Monetary Policy, Asset Prices and Inflation in Canada

Abstract

This paper uses a small open economy model that allows for the effects of asset price changes on aggregate demand and inflation to investigate the role stock price bubbles and exchange rate changes have played in the conduct of monetary policy in Canada. It argues that the Bank of Canada, in pursuing its primary objective of price stability, should respond to stock price bubbles and exchange rate changes irrespective of the policy regime. Estimates of the policy rules derived from the money growth targeting and inflation targeting regimes provide evidence that the Bank of Canada has systematically responded to stock price bubbles and exchange rate changes. This is consistent with the fact that estimates of the structural model indicate that stock price bubbles and exchange rate changes have significant effect on aggregate demand and inflation. I then use counterfactual simulation analysis to determine the benefit from responding to stock price bubbles and exchange rate changes. The results imply that responding to these asset price changes leads to lower average inflation and interest rates, but at the cost of increased volatility in both variables.

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1 Introduction

After a lengthy period of pursuing multiplicity of goals, many central banks all over the world decided to focus on the pursuit of price stability as their primary monetary policy objective. Following Taylor's (1993) monetary policy rule proposal, the literature has been filled with studies that determine whether the central banks should care about asset price fluctuations, such as stock price bubbles and exchange rate changes, when setting their policy instrument. It has been widely recognized that asset price changes play important role in determining business cycle conditions. For instance, the boom-bust cycles of stock markets during the late 1920s, 1990s and early 2000 in the US, the 1990s and early 2000 in Canada and the 1980s in Japan, the UK and the Scandinavian countries have been associated with significant changes in economic activities. Bernanke and Gertler (2001) have emphasized that asset market boom and busts have been important factors behind macroeconomic volatility in both industrialized and developing countries. Bordo and Jeanne (2001) show that the boom phase is associated with rising economic activities, whereas the bust phase is normally followed by a slowdown in economic activities. Detken and Smets (2003) have empirically showed that the boom phase of the cycle is typically associated with rising money, output and low interest rates.

Recent theoretical and empirical studies that use structural models to investigate the role asset prices should play in the conduct of monetary policy have varied in their conclusions and policy recommendations. Bernanke and Gertler (1999, 2001) incorporate a 'financial accelerator' into a dynamic new-Keynesian general equilibrium model to investigate the appropriate response of monetary policy to stock price bubbles.[1] They recommend that

[1] The financial accelerator is a situation where the existence of credit market frictions creates a mechanism by which endogenous changes in entrepreneurs/borrowers' balance sheets enhance the effects of exogenous

central banks should follow an aggressive inflation targeting rule if they want to stabilize output and inflation even when asset prices are volatile. Whether the asset price volatility is due to bubbles or to technological shocks, they find no significant marginal benefit from responding to asset prices. This view has been supported by Gilchrist and Leahy (2002) and Bullard and Schaling (2002). Cecchetti et al. (2000) using the Bernanke-Gertler model for simulations conclude differently. Their results call on central banks to respond modestly to stock market bubbles over and above the reaction to inflation and output gap. The difference between the two results comes from their assumptions on whether a central bank distinguishes between financial and technological shocks. Unlike Bernanke and Gertler (2001), Cecchetti et al. (2000) do not make that distinction and assume that the policy maker knows with certainty if the observed stock price movements are non-fundamental in nature, and most importantly, when the exogenous bubble is going to burst. The central bank with this knowledge can improve macroeconomic performance by reacting to stock price movements. However, they cautioned central banks not to target asset prices. Kontonikas and Ioannidis (2005) agree with Cecchetti et al. by concluding that interest rate settings that take into consideration asset price misalignment promote macroeconomic stability.

Other studies determine how the simple Taylor and inflation targeting rules change in a small open economy setting, where the exchange rate channel of the transmission mechanism is very significant and there is significant exchange rate pass-through to domestic consumer prices. Clarida et al. (1998) investigate whether the central banks of Japan and Germany have responded to international events when setting their short-term interest rates. They find that deviations from the purchasing power parity of the nominal exchange rate

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shocks: the value of assets held by entrepreneurs/borrowers will rise in good times, thereby amplifying the effects on net worth and investment, beyond the Tobin's q effects.

have had a significant but small effect on the settings of their respective interest rates. These results have been justified theoretically by Clarida et al. (2001). Taylor (1999), examining a candidate rule for the European Central Bank find a simple Taylor rule extended to include reaction to the exchange rate changes to be optimal for the European Central Bank, when compared to the pure Taylor rule. In their stochastic simulation experiments, Cecchetti, et al. (2000) conclude that when only financial shocks hit the economy, it is optimal to react to exchange rate changes. However, when the shocks come from the demand side of the economy, reacting to exchange rate changes becomes counterproductive. Batini and Nelson (2000) conclude differently. They claim that when the exchange rate equation is purely backward looking, reacting to exchange rate changes is always desirable.

In this paper, I take a different approach to the role asset prices should play in the conduct of monetary policy. Unlike most of the literature, I use a small open economy model of the Canadian economy to demonstrate that if stock price bubbles and exchange rate changes affect inflation directly or indirectly through aggregate demand, then the Bank of Canada with its primary objective of price stability will respond to stock price bubbles and exchange rate changes, irrespective of the policy regime. Historically, the Bank of Canada has followed money growth targeting strategy over the period 1975-1990, and an explicit inflation targeting strategy since 1991.[2] Inflation dynamics between the two monetary policy regimes have differed significantly. The average inflation, as measured by change in the Consumer Price Index (CPI), was 7.15 between 1975 and 1990 and 2.13 between 1991 and 2003. The pertinent question then is, can the Bank of Canada better control inflation by responding to stock price bubbles and exchange rate changes? To answer this question, I use

[2] Though the money growth targeting framework was officially abandoned in 1981, the bank of Canada continued to experiment with some form of monetary aggregate growth and nominal income targeting until it formally adopted the present inflation targeting framework in 1991. I therefore refer to the period 1975-1990 as the money targeting policy regime.

quarterly data over the period 1975-2003 to examine the relationship between monetary policy and asset price changes during the two policy regimes. The paper therefore pursues two objectives. First, to determines if the Bank of Canada has systematically responded to stock price bubbles and exchange rate changes during the two policy regimes. Second, to determine the marginal benefit from responding to these asset price changes. In pursuing these objectives, the paper offers an important contribution to the literature. It theoretically demonstrates that in an open economy where stock price bubbles and exchange rate changes impact on inflation and output, the derived policy rule will require a response to stock price bubbles and exchange rate changes, irrespective of the policy regime. Particularly, the paper demonstrates that if asset prices changes can proxy for short run shocks to money demand, as implicitly implied by Keynes' speculative demand for money, then following money growth targeting strategy will require policy response to stock price bubbles and exchange rate changes. The key interesting findings of the paper are summarized below.

First, estimates of the structural model indicate that stock price bubbles and exchange rate changes have significant effect on aggregate demand and inflation. Second, estimates of the policy rules consistent with money growth targeting and inflation targeting regimes provide evidence that the bank of Canada has systematically responded to stock price bubbles and exchange rate changes. It is important to note that this result does not suggest an independent role of asset price changes in the conduct of monetary policy. Rather, it suggests that asset price changes have significant effects on output and inflation, the two most important variables of concern to the Bank of Canada. Third, counterfactual simulation experiments reveal that irrespective of the policy strategy, an interest rate setting that takes into account stock price bubbles and exchange rate changes leads to a lower average inflation and interest rate, but at the cost of increased volatility in both variables.

The results also imply that during the money growth targeting regime, the Bank of Canada could have controlled inflation better if it had responded strongly enough to inflation and output growth gap while responding to stock price bubbles and exchange rate changes.

The remainder of this paper is organized as follows. Section 2 develops a small open economy model for the Canadian economy, and derives two monetary policy rules consistent with inflation targeting and money growth targeting strategies. Section 3 estimates the model parameters and the two monetary policy rules to determine the role stock price bubbles and exchange rate changes have played in the conduct of monetary policy in Canada. Section 4 conducts counterfactual simulation exercises to determine the marginal benefit from responding to stock price bubbles and exchange rate changes. Section 5 concludes the study.

2 A Small Structural Model of the Canadian Economy

This section develops a small open economy model of the Canadian economy to investigate the role asset prices have played in the conduct of monetary policy in Canada. I extend the Svensson (1997, 1999) closed economy model by including the external sector and explicitly accounting for the effects stock price bubbles and exchange rate changes have on output and inflation. This is a purely backward-looking model based on aggregate demand, aggregate supply, exchange rate and an exogenous stock price bubble equations. The log-linear form of the model is assumed to be:

$$y_{t+1} = \beta_0 + \beta_1 y_t - \beta_2(R_t - \pi_t) + \beta_3 q_t + \beta_4 \Delta e_{t-3} + \varepsilon_t \tag{1.1}$$

$$\pi_{t+1} = a_0 + a_1\pi_t + a_2 y_{t+1} + a_3 \Delta e_t + \mu_t \tag{1.2}$$

$$e_{t+1} = \theta_0 + \theta_1 e_t - \theta_2 R_t + \varkappa_t \tag{1.3}$$

$$q_{t+1} = \sigma_0 + \sigma_1 q_t + \nu_t \tag{1.4}$$

where y_t is the percentage gap between actual and potential real GDP (the output gap), π_t is the four-quarter inflation rate (in percentage), R_t is the nominal interest rate, Δe_t is the percentage change in the real exchange rate, and q_t is the percentage gap between the real aggregate stock price and its potential (real stock price bubble). All parameters are positive.

Equation (1.1), the IS curve, is modeled as an open economy version of Svensson's model. It incorporates all consumption and investment decisions as well as the foreign sector. It expresses the output gap as a function of its own lag, the lag of the real interest rate, the lag of stock price bubble and the fourth lag of the percentage change in the exchange rate.[3] The lagged output gap in the IS equation captures the persistence that characterizes cyclical movements in output in the data. The presence of the real stock price inflation can be motivated by the wealth effect and Tobin's q. Equation (1.2), which is the Phillips Curve (PC) and defines the supply side of the model, relates inflation to its lag, the contemporaneous output gap and the lag of the percentage change in the exchange rate. The lagged inflation term in the Phillips curve could be motivated either by backward-looking expectations or by contracting-type rigidities similar to those of Fuhrer and Moore (1995). Changes in the exchange rate affect prices because they are passed directly into import prices.[4] Equation (1.3) is a pure backward-looking equation for exchange rate determination, which relates the exchange rate to its lag and the lag of the interest rate. I assume that the disturbance term $\varkappa_t$ captures the time varying risk premium. Finally, equation (3.4) defines the exogenous bubble process of the real stock price.

In his small open economy model for the Canadian economy, Smet (1997) used one arbitrage equation to describe the determination of all types of asset prices. I specify each

[3] The real exchange rate is measured as units of home currency per unit of foreign currency, so that an increase in it is a real depreciation. I use the fourth lag of the change in exchange rate because I believe that at least it takes a year for a change in exchange rate to impact on output (I used quarterly data for the estimation).
[4] See Ball (1999) for a similar set up.

asset price equation separately for two simple reasons. First, the two assets (stock prices and exchange rates) considered in this study have different dynamic effects on output and inflation. For instance, while the real exchange rate affects the inflation rates directly and also indirectly through the IS equation, real stock price bubble affects the inflation rate only indirectly through its effect on the IS equation. Second, I am interested in the distinct dynamic effect of stock price bubbles. This requires that I explicitly incorporate stock price bubbles in the model. On the other hand, since all exchange rate changes affect the output gap and inflation, I explicitly incorporate the dynamics of all changes in the exchange rate in the model.[5]

The purely backward-looking nature of both the IS equation and the Phillips curve could be controversial. Recent studies have increasingly used a 'New Keynesian' Phillips curve in which expected future inflation replaces expected current inflation as a determinant of current inflation.[6] Mishkin (1999) criticized that specification and argues that models from which forward-looking Phillips curves are derived have the implication that monetary authorities do not have to act pre-emptively to control inflation. However, because of the lags in the transmission mechanism of monetary policies, central banks have in the past pursued pre-emptive policy actions to guide the path of policy control variables. Further, studies by Fuhrer (1997) and Fair (1993) show that estimate for the forward-looking expectations variable in the Phillips curve are not significantly different from zero. With regard to the IS curve, Goodhart and Hoffmann (2005) use data on selected OECD countries to demonstrate that including the expected future output gap in the IS equation introduces bias in the estimate of the real interest rate variable. In the case of Canada, they

[5] In addition, our specification of the exchange rate in the model and subsequently in the monetary policy instrument rule does not depend on a notion of an equilibrium exchange rate that may be difficult compared to equity prices.
[6] See, for example, Bernanke and Gertler (1999, 2001), and Rotemberg and Woodford (1999).

found that the real interest rate variable is significant but its coefficient has the wrong sign. When a purely backward-looking IS equation augmented with asset prices variables was re-estimated for Canada, the real interest rate variable became significant and obtained the right sign.

2.1 Inflation Targeting Regime

To understand how monetary policy should respond to asset prices, I need to first analyse the optimal policy rule when the Bank of Canada is following a flexible inflation-targeting strategy. Following much of the literature, I assume that the central bank has an intertemporal loss function represented by

$$\boldsymbol{L} = -\frac{1}{2} \underset{t}{\mathrm{E}} \left[\sum_{i=0}^{\infty} \beta^{i} \boldsymbol{L}_{t+i} \right] \qquad (1.5)$$

Where β is a discount factor. The period loss function is defined over the target variables π_t and y_t and takes the form

$$\boldsymbol{L}_{t+i}(\pi_{t+i}\ y_{t+i}) = -\frac{1}{2}\left[\pi_{t+i}^{2} + \lambda y_{t+i}^{2}\right] \qquad (1.6)$$

where the inflation target is normalized to zero and the target for the output gap is also zero. The symbol λ is the relative weight on output gap stabilization.[7] In any period $t+i$ the central bank is faced with the policy problem of choosing the time path for the policy instrument R_t by maximizing equation (1.5) subject to equations (1.1), (1.2) and (1.6). I will focus on the case where the central bank optimizes without commitment. As argued in the literature, this assumption is realistic, since in practice, no central bank makes such kind of binding commitment over the course of its future monetary policy.

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[7] This objective function is what Svensson (1997, 1999b) refers to as flexible inflation targeting. According to his terminology, a strict inflation targeting is where λ is equal to zero.

If the central bank follows an inflation-targeting strategy under discretion, the maximization can be divided into two stages. In the first stage, the central bank chooses π_t and y_t to maximize equation (1.6) subject to equation (1.2). In the second stage, the results in the first stage are used together with equation (1.1) to determine the optimal value of the policy instrument. The policy rule takes the form:

$$R_t = \overline{K} + g_1\pi_t + g_2 y_t + g_3 q_t + g_4 \Delta e_t + g_5 \Delta e_{t-3} \tag{1.7}$$

where

$$\overline{K} = \frac{\beta_0}{\beta_2} + \frac{\alpha_2\alpha_0}{\beta_2\lambda + \beta_2\alpha_2\alpha_2}$$

$$g_1 = \frac{\beta_2\lambda + \beta_2\alpha_2\alpha_2 + \alpha_2}{\beta_2\lambda + \beta_2\alpha_2\alpha_2}$$

$$g_2 = \frac{\beta_1}{\beta_2}$$

$$g_3 = \frac{\beta_3}{\beta_2}$$

$$g_4 = \frac{\alpha_2\alpha_3}{\beta_2\lambda + \beta_2\alpha_2\alpha_2}$$

$$g_5 = \frac{\beta_4}{\beta_2}$$

Details of the derivation of the optimal policy rule are provided in Appendix A1. The optimal interest rate rule derived above is the Taylor rule augmented with stock price bubbles and the change in exchange rates. The central message of the policy rule is that given the structure of the economy, the central bank's policy of flexible inflation targeting requires that the policy instrument should be adjusted to offset the effect of stock price bubbles and exchange rate changes on the output gap and inflation. Hence, the coefficients g_3, g_4 and g_5 must all be positive. It is important to note that these asset prices variables in the optimal policy rule do not play any direct role other than through their impact on the outlook for inflation and the output gap. The rationale behind the response to stock price bubbles and exchange rate changes is simple. From equations (1.1) and (1.2), these variables either feed directly to prices or indirectly through their effect on the output gap. As monetary policy affects inflation through the effect of the interest rate on the output gap, it is optimal to change the interest rate whenever there is an asset price shock to both the IS and the AS equations. In addition, responding to stock price bubbles and exchange rate changes pushes both the output gap and inflation in the same direction, helping the Bank of Canada to hit both inflation and output gap targets. This is consistent with the view of Cecchetti et al. (2002) on the role that asset prices should play in the conduct of monetary policy.

2.2 Monetary Growth Targeting Strategy

The optimal policy rule I derived for the flexible inflation targeting strategy requires the central bank to react to asset price changes. Since the Bank of Canada has followed a money growth targeting strategy in the past, I need to derive an optimal policy rule for the money growth targeting strategy that requires response to asset price changes. In doing so, I will demonstrate theoretically that responding to asset price changes in the money growth targeting strategy is the same as using interest rates (the policy instrument) to respond to short run changes in money demand. To accomplish this, I need to reformulate Friedman's money growth targeting rule with the interest rate as the policy instrument. This is important because the Bank of Canada cannot use the monetary aggregate as an instrument due to the fact that it does not have perfect control over it.[8] Also, since the model in equations (1.1) - (1.4) does not allow for any direct role of money in the economy, it is sufficient to treat

[8] See Goodhart (1994) for a more general discussion on central bank instruments.

monetary policy as if the Bank controls the short term interest rate directly, leaving the relationship between the short-term interest rate and the monetary aggregate in the background. This is made possible by using the quantity theory equation.

$$Mv = Py \tag{1.8}$$

where M is a given monetary aggregate, say *M2*, v is its velocity of money, y is the real income and P is the price level. Log-linearizing equation (1.8) and taking its first difference yields the relationship

$$\theta_t + \Delta v_t = \pi_t + \Delta y_t \tag{1.9}$$

where θ_t is growth rate of the monetary aggregate, π_t is the inflation rate, Δy_t is the growth rate in real output and Δv_t is the rate of change in the velocity of money. With the quantity equation and allowing for a change in potential output growth, the long-run equilibrium relationship in terms of equation (1.9) is

$$\theta_t^* + \Delta v_t^* = \pi_t^* + \Delta y_t^* \tag{1.10}$$

where the superscript * indicates the long-run values of the respective variables. Now let us assume that the central bank follows a money growth targeting rule with the objective of achieving an inflation target π^*, which equals its long-run value. Once again, I assume that the inter-temporal loss function to be maximized in period t is

$$Max\ -\frac{1}{2}\ \underset{t}{\mathrm{E}}\left[\sum_{i=0}^{\infty}\beta^i\ L_{t+i}\right] \tag{1.11}$$

and the β is again a discount factor. The period loss function is

$$L\ (\theta_{t+i})\ =\ --\frac{1}{2}\left[\theta_{t+i} - \theta^*_{t+i}\right]^2 \tag{1.12}$$

where θ_{t+i} is the period money growth rate and θ^*_{t+i} is the long-run money growth rate required to hit the long-run inflation target π^*. The first order condition for maximization of equation (1.12) is satisfied by equating the period money growth rate to its long-run value. Equating equation (1.9) and (1.10) and re-arranging terms yield

$$\Delta v_t - \Delta v_t^* = (\pi_t - \pi_t^*) + (\Delta y_t - \Delta y_t^*) \tag{1.13}$$

To reformulate equation (1.13) in terms of an interest rate rule, we follow Orphanides (2003) in assuming a simple formulation of money demand as a log-linear relationship between velocity deviations from its long run value and the rate of interest. The Orphanides specification in difference form is

$$\Delta v_t - \Delta v_t^* = \delta_1 \Delta R_t + b_t \tag{1.14}$$

Where $\delta_1 > 0$ and b_t represents the short run fluctuation in money demand. In his formulation, Orphanides avoided the short run fluctuations in the money demand by making b_t a constant. In my opinion, if the money growth targeting strategy is to be successful for policy purposes, the Bank must be able to control short run fluctuations in money demand (b_t) through the policy instruments at its disposal. I, therefore, depart from Orphanides by explicitly modelling the sources of short-run dynamics in money demand through the specification of the determinants of b_t. To start with, I argue that the financial sector of the economy is the main source of short run dynamics in money demand. According to Keynes (1936) and later Tobin's (1958) formalization, the speculative motive for holding money is mainly for securing profit from knowing better than the market, so that asset price changes and expectations of their future movements are the main source of short run fluctuations in money demand.

For instance, if stock prices increase above their current fundamental values, then a speculator who expects stock prices to fall in the future, will sell their stocks now so as to avoid losses when prices actually fall. This will lead to a temporal increase in money demand. Within the very short run when inflation and real income are constant, equation (1.8) implies that an increase in money demand leads to a reduction in velocity. Given that the long-run velocity is constant in the short-run, there will be a negative deviation of velocity from its long-run value. By logical extension, when domestic currency depreciates in an open economy where currency speculation is significant, foreign exchange speculators who expect future appreciation of the currency will move into the domestic currency. This will lead to a temporary increase in demand for domestic currency. Again, within the very short run when inflation and real income are constant, equation (1.8) implies that the temporary increase in money demand will lead to a fall in short run velocity and a negative deviation of velocity from its long-run value. Consequently, equation (1.14) becomes,

$$\Delta v_t - \Delta v_t^* = \delta_1 \Delta R_t - \delta_2 q_t - \delta_3 \Delta e_t \tag{1.15}$$

where all the parameters are positive and q_t and Δe_t are as previously defined. Even if velocity changes in the short run equal their equilibrium value ($\Delta v_t = \Delta v_t^*$), stock price bubbles and exchange rate changes will induce an interest rate change in a direction that satisfies equation (1.15). For instance, in an economy where stock price bubble affect aggregate demand, an increase in stock prices over the fundamental value will require the central bank, which is concerned with price stability, to increase the short run interest rate to offset the inflationary effect of the stock price bubbles. Substituting equation (1.15) into equation (1.13) and re-arranging terms yields,

$$R_t = \beta_r R_{t-1} + \beta_\pi (\pi_t - \pi_t^*) + \beta_{\Delta y} (\Delta y_t - \Delta y_t^*) + \beta_q q_t + \beta_e \Delta e_t \tag{1.16}$$

where β_π, β_y, β_q, and $\beta_e > 0$ and $\beta_r = 1$.

The main difference between the money growth targeting policy rule (equation 1.16) and the inflation targeting policy rule (equation 1.7) is that the money growth targeting policy rule responds to perceived imbalances between the growth of aggregate demand and aggregate supply and not the output gap. Also, the lagged value of the interest rate (the policy instrument) is explicitly used as a baseline for policy adjustments in the optimal monetary targeting rule. Orphanides (2003) suggests that the optimal values of the coefficients on the inflation and output growth gap variables (β_{π} and β_{y} respectively) are 0.5 each.[9]

3 Estimation of the Structural model and the Policy Rules

In this section, I estimate the model together with the two policy rules so as to determine the historic role asset prices have played in the conduct of monetary policy in Canada. I use quarterly data spanning the period 1975:1–2003:3.[10] All variables used for the estimation were obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). The interest rate variable is the quarterly bank rate expressed as an annual rate.[11] The inflation measure is the four-quarter rate of change of the consumer price index. The real stock price bubbles, which is supposed to measure non-fundamental changes in broad stock prices, is measured as the percentage deviation of real stock prices from their potential. The output gap is also defined as the difference between the actual real GDP and the potential real GDP[12]. Finally, the real exchange rate variable is the real bilateral Canadian-United States exchange rate defined as units of the home currency per unit of the foreign currency.[13]

[9] I will experiment with these coefficients in our counterfactual simulation experiments.
[10] The data period was chosen to correspond with the money growth targeting and the inflation targeting regimes as followed by the Bank of Canada.
[11] Results using the three-month Treasury bill rates were almost identical and are, therefore, not reported.
[12] We follow much of the literature by using the Hodrick-Prescott filter with a smoothing parameter of 1600 to calculate the potential values of both the real GDP and the aggregate stock price.
[13] We experimented with other definition of the real exchange rates such as the IFS definition of real effective exchange rates (REER). Results were qualitatively and quantitatively the similar to the one reported.

3.1 Model Parameter Estimates

The estimated equations using the entire sample period are shown below. The standard error of the residual, the Durbin-Watson statistics and the adjusted-R^2 are reported below the equations.

(IS) $$y_t = \underset{(0.07)}{0.06} + \underset{(0.04)}{0.84}\, y_{t-1} - \underset{(0.03)}{0.08}\, (R_{t-1} - \pi_{t-1}) + \underset{(0.01)}{0.02}\, q_t + \underset{(0.03)}{0.06}\, \Delta e_{t-4} + \varepsilon_t$$

$\sigma_\varepsilon = 0.64$ $\quad$ $DW = 1.65$ $\quad$ Adjusted-$R^2 = 0.82$

(PC) $$\pi_t = \underset{(0.10)}{0.07} + \underset{(0.01)}{0.96}\, \pi_{t-1} + \underset{(0.03)}{0.19}\, y_t + \underset{(0.03)}{0.08}\, \Delta e_t + \mu_t$$

$\sigma_\mu = 0.65$ $\quad$ $DW = 1.50$ $\quad$ Adjusted-$R^2 = 0.96$

The equations were estimated separately by OLS[14]. I tested for heteroscedasticity in all the regressions using the Breusch-Pagan test, and concluded that the error terms of each regression were correlated with the regressors. I, therefore, corrected the error term of all regressions for heteroscedasticity using White's procedure. Hence the "*t*" and the "*F*-statistics" are asymptotically valid.[15] All coefficients have the expected signs. The results for the IS curve suggest that the real interest rate, the real exchange rate and the stock price bubbles have significant effect on the output gap. A depreciation of the real exchange rate makes domestic goods more competitive and increases net exports. Given that Canada is a small open economy where net exports account for a significant percentage of aggregate demand, it is not surprising that the real exchange rate is an important determinant of aggregate demand. The estimated coefficient for the stock price bubbles reflects the significant share of equity in private sector wealth and the wealth and Tobin q effects on

[14] All variables used in the regression are stationary.

[15] I used the same procedure in estimating the policy rules.

aggregate demand. Overall, the estimated IS equation is comparable to that of Goodhart and Hofmann (2005), who also use quarterly Canadian data.

The estimated Phillips curve indicates that all the coefficients are significant at the 1% level. The coefficient estimates implies that an increase in the output gap by one percentage point leads to an increase in the inflation rate by 0.19-percentage point. The significance of the real exchange rates variable suggests that besides affecting the output gap, the exchange rate has a greater and more immediate effect on inflation through imports prices. Based on these dynamic effects of asset prices on output and inflation, I argue that if the Bank of Canada cares about price and output stability, then it should react to asset price developments when deciding on the policy instruments. Estimates of the exchange rates and the stock price bubble equations are reported in appendix A1.

With a backward-looking model, the Lucas critique applies. One way of dealing with this situation is to test for the stability of the model over the relevant historical period. I, therefore, conducted a number of structural stability tests on both the IS and Phillips curve equations. Firstly, I conducted Chow's breakpoint test for both equations using 1990:4 as the break point date (the shift from money growth targeting to inflation targeting strategy occurred at that period). The null hypothesis of a constant coefficient vector over the two periods could not be rejected. The p-values of the F-tests are 0.58 and 0.27 for the IS and the Phillips curve respectively. Secondly, I took a broader view of the stability of the model by conducting the Brown *et al* (1997) CUNSUM test which is based on the cumulated sum of the residuals. Again the tests did not indicate any sub-sample instability in either of the two equations. The results of the tests are provided in appendix A2.

3.2 Estimated Policy Rules

Given the empirical model described above, I now estimate the monetary policy rules to determine whether the Bank of Canada has systematically responded to asset price developments. I am also interested in determining whether the regime specific policy rules differ significantly in their response to stock price bubbles and exchange rate changes.

Money growth targeting rules

Table 3.1 reports estimates of three specifications of the policy rules consistent with the money growth targeting strategy (coefficient standard errors are given in parentheses, and the standard errors of the residuals and the adjusted-R^2 are reported). The dependent variable is the short term interest rate (the bank rate) and the first two estimates are over the money growth targeting regime period of 1975:4 to 1990:4. The baseline specification, reported on the first row, shows the response of the policy instrument to only inflation and the output growth gap. All of the coefficients are significant at the 5% significance level. The estimated parameters for inflation and output growth gap are significantly lower than the optimal values (0.5 for each) suggested by Orphanides (2003), implying that during the money targeting period, which includes the great inflation era of the 1970s and 1980s, the Bank of Canada responded much less to inflation and output growth gap than was required to fight inflation. The second row contains the specification that adds to the policy rule the current value of stock price bubbles and the percentage change in the real exchange rate. The estimates indicate that during the money growth targeting regime, the Bank of Canada increased the bank rate significantly in response to depreciation in the bilateral real exchange rate and stock price bubbles.

The result, especially with regard to exchange rates, should not come as a surprise. Being a small open economy with a significant external sector, the monetary authority in

Canada has to pay particular attention to developments in the foreign exchange market, especially when exchange rates have a direct effect on inflation. As Smet (1997) argues, the reaction to changes in the exchange rates is optimal because during the 1980's and the first part of the 1990's, nominal shocks became relatively the more important determinant of exchange rate changes than real shocks in Canada, justifying a policy response. Other parameter estimates are almost unchanged from the baseline specification, with the exception of the output growth gap parameter, which decreased significantly. Based on these estimate and our theoretical derivation of the final policy rule in section 2, it can be concluded that during the money growth targeting regime, the central bank systematically adjusted its policy instrument to accommodate short run fluctuations in money demand as captured by stock price bubbles and changes in the exchange rates.

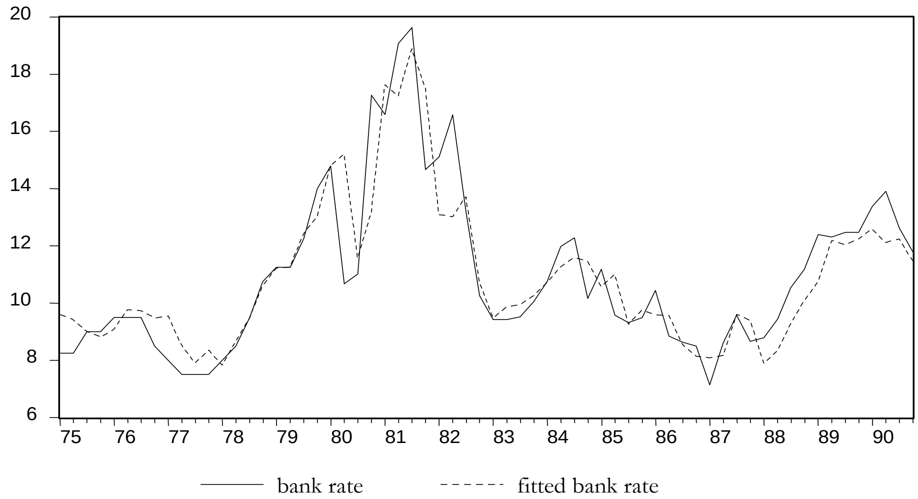
Table 3.1: Estimated Money Growth Targeting Policy Rules

	β_o	β_π	$\beta_{\Delta y}$	β_{R-1}	$\beta_{\Delta e}$	β_q	see	Adj-R^2
1. Baseline	1.06	0.18	0.25	0.78	----	-----	1.43	0.75
(1975:1-1990:4)	(0.76)	(0.08)	(0.09)	(0.07)				
2. Adding asset prices	1.50	0.14	0.13	0.77	0.29	0.05	1.32	0.78
(1975:1-1990:4)	(0.59)	(0.06)	(0.07)	(0.07)	(0.12)	(0.02)		
3. Overall sample	0.43	0.16	0.20	0.84	0.16	0.02	1.10	0.91
(1975:1-2003:4)	(0.26)	(0.05)	(0.06)	(0.04)	(0.05)	(0.01)		

Figures 3.1 and 3.2 show the actual and the fitted values of the policy instrument (bank rates) for the money growth targeting regime with and without response to asset prices respectively. The actual and fitted values are closer for the policy rule specification that includes asset prices than for the one that does not include asset prices. Further, the in-sample forecast evaluation indicates that the root mean squared errors are 1.92 and 2.24 respectively for the policy rule with and without asset prices. In the final specification,

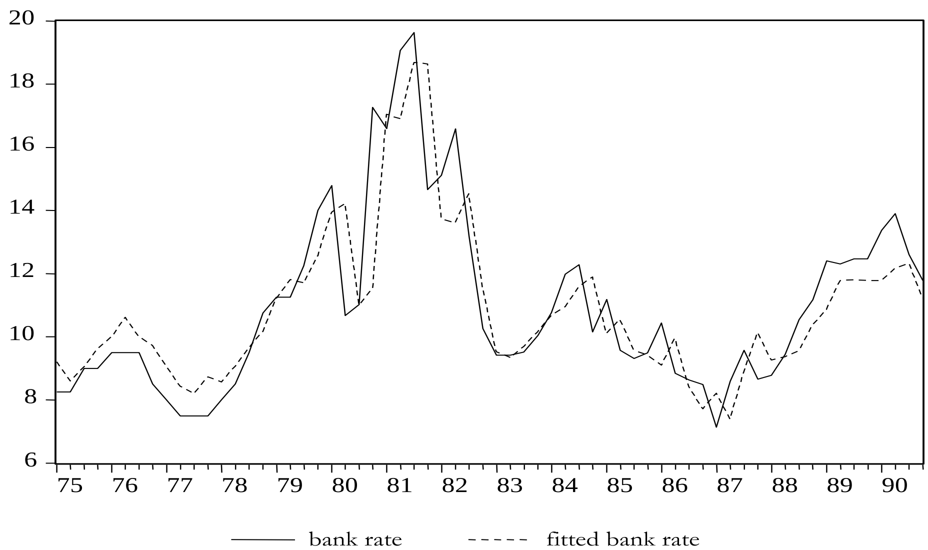
Money Growth Targeting Regime

Figure 3.1: Actual and Fitted Values of the Bank Rate (With Asset Prices)



Money Growth Targeting Regime

Figure 3.2: Actual and Fitted Values of the Bank Rate (Without Asset Prices)



reported on the third row, I estimated the policy rule for the entire sample period (1975:1-2003:4) in order to investigate if the Bank of Canada has followed the same policy rule despite the shift in the policy regime. Chow's break point test using 1990:4 as the break point rejected the null hypothesis of constant parameters at the 10% significance level over the two periods. The p-value of the F-tests is 0.06. Hence the Bank of Canada has not followed the same policy rule over the entire period.

Inflation targeting rules

I now estimate the inflation-targeting policy rules (equation 1.7). Table 1.2 reports three estimated specifications of the policy rule (coefficient standard errors are given in parentheses, and the standard errors of the residuals and the adjusted-R^2 are also reported). As in the case of money growth targeting, the first two specifications use data over the inflation targeting period (1991:1-2003:4), and the last specification uses data over the whole sample period (1975:1-2003:4). The baseline rule, reported on the first row indicates that during the inflation-targeting regime, the Bank of Canada responded actively to both inflation and the output gap. Both parameter estimates are highly significant. In the second specification, reported on the second row, I allow for the possibility that the Bank of Canada systematically responded to both stock price bubbles and exchange rate changes.[16] The overall fit, in terms of the adjusted R^2, improves. The parameter estimates also exhibit some

Table 3.2: Estimated Inflation Targeting Policy Rules

	g_o	g_π	g_y	$g_{\Delta e}$	g_q	see	Adj-R^2
1. Baseline	4.14	1.06	0.59	----	-----	1.76	0.53
(1991:1-2003:4)	(0.47)	(0.17)	(0.20)				
2. Adding asset prices	3.36	1.28	0.97	0.38	-0.11	1.40	0.70
(1991:1-2003:4)	(0.43)	(0.14)	(0.18)	(0.13)	(0.02)		
3. Overall sample	4.54	0.79	0.63	0.19	0.02	1.53	0.61
(1975:1-2003:4)	(0.35)	(0.07)	(0.15)	(0.09)	(0.02)		

[16] In all the estimation we eliminated the three lagged percentage change in the exchange rate because it was consistently not significant and carried the wrong sign. This is also the case with the money growth targeting policy rules.

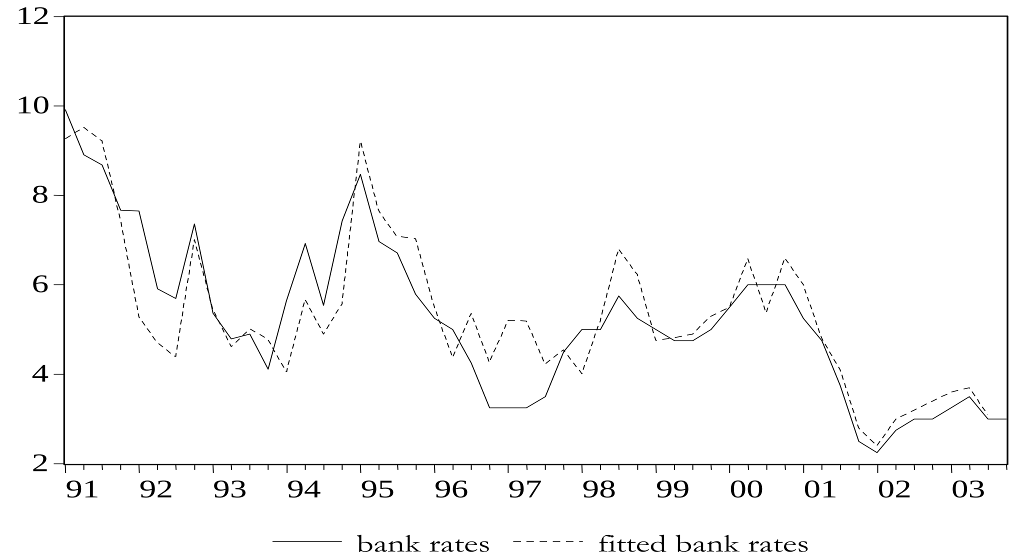
interesting patterns. First, the coefficients on the inflation and output gap suggest that during the inflation-targeting period, policy responded more heavily to inflation and to the output gap. In particular, the coefficients are close to the stability criterion of policy response to changes in the inflation and output gap proposed by Taylor (1993).[17] Second, the coefficient of the stock price bubbles is negative and five times the size of the one obtained for the money growth-targeting regime. The significance of the coefficient does not necessarily mean that over the relevant period, the Bank of Canada attempted to raise stock prices over their fundamental values. It is possible that having been able to bring inflation under control, the bank has been less constrained to use its policy instrument to pursue other objectives, which led to policy ease, and the stock market reflected that ease. Also, as Smet (1997) argues, the negative coefficient on the share price inflation variable may imply that both the Bank of Canada and the stock market respond to news about underlying inflation that is not captured by the variables in the estimated policy rule. Finally, the Bank of Canada has continued to respond strongly to exchange rate changes due to the openness and the dependence of the economy on the external sector. Figures 3.3 and 3.4 plot the actual and fitted values of the bank rate with and without response to asset prices in the policy rules, respectively. It is obvious that the policy rule that reacts to asset prices broadly describes better the time path of the policy decisions with some relative degree of consistency. The in-sample forecast root mean square errors are 1.86 and 2.15 for with and without response to asset prices, respectively. In the third specification, I estimate the inflation targeting policy rule using data for the entire sample period. All coefficients except the constant decreased and the sign on the stock price inflation coefficient became positive, though it is not statistically significant. To test if the Bank of Canada followed the inflation targeting rule

[17] According to Taylor (1993), policy stability requires that $g_\pi = 1.5$ and $g_y = 0.5$.

over the entire period, we conducted a chow's break point test using 1990:4 as the break point. The null hypothesis of constant parameter was rejected at the 5% significance level over the period with a p-value of 0.03.

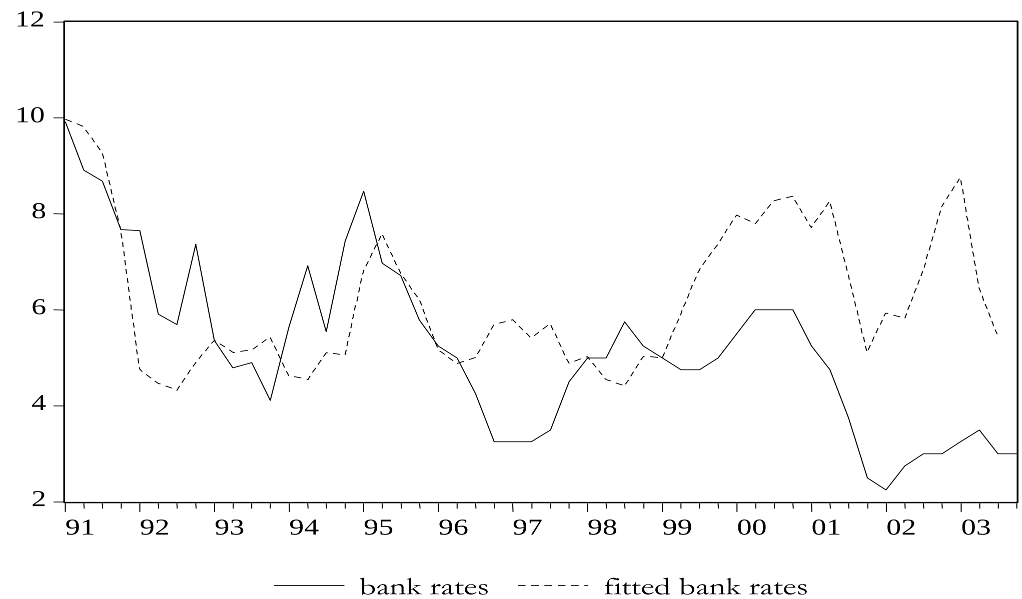
Inflation Targeting Regime

Figure 3.3: Actual and Fitted Values of Bank Rate (With Asset Prices)



Inflation Targeting Regime

Figure. 3.4. Actual and Fitted Values of Bank Rates (Without Asset Prices)



4 Counterfactual Simulation Experiments

The estimated coefficients of the two policy rules and their plots suggest that the Bank of Canada has systematically responded to the stock price bubbles and changes in the exchange rates. It does not provide the framework for determining the marginal benefit from responding to stock price bubbles and exchange changes. In this section, I use simple counterfactual simulation techniques to determine if the response to stock price bubbles and exchange rate changes was desirable in terms of the overall macroeconomic stability. For this exercise, I experiment with our empirical model and subject it to random shocks of the magnitude experienced in the past. The differences between the actual and the estimated values of the endogenous variables in the model during the estimation period were assumed to be the estimated shocks that hit the economy during the entire sample period. [18] I used both our estimated policy rules and two others suggested by Taylor (1993) and Orphanides (2003) to simulate values for the interest rates, inflation, output gap, output growth gap, and the interest rate for 115 periods.[19] I used 1974:4 as the initial condition. Table 4.1 below presents simulated and actual summary statistics of selected variables that can be used to measure the performance of various policy rules with and without response to asset prices. For each of the variables the first column is the averages and the second column is the variances.

Interesting patterns emerge from the statistics. Irrespective of the policy rule followed, responding to stock price bubbles and exchange rate changes leads to lower averages of the inflation and interest rate, but, an increase in their volatility. The effects of the policy rule response to asset price changes on the output gap are mixed. Whereas the

[18] The estimated equations for the exogenous stock price bubble process and the exchange rate used for these experiments are reported in Appendix A1.

[19] For this experiment, the negative coefficient on the real stock price bubble variable in the inflation targeting policy rules was changed to positive. Results with the negative coefficient were clearly inferior.

money growth targeting policy rules yield a reduction in the average output gap and an increase in its volatility, the inflation targeting policy rules leaves the average output gap unchanged but reduce its volatility. The results become more interesting when we use both the recommended Orphanides' rules (for money growth targeting) and the Taylor's rule (for inflation targeting) to conduct the simulation experiments. The results indicate that if the

Table 4.1: Simulated and Actual Statistics

	Inflation		Bank rate*		Output gap		Output growth gap	
A. Money growth targeting	Avg.	Var.	Avg.	Var.	Avg.	Var.	Avg.	Var.
Our estimated rule without asset prices	5.14	6.23	8.35	0.13	0.02	2.14	-0.07	3.03
Our estimated rule with asset prices	5.06	6.91	8.45	0.31	-0.03	2.18	-0.07	3.03
Orphanides rule without asset prices	1.51	11.36	7.65	1.35	-0.07	2.35	-0.08	3.52
Orphanides rule with asset prices	1.44	12.02	7.67	1.56	-0.09	2.42	-0.08	3.52
B. Inflation targeting								
Our estimated rule without asset prices	4.08	6.73	8.31	1.96	-0.24	2.17	-0.08	3.09
Our estimated rule with asset prices	4.03	6.99	8.28	2.82	-0.24	2.02	-0.07	2.87
Taylor rule without asset prices	3.35	6.89	8.16	2.56	-0.39	2.49	-0.08	3.28
Taylor rule with asset prices	3.31	7.15	8.13	3.24	-0.39	2.33	-0.07	3.04
C. Actual Statistics	4.92	11.86	8.42	1.64	-0.05	2.31	-0.04	3.53

*Note: To conform to standard practice, the variances reported are for the change in the interest rate.

Bank of Canada had followed the Orphanides rule over the entire period, average inflation and the bank rate would have been much smaller than in all other policy rules and the historical values (actual statistics).[20] For instance, following the Orphanides' rule, the average inflation would have been 1.51 when policy does not response to asset prices and 1.44 when policy response to asset prices. The averages of the interest rate would have been 7.65 with

[20] It must be recalled that the recommended response to inflation and the output growth gap in the Orphanides' rule is higher than the estimated historical value obtained in section 3.

no response to asset prices and 7.67 when policy responds to asset prices. On the other hand, if the Taylor's rules were followed over the entire period, the averages of inflation would have been 3.35 when policy does not respond to asset prices and 3.31 when policy responds to asset prices. The averages of the interest rate would have been 8.16 with no response to asset prices and 8.13 when policy responds to asset prices. However, in comparison, the Taylor's rules would have yielded lower variability in inflation and a higher variability in the interest rates. For both recommended policy rules, the average output gap would have been negative, though, a bit higher (in absolute terms) for the Orphanides' rules.

Some lessons can be drawn from these results. First, interest rate setting that takes into account asset price changes, namely stock price bubbles and exchange rate changes, leads to a lower average inflation and interest rate, but at the cost of increased volatility in inflation and the interest rate. Second, the results imply that during the money growth targeting regime the bank of Canada did not respond strongly enough to inflation and the output growth gap. In other words, if the bank of Canada had followed the Orphanides rule by responding strongly to inflation and the output growth gap while responding to asset prices, the economy would have performed better than it did during the period under study.

5 Conclusion

In this paper I use a small open economy model of the Canadian economy and policy rules derived from the money growth targeting and inflation targeting regimes to examine the empirical response of monetary policy to stock price bubbles and exchange rate changes. The intuition is that stock price bubbles and exchange rate changes affect inflation either directly or indirectly through aggregate demand. Hence, I theoretically show that irrespective of the monetary policy regime, the Bank of Canada in pursuing its primary objective of price stability should respond to stock price bubbles and exchange rate changes. Estimates of the policy rules provide evidence that the bank of Canada has systematically responded to stock price bubbles and exchange rate changes during both the money growth targeting and inflation targeting policy regimes. These results do not suggest an independent role of asset prices in the conduct of monetary policy. They rather reflect the significant effect asset price changes have on output and inflation, as demonstrated by the estimated coefficients for both the IS and the Phillips curve equations.

The simulation experiments undertaken to determine the marginal benefit from responding to stock price bubbles and exchange rate changes yielded two important results: First, interest rate setting that takes into account stock price bubbles and exchange rate changes leads to lower average inflation and interest rates, but, at the cost of increased volatility in both variables. Therefore, the benefit from reacting to stock price bubbles and exchange rate changes depends on how much variability in inflation and interest rate the bank of Canada is willing to accept for controlling inflation. Second, the results imply that during the money growth targeting regime, the bank of Canada could have controlled inflation better, if it had respond strongly enough to inflation and output growth gap while responding to asset price changes. This demonstrates that sometimes the poor performance of a monetary policy may be due to the lack of commitment on the part of policy makers when faced with challenging economic circumstances.

The paper, therefore, offers an important contribution to the literature on monetary policy and asset prices. It theoretically demonstrates that in an open economy where stock price bubbles and exchange rate changes impact on inflation and output, the derived policy rule will require a response to stock price bubbles and exchange rate changes, irrespective of the policy regime. Particularly, the paper demonstrates that if asset prices changes can proxy for short run shocks to money demand, as implicitly implied by Keynes' speculative demand for money, then following money growth targeting strategy will require policy response to stock price bubbles and exchange rate changes. The empirical results from the estimation of the policy rules consistent with money targeting and inflation targeting regimes confirmed this theoretical claim.

Appendix A1

Derivation of the Optimal Policy Rule for the Inflation Targeting Regime

The central bank in each period (i) is assumed to maximize a loss function of the form:

$$L_t = -\frac{1}{2}\left[\pi_{t+i}^2 + \lambda y_{t+i}^2\right] + F_i \qquad \text{(A1.1)}$$

subject to

$$\pi_{t+i} = a_0 + a_1\pi_t + a_2 y_{t+i} + a_3 f_i \qquad \text{(A1.2)}$$

where $F = -\frac{1}{2}\underset{t}{\mathrm{E}}\left[\sum_{i=2}^{\infty}\beta^i L_{t+i}\right]$, and $f_i = \Delta e_t$ are taken as given.

Consider the Lagrangian corresponding to stage one:

$$L = -\frac{1}{2}\left[\pi_{t+i}^2 + \lambda y_{t+i}^2\right] + F_i - \Psi\left[\pi_{t+i} - a_1\pi_t - a_2 y_{t+i} + f_i\right] \qquad \text{(A1.3)}$$

where the variable Ψ is the Lagrange multiplier of the inflation constraint at time t (the shadow cost of inflation). Taking the derivative of the Lagrangian with respect to π_{t+1} and y_{t+1} (that is, i=1) gives the following first order conditions (FOCs) as:

$$-\pi_{t+1} - \Psi = 0 \qquad \text{(A1.4)}$$

$$-\lambda y_{t+1} + \alpha_2\Psi = 0 \qquad \text{(A1.5)}$$

These FOCs together with the constraint constitute the optimal solution as follows:

Substituting equation (A1.4) into equation (A1.5) yields;

$$y_{t+1} = -\frac{\alpha_2}{\lambda}\pi_{t+1} \qquad \text{(A1.6)}$$

We can use equation (A1.6) to rewrite equation (1.2) as,

$$y_{t+1} = -\frac{\alpha_2\alpha_0}{\lambda + \alpha_2\alpha_2} - \frac{\alpha_2\alpha_1}{\lambda + \alpha_2\alpha_2}\pi_t - \frac{\alpha_2\alpha_3}{\lambda + \alpha_2\alpha_2}\Delta e_t \qquad \text{(A1.7)}$$

Equation (A1.7) is substituted into equation (1.1) to determine the optimal value of the policy instrument, which is:

$$R_t = \frac{\beta_0}{\beta_2} + \frac{\alpha_2\alpha_0}{\beta_2\lambda + \beta_2\alpha_2\alpha_2} + \left(\frac{\beta_2\lambda + \beta_2\alpha_2\alpha_2 + \alpha_2}{\beta_2\lambda + \beta_2\alpha_2\alpha_2}\right)\pi_t + \left(\frac{\beta_1}{\beta_2}\right)y_t + \left(\frac{\beta_3}{\beta_2}\right)q_t$$
$$+ \left(\frac{\alpha_2\alpha_3}{\beta_2\lambda + \beta_2\alpha_2\alpha_2}\right)\Delta e_t + \left(\frac{\beta_4}{\beta_2}\right)\Delta e_{t-3} \qquad \text{(A1.8)}$$

Estimation

1. Bubble Process

$$q_t = \underset{(0.68)}{-0.21} + \underset{(0.06)}{0.78}\, q_{t-1} \qquad \text{(A1.9)}$$

$\sigma_v = 6.87$ $\quad DW = 1.60$ $\quad$ Adjusted-$R^2 = 0.61$

2. Exchange rate

$$e_t = \underset{(0.01)}{0.02} + \underset{(0.02)}{0.96}\, e_{t-1} - \underset{(0.001)}{0.002}\, R_{t-1} \qquad \text{(A1.10)}$$

$\sigma_\varkappa = 0.02$ $\quad DW = 1.40$ $\quad$ Adjusted-$R^2 = 0.98$

Appendix A2

Fig. A2.1: Stability test for the Phillips curve

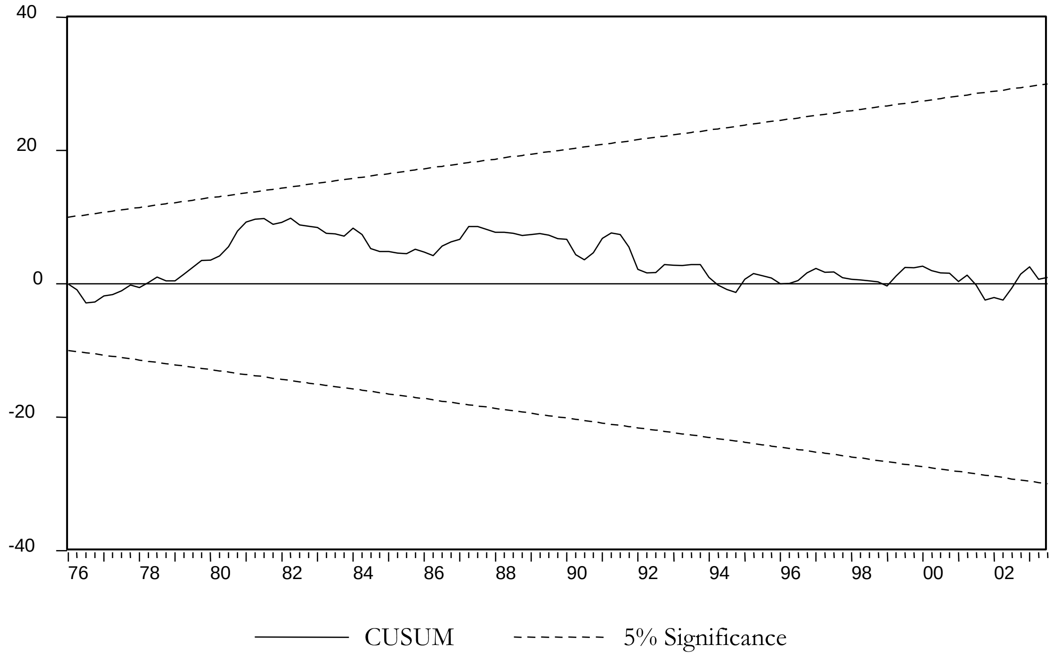
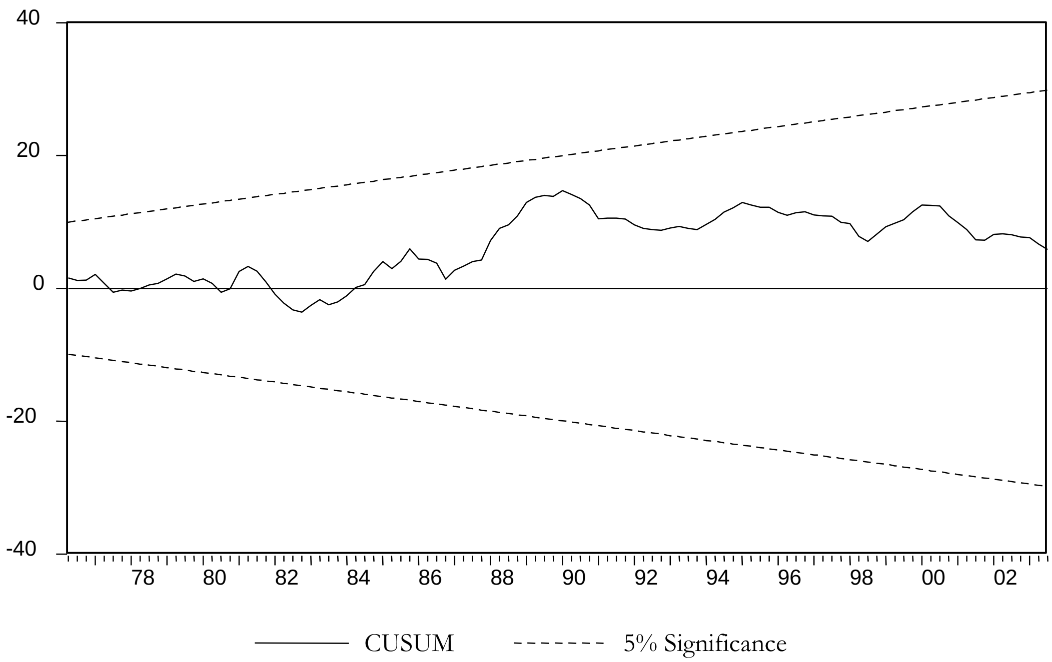


Fig. A2.2: Stability test for the IS curve



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