

# Asset Prices, Output, and Monetary Policy in a Small Open Economy

Christopher Malikane<sup>†</sup> and Willi Semmler<sup>‡</sup>

<sup>†</sup>University of the Witwatersrand, School of Economic and Business Sciences, 1 Jan Smuts Avenue, Johannesburg 2050, South Africa

<sup>‡</sup>New School for Social Research, Department of Economics, 65 Fifth Avenue, New York N.Y. 10003, USA

## Abstract

We formulate a macro-model of a small open economy in order to investigate the relative performance of rules that systematically respond to asset prices and those that do not. Our model consists of three asset prices: the stock price, the long-term interest rate or bond price, and the exchange rate. The dynamics of these asset prices interact with two Phillips curves for nominal wages and prices, and the resultant law of motion for the share of wages in national income, a dynamic IS curve that describes output adjustment and a Taylor-type interest rate policy rule. On the basis of estimations of this model, we find that if the central bank systematically and explicitly responds to real exchange rate and stock price fluctuations, it tends to substantially reduce the volatility of macro variables. Specifically, we find that policy rules that respond systematically to asset price movements substantially dominate rules that do not.

**Key words:** interest rate policy rules, asset prices, wage and price Phillips curves

JEL Classification Numbers: C30; C32; E30; E52

---

<sup>1</sup>E-mail:malikanec@sebs.wits.ac.za. Fax:+27-11-717-8081

# 1 Introduction

Asset prices play an important role in the transmission of monetary policy to output and inflation. According to Tobin (1969), one of the powerful ways in which monetary policy affects aggregate demand is by changing the valuations of physical assets relative to their replacement cost, the  $q$  ratio. In his address to the Southern Economic Association in 1978, Tobin further argued that "whether the central bank is seeking to influence investment spending on its own, or merely to counter other disturbances,  $q$  is an indicator it should watch." Economists are however divided on whether the central bank should watch the nominal stock price, which to a large extent determines fluctuations in  $q$ , in its conduct of monetary policy.

On the one side, there are those who argue that central banks should systematically and explicitly respond to asset price movements. Among these are Kent and Lowe (1997), Smets (1997), Cecchetti et.al. (2000), Blanchard (2000), Borio and Lowe (2002) and Semmler and Zhang (2004). These authors argue that financial market imbalances, if not countered at an early stage, may build up and cause widespread financial instability, large asset price cycles, which would culminate in large scale losses in the banking sector. On the other side, there are those who argue that central banks should not respond to asset price movements. Among these authors are Bernanke and Gertler (2001), Mishkin (2001), Gilchrist and Leahy (2002). The argument here is that since asset prices tend to exhibit large swings, a policy rule that responds to them would tend to exhibit large swings in the interest rate. This in turn would tend to generate large volatility in both output and inflation. Bernanke and Gertler (1999) also point out that adjusting the interest rate to "prick" perceived asset price bubbles runs the risk of generating financial panics. They argue for a flexible inflation targeting rule as the best policy response to stabilize the economy.

The debate about the role of asset prices in setting monetary policy is not . Those who argue that central banks should systemati-

cally respond to asset price movements, especially Genberg (2001), point out that "policy reactions to asset prices must not follow a mechanical rule, since the appropriate response depends on the underlying shock". Those who argue that central banks should not respond to asset prices, especially Bernanke and Gertler (1999), point out that "central banks should ignore movements in stock prices that do not appear to be generating inflationary or deflationary pressures". These statements suggest a considerable degree of judgement on the side of policymakers. Nevertheless quantitative analyses and assessments of the relative performance of rules that respond to asset prices and those that do not, posit interest rate rules as if the central bank follows them mechanically.

Despite continued disagreement on the role of asset prices in monetary policy, empirical estimations of interest rate rules find that central banks do systematically respond to asset prices. Mohanty and Klau (2004) find that a number of central banks in emerging market economies systematically respond to exchange rate fluctuations. Chadha, Sarno and Valente (2004) find that central banks in the US, the UK and Japan systematically respond to both the exchange rate and the stock price. Using data for France, Germany and Italy, Siklos, Werner and Bohl (2004) find that asset prices can be highly relevant as instruments in the estimation of forward-looking policy rules in these countries. However they do not recommend asset prices to be specified as separate arguments in the policy rule.

This paper uses Blanchard (1981) type macro-model as a benchmark framework of the real-financial interaction. Exchange rate dynamics of Dornbusch (1976) have been added to this model type by Gavin (1989), within the context of a simple price adjustment rule. In this study, this price adjustment rule is replaced by a more elaborate specification of the wage-price dynamics following Flaschel and Krolzig (2006), extended to the open economy by an exchange rate term in the price Phillips curve to capture import prices. The share of wages in national income affects output via the rate of profit in the dynamics of the stock price and it also appears in the output adjustment equation explicitly. Rather than

constrain financial markets to affect aggregate demand via only the stock price, this study specifies the joint effects of the long term interest rate and the stock price on aggregate demand. The short term interest rate is assumed to be a policy instrument used by the central bank to control the economy, and it moves both the long term interest rate and the stock price.

Based on our estimation of this model, we find that rules that do not explicitly respond to asset price movements are inferior to rules that respond explicitly to asset prices. In an overwhelming majority of cases, the volatility of macro aggregates under a rule that does not respond to asset prices is almost twice as when the central bank responds to asset prices. Among the rules that explicitly respond to asset prices, we find that a rule that leans against the wind of asset price changes slightly dominates a rule that targets asset prices around their perceived fundamental values.

The paper is structured as follows: section 2 provides an outline of the model, section 3 presents an analysis of the stability properties of the model under a policy rule that does not respond systematically to asset price movements, section 4 estimates the parameters of the model and then using these estimations, this section simulates the empirical model under alternative interest rate rules. Section 5 is the conclusion.

## **2 Outline of the model**

The model features two Phillips curves, one for nominal wages and the other for prices. This approach to the supply-side of the economy is consistent with Blinder's (1997) proposed skeletal macro-model for policy analysis. Recent developments in dynamic stochastic general equilibrium models point to a direction similar to the one used in this paper. For example Erceg, Henderson, and Levine (2000), Huang and Liu (2001), Amato and Laubach (2003), and Christiano, Eichenbaum and Evans (2005), all conclude that a separate inertial specification of nominal wage inflation in its in-

teraction with inertial price inflation dynamics better mimicks observed behaviour of the economy under monetary shocks.

Output adjustment in this model is summarized by a reduced-form dynamic IS specification. There are three asset prices: the real stock price, the real exchange rate and the nominal interest rate on long-term bonds. The central bank controls the economy by using the short-term interest rate as a policy instrument, and follows a Taylor-type interest rate rule. The labour market is linked to the goods market by a simple specification of Okun's law. The following equations summarize the structure of our model:

$$\hat{p} = \kappa_p (\hat{w} - \chi) + (1 - \kappa_p) \pi + \beta_p (U - U_0) + \beta_{pu} (u - u_0) + \theta \dot{e} \quad (1)$$

$$\hat{w} = \kappa_w \hat{p} + (1 - \kappa_w) \pi + \beta_w (V - V_0) - \beta_{wu} (u - u_0) + \chi \quad (2)$$

$$\dot{\pi} = \beta_\pi (\hat{p} - \pi) \quad (3)$$

$$\dot{U} = \alpha_0 - \alpha_1 U + \alpha_2 q + \alpha_3 u + \alpha_4 e - \alpha_5 (r^l - \pi) \quad (4)$$

$$\dot{q} = \beta_{fq} [\rho + \pi_e - (r - \pi)] - \beta_{qq} (q - q_0) \quad (5)$$

$$\dot{\pi}_e = \beta_{\pi_e} (\dot{q} - \pi_e) \quad (6)$$

$$\dot{e} = \beta_e (r r^f + \epsilon - (r - \pi)) - \beta_{ee} (e - e_0) \quad (7)$$

$$\dot{\epsilon} = \beta_\epsilon (\dot{e} - \epsilon) \quad (8)$$

$$\dot{r}^l = \beta_{r^l} (r + \pi_{r^l} - r^l) - \beta_{r^l r^l} (r^l - r_0^l) \quad (9)$$

$$\dot{\pi}_{r^l} = \beta_{\pi_{r^l}} (\dot{r}^l - \pi_{r^l}) \quad (10)$$

$$\dot{r} = \phi_r (r_0 - r) + \phi_\pi (\pi - \pi_0) + \phi_U (U - U_0) + z \quad (11)$$

$$z = \phi_q (q - q_0) + \phi_e (e - e_0) \quad (12)$$

$$V = V_0 + \beta_V (U - U_0) \quad (13)$$

$$\rho = \omega_0 - \omega_1 u + \omega_2 U \quad (14)$$

Where  $\hat{p}$  is price inflation,  $\hat{w}$  is nominal wage inflation,  $\pi$  is expected price inflation,  $U$  is the rate of capacity utilization,  $e$  is the log of the real exchange rate,  $u$  is the log of the share of wages

in national income,  $V$  is the rate of employment,  $\rho$  is the rate of profit,  $q$  is the real stock price,  $r^l$  is the long-term interest rate. The exogenous variables are the growth rate of labour productivity  $\chi$ , the foreign real interest rate  $rr^f$  and  $\xi$  is the risk premium in the relevant financial market.

Equations (1)–(3) constitute the wage-price spiral of the model, which follows Flaschel, Gong and Semmler (2001) and Asada et.al. (2006). In (1) price inflation is determined by the weighted average of the productivity-adjusted nominal wage inflation and price inflation expectations, excess demand pressures measured by a positive gap in the rate of capacity utilization, and import prices filter through the domestic economy via real exchange rate depreciations. In (2) nominal wage inflation is set to take account of the weighted average of current and expected price inflation. Tightness in the labour market measured by excess rate of employment exerts upward pressure on nominal wage inflation. In (3) price inflation expectations are formed adaptively, which imparts a degree of inertia in the wage-price dynamics.

Note that, following Blanchard and Katz (1999) and Flaschel and Krolzig (2006), there is an error-correction term in both wage and price inflation formation whereby, when the wage share is above the steady state, workers moderate their nominal wage demands and firms increase prices to recoup profitability losses. By assuming that productivity gains are fully transferred to workers, at the steady state, nominal wages inflate at a rate equal to the sum of the inflation target and the growth rate of labour productivity. The latter steady state requirement ensures that the real share of wages in national income is stationary in the long run.

In the model versions of Blanchard (1981) and Gavin (1989) monetary policy affects aggregate demand via the arbitrage relation that links the money market and the stock market. The version of the model considered in this paper further includes on the demand side the share of wages and, in a very simple way, the cost of credit. The effect of changes in the share of wages on aggregate demand were long noted by Keynes (1936, Chapter 19). Furthermore, following Bernanke and Gertler (1995), in so far as the long rate is

correlated with the lending rate, a rise in the long rate increases the interest burden of the private sector, reduces retained earnings of firms and savings of households, and therefore increases the external risk premium. Tight credit conditions are therefore reflected in high long-term interest rates. These features of aggregate demand are captured in (4).

Equations (5)–(10) describe the dynamic adjustment of asset prices. In (5) the real stock price adjusts in response to the gap between the rate of profit and the short-term interest rate. In eq. (6), the expected rate of capital gain on stocks is assumed to adjust adaptively. Eq. (7) postulates that the real exchange rate adjusts in response to the gap between the foreign and domestic real interest rates, augmented by the expected rate of depreciation. In eq. (8) the adjustment of the expected rate of real exchange rate depreciation is described as adaptive. Eq. (9) postulates that the long-term interest rate adjusts in response to the term spread, which is the gap between the short and the long rates. Again expected capital losses from holding bonds are assumed to adjust adaptively in eq. (10).

These asset price dynamics are assumed to exhibit error-correction to capture some degree of rationality in financial markets. When an asset price is above its steady state value rational agents expect it to sooner or later return to its steady state, they then take short positions on the asset, thus exerting some fundamentals pull on the actual asset price. The last dynamic equation (11) describes the behaviour of the central bank, which exhibits interest rate smoothing, responds to the inflation and capacity utilization rates and  $z$ , which is a linear combination of real exchange rate and stock price fluctuations around their steady state values.

The static equations in the model are captured in (12)–(14). Eq. (12) describes  $z$  which measures asset price imbalances. These imbalances are determined by movements in the real exchange rate and the stock price. In our framework  $z$  can either be positive or zero, thus allowing for the consideration of policy rules that react to asset prices. Eq. (13) describes the link between the goods and

labour markets via Okun's law in levels. Eq. (14) is the linearized rate of profit, which is negatively dependant on the wage share and positively driven by the rate of capacity utilization.

The reduced-form wage-price dynamics of the model can be written as:

$$\hat{w} - \chi = \lambda \left[ (\kappa_w \beta_p + \beta_w \beta_V) (U - U_0) + \vartheta_{wu} (u - u_0) + \kappa_w \theta \dot{e} \right] + \pi \quad (15)$$

$$\hat{p} - \pi = \lambda \left[ (\kappa_p \beta_w \beta_V + \beta_p) (U - U_0) + \vartheta_{pu} (u - u_0) + \theta \dot{e} \right] \quad (16)$$

$$\dot{\pi} = \beta_\pi \lambda \left[ (\kappa_p \beta_w \beta_V + \beta_p) (U - U_0) + \vartheta_{pu} (u - u_0) + \theta \dot{e} \right] \quad (17)$$

Where  $\lambda = \frac{1}{1 - \kappa_w \kappa_p}$ ,  $\vartheta_{wu} = (\kappa_w \beta_{pu} - \beta_{wu})$  and  $\vartheta_{pu} = (\beta_{pu} - \kappa_p \beta_{wu})$ . The law of motion for the share of wages in national income is derived by subtracting (16) from (15) and applying (13) to obtain the following equation:

$$\dot{u} = \lambda \left[ ((1 - \kappa_p) \beta_w \beta_V - (1 - \kappa_w) \beta_p) (U - U_0) - \psi (u - u_0) - (1 - \kappa_w) \theta \dot{e} \right] \quad (18)$$

Where  $\dot{u} = \hat{w} - \hat{p} - \chi$  and  $\psi = [(1 - \kappa_w) \beta_{pu} + (1 - \kappa_p) \beta_{wu}]$ . Given the Blanchard-Katz error-correction terms in the wage-price specifications, eq. (18) shows that the share of wages in national income tends to return to its steady state value after a shock at a speed  $\psi$ . If nominal wages are highly flexible, i.e.  $\beta_w$  sufficiently large, the rate of capacity utilization will positively affect the wage share. And if in addition, the wage share enters positively in aggregate demand, this would create a potentially destabilizing positive feedback channel between economic activity and the share of wages from this partial perspective. Strong error-corrections would therefore help the system achieve stability in these situations.



### 3 Dynamics of the model

There are four key dynamic processes that drive this system. First is the well-known Mundell effect, which interacts inflation expectations and output. This interaction exhibits positive feed-back and is therefore potentially destabilizing. Second is the Blanchard-Tobin effect, which interacts the stock price and output. This interaction also exhibits positive feed-back and is therefore potentially destabilizing. Third is the Dornbusch effect, which interacts the real exchange rate and output. This interaction too exhibits positive feedback, since a fall in the nominal interest rate will lead to a depreciation, which would drive output upwards, exert inflationary pressures which would further reduce the real interest rate.

The fourth is the often-ignored Rose (1967) effect investigated extensively by Flaschel and Krolzig (2006) among others. This effect interacts the share of wages in national income with the goods market. Given the inherent ambiguities in the effects of economic activity on the wage share on the one hand, and the effect of the wage share on economic activity on the other, the dynamics of this effect are taxonomic. All these economic processes can be destabilizing if the relevant error-correction forces are too weak.

In order to conduct stability analysis of the model, we use the approach proposed and proven in Chiarella et.al. (2006), which is suitable for high-dimensional dynamical systems. This approach is based on sequential additions of dimensions of the model, analysing the stability properties of each sub-system, until the entire system is reconstituted. The parameter configurations that yield stability in each sub-system then collectively yield the necessary and sufficient stability conditions for the stability of the entire system. We shall here simply state the lemma that underlies this approach

#### **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  $\beta$  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  $h(0) = 0$ ,  $|J^{(n)}(0)| \neq 0$ , and let  $\lambda_1, \dots, \lambda_n$  be eigenvalues of  $J^{(n)}(0)$ . Furthermore for  $0 < \beta \leq \varepsilon$ ,  $|J^{(n+1)}(\beta)| \neq 0$  and of opposite sign to  $|J^{(n)}(\beta)|$ . Then for all  $\beta$  sufficiently small,  $n$  eigenvalues of  $J^{(n+1)}(\beta)$  are close to  $\lambda_1, \dots, \lambda_n$ , 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). Now, the core dynamics of the model are captured by the following 10D system:

$$\dot{\pi} = \beta_\pi \lambda \left[ (\kappa_p \beta_w \beta_V + \beta_p) U + \vartheta_{pu} u + \theta \dot{e} \right] \quad (19)$$

$$\dot{u} = \lambda \left[ [(1 - \kappa_p) \beta_w \beta_V - (1 - \kappa_w) \beta_p] U - \psi u - (1 - \kappa_w) \theta \dot{e} \right] \quad (20)$$

$$\dot{U} = -\alpha_U U + \alpha_q q \pm \alpha_u u + \alpha_e e - \alpha_r (r^l - \pi) \quad (21)$$

$$\dot{q} = \beta_q (-\omega_1 u + \omega_2 U + \pi_e - (r - \pi)) - \beta_{qq} q \quad (22)$$

$$\dot{\pi}_e = \beta_{\pi_e} (\beta_q (-\omega_1 u + \omega_2 U + \pi_e - (r - \pi)) - \beta_{qq} q - \pi_e) \quad (23)$$

$$\dot{e} = -\beta_e (r - \epsilon - \pi) - \beta_{ee} e \quad (24)$$

$$\dot{\epsilon} = \beta_\epsilon (-\beta_e (r - \epsilon - \pi) - \beta_{ee} e - \epsilon) \quad (25)$$

$$\dot{r}^l = \beta_{r^l} (r + \pi_{r^l} - r^l) - \beta_{r^l r^l} r^l \quad (26)$$

$$\dot{\pi}_{r^l} = \beta_{\pi_{r^l}} (\beta_{r^l} (r + \pi_{r^l} - r^l) - \beta_{r^l r^l} r^l - \pi_{r^l}) \quad (27)$$

$$\dot{r} = -\phi_r r + \phi_\pi \pi + \phi_U U \quad (28)$$

The formulation of the model leads to some linear dependencies between the rows of the Jacobian of the system, making it easy to analyse the dynamics of the model on the basis of the simplified sign structure of the Jacobian. Specifically, there are dependencies between (19) and (20), (22) and (23), (23) and (24), and (25)

and (26). After conducting the necessary operations, which do not affect the sign of the Jacobian determinant, we obtain the following sign structure:

$$|J^{(10)}| = \begin{vmatrix} 0 & - & + & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ + & - & \pm & 0 & 0 & 0 & - & 0 & 0 & + \\ + & \pm & - & + & 0 & + & 0 & - & 0 & 0 \\ + & - & + & - & + & 0 & 0 & 0 & 0 & - \\ 0 & 0 & 0 & 0 & - & 0 & 0 & 0 & 0 & 0 \\ + & 0 & 0 & 0 & 0 & - & + & 0 & 0 & - \\ 0 & 0 & 0 & 0 & 0 & 0 & - & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & + & + \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & - & 0 \\ + & 0 & + & 0 & 0 & 0 & 0 & 0 & 0 & - \end{vmatrix}$$

Note that, though it is a necessary but not a sufficient condition for stability, the trace of this determinant matrix is negative. If the diagonal entries are large enough, the error-correction terms would enforce stability in this system. If we proceed from the bottom right of this matrix towards the top left, it can be easily seen that the bottom right 7D sub-system, which incorporates the interaction between the short term interest rate and financial markets is stable.

We now extend the considered dynamics to 8D by incorporating goods market dynamics. By expanding along the first column of this now 8D sub-system, it can be shown that this sub-system is stable provided that  $\beta_q \omega_U \alpha_q$  is sufficiently small. This parameter product captures the Blanchard-Tobin real-financial interaction, since it points to the impact of aggregate demand and hence output on profitability, the speed of adjustment of the stock price, and the impact of the stock price on aggregate demand.

If the Blanchard-Tobin interaction is strong enough, it can be destabilizing. Therefore stability requires sluggish adjustment of the stock price to the gap between the profit rate and the real short term interest rate, weak response of the profit rate to aggregate

demand movements, and weak impact of the stock price on aggregate demand. In this still partial perspective, the error-correction terms, if they are strong enough, can tame this destabilizing feedback loop. In addition, a strong enough response by the central bank to the rate of capacity utilization would help enhance macro stability.

Extending the dynamics to include the share of wages on national income leads to a taxonomic result with four cases: a) capacity utilization positively affects the wage share and the wage share in turn positively affects aggregate demand, b) capacity utilization negatively affects the wage share and the wage share in turn positively affects aggregate demand, c) capacity utilization positively affects the wage share and the wage share in turn negatively affects aggregate demand, d) capacity utilization negatively affects the wage share and the wage share in turn negatively affects aggregate demand.

Case a: stability would require that  $\beta_{\pi_{r,t}}$ ,  $\phi_r$ ,  $\phi_U$  and  $(1 - \kappa_w)\theta\beta_e$  be sufficiently small. Since we know that a strong enough  $\phi_U$  helps fight the potentially destabilizing Blanchard-Tobin effects, there is therefore a "corridor" of parameter values within which the central bank's response to the rate of capacity utilization is stabilizing. Furthermore, sluggish adjustment of the real exchange rate and of expectations in the bond market promotes macro stability. In addition nominal wages must be highly indexed to current price inflation and the pass-through parameters must be small.

It is then fairly straightforward to characterise the parameter configurations for stability implied by the remaining three cases. In case b) stability would require that  $\beta_{\pi_{r,t}}$  and  $\phi_r$  be sufficiently large, but  $\phi_U$  and  $(1 - \kappa_w)\theta\beta_e$  be sufficiently small. In case c) stability would require that  $\beta_{\pi_{r,t}}$  and  $\phi_r$  be sufficiently small, but  $\phi_U$  and  $(1 - \kappa_w)\theta\beta_e$  be sufficiently large. In case d) stability would require that  $\beta_{\pi_{r,t}}$  and  $\phi_r$  be sufficiently small, but  $\phi_U$  and  $(1 - \kappa_w)\theta\beta_e$  be sufficiently large.

Lastly, incorporating inflation expectations leads to the reconstitution of the 10D system. At this level, stability analysis leads

to complex results. Since we know that the entries in the first row of the determinant of the Jacobian are  $\beta_\pi\beta_w\beta_V$  and  $\beta_\pi\beta_{wu}$ , which are coefficients associated with  $U$  and  $u$  respectively, we can intuitively deduce the stability requirements of the system at this high-dimensional level. If the 9D sub-system is stable, then for the full 10D system to retain this stability property we would require that  $\beta_\pi$ ,  $\beta_w$ , and  $\beta_V$  be sufficiently small. This will guarantee that if the additional eigenvalue has positive real parts, this centrifugal forces are dominated by the centripetal forces contained in the 9D sub-system. Note that we exclude  $\beta_{wu}$  from consideration since we know that, at low levels of dimension, stability is helped by strong error-correcting terms, which include the wage share error-correction where a high  $\beta_{wu}$  plays a stabilizing role.

## 4 Empirical analysis

### 4.1 Data description and estimation

The data used to estimate the parameters of the model has been collected from the South African Reserve Bank. One of the major problems with this dataset is the absence of a measure of the unemployment rate. To circumvent this problem, we assume 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. In the estimations below the latter approach was adopted because it provides some information on the interactions between the goods and labour markets and makes better use of available information.

Table 1 summarizes the data used to estimate the parameters of the model.

Table 1: Data Description

Variable	Measure
price level	consumer price index (metropolitan areas)
nominal wage level	nominal remuneration per worker
short-term interest rate	90-day Treasury bill rate
long-term interest rate	>10 year government bond
output	real gross domestic product
employment	number employed in non-agricultural sectors
profit rate	gross operating surplus per fixed capital
real exchange rate	South African Rand per US dollar
wage share	total employee compensation per output

Next we explain the strategy adopted in estimating the model. 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 2 gives a summary of the estimated parameters.

The results suggest that price inflation is driven more by expectations than by the productivity-adjusted nominal wage inflation. Similarly nominal wage inflation is driven more by inflation expectations than current price inflation. The wage share error correction term was found to be insignificant and was therefore not included in the final estimation. Nominal wage inflation appears to be more flexible to demand pressures than price inflation. This result however, should be interpreted with caution since the gap in the employment rate is here proxided by the percentage gap in the employment level. There is some wage share error-correction in the price inflation rate, although it is quantitatively small. The results suggest that  $[(1 - \kappa_p) \beta_w \beta_V - (1 - \kappa_w) \beta_p] \approx 0.045$ , implying that the rate of capacity utilization positively affects the wage share.

Table 2: Estimated Parameters of the Model

wage-price	$\kappa_p = 0.23$ (0.04)	profit rate	$\omega_u = 0.13$ (0.004)
	$\kappa_w = 0.30$ (0.15)		$\omega_U = 0.14$ (0.01)
	$\beta_p = 0.14$ (0.06)	asset prices	$\beta_q = 0.58$ (0.05)
	$\beta_w = 0.62$ (0.12)		$\beta_{qq} = 0.69$ (0.06)
	$\beta_{pu} = 0.003$ (0.002)		$\beta_{\pi_e} = 0.36$ (0.01)
	$\beta_{wu} = 0.00$ (0.00)		$\beta_e = 0.29$ (0.08)
	$\theta = 0.07$ (0.01)		$\beta_{ee} = 0.29$ (0.04)
	$\beta_\pi = 0.36$ (0.01)		$\beta_\epsilon = 0.21$ (0.02)
output	$\alpha_U = 0.23$ (0.04)		$\beta_{r,l} = 0.17$ (0.02)
	$\alpha_e = 0.00$ (0.00)		$\beta_{r,l,r,l} = 0.16$ (0.03)
	$\alpha_r = -0.05$ (0.02)		$\beta_{\pi,r,l} = 0.34$ (0.01)
	$\alpha_u = -0.03$ (0.015)	policy rule	$\phi_r = 0.25$ (0.03)
	$\alpha_q = 0.015$ (0.004)		$\phi_\pi = 0.10$ (0.03)
Okun's law	$\beta_V = 0.30$ (0.03)		$\phi_U = 0.80$ (0.06)

Estimations of the dynamic IS equation revealed that the real exchange rate does not play a significant role in determining aggregate demand, and that the wage share negatively affects the rate of capacity utilization. Therefore we have a stable Rose effect, where a rise in the wage share negatively affects the rate of capacity utilization, which in turn should lower the wage share.

## 4.2 Dynamic properties of the model under alternative policy objectives

The estimated policy rule is incapable of stabilizing the model. The reaction of the central bank to the inflation gap and the rate of capacity utilization were then set as follows:  $\phi_\pi = 2.5$  and  $\phi_U = 0.5$ . The interest rate smoothing parameter remained  $\phi_r = 0.25$ . Parameters of similar magnitude, especially the reaction of the central bank to inflation and the rate of capacity utilization, are also used by Bernanke and Gertler (2001) in their simulations. The behaviour of the model under following policy rules is therefore investigated:

$$\dot{r} = -0.25r + 2.5\pi + 0.5U \quad (29)$$

$$\dot{r} = -0.25r + 2.5\pi + 0.5U + 0.5\dot{q} + 0.5\dot{e} \quad (30)$$

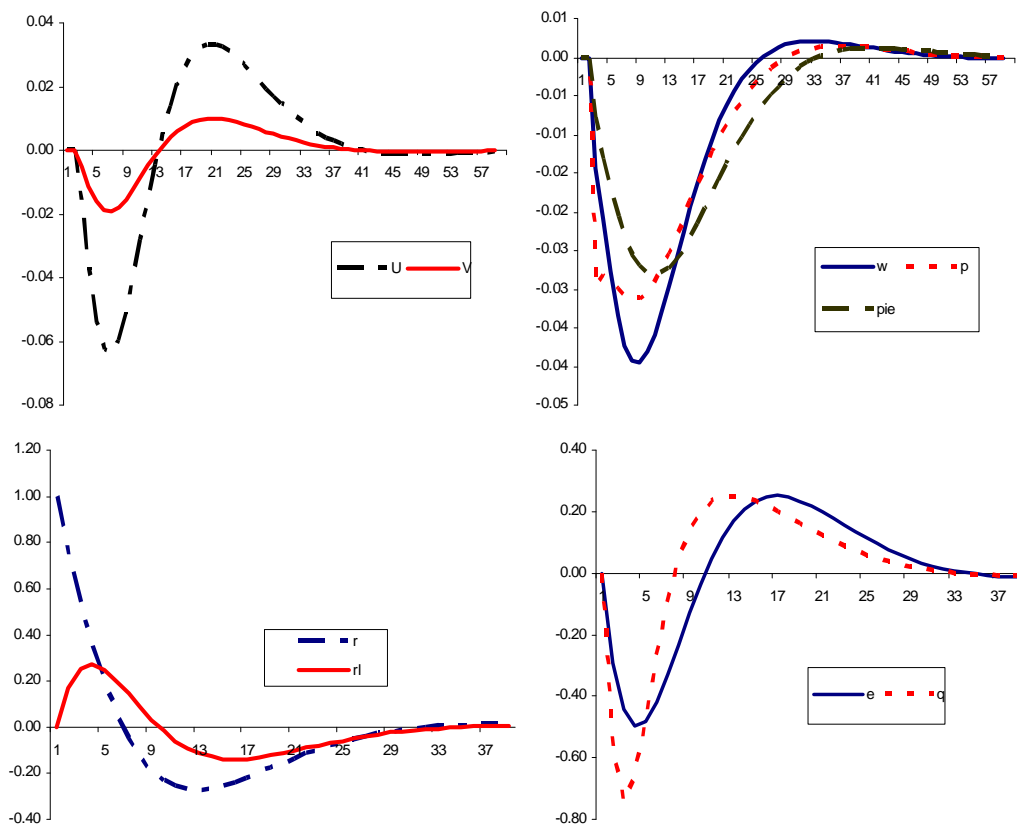
$$\dot{r} = -0.25r + 2.5\pi + 0.5U + 0.5e + 0.5q \quad (31)$$

Rules (30) and (31) express different forms in which a central bank can respond directly to asset prices. Cecchetti et.al. (20\*\*) note that their argument does not imply that the central bank should target asset prices. Our understanding then is that, despite the degree of judgement that should be exercised in assessing asset price behaviour, a rule such as (30), where a central bank leans against rates of change of asset prices best captures Cecchetti et.al.'s approach. In eq. (30) the central bank does not have to use information about the fundamental value of asset prices, it just responds to the rates of inflation in these asset prices as they move, possibly mapping out a variable fundamental trend, over time. We shall refer to rule (30) as "leaning against the wind of asset price changes". We shall refer to rule (31) as an asset price targeting rule, where the central bank moves the short term nominal interest rate when asset prices deviate from their steady state values (as perceived by the central bank).

We simulate the model by subjecting it to a positive, percentage shock to the nominal short term interest rate. Figure 1 illustrates the dynamic responses of macro-variables under the Bernanke-Gertler type rule. The response of key variables of the model to this shock are that: the long rate rises, the real stock price falls, the real exchange rate appreciates, price and wage inflation rates fall. These responses are consistent with theoretical prediction.

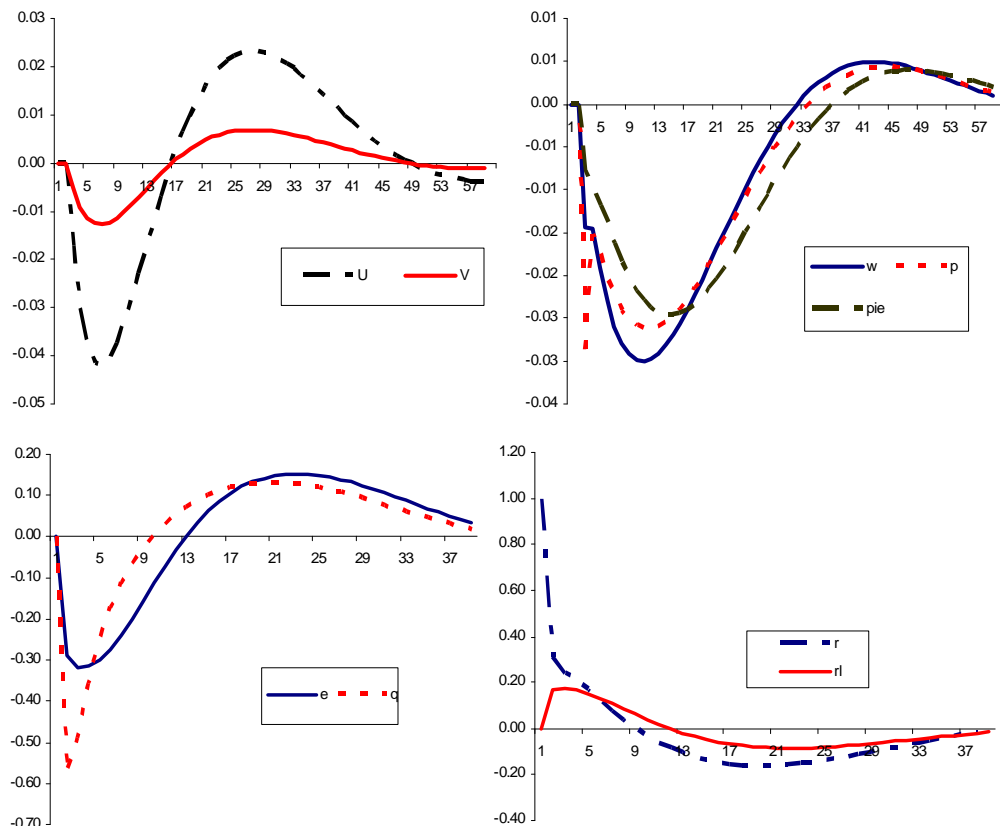


Figure 1: Responses to a positive interest rate shock (Bernanke-Gertler type)



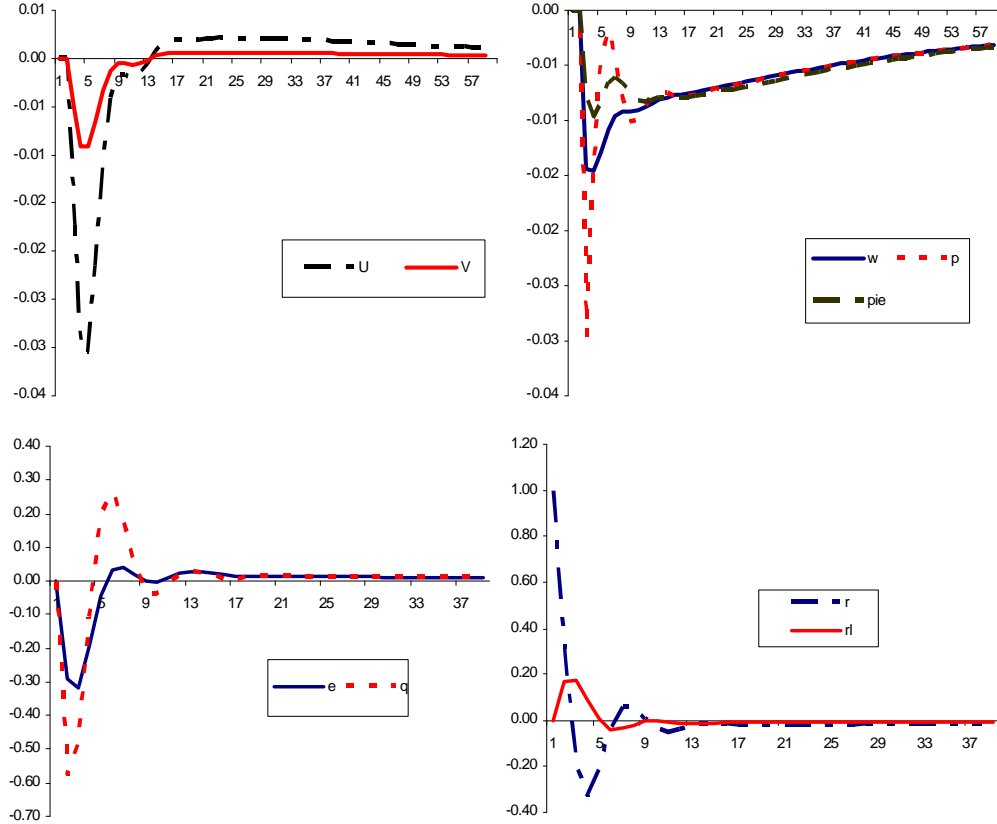
These results show that a simple Taylor type rule augmented with a smoothing term is capable of providing stability to the economy. Nevertheless a question arises as to whether such a rule outperforms rules that explicitly incorporate asset price fluctuations. Figure 2 illustrates the behaviour of the economy when the central bank leans against the wind of asset price changes (rule 30).

Figure 2: Responses under leaning against the wind of asset price changes



Compared to the Bernanke-Gertler type rule, leaning against the wind of asset price changes tends to reduce the volatility of macro-aggregates. Though qualitatively, the economy behaves in a similar way under both rules, leaning against the wind of asset price changes appears to reduce the amplitude of the impulse responses across all variables. Next we present results under asset price targeting (rule 31). These results are illustrated in figure 3.

Figure 3: Responses under asset price targeting



Asset price targeting also appears to dominate the Bernanke-Gertler rule. In order to present another alternative assessment of the relative performance of asset price targeting, leaning against the wind of asset price changes, and the Bernanke-Gertler rule, we computed volatilities of key macroeconomic variables. These volatilities were computed by taking the standard deviations of these variables from their steady state values, which in our simulations were normalized to zero, over some time horizon. These computations are presented in table 3.

Table 3: Macro volatility under alternative policy rules

variable	horizon	Bernanke-Gertler	Asset price targeting	Leaning
$\hat{p}$	2 years	0.028	0.013	0.013
	5 years	0.024	0.010	0.010
	10 years	0.017	0.008	0.008
$\hat{w}^*$	2 years	0.030	0.011	0.011
	5 years	0.026	0.010	0.010
	10 years	0.019	0.008	0.008
$U$	2 years	0.049	0.018	0.019
	5 years	0.037	0.012	0.012
	10 years	0.028	0.008	0.008
$V$	2 years	0.015	0.006	0.006
	5 years	0.011	0.004	0.004
	10 years	0.006	0.003	0.003
$u$	2 years	0.015	0.010	0.010
	5 years	0.023	0.010	0.010
	10 years	0.017	0.006	0.006
$\rho$	2 years	0.008	0.003	0.003
	5 years	0.007	0.002	0.002
	10 years	0.009	0.002	0.002
$r$	2 years	0.503	0.403	0.403
	5 years	0.365	0.260	0.256
	10 years	0.258	0.180	0.179
$r^l$	2 years	0.193	0.095	0.095
	5 years	0.150	0.061	0.061
	10 years	0.108	0.043	0.043
$e$	2 years	0.373	0.170	0.168
	5 years	0.282	0.110	0.106
	10 years	0.204	0.075	0.075
$q$	2 years	0.456	0.302	0.302
	5 years	0.330	0.192	0.192
	10 years	0.232	0.134	0.133

Across all variables, and across the three time horizons, we find that the Bernanke-Gertler type rule is dominated by both asset price targeting and leaning against the wind of asset price changes. The results show that asset price targeting is slightly dominated by

leaning against the wind of asset price changes. For example, the short term interest rate is slightly more volatile under asset price targeting over the 5 and 10-year horizons. Variations of the same results can be seen for both the volatilities of the real exchange rate and the stock price. Our model shows that the inferiority of the Bernanke-Gertler type rule is quite significant. Compared to the other two rules, this rule generates very large instrument volatility, and hence large volatility in financial markets. Real variables are also substantially more volatile under the Bernanke-Gertler rule. Both financial market and real volatilities are in some variables more than twice as much as under policy rules that explicitly respond to asset prices.

## **5 Conclusion**

We have formulated a dynamic, high-dimensional macro-model to assess the performance of alternative monetary policy rules. From a practical perspective, our model is similar to the one proposed by Blinder (1997) for monetary policy analysis. It contains separate Phillips curves for nominal wages and prices, Okun's law that links the goods and labour markets, and output is demand determined. We have extended this framework to incorporate three asset prices: the real exchange rate, the stock price and the long-term interest rate. Monetary policy affects the long rate, and it also influences the stock price directly. The long rate is then allowed to enter output determination over and above the real stock price and exchange rate to capture cost of credit effects.

In order to describe monetary policy, we specified two types of interest rate rules. In one extreme is a rule that does not respond explicitly to asset price fluctuations, in another extreme are two rules that respond to asset price fluctuations. In these latter rules, one leans against the wind of asset price changes, and the other targets asset prices. The three rules were then embedded in our model to describe the behaviour of the central bank in response to aggregate shocks.

Based on this model structure, we find that rules of the type proposed by Bernanke and Gertler (2001) are inferior to rules augmented by an explicit reaction of the central bank to asset price fluctuations. Specifically, leaning against the wind of asset price changes dominates a rule that does not react to asset prices at all. The Bernanke-Gertler type rule generates substantial macroeconomic volatility, in some instances more than twice as much as rules that respond to asset price fluctuations. Our finding therefore supports the approach proposed by Cecchetti, Genberg and Wadhvani (2000) among others.

### **References**

Amato J.D. and T. Laubach. 2003. Estimation and control of an optimization-based model with sticky prices and wages. *Journal of Economic Dynamics and Control* 27, p.1181–1215.

Asada T. et.al. 2006. Keynesian dynamics and the wage-price spiral: A baseline disequilibrium model. *Journal of Macroeconomics* 28, 90–130.

Bernanke and Gertler. 2001. Should central banks respond to movements in asset prices? *American Economic Review*, *American Economic Review Papers and Proceedings* 91, p.253–257.

Bernanke . and M. Gertler. 1999. Monetary Policy and Asset Price Volatility. *Federal Reserve Bank of Kansas Economic Review*, Fourth Quarter.

Bernanke B.S. and M. Gertler. 1995. Inside the Black Box: The credit channel of monetary policy transmission. *Journal of economic perspectives* 9, p.27–48.

Blanchard O.J. 2000. Bubbles, Liquidity traps, and Monetary Policy: Comments on Jinushi et al, and on Bernanke.

Blanchard O.J. and L.F. Katz. 1999. Wage dynamics: Reconciling theory and evidence. *American Economic Review* 89, p.69–74.

Blanchard O.J. 1981. Output, the stock market, and interest rates. *American Economic Review* 71, p.132–143.

Blinder. A.S. 1997. Is there a core of practical macroeconomics that we should all believe? *American Economic Review* 87, 240–243.

Borio C. and P. Lowe. 2002. Asset prices, financial and monetary stability: exploring the nexus. BIS Working Paper No. 114.

Cecchetti S., Genberg H., Lipsky J. and S. Wadhvani. 2000. Asset prices and central bank policy. Geneva Report on the World Economy 2. CEPR and ICMB.

Chiarella C., Flaschel P., Franke R., and W. Semmler. 2006. A high-dimensional model of real-financial interaction: The cascade-of-stable-matrices approach. In C. Chiarella et.al. (eds.). *Quantitative and Empirical Analysis of Nonlinear Macromodels: Contributions to Economic Analysis*. Elsevier, Amsterdam, p.389–383.

Christiano, Eichenbaum and Evans. 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy* 113, p.1–45.

Dornbusch R. 1976. Expectations and exchange rate dynamics. *Journal of Political Economy* 84, p.1161–1176.

Erceg C.J., Henderson D.W. and A.T. Levin. 2000. Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics* 46, p.281–313.

Flaschel P. and H-M. Krolzig. 2006. Wage-price Phillips curves and macroeconomic stability: Basic structural form, estimation and analysis. In C. Chiarella et.al. (eds.). *Quantitative and Empirical Analysis of Nonlinear Macromodels: Contributions to Economic Analysis*. Elsevier, Amsterdam, p.7–43.

Flaschel P., Gong G. and W. Semmler. 2001. A Keynesian macroeconomic framework for the analysis of monetary policy rules. *Journal of Economic Behaviour and Organization* 46, 101–136.

Gavin. 1989. The stock market and exchange rate dynamics. *Journal of International Money and Finance* 8, p.181–200.

Genberg H. 2001. Asset prices, monetary policy and macroeconomic stability. *De Economist* 149, p.433–453.

Gilchrist S. and J.V. Leahy. 2002. Monetary policy and asset prices. *Journal of Monetary Economics* 49, p.75–97.

Huang K.X.D. and Z. Liu. 2002. Staggered price-setting, staggered wage-setting, and business cycle persistence. *Journal of Monetary Economics* 49, p.405–433.

Kent C. and Lowe P. 1997. Asset price bubbles and monetary policy. Research Discussion Paper 9707. Reserve Bank of Aus-

tralia

Mishkin F. 2001. The transmission mechanism and the role of asset prices. NBER Working Paper No. 8617.

Rose H. 1967. On the non-linear theory of the employment cycle. *Review of Economic Studies* 34, p.153–173.

Semmler W. and W. Zhang. 2004. Asset Price Volatility and Monetary Policy Rules: A Dynamic Model and Empirical Evidence. Center for Empirical Macroeconomics, New School University.

Siklos P.L., Werner T., and M.T. Bohl. 2004. Asset prices in Taylor rules: Specification, estimation, and policy implications for the ECB. Deutsche Bundesbank Discussion Paper No.22/2004.

Smets F. 1997. Financial asset prices and monetary policy. Theory and evidence. BIS Working Paper No.47.

Tobin J. 1978. Monetary policies and the economy: The transmission mechanism. *Southern Economic Journal* 44, p.421–431.

Tobin J. 1969. A general equilibrium approach to monetary theory. *Journal of Money, Credit and Banking* 1, p.1–29.