DP2006/05

Should Monetary Policy Attempt to Reduce Exchange Rate Volatility in New Zealand?

Dominick Stephens

May 2006

JEL classification: E52, E58

Discussion Paper Series

DP2006/05

Should Monetary Policy Attempt to Reduce Exchange Rate Volatility in New Zealand?[1]

Dominick Stephens[2]

Abstract

Previous research has suggested that including exchange rate stabilisation within the goals of monetary policy significantly increases the volatility of inflation, output and interest rates, and that the benefits of exchange rate stabilisation therefore do not justify the costs. The current paper tests whether this finding is *robust* when various alternative models of exchange rate determination are considered. The analysis is carried out in the context of optimal full-information monetary policy rules in a New Keynesian model that is calibrated to represent the New Zealand economy. For the models that feature rational expectations, we support the conclusion that seeking to avoid exchange rate volatility would have more costs than benefits. Indeed, a major cost of including the exchange rate within the goals of monetary policy is that inflation expectations become less anchored to the inflation target, meaning that larger movements in nominal interest rates are required to control inflation.

---

[1] The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. I would like to thank Kirdan Lees and David Hargreaves, this paper benefited enormously from their advice. All errors and omissions are my own.

[2] Address: Economics Department, Reserve Bank of New Zealand; PO Box 2498, 2 The Terrace, Wellington, New Zealand. Tel: 64-4-471 3626; fax: 64-4-473 1209; *email address:* Dominick.Stephens@rbnz.govt.nz.

1 Introduction

The introduction of inflation targeting in New Zealand heralded an era of more stable inflation, output, and interest rates. The exchange rate, however, has remained quite volatile. This has prompted questions about whether a less activist monetary policy could, or should, attenuate exchange rate volatility. To date, the economic literature has suggested that using interest rate settings to attenuate exchange rate volatility would be too costly in terms of additional volatility in inflation. Gali and Monacelli (2005) showed that in a small open economy version of the Calvo sticky price model, there is a necessary trade-off between the stabilisation of the exchange rate and the stabilisation of domestic inflation and the output gap. In two New Zealand papers, West (2003) and Hampton et al (2003) both concluded that the benefits of exchange rate stabilisation would not justify the costs of more volatile inflation. These papers were based on the uncovered interest rate parity (UIP) theory of exchange rate determination, with persistent portfolio shocks. The main contribution of the current paper is to test whether the previous finding that it is costly to stabilise the exchange rate is *robust* when a range of alternative models of exchange rate determination and macroeconomic behaviour are considered. A further innovation of the current paper is that the analysis is carried out in the context of the optimal monetary policy rule, rather than simple, monetary policy rules.

We employ a novel strategy for testing whether the benefits of attempting to stabilise the exchange rate justify the costs. We compare the optimal behaviour of two hypothetical central banks: one that is concerned only with inflation and output, and one that is concerned with the exchange rate in addition to inflation and output. Both hypothetical central banks operate within the same model economy and have full and perfect information. For each central bank, we calculate and compare the optimal reaction function. We also compare their behaviour when faced with various shocks. If the two optimising central banks behave similarly, one concludes that the central bank that cares about the exchange rate finds it too costly in terms of output and inflation to attempt to use monetary policy smooth the exchange rate. Alternatively, if the optimal rule for the central bank that is concerned with the exchange rate is very different, one can safely conclude that the benefits of stabilising the exchange rate outweigh the costs.

Note that this experiment is not an attempt to evaluate whether or not the exchange rate should be in the loss function. Rather, we ask the following question in this research: "If the exchange rate was included in the loss function, would the central bank behave any differently than if the exchange rate were not in the loss function?"

First, a baseline New Keynesian model of the New Zealand economy is constructed. The model features strong forward- and backward-looking elements, and the exchange rate is determined purely by UIP. Since this model is similar to the one used by West (2003), we expect to replicate the result that it is too costly to attempt to smooth the exchange rate (though in practice we draw some interesting additional conclusions that result from the use of full-information optimal policy).

We then specify four alternative models, examining how the results change under different assumptions about exchange rate determination.

Section 2 below outlines the baseline model, and specifies the alternative models. Section 3 begins with a results summary, and then details the results for each model. Section 4 concludes.

2 The baseline model

The small, New Keynesian model used in this paper was inspired by the model used in Leitemo and Söderström (2003) and Svensson (1998). The model is calibrated to represent the New Zealand economy as much as possible – the models estimated in Lees (2003) and Warburton and Lees (2003) are the main guides to the calibration. However, the role of the exchange rate has been 'beefed up' relative to the aforementioned empirical studies. The baseline model is calibrated to be plausible but not precise. The focus of the current research is to investigate how optimal policy changes when the model of exchange rate determination changes. Therefore it is the *differences* between the baseline and the alternative models that really matter. The qualitative results are not sensitive to changes in most parameters, except for the degree of interest rate smoothing (discussed in section 2.5).

All variables in the model are quarterly, and are defined as percentage-point deviations from their respective steady-state equilibria.

2.1 Aggregate demand

The output gap features strong forward- and backward-looking elements, and is influenced by monetary policy, the exchange rate, and foreign output:

$$y_t = 0.8y_{t-1} + 0.1E_t y_{t+1} - 0.2(i_{t-1} - \pi_{t-1}) - 0.1q_t + 0.2y_t^f + \varepsilon_{yt} \tag{1}$$

$$\sigma_{\varepsilon y} = 0.6$$

y_t = the output gap at time *t*
i_t = a quarterly nominal interest rate
π_t = the quarterly rate of inflation
q_t = the real exchange rate
ε_{yt} = a normally distributed random demand shock at time *t*
$\sigma_{\varepsilon y}$ = the standard deviation of ε_{yt}

E_t denotes a rational expectation at time *t* of the subsequent variable, and the superscript *f* represents foreign variables.

The parameter values in equation (1) are close to the values found by Lees (2003) in his empirical estimation of a similar model for the New Zealand economy, with some exceptions. Lees (2003) found that the forward-looking component of the aggregate demand equation and the real exchange rate term were both insignificant, whereas here we have calibrated non-zero values for these terms. The variance of aggregate demand shocks is set to approximately equal the root mean squared error (RMSE) of one-quarter-ahead gross domestic product (GDP) forecast errors made by the Reserve Bank of New Zealand (RBNZ). See McCaw and Ranchhod (2002) for information on RBNZ forecast errors.

Note that the sum of the backward-looking and forward-looking inertia in the aggregate demand equation equals 0.9 < 1. Provided that $i_{t-1} - \pi_{t-1}$ and y_t^f are stationary, the domestic output gap will therefore also be stationary. This implies that, even in the absence of anti-cyclical monetary policy, output returns to equilibrium. Inflation and output are therefore self-stabilising in this model.

2.2 Inflation

CPI inflation is given a Phillips Curve equation,

$$\pi_t = 0.5E_t\pi_{t+1} + 0.5\pi_{t-1} + 0.2y_{t-1} + 0.5\pi_t^m + \varepsilon_\pi \tag{2}$$

$$\sigma_{\varepsilon\pi} = 0.3$$

where π_t^m denotes the inflation rate of imported goods and services – the calibrated parameter on π_t^m of 0.5 is roughly equal to the weight of tradable goods in the New Zealand CPI. ε_π is a normally distributed random shock to domestic prices, with standard deviation $\sigma_{\varepsilon\pi}$. At 0.3, $\sigma_{\varepsilon\pi}$ approximately equals the RMSE of one-quarter-ahead inflation forecast errors made by the RBNZ (see McCaw and Ranchhod, 2002). The long-run Phillips Curve is vertical, and the output gap affects inflation with a one period lag. Note that we have not specified a separate equation for domestic inflation. A shock to imported inflation has flow-on effects on the general level of prices, including domestic prices. A shock to imported inflation may affect domestic prices since even non-tradable goods will embody some tradable inputs. The exchange rate affects the price of imported goods, through the equation:

$$\pi_t^m = (1-\kappa)\pi_{t-1}^m + \kappa\Delta q_t \tag{3}$$

where $0 < \kappa < 1$ is the rate of pass through from the exchange rate to import prices. In the baseline model $\kappa = 0.5$, meaning that import prices respond asymptotically to exchange rate changes, with a half-life of one quarter.[3] (Note that importers pass changes in the *equilibrium* exchange rate through to prices immediately.)

[3] $\kappa = 0.5$ is consistent with the full sample estimate of Campa and Goldberg (2002), who report that exchange rate pass-through into import prices for New Zealand is 0.47 – 0.58 in the first quarter, and 0.62 – 0.77 in the long run. In the baseline model, the implied exchange rate pass-through into consumer prices for the first two quarters is 0.26. This compares to empirical estimates that range from 0.1 in Lees (2003) to 0.2 – 0.4 in Munro (2003).

Foreign sector

The foreign sector is represented by simple stationary processes with persistence for output and inflation, following Svensson (1998). The foreign central bank follows the Taylor rule, with weights of 1.5 on inflation and 0.5 on output.

$$y_t^{\,f} = 0.8 y_{t-1}^{\,f} + \varepsilon_{y^f t} \tag{4}$$

$$\sigma_{y_t^f} = 0.3$$

$$\pi_t^{\,f} = 0.8 \pi_{t-1}^{\,f} + \varepsilon_{\pi t} \tag{5}$$

$$\sigma_{\pi_t^f} = 0.3$$

$$i_t^{\,f} = 1.5 \pi_t^{\,f} + 0.5 y_t^{\,f} \tag{6}$$

2.3 Exchange rate

The real exchange is given by:

$$q_t = \widetilde{E}_t q_{t+1} + (i_t - E_t \pi_{t+1}) - (i_t^f - E_t \pi_{t+1}^f) + \gamma y_t^f + u_t^q \tag{7}$$

$\widetilde{E}_t q_{t+1}$ is the expectation of next period's exchange rate at time *t*. In the baseline model this expectation is fully rational, although one of the alternative models explores the implications of using adaptive expectations instead.

The foreign demand term in equation (7) represents the effect of commodity prices on the exchange rate, where commodity prices are a linear function of foreign demand. In the baseline model $\gamma = 0$, meaning that (7) is simply the familiar UIP condition (γ is non-zero only in the commodity prices model).

The term u_t^q is a risk premium that exhibits some persistence:

$$u_t^q = \rho_q u_{t-1}^q + \varepsilon_{qt}, \quad 0 \le \rho < 1. \tag{8}$$

where ε_{qt} is a normally distributed random error. In the baseline model

$$\rho = 0.3\,,\ \sigma_u = 2\,,\ \text{and}\ \sigma_\varepsilon = 1.67\,.$$

2.4 Monetary policy

The central bank is assumed to minimise an intertemporal loss function of the form:

$$E_t \sum_{t=0}^{\infty} \beta^t L_t \tag{9}$$

where β is the discount factor, and L_t represents the period loss function. As explained in section 1, the aim of this paper is to compare the optimal monetary policy responses of a central bank that cares about the exchange rate to the optimal monetary responses of a central bank that does not care about the exchange rate. This involves running the model under two alternative period loss functions. First, a standard loss function,

$$L_t = y_t^2 + \pi_t^2 + \Delta i_t^2 \tag{10}$$

where the central bank places equal weight on deviations of output and inflation from target, and also has a preference for avoiding sharp changes to the policy instrument, i_t.

The loss function weight on the change in the interest rate is set to 1 because this gives the most realistic impulse responses in the baseline model.[4] Under the standard loss function, the central bank places no explicit weight on the exchange rate, although it may react to exchange rate shocks in pursuit of its other goals.

Secondly, we posit an alternative loss function, whereby the central bank places explicit weight on the exchange rate

[4] There is no theoretical guidance for the degree of interest rate smoothing in the loss function. However, many authors have adopted a coefficient of 0.1 for models that use annual interest rates, for example, Svensson (1998), Lees (2003). An interest rate smoothing coefficient of 0.1 on annual interest rates would be approximately equivalent to 1.6 in the current model, where quarterly interest rates are used. Therefore, the current model includes less interest rate smoothing than has become the literature standard.

$$L_t = y_t^2 + \pi_t^2 + \Delta i_t^2 + q_t^2 . \qquad (11)$$

The quantitative results are generally unaffected by the relative weights in the loss function, except in the case of the interest rate smoothing parameter. If a lower interest rate smoothing parameter is chosen then conclusion 1 in section 4 no longer holds. However, this model already includes less interest rate smoothing than is standard in the literature, and to lower the interest rate smoothing further would create unrealistic policy responses to shocks. More details on the sensitivity of the model to the degree of interest rate smoothing can be found in the appendix.

3 Alternative models

The baseline model includes the standard, theoretically driven model of exchange rate determination, with rational expectations and UIP. However, observed behaviour of the New Zealand exchange rate is difficult to reconcile with this model. West (2003) drew his conclusions about exchange rate smoothing based only on models similar to my baseline. This paper tests whether those conclusions are robust under alternative models of exchange rate determination. Four alternative models are proposed – three feature alternative exchange rate mechanisms, and one features a different rate of exchange rate pass-through. Each model is designed to be consistent with observed exchange rate behaviour. The models are compared and summarised in table 1 overleaf, and are detailed below.

3.1 Slow pass-through model

$$\kappa = 0.1 \text{ instead of } \kappa = 0.5 .$$

The true rate of exchange rate pass-through into prices is difficult to measure. In particular, there is evidence to suggest that it has slowed considerably in recent years.[5] The first alternative model tests the effect that much slower pass-through would have on the conclusions.

[5] Campa and Goldberg (2002) estimate that exchange rate pass-through into import prices was 0.08 in a post-1999 sample, compared to their 0.47 for a post 1989 sample.

Table 1
Summary of alternative exchange rate models

	κ (rate of exchange rate pass-through)	ρ (persistence of UIP shocks)	γ (effect of commodity prices on exchange rate)	$E_t q_{t+1}$	σ_ε (standard deviation of exchange rate shocks)
Base case model	0.5	0.3	0	Rational	1.67
Slow pass-through to import prices	0.1				
Persistent deviations from UIP		0.9			0.63
Exchange rate influenced by commodity prices			0.25		1.67
Adaptive expectations				90% adaptive	0.17

Blank spaces indicate no change from baseline model

3.2 Persistent deviations from uncovered interest parity

In this model, exchange rate shocks are far more persistent, with

$$\rho = 0.9 \text{ instead of } \rho = 0.3.$$

The total variability of the exchange rate is left unchanged by reducing the standard deviation of UIP shocks:

$$\sigma_u = 2, \ \sigma_\varepsilon = 0.63.$$

3.3 Commodity prices model

$$\gamma = 0.25$$

Chen and Rogoff (2002) present empirical evidence that commodity export prices directly affect the New Zealand exchange rate. The "Commodity Prices Model" postulates that world commodity prices are a linear function of world demand, and in turn, the exchange rate is partly a linear function of world commodity prices. This can be represented by world demand entering the exchange rate equation in a linear fashion. In this model, the exchange rate provides the domestic economy with a buffer against foreign shocks.

3.4 Adaptive expectations model

This model is motivated by the observation that the exchange rate appears to be more sensitive to interest rates than could be justified by UIP; see for example Stephens (2004). Such over-sensitivity could be explained by exchange rate expectations being partly adaptive. Suppose that exchange rate expectations are based on the current exchange rate, with a small weight on the rational expectation:

$$\widetilde{E}_t q_{t+1} = 0.9 q_t + 0.1 E_t q_{t+1} \tag{12}$$

Substituting into equation (7) gives

$$q_t = 0.9 q_t + 0.1 E_t q_{t+1} + (i_t - E_t \pi_{t+1}) - (i_t^{\ f} - E_t \pi_{t+1}^{\ \ f}) + u_t^q \tag{13}$$

Rearranging,

$$q_t = E_t q_{t+1} + 10(i_t - E_t \pi_{t+1}) - 10(i_t^{\ f} - E_t \pi_{t+1}^{\ \ f}) + 10 u_t^q \tag{14}$$

In this model, the exchange rate is 10 times more sensitive to changes in real interest rates. Note that the exchange rate is also 10 times more sensitive to UIP shocks. In order to preserve the overall (observable) variability of the exchange rate, the standard deviation of exchange rate shocks is reduced by a factor of 10:

$$\sigma_u = 0.2\,,\ \sigma_\varepsilon = 0.167\,.$$

4 Results

Drawing conclusions from this paper involves analysing and interpreting 200 impulse responses. To aid interpretation, section 4.1 summarises the main results. Section 4.2 then goes into more detail on the results for the baseline model. Sections 4.3 to 4.6 detail and discuss the results of each alternative model only where they differ substantially from the baseline model.

4.1 Results summary

Table 2 summarises the results. The second and third columns summarise the results from the baseline model, while the fourth column shows how these results change when the model of exchange rate determination is changed.

Table 2
Summary of results

	Base case reaction	**Change in reaction if central bank cares about exchange rate**	**Which alternative models change result?**
Price shock	Raise then gently ease	Very little	None
Output shock	Raise then gently ease	Very little	Adaptive Expectations
Exchange rate shock	No reaction	Aggressive initial easing	Persistent Deviations, Adaptive Expectations
Foreign shock	Small tightening cycle	Very little	None

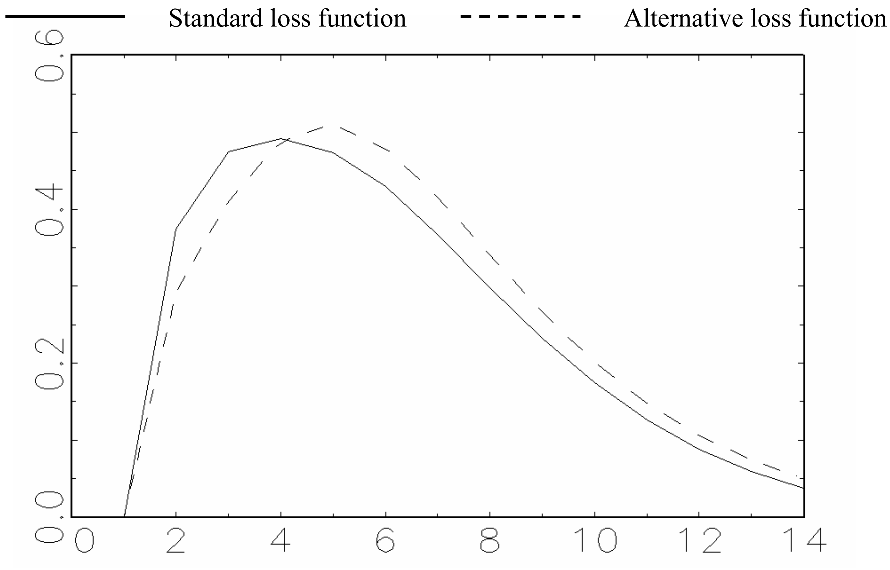
The key results of the baseline model are that:

1) The costs outweigh the benefits of reacting more gradually to demand shocks in the interests of smoothing the exchange rate. Figure 1 shows that the alternative central bank (which is concerned

about exchange rate volatility) reacts to demand shocks in a similar manner to the standard central bank.[6]

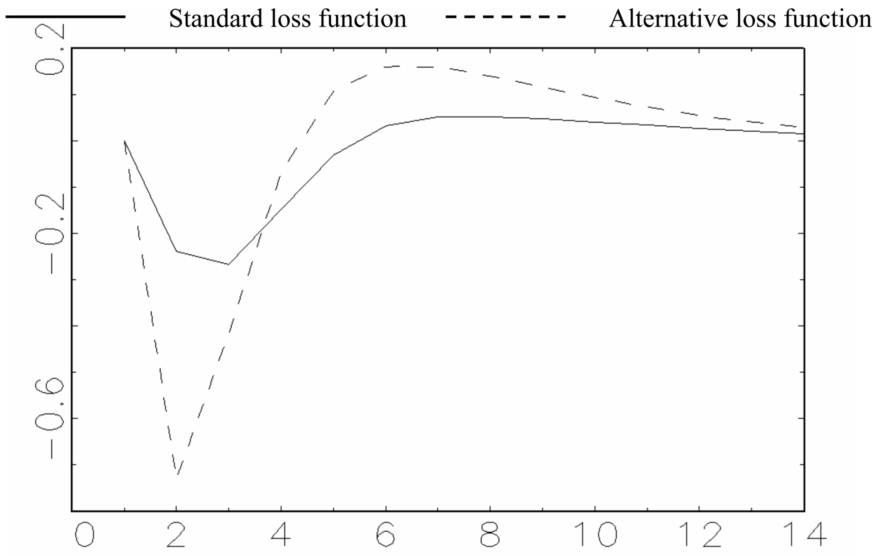
2) However, the alternative and standard central banks react differently to pure exchange rate shocks (portfolio shocks). Figure 2 shows that the alternative central bank lowers interest rates sharply to offset a positive exchange rate shock, while the standard central bank does not.
3) The two central banks behave in a very similar manner when confronted with price shocks or foreign demand shocks.

Figure 1
Interest rate reactions to demand shock, baseline model



[6] The alternative central bank is slightly more gradualist, as expected. However, the difference is too small to be described as 'significant'.

Figure 2
Interest rate reactions to exchange rate shock, baseline model



Looking at the baseline model alone, we largely support the results of West (2003) and Hampton et al (2003) with one key exception. Under full information, a central bank that cares about the exchange rate should react to portfolio exchange rate shocks, while a standard central bank should not. Of course, the applicability of this result to the real world is limited by a central bank's ability to distinguish portfolio exchange rate shocks from other movements in the exchange rate.

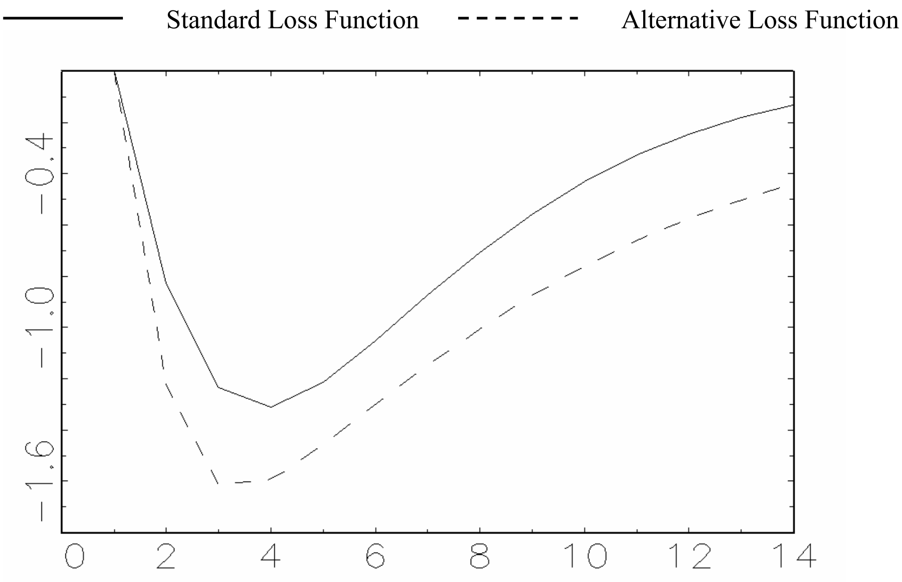
In most cases, the key results 1) to 4) above are not affected by adopting an alternative model of the exchange rate. However, changing the model of the exchange rate alters a few of the results in important ways, as summarised below.

1) If exchange rate shocks are very persistent, then *both* central banks should react to pure exchange rate shocks (see figure 3). This contrasts with the baseline model, where the standard central bank should not react to pure exchange rate shocks.
2) If commodity prices affect the exchange rate, then *neither* central bank should move interest rates in response to foreign demand shocks. This can be interpreted as suggesting that the exchange

rate should be allowed to perform its function as a shock absorber to foreign shocks.

3) If exchange rate expectations are adaptive, the results change substantially. In nominal interest-rate terms, the alternative central bank reacts more aggressively to all types of shocks, and both central banks react strongly to pure exchange rate shocks. This follows from the fact that the central bank has far more influence over exchange rates in a model that features adaptive exchange rate expectations.

Figure 3
Interest rate reaction to exchange rate shock, persistent deviations model



Some alternative models also illustrate another major cost of targeting the exchange rate: including the exchange rate within the goals of monetary policy affects inflation expectations. Since agents know that the central bank is less single-minded in its inflation target, they *expect* larger deviations of inflation from target. These expectations will be self-fulfilling to some extent. Consequently, the alternative central bank receives less help from favourable expectations, and has far more work to do in returning inflation to target. It therefore suffers disproportionately large increases in inflation variability in return for modest decreases in the exchange rate cycle.

4.2 Baseline model results

The standard central bank

Figure 4 shows the impulse responses for four shocks to the baseline model. The shocks occur in period 2. In each case, the solid line represents the impulse responses under the standard loss function, while the dotted lines show the impulse responses when the exchange rate is included in the reaction function (henceforth, alternative reaction function). We begin by making some observations on the standard central bank, represented by the solid lines.

With a standard reaction function, the baseline model has sensible impulse responses. In the event of a one standard deviation price shock, the central bank tightens interest rates by around 100 basis points (bp), and causes a negative output gap. The increase in real interest rates causes the exchange rate to appreciate initially and then to depreciate, in line with the UIP relationship.

The standard central bank responds to a positive demand shock by tightening policy by 200bp over the course of a year. This quickly offsets the positive output gap. Note that the central bank runs a negative output gap for a period, in order to return inflation to target more quickly. The response of inflation to a demand shock is a good illustration of the lag structure of this model. The immediate effect on inflation is a small fall, due to the exchange rate appreciation (which, in turn, is caused by the interest rate increase). Subsequently, there is a long period of positive inflation, caused by the lagged effect of the demand shock, and by the persistence of inflation itself.

In the case of an exchange rate shock, the standard central bank reacts only slightly. It prefers to allow the exchange rate to readjust autonomously. Lowering interest rates would offset the exchange rate spike – but the standard central bank is not concerned with the exchange rate *per se*. Indeed, due to lags in the transmission mechanism, monetary policy cannot offset the *immediate* impact of the exchange rate on inflation or output. Lowering interest rates substantially would only cause a positive output gap in later periods. The standard central bank's most prudent course of action is to "look through" portfolio exchange rate shocks.

The standard central bank tightens monetary policy in response to foreign demand shocks, and the impulse responses are similar to those of a domestic demand shock, only more muted.

The alternative central bank

The first row of figure 4 shows that, in the case of a price shock, the alternative central bank behaves in a very similar fashion to the standard central bank.

In the case of an output shock, the central bank that cares about the exchange rate is slightly more gradualist than the standard central bank. This reduces the initial exchange rate spike at the cost of additional inflation and output variability.

There is no guide as to whether or not the policy responses are "significantly different". However casual inspection suggests that the difference between the two reactions is very small. Sensitivity analysis shows that the degree of difference in the behaviour of the two central banks depends on two main factors:

- i) A higher penalty on changes in the interest rate in the loss function induces the standard central bank to be more gradualist, reducing the difference between the two central banks.
- ii) The more self-stabilising the model is, the lower the "cost" of gradualism in terms of inflation and output. Under a more self-stabilising specification, the alternative central bank can "afford" to be more gradualist, and its behaviour then differs more from that of the standard central bank.

The central bank that cares about the exchange rate drops interest rates sharply in the face of a pure exchange rate shock, while the standard central bank does not react much. This is a significant departure from the results of West (2003) and Hampton et al (2003). The reason we find such a different result is that the previous authors allowed only for *simple* policy rules. Simple policy rules cannot distinguish pure exchange rate shocks from exchange rate movements that are consistent with economic fundamentals. An optimal central bank operating under full information can make the distinction perfectly, and can respond perfectly. While this is a crucial finding, its applicability to the real world is limited by a real-world central bank's ability to distinguish pure exchange rate shocks from movements in exchange rate fundamentals.

The alternative central bank behaves in a slightly more gradual manner than the standard central bank in the case of a foreign demand shock, but as in the case of a demand shock, the difference in the reactions is very small.

Table 3 below compares the optimal reaction functions of the standard central bank and the alternative central bank. Each number represents the percentage-point reaction of interest rates to a 1% increase in the relevant variable. Note that a full information optimal reaction function allows the central bank to react differently to a shock and to a deviation from target. Some readers may be more familiar with simple policy rules, which do not allow the central bank to draw this distinction. Table 3 shows that the alternative central bank is slightly more gradualist in the face of output shocks, and is much more activist in responding to exchange rate shocks.

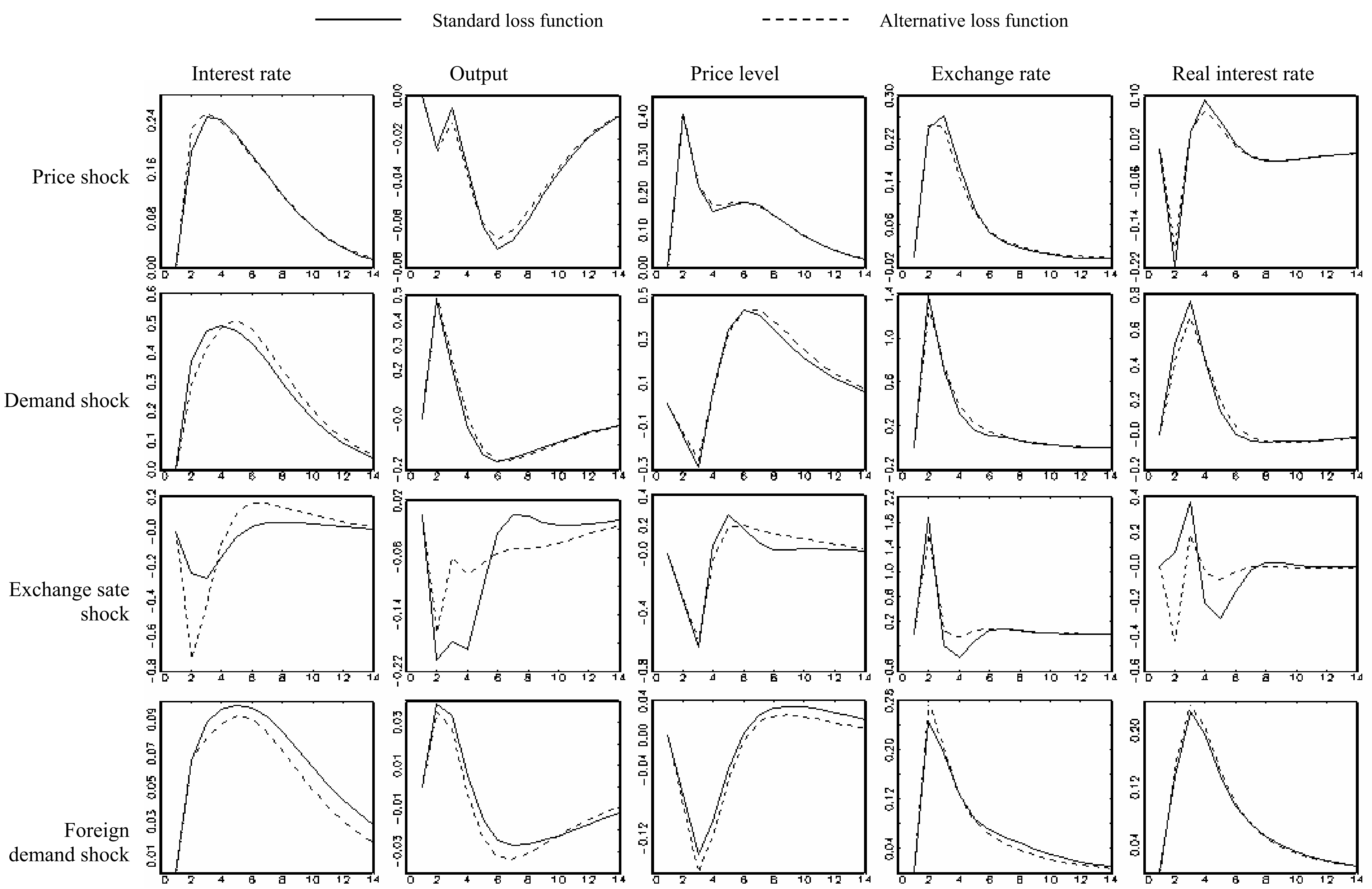
Table 3
Optimal reaction functions, baseline model

		Standard loss function	**Alternative loss function**
Output shock	ε_{yt}	0.62	0.49
Inflation shock	$\varepsilon_{\pi t}$	0.63	0.75
Exchange rate shock	ε_{qt}	-0.14	-0.44
Output (lagged)	y_{t-1}	0.62	0.54
Inflation (lagged)	π_{t-1}	0.44	0.47
Exchange rate (lagged)	q_{t-1}	0.48	0.60
Imported inflation (lagged)	π_{t-1}^{m}	0.79	0.98
Interest rate (lagged)	i_{t-1}	0.33	0.20
Foreign output	y_t^f	0.22	0.22
Foreign inflation	π_t^f	0.59	0.89

4.3 Slow pass-through model results

In tables 4-7 the *shading* show where the optimal reaction functions of the alternative models differ relative to those of the baseline model, table 3.

Figure 4 Impulse responses: Baseline model



In table 4, the shaded areas show that *all* of the optimal reaction function parameters under the slow pass-through model differ from those of the baseline model.

The impulse responses of figure 5 show that slowing the rate of pass-through in the model changes the impulse responses. However, slower pass-through does not alter the conclusion of the baseline model – the standard and the alternative central banks behave very similarly, except in the case of a pure exchange rate shock.

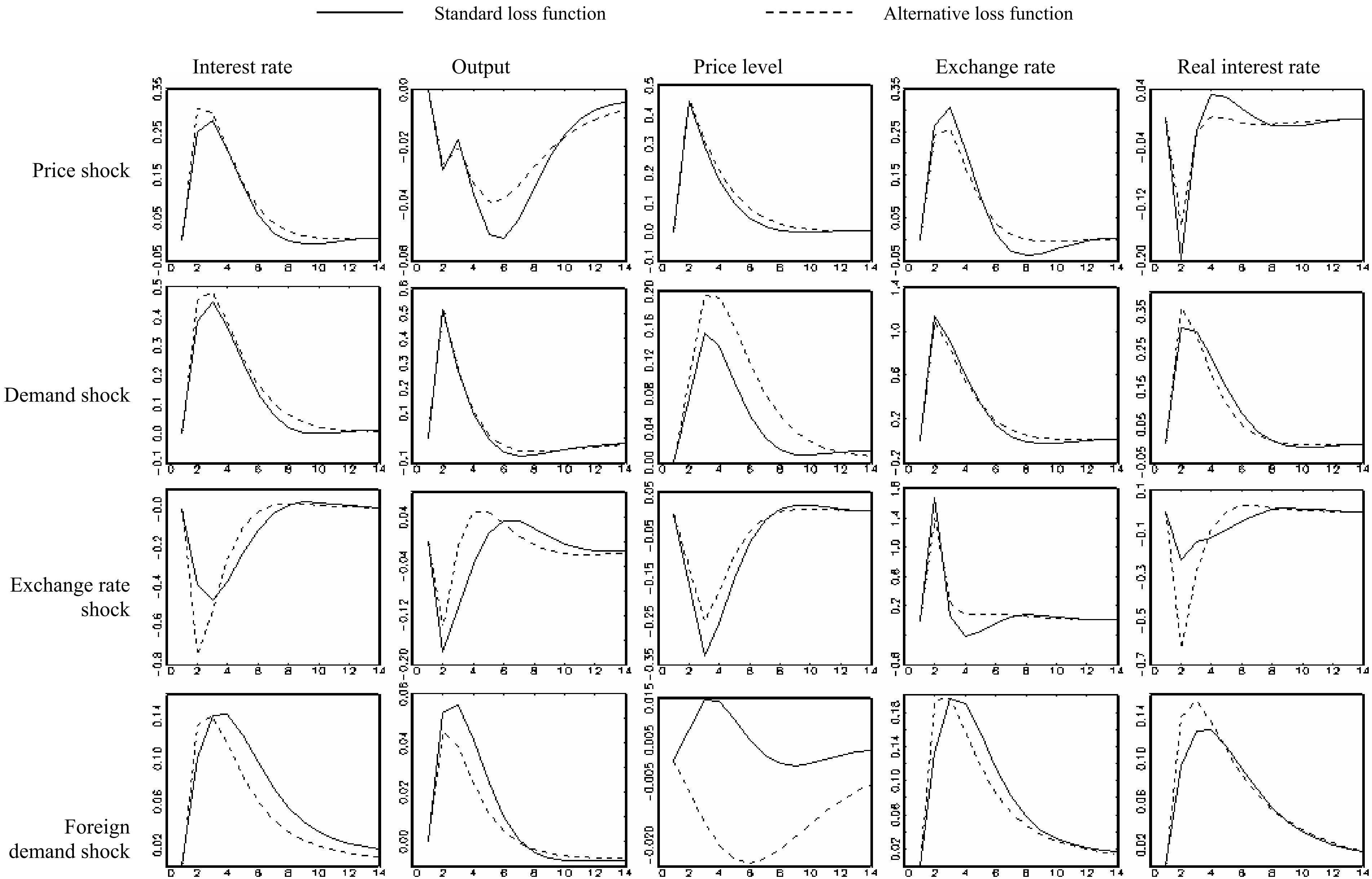
Table 4
Optimal reaction functions, slow pass-through model

		Standard loss function	**Alternative loss function**
Output shock	ε_{yt}	0.64	0.76
Inflation shock	$\varepsilon_{\pi t}$	0.83	1.02
Exchange rate shock	ε_{qt}	-0.23	-0.45
Output (lagged)	y_{t-1}	0.67	0.81
Inflation (lagged)	π_{t-1}	0.54	0.66
Exchange rate (lagged)	q_{t-1}	0.14	0.17
Imported inflation (lagged)	π^m_{t-1}	1.7	2.01
Interest rate (lagged)	i_{t-1}	0.24	0.07
Foreign output	y^f_t	0.34	0.44
Foreign inflation	π^f_t	0.52	0.67

The effect of targeting the exchange rate on inflation expectations

Careful consideration of the demand shock in figure 5 illuminates an interesting property of the model. The alternative central bank holds nominal interest rates higher than the standard central bank, yet inflation is higher. This can be explained by differences in inflation expectations when the central banks have different loss functions. Agents know that the alternative central bank is concerned about its effect on the exchange rate. They understand that the alternative central bank will react more gradually to demand shocks, and will devote less attention to controlling inflation. They

Figure 5 Impulse responses: Slow pass-through model



therefore expect more inflation. Since inflation expectations are less well anchored at target, expectations exert a less favourable influence on inflation outcomes, leaving the alternative central bank with more work to do to return inflation to target. If the central bank includes exchange rate stabilisation within its objectives, then inflation will be less well anchored at target, making inflation control more difficult. Note that this result was apparent to a greater or lesser extent in the baseline model as well as all of the alternative models.

4.4 Persistent deviations model results

Table 5
Optimal reaction functions, persistent deviations model

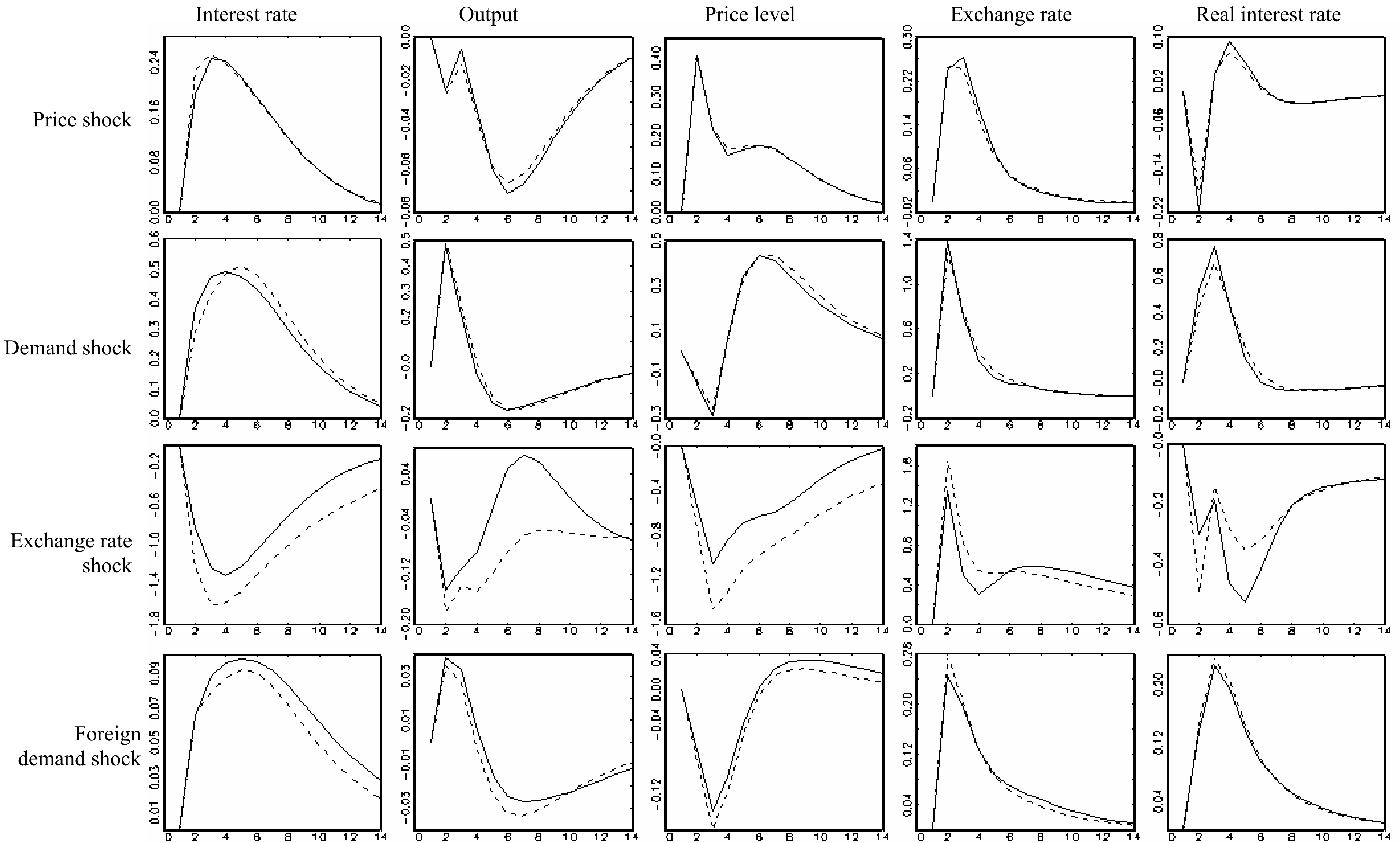
		Standard loss Function	Alternative loss Function
Output shock	ε_{yt}	0.62	0.49
Inflation shock	$\varepsilon_{\pi t}$	0.63	0.75
Exchange rate shock	ε_{qt}	-1.4	-1.9
Output (lagged)	y_{t-1}	0.62	0.54
Inflation (lagged)	π_{t-1}	0.44	0.47
Exchange rate (lagged)	q_{t-1}	0.48	0.60
Imported inflation (lagged)	π_{t-1}^{m}	0.79	0.98
Interest rate (lagged)	i_{t-1}	0.33	0.20
Foreign output	y_t^f	0.22	0.22
Foreign inflation	π_t^f	0.59	0.89

The impulse responses when deviations from UIP are more persistent are exactly the same as the baseline model in all cases except for an exchange rate shock, as shown in figure 6.

The effect on inflation and output of an exchange rate shock is longer lasting in the persistent deviations model. Consequently, both central banks are able to use interest rates to offset the inflation and output gap effects. Note that the two central banks behave in a similar fashion, indicating that concern for inflation and output is the primary reason to cut interest rates. In this model, there is very little that the central bank can do to affect the exchange rate.

Figure 6 Impulse responses: Persistent deviations model

——— Standard Loss Function - - - - - - Alternative Loss Function



4.5 Commodity prices model results

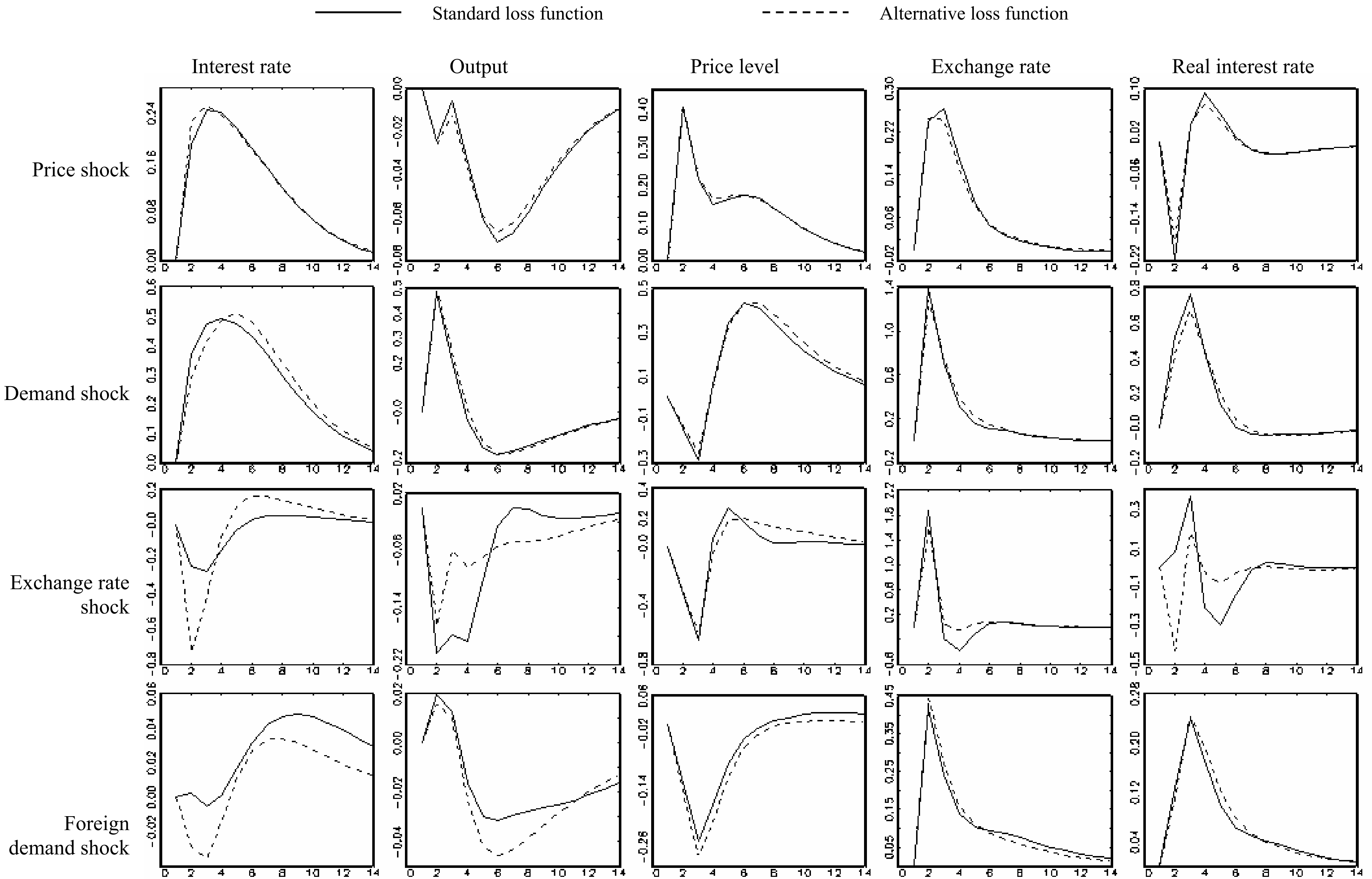
In the commodity prices model, the exchange rate is correlated with foreign demand via commodity prices. Table 6 shows that the optimal reaction functions are the same as in the baseline model, except for the reaction to foreign demand disturbances and exchange rate shocks. The impulse responses for to a foreign demand shock in this model are shown in figure 7. The standard central bank no longer reacts much to foreign demand shocks – it prefers to allow the exchange rate to work as a shock absorber. The alternative central bank behaves in broadly the same manner, although it reduces interest rates slightly in response to the foreign demand shock.

Table 6
Optimal reaction functions, commodity prices model

		Standard loss Function	Alternative loss Function
Output shock	ε_{yt}	0.62	0.49
Inflation shock	$\varepsilon_{\pi t}$	0.63	0.75
Exchange rate shock	ε_{qt}	-0.14	-0.44
Output (lagged)	y_{t-1}	0.62	0.54
Inflation (lagged)	π_{t-1}	0.44	0.47
Exchange rate (lagged)	q_{t-1}	0.48	0.60
Imported inflation (lagged)	π_{t-1}^{m}	0.79	0.98
Interest rate (lagged)	i_{t-1}	0.33	0.20
Foreign output	y_t^f	0.01	0.10
Foreign inflation	π_t^f	0.59	0.89

The commodity prices model draws out another interesting conclusion: even if the central bank is concerned about exchange rate volatility, it should always allow the exchange rate to perform its positive function of insulating the domestic economy from foreign demand shocks.

Figure 7 Impulse responses: Commodity prices model



4.6 Adaptive expectations model results

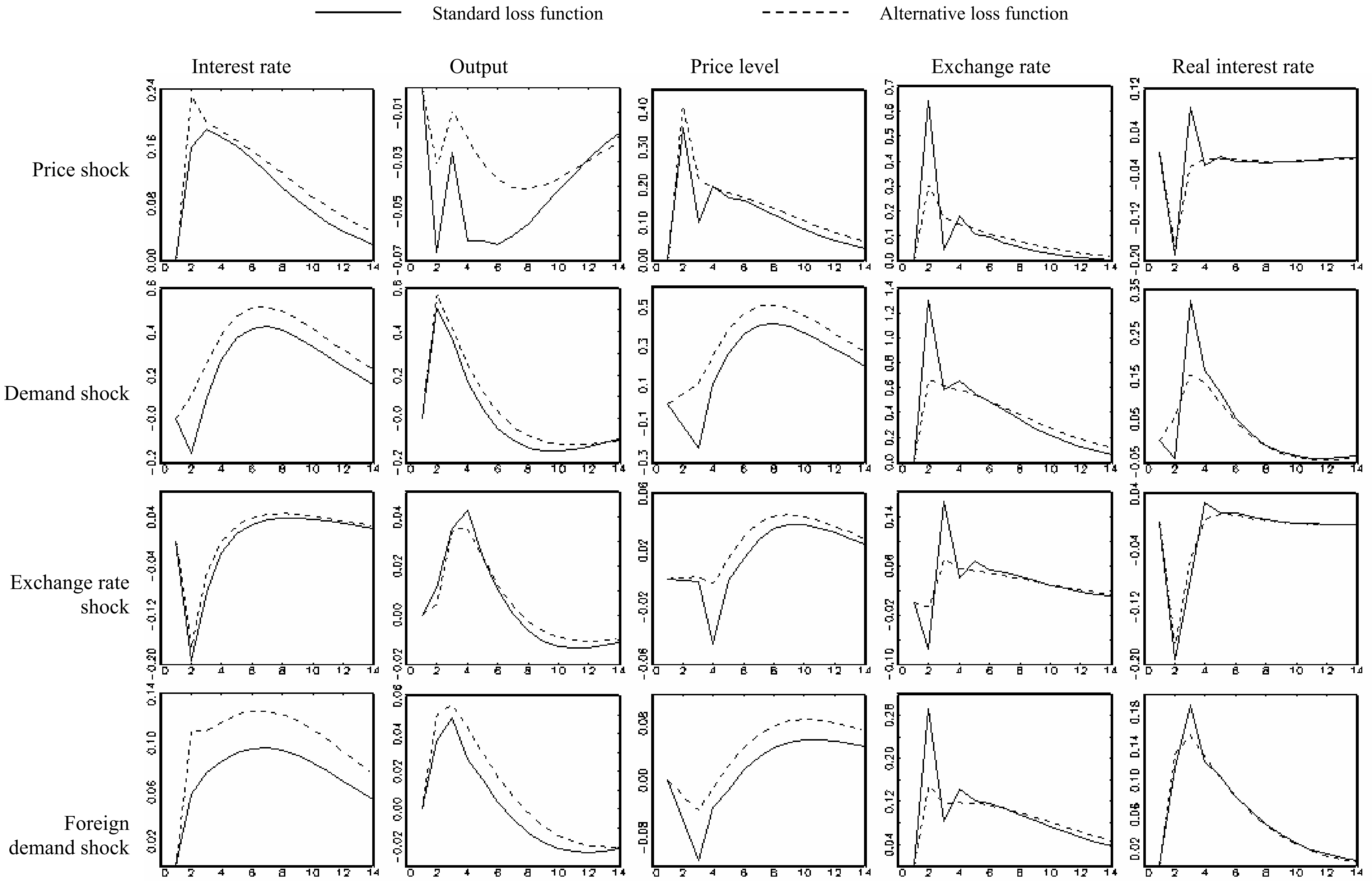
Table 7
Optimal reaction functions in adaptive expectations model

		Standard loss Function	Alternative loss Function
Output shock	ε_{yt}	-0.26	0.18
Inflation shock	$\varepsilon_{\pi t}$	0.53	0.77
Exchange rate shock	ε_{qt}	-1.16	-1.04
Output (lagged)	y_{t-1}	-0.10	0.29
Inflation (lagged)	π_{t-1}	0.21	0.42
Exchange rate (lagged)	q_{t-1}	0.55	0.58
Imported inflation (lagged)	π^{m}_{t-1}	0.82	0.97
Interest rate (lagged)	i_{t-1}	0.07	0.01
Foreign output	y^{f}_{t}	0.19	0.37
Foreign inflation	π^{f}_{t}	1.23	1.01

Modelling exchange rate expectations as adaptive significantly alters the properties of the model. The central bank can have a significant, immediate effect on the exchange rate. This means that in the case of an exchange rate shock, both central banks find it worthwhile reacting directly.

Again, it is interesting to note that reacting to the exchange rate partly "unhinges" inflation expectations. In real terms, the alternative central bank is more gradualist than the standard central bank. However, the alternative central bank causes inflation expectations to become more volatile. It is actually required to move nominal interest rates by more than the standard central bank, in order to achieve its more modest real interest rate settings. The adaptive expectations model is an example of a model in which more gradualist monetary policy would actually exacerbate the exchange rate cycle.

Figure 8 Impulse responses: Adaptive expectations model



5 Conclusions

We draw four main conclusions from this paper.

1. *For models of the exchange rate that feature rational expectations, we concur that the costs of reacting to the exchange rate outweigh the benefits.*

We found that a central bank operating optimal monetary policy under a loss function that includes the exchange rate behaves very similarly to an optimal central bank that is not directly concerned with the exchange rate. This implies that the increased costs of inflation and output volatility outweigh the benefits of reduced exchange rate volatility. This result holds under various models of exchange rate determination, so long as those models featured rational expectations.

2. *A central bank that is concerned about the exchange rate should react strongly to portfolio exchange rate shocks if it can identify them, but should be careful not to counter the exchange rate's shock absorber effect.*

We found that the optimal monetary policy for a central bank that is concerned with the exchange rate is to cut interest rates sharply to offset portfolio exchange rate shocks. However, the recommended interest rate reaction is concurrent with the exchange rate shock. The applicability of this result in the real world is limited by a central bank's ability to identify pure exchange rate shocks in a timely fashion. Furthermore, the commodity prices model showed that the central bank should be very careful not to erode the exchange rate's positive function as a buffer against foreign shocks.

3. *If exchange rate expectations are adaptive, then smoothing the exchange rate may be justified.*

We specified a model that is consistent with the observed behaviour of the exchange rate, and featured adaptive exchange rate expectations. In such a model, the central bank has a powerful influence over the exchange rate, and therefore interest rates may be very effective at attenuating the exchange rate cycle with little cost. However, the central bank that is concerned with exchange rate volatility is not more gradualist in nominal terms. Rather, it must move nominal interest rates more aggressively since inflation expectations are less well-anchored at target. (Though in terms of the real interest rate the alternative central bank is more gradualist.) Also, even a standard central bank should react very aggressively to pure exchange rate shocks in an adaptive expectations world.

4. *A major cost of targeting the exchange rate is that inflation expectations exhibit greater volatility around the inflation target.*

In a model with strongly forward looking dynamics and rational expectations, inflation expectations play a very important role. If the central bank chooses to include the exchange rate within its goals, then inflation expectations will be less well-anchored at the inflation target. These less favourable inflation expectations make the central bank's inflation control objective more difficult to achieve, and results in more variable inflation. Loss of inflation targeting credibility is a very important risk for a central bank that is considering including exchange rate stabilisation within its goals.

References

Campa J M, and L Goldberg (2002), "Exchange rate Pass through to import prices: a macro or micro phenomenon?" *National Bureau of Economic Research, Working Paper,* 8934.

Chen Y, and K Rogoff (2002), "Commodity currencies and empirical exchange rate puzzles," International Monetary Fund, *IMF Working Papers*, 02/27.

Galí J, and T Monacelli (2005), "Monetary policy and exchange rate volatility in a small open economy," *Review of Economic Studies*, 72(3):707-34.

Hampton T, D Hargreaves and J Twaddle (2006), "Other stabilisation objectives within an inflation targeting regime: some stochastic simulation experiments," *Reserve Bank of New Zealand Discussion Paper*, forthcoming.

Lees K (2003), "The stabilisation problem: the case of New Zealand," *Reserve Bank of New Zealand Discussion Paper,* DP2003/08.

Leitemo K, and U Söderström (2001), "Simple monetary policy rules and exchange rate uncertainty," *Sveriges Riksbank Working Paper*, 122.

McCaw S, and S Ranchhod (2002), "The Reserve Bank's forecasting performance," *Reserve Bank of New Zealand Bulletin,* 65(4):5-23.

Munro A (2005), "UIP, expectations and the Kiwi," *Reserve Bank of New Zealand Discussion Paper,* DP2005/05.

Stephens D (2004), "The equilibrium exchange rate according to PPP and UIP," *Reserve Bank of New Zealand Discussion Paper,* DP2004/03.

Svensson L E O (1998), "Open-economy inflation targeting," *Journal of International Economics*, 50(1):155-83.

Warburton S, and K Lees (2005), "A happy "halfway-house"? Medium term inflation targeting in New Zealand," *Reserve Bank of New Zealand Discussion Paper,* DP 2005/03.

West K (2003), "Monetary policy and the volatility of exchange rates in New Zealand," *Reserve Bank of New Zealand Discussion Paper,* DP 2003/09.

Appendix A
Sensitivity to the loss function weight on changes in the interest rate

Figure A1 shows the effect of the interest rate smoothing parameter in the loss function. Reducing interest rate smoothing to 0.25 (compared to 1 in the baseline model) makes the standard central bank far more reactive. In the case of a 1 standard deviation output shock, the central bank immediately raises annual interest rates by 400 basis points. It would appear, therefore, that less interest rate smoothing than the baseline model is an unrealistic assumption, since the baseline model features a more realistic reaction to a typical output shock.

Figure A1 Impulse responses: Less interest rate smoothing