The Role of the Exchange Rate in Monetary Policy Rules: Evidence from a Dynamic Keynesian Model

Christopher Malikane[†] and Willi Semmler[‡]

[†]University of the Witwatersrand, School of Economic and Business Sciences, 1 Jan Smuts Avenue, Johannesburg 2050, South Africa
[‡]New School for Social Research, Department of Economics, 65 Fifth Avenue, New York N.Y. 10003, USA

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Abstract

A dynamic Keynesian model of a small open economy is used to investigate the role of the exchange rate in the monetary policy rule. The model consists of four core components that are relevant for practical macroeconomics as suggested by Blinder (1997): separate Phillips curves for nominal wages and prices, Okun's law which links the goods and labour markets, a dynamic IS curve, and an interest parity relation that determines real exchange rate adjustment. The model shows that if the central bank responds to real exchange rate fluctuations, it tends to enforce faster convergence of macro variables in response to shocks. These results are supported by simulations of an estimated macroeconometric model of the South African economy.

[1]E-mail:malikanec@sebs.wits.ac.za. Fax:+27-11-717-8081

1 Introduction

In small open economies, the exchange rate undoubtedly plays a significant role in the transmission of monetary policy. Yet, as the literature review in Taylor (2001) shows, there is no consensus on the role that the exchange rate should play in monetary policy rules. Bernanke and Gertler (1999) for example, argue that positive interest rate movements in response to exchange rate depreciation may worsen the balance sheet of firms and make economic contractions more severe. Leitmo and Söderström (2005) find little improvement when the real exchange rate is included in the policy rule. They then conclude that a simple Taylor rule is sufficient to stabilize small open economies.

On the other hand, some authors argue that there are significant benefits when central banks respond explicitly to real exchange rate fluctuations. Mishkin (2000) proposes that emerging market economies should smooth exchange rate fluctuations in their conduct of monetary policy. Ball (1999), Batini, Harrison and Millard (2001), Dennis (2003) and Wollmershäuser (2006) find significant evidence in favour of explicitly introducing an exchange rate term in the policy rule followed by the central bank. Within the context of an empirical model of the Australian economy, Dennis (2003) shows that there are significant gains when the central bank responds systematically to the real exchange rate. An empirical study by Mohanty and Klau (2004) also finds that many central banks in emerging market economies react systematically to exchange rate movements.

This paper approaches the role of the exchange rate in monetary policy rules from a dynamic Keynesian perspective. The model used in this study is an open economy extension of model types developed in Chiarella and Flaschel (2000, Chapter 5), and is similar to the model in Flaschel, Gong and Semmler (2001) when it comes to modelling the supply side. These model types contain separate Phillips curves for nominal wages and prices. The rate of employment is linked to the rate of capacity utilization via Okun's law and output is demand-determined. The adjustment of the real exchange rate is determined by the real spread between domestic and foreign interest rates, augmented by expected real exchange rate depreciation. This model type is to a very large extent similar to the skeletal practical macro-model proposed by Blinder (1997). Yet, by seriously considering real wage effects on aggregate demand, this model differs with the modern view of macroeconomics as defined by Fair (2004, Chapter 7).

At a theoretical level we show that if the central bank explicitly responds to real exchange rate fluctuations in its policy rule, this will enhance the stability properties of the economy. This theoretical result is confirmed empirically in the case of the South African economy, where we find that a Taylor-type rule that is augmented with an interest rate smoothing term, but does not react explicitly to the real exchange rate, tends to generate large persistence of macro shocks. When the policy rule of the central bank is augmented with a slight reaction to real exchange rate fluctuations, macro variables return faster to their steady state values after a shock.

The paper is structured as follows: section 2 presents the model used in the paper, section 3 provides an analysis of the role of the real exchange rate in the policy rule by way of investigating the stability properties of the model, section 4 estimates and simulates the model using quarterly data for the South African economy, and section 5 is the conclusion.

2 Outline of the model

In this section we present the structure of the model used in this paper. Let U and V denote the rates of capacity utilization and employment respectively. Also, denote the growth rate of any variable z by $\widehat{z} \equiv \frac{\dot{z}}{z}$. Further denote medium term inflationary expectations by π^e. The key equations underlying the model are:

$$
\begin{aligned}
\widehat{w} &= \kappa_w \widehat{p} + (1-\kappa_w)\pi^e + \beta_w (V - V_0) - \beta_{uw} (u - u_0) + n_x && (1)\\
\widehat{p} &= \kappa_p(\widehat{w} - n_x) + (1-\kappa_p)\pi^e + \beta_p (U - U_0) + \beta_{up} (u - u_0) + \vartheta \dot{q} && (2)\\
\dot{\pi}^e &= \beta_{\pi^e} (\widehat{p} - \pi^e) && (3)\\
\dot{U} &= -\gamma_U (U - U_0) + \gamma_u (u - u_0) - \gamma_r (r - \pi^e - rr_0) + \gamma_q (q - q_0) && (4)\\
V &= V_0 + \beta_V (U - U_0) && (5)\\
\dot{q} &= \beta_q (rr^f + \epsilon + \xi - r + \pi^e) && (6)\\
\dot{\epsilon} &= \beta_\epsilon \left(\dot{q} - \epsilon\right) && (7)\\
\dot{r} &= -\phi_r (r - r_0) + \phi_\pi (\pi^e - \pi_0) + \phi_U (U - U_0) + \phi_q (q - q_0) && (8)
\end{aligned}
$$

Where $0 < \kappa_p < 1$, $0 < \kappa_w < 1$, and w is the nominal wage rate, p the aggregate price index, n_x is the growth rate of labour productivity, and q is the log of the real exchange rate. Eq. (1) says nominal wages inflate in response to the weighted average of current price inflation and medium term inflation expectations, and they also respond to the tightening of the labour market. When the labour market is at equilibrium, nominal wages inflate at a steady rate $(\pi_0 + n_x)$, where n_x is a constant growth rate of labour productivity. In eq. (2) prices inflate in response to the weighted average of nominal wage inflation in excess of labour productivity and medium term inflation expectations. Price inflation also responds to excess demand in the goods market measured by the rate of capacity utilization gap and the rate of real exchange rate depreciation to capture the impact of import prices on domestic inflation.

Note that, following a recent modelling approach proposed by Asada et.al. (2006), we have augmented the two Phillips curves by Blanchard-Katz error-correction terms, captured by the percentage deviation of the wage share from its steady state value, which is denoted by $(u - u_0)$. These terms capture the prevailing environment in the wage-bargaining process. When the wage share is above the steady state, workers moderate their wage demands in the light of these gains and firms in turn inflate prices to counter excess unit labour costs. Eq. (3) posits an adaptive adjustment mechanism of medium term inflationary expectations.

The goods market is described by (4), which is a reduced-form dynamic IS relationship. The share of wages in national income is assumed to affect aggregate demand, in addition to the conventional negative real interest rate and positive real exchange rate effects. The effect of income distribution on aggregate demand depends on parameters in the underlying consumption and investment functions (see also Chiarella and Flaschel (2000), Chapter 5). For example, a stronger positive response of consumption to the wage share compared to the negative response of investment boosts aggregate demand. We also assume that the leakage of due to imports when domestic output rises is sufficiently small, rendering $\gamma_U > 0$. Associated with goods market dynamics is a simple Okun-type relationship in eq. (5), which links the goods and labour markets, where the response of the employment rate to excess demand in the goods market is measured by $\beta_V > 0$.

Eqs. (6) and (7) describe real exchange rate dynamics in the model. As in Ball's (1999) version, we assume some degree of imperfection in global capital flows by postulating that the rate of real exchange rate depreciation is determined by the gap between the domestic and foreign real interest rates, where rr^f is the foreign real interest rate and ξ is the risk premium. We augment this formulation by an expected depreciation term as in Asada et.al. (2003, Chapter 5). The flexibility of the real exchange rate is measured by the parameter $\beta_q > 0$. Accompanying this determination of the real exchange rate is an adaptive expectations mechanism wherein the expected rate of depreciation adjusts at the speed $\beta_\epsilon > 0$.

Lastly in (8), the model closed with a Taylor-type rule in which the central bank is assumed to engage in some interest rate smoothing. When the nominal interest rate is above the equilibrium rate r_0, the nominal rate is adjusted downwards. The central bank also targets the medium-term inflation rate, where π_0 is the inflation target and the bank also reacts to the rate of capacity utilization. In addition the central bank responds to fluctuations in the real exchange rate by leaning against the wind of deviations of the real exchange rate from its steady state value.

The reduced-form expression of the wage-price spiral can be written as:

$$\widehat{w} = \lambda\left[\beta_w (V - V_0) + \kappa_w \beta_p (U - U_0) + \theta_{wu} (u - u_0) + \kappa_w \vartheta \dot{q}\right] + \pi^e + n_x \quad (9)$$

$$\widehat{p} = \lambda\left[\kappa_p \beta_w (V - V_0) + \beta_p (U - U_0) + \theta_{pu} (u - u_0) + \vartheta \dot{q}\right] + \pi^e \quad (10)$$

$$\dot{\pi}^e = \beta_{\pi^e} \lambda\left[\kappa_p \beta_w (V - V_0) + \beta_p (U - U_0) + \left(\beta_{up} - \kappa_p \beta_{uw}\right)(u - u_0) + \vartheta \dot{q}\right] \quad (11)$$

Where $\lambda = \frac{1}{1-\kappa_p\kappa_w}$, $\theta_{pu} = \left(\beta_{up} - \kappa_p\beta_{uw}\right)$ and $\theta_{wu} = \left(\kappa_w\beta_{up} - \beta_{uw}\right)$. Now, denote the log of the real wage share in national output by u. It follows that $\dot{u} = \widehat{w} - \widehat{p} - n_x$. Using (9) and (10), and linearizing the growth rate of the wage share we obtain:

$$\dot{u} = \lambda\left[\beta_w(1-\kappa_p)(V - V_0) + \beta_p(\kappa_w - 1)(U - U_0) - \psi(u - u_0) + \vartheta(\kappa_w - 1)\dot{q}\right] \quad (12)$$

Where $\psi = \left[\beta_{up}(1-\kappa_w) + \beta_{uw}(1-\kappa_p)\right] > 0$. The response of the wage share to labour market pressures depends on wage flexibility β_w and the indexation parameter κ_p in the price Phillips curve. For example if these parameters are sufficiently large, the real wage and hence the wage share will be pro-cyclical. Also, as long as $\kappa_w \ll 1$, a real exchange rate depreciation leads to strong contraction in the wage share. This in turn may affect aggregate demand, and hence output, in ways investigated by Krugman and Taylor (1978), Larrain and Sachs (1986), and Taylor (1991, Chapter 7). This channel is usually ignored in macro models formulated along the lines of Ball (1999) and Svensson (1997), including forward-looking models in the new-Keynesian tradition.

3 Stability properties of the model

In this section we show that an explicit reaction of the central bank to real exchange rate fluctuations tends to enhance macroeconomic stability. We first express the integrated dynamical model in reduced-form by eliminating the rate of exchange rate depreciation using (6), and setting the steady state values to zero for simplicity. This results in the following 6D system of differential equations:

$$\dot{q} = \beta_q(-r + \epsilon + \pi^e) \tag{13a}$$

$$\dot{\epsilon} = \beta_\epsilon \beta_q(-r + \pi^e) + (\beta_\epsilon - 1)\,\epsilon \tag{13b}$$

$$\dot{r} = -\phi_r r + \phi_\pi \pi^e + \phi_U U + \phi_q q \tag{13c}$$

$$\dot{U} = -\gamma_U U + \gamma_u u - \gamma_r\,(r - \pi^e) + \gamma_q q \tag{13d}$$

$$\dot{\pi}^e = \beta_{\pi^e}\lambda\left[\left(\kappa_p \beta_w \beta_V + \beta_p\right) U + \theta_{pu} u + \vartheta \beta_q\,(-r + \epsilon + \pi^e)\right] \tag{13e}$$

$$\dot{u} = \lambda\left[\left(\beta_w(1-\kappa_p)\beta_V - \beta_p(1-\kappa_w)\right) U - \psi u - \vartheta(1-\kappa_w)\beta_q\,(-r + \epsilon + \pi^e)\right] \tag{13f}$$

The first 2 equations represent the dynamics of the foreign exchange market integrated with the monetary policy rule. This set up of the integrated model facilitates a relatively easy partial isolation of the behaviour of the foreign exchange market as a possible source of instability in the entire economy. In considering the stability properities of the model, we follow the method proposed by Chiarella et.al. (2006). The method is summarized by the following Lemma:

Lemma

Let $J^{(n)}(\beta)$ be $n \times n$ matrices, $h(\beta) \in \mathbb{R}^n$ row vectors, and $h_{n+1}(\beta)$ real numbers, all three varying continuously with β over some interval $[0, \varepsilon]$. Put

$$J^{(n+1)}(\beta) = \begin{bmatrix} J^{(n)}(\beta) & z \\ h(\beta) & h_{n+1}(\beta) \end{bmatrix} \in \mathbb{R}^{(n+1)\times(n+1)}$$

Where z is an arbitrary column vector, $z \in \mathbb{R}^n$. Assume $h(0) = 0$, $\left|J^{(n)}(0)\right| \neq 0$, and let $\lambda_1, ..., \lambda_n$ be eigenvalues of $J^{(n)}(0)$. Furthermore for $0 < \beta \leq \varepsilon$, $\left|J^{(n+1)}(\beta)\right| \neq 0$ and of opposite sign to $\left|J^{(n)}(\beta)\right|$. Then for all β sufficiently small, n eigenvalues of $J^{(n+1)}(\beta)$ are close to $\lambda_1, ..., \lambda_n$, whilst the $(n+1)\,st$ eigenvalue is a negative real number. In particular, if matrix $J^{(n)}(0)$ is asymptotically stable.

Proof of this lemma is provided in Chiarella et.al. (2006). Before analysing the dynamics of the system we first exploit the linear dependencies of the rows of the determinant of the Jacobian of the system. First, multiply (13a) by β_ϵ, and subtract (13b) from the resultant (13a). Second, multiply (13e) by $(1-\kappa_w)$ and multiply (13f) by β_{π^e}, then add the resultant (13e) to the resultant (13f). Third, multiply (13a) by $\beta_{\pi^e}\lambda\vartheta$ and subtract the resultant (13a) from (13e). These operations do not change the sign of the determinant of the Jacobian of the system. The sign structure of the resultant Jacobian is as follows:

$$\left|J^{(6)}\right| = \begin{vmatrix} 0 & \pm & 0 & 0 & 0 & 0 \\ 0 & \pm & - & 0 & + & 0 \\ + & 0 & - & + & + & 0 \\ + & 0 & - & - & + & \pm \\ 0 & 0 & 0 & + & 0 & + \\ 0 & 0 & 0 & \pm & 0 & - \end{vmatrix}$$

We note that the interaction between real exchange rate dynamics and the short term interest rate is described by the top left 3D sub-system. The ambiguous entry in this sub-system is $\beta_\epsilon\left(\beta_q-1\right)+1$. Note that $\left|J^{(3)}\right|<0$ if for $\beta_q<1$, β_ϵ is sufficiently small. If $\beta_\epsilon\left(\beta_q-1\right)+1>0$ under these conditions, then all the other Routh-Hurwitz conditions for stability are met. Importantly, if the central bank does not react to real exchange rate misalignments the determinant of this sub-system will be zero, therefore a reaction of the central bank enhances stability in this sub-system.

Henceforth, to simplify our stability analysis, we shall indeed assume that $\beta_\epsilon\left(\beta_q-1\right)+1>0$ and that $\beta_\epsilon<1$. This definitizes the signs of the system Jacobian as follows:

$$\left|J^{(6)}\right| = \begin{vmatrix} 0 & + & 0 & 0 & 0 & 0 \\ 0 & - & - & 0 & + & 0 \\ + & 0 & - & + & + & 0 \\ + & 0 & - & - & + & \pm \\ 0 & 0 & 0 & + & 0 & + \\ 0 & 0 & 0 & \pm & 0 & - \end{vmatrix}$$

Proceeding to integrate output dynamics in the now considered 3D sub-dynamics extends the system under consideration to 4D. We exploit the fact that implicitly, there is a parameter that measures the speed of adjustment of output when aggregate demand exceeds output, buried in the γ parameters of the output adjustment equation. It can be therefore shown, that $\left|J^{(4)}\right| > 0$ by expanding down the second column of the top left 4D sub-system. Extending this sub-system to 5D by considering the dynamics of inflation expectations shows that if $\gamma_q\left(\phi_r - \phi_\pi\right) < 0$ then we have $\left|J^{(5)}\right| < 0$. This implies that the central bank should be relatively more aggressive against inflation expectations compared with its desire to smooth interest rates. Rounding-off our stability analysis of the model by adding wage share dynamics, thus re-constituting the entire 6D dynamics, it can be shown that:

$$\left|J^{(6)}\right| = \lambda\left[\beta_w(1-\kappa_p)\beta_V - \beta_p(1-\kappa_w)\right] \cdot \gamma_q\left(\phi_\pi - \phi_r\right) - \lambda\psi \cdot \left|J^{(5)}\right|$$

This condition shows that a strong error-correction in the wage share contributes to macro-stability, and stronger reaction to inflation expectations relative to interest rate smoothing tends to be stabilizing when the rate of capacity utilization positively affects the wage share. This can be shown by expanding along the last row.

Summarizing the stability conditions of the model, we require that $\beta_\epsilon\left(\beta_q - 1\right) + 1 > 0$ and that $\beta_\epsilon < 1$, in addition we require that $(\phi_\pi - \phi_r) > 0$ and that the rate of capacity utilization positively affects the wage share. Within this context we note that $\phi_q > 0$ enhances the stability properties of the model by permitting the short term interest rate to move in the light of movements in the foreign exchange market. Because of the negative sign that attaches to the nominal interest rate in the real exchange rate adjustment equation, this makes the foreign exchange market to return to its steady state faster.

4 Model Estimation and Simulations

4.1 Data and Estimation

The model is estimated using quarterly data from 1970:1 to 2006:4, sourced from the South African central bank website. The problem with this dataset is the absence of a measure of the unemployment rate. To circumvent this problem we assumed that movements in and out of the labour force are negligible, with the result that fluctuations in the unobserved rate of employment are mainly driven by fluctuations in the level of employment around its capacity level.

We now turn to the estimated parameters, starting with the wage-price module of the model. The price level is measured by the CPI, and the nominal wage is calculated by dividing nominal employee compensation by the employment level. For medium-term inflation expectations, we used the 4-quarter moving average of the inflation rate. Since there is a simultaneous feedback between nominal wage and price inflation, we estimated the wage-price dynamics by means of instrumental variables. The price and wage inflation instruments were constructed by taking lags of both variables up to 4 quarters.

Table 1 shows the estimated parameters of the model. The wage-price module gives parameter estimates for eqs. (1)–(3). We found that the Blanchard-Katz error correction term does not enter significantly in the wage inflation equation, and enters significantly with a small effect and correct sign in the price inflation equation. The results show that wages are more flexible than prices in response to demand pressures, although this result should be interpreted with caution given the data underlying the employment rate variable.

[Table 1 about here]

In both wage and price inflation estimations, the inflation expectations term dominates the movements in both inflation rates, implying that both wage and price inflation have considerable degree of inertia. Next we consider aggregate demand estimations. The results suggest that the share of of wages affects aggregate demand negatively. The impact of the real exchange rate on output is significant and has the correct sign after 8 quarters. This may suggest that net exports play a small role in aggregate demand in the economy.

Okun's law estimation suggests that the employment rate adjusts by 0.3% for each percentage increase in the rate of capacity utilization which, despite the potential problems pertaining to the employment rate data, is in line with fairly standard empirical results in the literature (see Blanchard, **). The expected rate of real exchange rate depreciation is measured by a 4-quarter moving average of $\triangle q_t$, i.e. $\epsilon_t = \frac{1}{4}\sum_{j=1}^{4} \triangle q_{t-j}$ and in turn, $\triangle q_t = q_t - q_{t-4}$. The estimation results show fairly sluggish real exchange rate adjustment, since here $\beta_\epsilon \left(\beta_q - 1\right) + 1 = 0.87 > 0$, which should significantly add to the stability of the estimated model.

The last equation we estimate is the interest rate policy rule. Since the rate of real exchange rate depreciation, nominal wage and price inflation rates are measured on an annualized basis, we estimated the interest rate rule on the same basis by considering a 4-quarter lag in the smoothing term. The deviation of the real exchange rate from its steady state does not enter significantly in the estimation of the policy rule. The estimated policy rule is thus without the reaction of the central bank to percentage deviations of the real exchange rate from its steady state. The estimated policy rule exhibits a relatively strong reaction by the central bank against fluctuations in the rate of capacity utilization compared with inflation expectations.

4.2 The Role of the Exchange Rate in the Policy Rule

We investigate the performance of two alternative policy rules. The first rule is the estimated policy rule. The second rule augments the estimated policy rule with a real exchange rate term. The central bank is made to respond slightly to the real exchange rate with parameter $\phi_q = 0.1$. We subject the model to a temporary expansionary, one percentage point interest rate shock. Figure 1 illustrates the behaviour of macro variables in response to this shock, under the estimated policy rule.

[Figure 1 about here]

In line with theoretical expectation, a reduction in the nominal interest rate leads to an increase in the rate of capacity utilization and, through Okun's law, it also leads to an increase in the employment rate. The real exchange rate jumps upward, and further depreciates as a result, exhibiting "delayed overshooting" as found in the empirical analysis by Eichenbaum and Evans (1995) in the case of the US. Price and wage inflation also rise gradually in response to a fall in the nominal interest rate. Of importance for our paper is the persistence of the effects of this shock on these macro aggregates. The shock takes significantly more than 40 quarters (10 years) to die out.

Compare these responses with those under a policy rule that responds explicitly to the real exchange rate. Figure 2 illustrates the responses of macro variables to a temporary, but expansionary percentage point shock to the nominal interest rate.

[Figure 2 about here]

Macro variables converge faster to the steady state when the central bank responds to the real exchange rate. This can be explained by noting that the real exchange rate channel is the fastest channel through which monetary policy affects inflation and hence output. Allowing for this channel to feedback into interest rate setting increases the power of monetary policy to stabilize the economy. We should, nevertheless add that more aggressive responses of the central bank to real exchange rate fluctuations tends to generate aggregate volatility, as the variables then converge in a high-frequency cyclical fashion, though with lower amplitude.

5 Conclusion

In this paper, we have used a practical Keynesian macro-model for a small open economy to investigate the role of the exchange rate in an interest rate policy rule. The model is practical in the sense of Blinder (1997), in that it contains separate Phillips curves for nominal wages and prices, has an IS-type adjustment relationship in which output is demand-determined in the short run, there is Okun's law that links the goods market and the labour market, and aggregate demand directly responds to the interest rate, and is therefore sensitive to monetary policy. An interest rate parity relationship was added in this framework to determine the real exchange rate.

This practical core macro-model is very similar to model types developed by Chiarella and Flaschel (2000) among others. However in these model types, wage-price dynamics reduce to dynamics of income distribution. Income distribution in turn plays a role in the IS component of the model. This role is neglected in many Ball-Svensson type macro-models that are currently workhorses for monetary policy analysis, and has been highlighted by Fair (2004, Chapter 7) in his critique of the "modern" view of macroeconomics.

Our findings motivate for an explicit consideration of the real exchange rate in monetary policy rules. A central bank that does not respond to real exchange rate fluctuations tends to generate persistence of macro shocks. By responding slightly to the real exchange rate, the central bank improves the performance of the economy in the face of these shocks. Macro variables return faster to their steady state values when the real exchange rate appears explicitly in the policy rule of the central bank.

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Figure 1: Effect of Expansionary Interest Rate Shock (Estimated Rule)

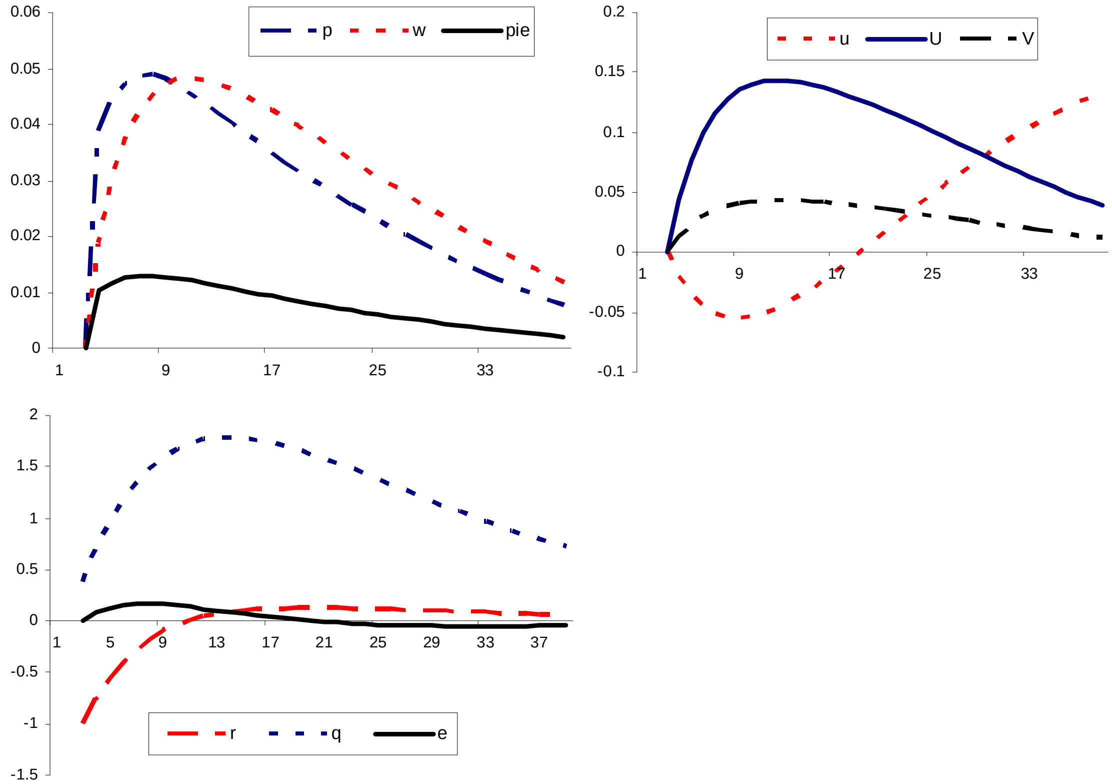

Figure 2: Effect of Expansionary Interest Rate Shock (Augmented Rule)

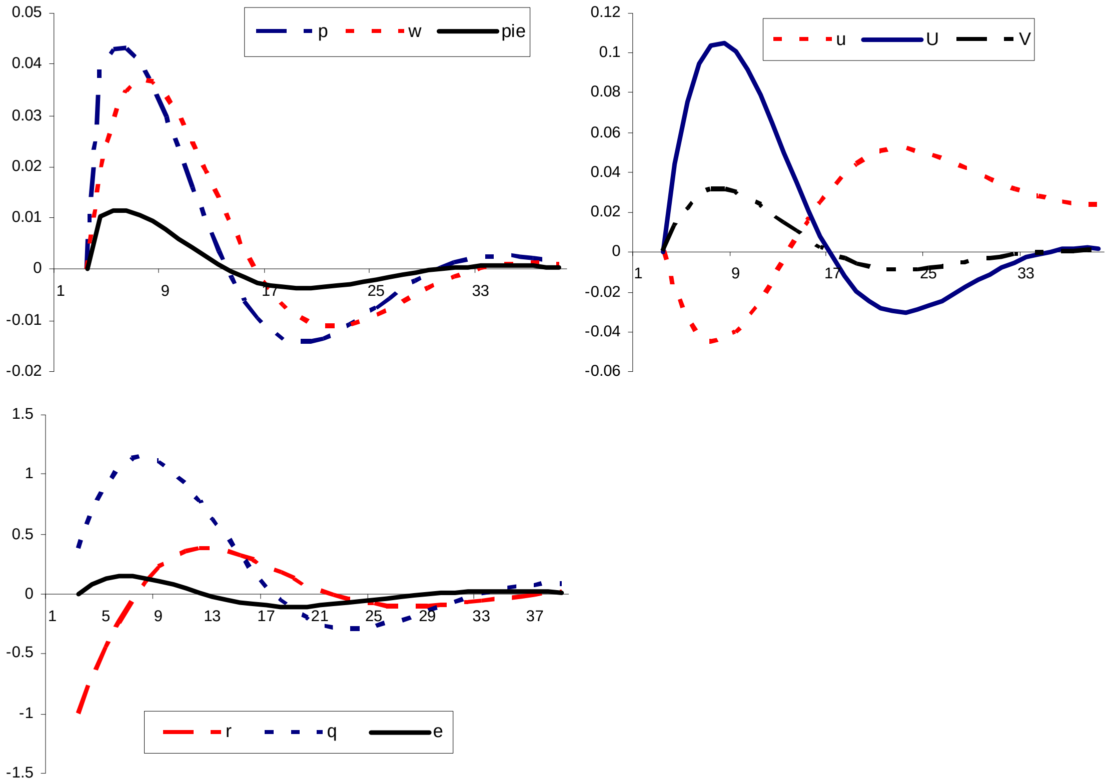

Table 1: Estimated Parameters of the Model

wage-price module	$\kappa_p = 0.23\,(0.04)$	Output adjustment	$\gamma_U = 0.14\,(0.03)$
	$\kappa_w = 0.30\,(0.15)$		$\gamma_r = 0.04\,(0.02)$
	$\beta_p = 0.14\,(0.06)$		$\gamma_q = 0.011\,(0.01)$
	$\beta_w = 0.62\,(0.12)$		$\gamma_u = -0.03\,(0.01)$
	$\beta_{pu} = 0.003\,(0.002)$	Real exchange rate	$\beta_q = 0.38\,(0.10)$
	$\beta_{wu} = 0.00\,(0.00)$		$\beta_e = 0.21\,(0.02)$
	$\theta = 0.07\,(0.01)$	Interest rate rule	$\phi_r = 0.25\,(0.03)$
	$\beta_\pi = 0.36\,(0.01)$		$\phi_\pi = 0.10\,(0.03)$
Okun's law	$\beta_V = 0.30\,(0.03)$		$\phi_U = 0.80\,(0.06)$