1.089\ [0.5801]$	$\mathsf{F}_{\mathsf{het}}(10,50)$	$= 0.739\ [0.6849]$

Housing prices, 1983:4–2001:4

$$\widehat{\Delta ph}_t = \underset{(0.402)}{1.12}\ \Delta p_{t-2} + \underset{(0.0211)}{0.0448}\ \Delta s_{t-2} - \underset{(0.391)}{1.44}\ \Delta RL_t + \underset{(0.0934)}{0.169}\ \Delta y_{t-2}$$
$$+ \underset{(0.224)}{1.04}\ \Delta cr_{t-2} - \underset{(0.0295)}{0.104}\ \Delta u_{t-3}$$
$$- \underset{(0.0278)}{0.108}\ [ph - p - 0.5y - 0.25cr + 4(RL(1 - TMNI50) - \Delta_4 pu)]_{t-1}$$

$$OLS,\ T = 73,\ \hat{\sigma} = 0.0168$$

$\mathsf{F}_{\mathsf{Chow}(1992:4)}(37,25)$	$= 0.478\ [0.9796]$	$\mathsf{F}_{\mathsf{ar}(1-4)}(4,58)$	$= 2.033\ [0.1017]$
$\mathsf{F}_{\mathsf{Chow}(2000:1)}(8,54)$	$= 1.050\ [0.4111]$	$\mathsf{F}_{\mathsf{arch}(1-4)}(4,65)$	$= 1.684\ [0.1643]$
$\chi^2_{\mathsf{nd}}(2)$	$= 0.268\ [0.8747]$	$\mathsf{F}_{\mathsf{het}}(18,54)$	$= 1.924\ [0.0333]$

Exchange rate, 1973:1–2001:4

$$\Delta\hat{e}_t = \underset{(0.0787)}{0.201}\ \Delta e_{t-1} - \underset{(0.0332)}{0.127}\ (e - p + pk)_{t-1} - \underset{(0.175)}{0.32}\ \Delta p^*_t - \underset{(0.101)}{0.346}\ \Delta r_t$$
$$- \underset{(0.144)}{0.215}\ \Delta(rb_{t-1} - \Delta p_{t-2}) - \underset{(0.0321)}{0.13}\ \Delta oilST_t\ \underset{(0.227)}{0.417}\ RISK_t$$

$$OLS,\ T = 116,\ \hat{\sigma} = 0.015$$

$\mathsf{F}_{\mathsf{Chow}(1987:3)}(58,49)$	$= 0.430\ [0.9989]$	$\mathsf{F}_{\mathsf{ar}(1-4)}(4,103)$	$= 0.419\ [0.7949]$
$\mathsf{F}_{\mathsf{Chow}(1999:1)}(12,95)$	$= 0.500\ [0.9101]$	$\mathsf{F}_{\mathsf{arch}(1-4)}(4,108)$	$= 0.171\ [0.9528]$
$\chi^2_{\mathsf{nd}}(2)$	$= 12.355\ [0.0021]$	$\mathsf{F}_{\mathsf{het}}(16,99)$	$= 0.711\ [0.7766]$

Inflation and wage growth, 1972:4–2001:4

$$\Delta\hat{p}_t = \underset{(0.031)}{0.27}\ \Delta w_t + \underset{(0.021)}{0.13}\ \Delta w_{t-1} + \underset{(0.0092)}{0.036}\ \Delta pm_t + \underset{(0.0082)}{0.065}\ \Delta pe_t + \underset{(0.012)}{0.039}\ \Delta y_{t-1}$$
$$- \underset{(0.0058)}{0.055}\ [p_{t-3} - 0.65\,(w_{t-2} - pr_{t-1} + te_{t-1}) - 0.35pm_{t-1} - 0.5ti_{t-1}]$$

$$\Delta\hat{w}_t = \underset{(0.095)}{0.39}\ \Delta p_{t-1} + \underset{(0.097)}{0.37}\ \Delta p_{t-2} - \underset{(0.11)}{0.48}\ \Delta h_t - \underset{(0.012)}{0.094}\ \left[(w - p - pr)_{t-1} + 0.1u_{t-2}\right]$$

$$FIML,\ T = 117,\ \hat{\sigma}_{\Delta p} = 0.004,\ \hat{\sigma}_{\Delta w} = 0.009$$

$\mathsf{F}_{\mathsf{ar}(1-5)}(20,198)$	$= 1.58\ [0.06]$
$\chi^2_{\mathsf{nd}}(4)$	$= 4.65\ [0.32]$
$\mathsf{F}_{\mathsf{het}}(135,186)$	$= 1.26\ [0.07]$

Unemployment, 1972:4–2001:4

$$\Delta\hat{u}_t = \underset{(0.064)}{0.38}\ \Delta u_{t-1} - \underset{(0.017)}{0.059}\ u_{t-1} - \underset{(0.31)}{1.6}\ \Delta_4 y_t + \underset{(0.5)}{1.1}\ \Delta\,(w - p)_{t-1} + \underset{(0.68)}{1.8}\ N1649AT_t$$

$$\hat{\sigma} = 0.06$$

A.3 The financial indicator

The following regression model is used to predict FS:

$$
\begin{aligned}
\widehat{FS}_t \;=\; & + \underset{(0.5)}{0.04}\ \ln\left(\tfrac{1}{4}\textstyle\sum_{i=0}^{3} U_{t-i}\right) - \underset{(0.19)}{0.40}\ \Delta_4\left(ph - p - y_t\right) \\
& - \underset{(0.06)}{0.02}\ \ln\left(\tfrac{1}{2}\left[(OSE/CPI)_t + (OSE/CPI)_{t-4}\right]\right) + \underset{(0.93)}{2.94}\ \left(RL_t\left(1 - TD_t\right) - \Delta_4 pu_{t-1}\right) \\
& - \underset{(0.34)}{0.49}\ \left((e - p + pk)_t + (e - p + pk)_{t-4}\right) + \underset{(0.07)}{0.28}\ \ln\left(RL \times K1M/P \times Y\right)_t \\
& \underset{(0.05)}{0.14}\ TAPDUM_t - \underset{(0.03)}{0.27}\ CRISIS91_t - \underset{(0.04)}{0.09}\ SD\_1997\_1_t + \underset{(0.24)}{0.27}
\end{aligned}
$$

$$\hat{\sigma} = 0.05$$

It is estimated on data for the period 1985(1) to 1998(4).

The exact specification of FS2 is

$$FS2 = FS - 0.28 \log\left(RL \times K1M/P \times Y\right) - 2.94(RL(1 - TD) - \Delta_4 pu_{t-1})),$$

where TD is the direct tax rate.

All variables enter the equation with the expected sign. An increase in the debt service ratio, the real interest rate or in the unemployment rate increase the degree of financial vulnerability, while increases in domestic asset prices have a negative effect on the indicator. The negative effect of a currency depreciation on the indicator suggests that the expansionary effects of a weaker currency through increased demand and profitability dominates the negative effects through a heavier foreign debt burden.

B Tables

B.1 Supply shock

B.2 Demand shock

Table B.1: Supply shock. Loss function evaluation based on relative MSTE (M) (to the FLX Rule) 1995:1 to 2000:4
$\pounds(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative MSTE						
		FLX/NoShift	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
λ	ϕ							
0	0	0.881	1	1.008	1.056	1.018	0.920	0.983
0	0.1	1.000	1	0.965	1.081	0.993	0.878	0.925
0	0.5	1.267	1	0.906	1.111	0.959	0.819	0.843
0	1.0	1.425	1	0.884	1.122	0.947	0.798	0.813
0.5	0	0.821	1	1.057	1.051	0.997	0.942	0.981
0.5	0.1	0.888	1	1.042	1.058	0.992	0.929	0.966
0.5	0.5	0.994	1	1.000	1.078	0.977	0.892	0.922
0.5	1.0	1.034	1	0.967	1.092	0.966	0.864	0.888
1	0	0.814	1	1.063	1.050	0.995	0.945	0.981
1	0.1	0.830	1	1.054	1.054	0.992	0.937	0.972
1	0.5	0.886	1	1.025	1.067	0.983	0.913	0.943
1	1.0	0.947	1	0.999	1.079	0.974	0.890	0.917
2	0	0.811	1	1.066	1.049	0.994	0.946	0.981
2	0.1	0.819	1	1.061	1.052	0.992	0.942	0.976
2	0.5	0.850	1	1.044	1.060	0.986	0.927	0.959
2	1.0	0.887	1	1.026	1.068	0.981	0.912	0.941

Table B.2: Supply shock. Loss function evaluation based on relative variances (to the FLX Rule) 1995:1 to 2000:4
$\pounds(\lambda, \theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative SDEV						
		FLX/NoShift	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
λ	ϕ							
0	0	1.286	1	1.004	1.078	1.017	0.877	0.975
0	0.1	1.397	1	0.961	1.096	0.991	0.845	0.917
0	0.5	1.590	1	0.903	1.119	0.958	0.802	0.838
0	1.0	1.676	1	0.882	1.126	0.946	0.787	0.810
0.5	0	0.864	1	1.057	1.052	0.997	0.934	0.980
0.5	0.1	0.892	1	1.042	1.059	0.992	0.921	0.965
0.5	0.5	0.989	1	0.999	1.079	0.977	0.886	0.920
0.5	1.0	1.082	1	0.967	1.093	0.966	0.859	0.887
1	0	0.839	1	1.063	1.050	0.994	0.940	0.980
1	0.1	0.854	1	1.054	1.054	0.992	0.933	0.972
1	0.5	0.912	1	1.025	1.067	0.982	0.909	0.942
1	1.0	0.974	1	0.999	1.079	0.974	0.887	0.916
2	0	0.825	1	1.066	1.048	0.993	0.944	0.981
2	0.1	0.833	1	1.061	1.050	0.992	0.940	0.976
2	0.5	0.865	1	1.044	1.058	0.986	0.925	0.959
2	1.0	0.901	1	1.026	1.067	0.980	0.910	0.941

Table B.3: Demand shock. Loss function evaluation based on relative MSTE (M) (to the FLX Rule) 1995:1 to 2000:4
$\pounds(\lambda, \theta) = M[\Delta_4 pu_t] + \lambda M[\Delta_4 y_t] + \phi M[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative MSTE						
		FLX/NoShift	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
λ	ϕ							
0	0	1.114	1	0.847	1.043	0.922	1.099	0.974
0	0.1	1.178	1	0.871	1.060	0.982	1.056	0.951
0	0.5	1.336	1	0.914	1.091	1.086	0.970	0.905
0	1.0	1.437	1	0.934	1.106	1.132	0.927	0.882
0.5	0	0.871	1	0.991	1.028	0.937	1.134	1.008
0.5	0.1	0.892	1	0.990	1.035	0.957	1.117	0.998
0.5	0.5	0.965	1	0.986	1.056	1.014	1.067	0.968
0.5	1.0	1.039	1	0.983	1.072	1.057	1.025	0.943
1	0	0.843	1	1.015	1.026	0.940	1.140	1.014
1	0.1	0.855	1	1.013	1.030	0.951	1.130	1.008
1	0.5	0.901	1	1.008	1.044	0.990	1.096	0.987
1	1.0	0.951	1	1.002	1.057	1.025	1.063	0.967
2	0	0.826	1	1.030	1.024	0.941	1.143	1.017
2	0.1	0.832	1	1.028	1.026	0.948	1.138	1.014
2	0.5	0.858	1	1.024	1.035	0.971	1.117	1.001
2	1.0	0.889	1	1.019	1.044	0.995	1.095	0.988

Table B.4: Demand shock. Loss function evaluation based on relative variances (to the FLX rule) 1995:1 to 2000:4
$\pounds(\lambda, \theta) = V[\Delta_4 pu_t] + \lambda V[\Delta_4 y_t] + \phi V[\Delta r_t]$ for $\lambda \in (0, 0.5, 1, 2)$, $\phi \in (0, 0.1, 0.5, 1)$.

Central Bank preferences		Loss based on relative SDEV						
		FLX/NoShift	FLX/FLX	SM/FLX	MCI/FLX	PH/FLX	OSE/FLX	CMP/FLX
λ	ϕ							
0	0	0.741	1	1.280	0.942	0.939	1.214	1.061
0	0.1	0.983	1	1.126	1.048	1.094	1.032	0.949
0	0.5	1.333	1	1.022	1.107	1.176	0.905	0.875
0	1.0	1.473	1	0.999	1.119	1.194	0.875	0.859
0.5	0	0.803	1	1.054	1.017	0.944	1.150	1.025
0.5	0.1	0.830	1	1.048	1.027	0.969	1.128	1.011
0.5	0.5	0.921	1	1.029	1.054	1.034	1.064	0.971
0.5	1.0	1.009	1	1.016	1.073	1.076	1.016	0.942
1	0	0.806	1	1.044	1.020	0.944	1.147	1.023
1	0.1	0.820	1	1.041	1.025	0.957	1.135	1.016
1	0.5	0.872	1	1.031	1.042	1.000	1.096	0.991
1	1.0	0.928	1	1.021	1.057	1.037	1.060	0.969
2	0	0.807	1	1.039	1.021	0.944	1.146	1.022
2	0.1	0.815	1	1.037	1.024	0.951	1.139	1.018
2	0.5	0.842	1	1.032	1.033	0.976	1.117	1.005
2	1.0	0.875	1	1.026	1.043	1.001	1.094	0.990