Should Canadian Monetary Policy Respond to Asset Prices? Evidence from a Structural Model

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Abstract

Although the Bank of Canada admits asset prices are considered in its policy deliberations because of their effects on inflation or output gap, the Bank of Canada denies trying to stabilize asset prices around fundamental values. However, since the start of the Bank of Canada we have seen a boom as well as a bust in the stock market. Are we to believe that the Bank of Canada did not react to these stock market fluctuations, apart from their impact consequences on economy? We investigate this issue by using a structural model based on the New Keynesian framework that is augmented by a stock market variable. We use an econometric method that allows us to distinguish the direct effect of stock prices on Bank of Canada policy rates from indirect effects via inflation or GDP. Our results suggest that stock market stabilization plays a larger role in Bank of Canada interest rate decisions than it is willing to admit. Furthermore, these results should give new relevant insights into the influence of stock market index prices on monetary policy in Canada and should provide relevant insights regarding the opportunities and limitations of incorporating financial indicators in monetary policy decision making. They should give financial market participants, such as analysts, bankers and traders, a better understanding of the impact of stock market index prices on the Bank of Canada policy. The results imply that the preferences of the monetary authority have changed between the different subperiods. In particular, the parameter associated with the implicit target of inflation has been reduced significantly. The findings suggest that the introduction of inflation targeting in Canada was accompanied by a fundamental change in the objectives of monetary policy, not only with respect to the average target, but also in terms of precautions taken to keep inflation in check in the face of uncertainty about the economy.

1 Introduction

The study of Central Bank behaviour has attracted considerable interest in recent years. Attention has focused on two rather different issues. One has to do with whether Taylor's rule (Taylor, 1993) adequately describes Central bank behaviour. However, empirical evidence suggests that actual interest rate policy appears more cautious than might be expected based on Taylor rule specification (e.g., see Clarida etal. 1999; Rudebusch and Svensson, 1999). On other hand, one has the establishment of the appropriate monetary policy response to asset price movements. Should the Central Bank care about the financial instability associated with large asset price fluctuations? This question whether central banks should react to asset prices has regained interest of policymakers and academics after the Japanese asset price bubble in the late 1980s, the new technology stock market boom in the late 1990s, and the recent financial and economic crisis (2007). In fact, the recent financial crisis has shown that the economic consequences of financial instability can be devastating. The pre-crisis consensus that asset prices should only affect monetary policy decisions insofar as they affect inflation or output gap, has come under discussion.

Recent analyses of central bank behaviour begin with a policy objective function and construct policy rule by optimizing the objective function subject to a system of constraints. In fact, central banks set interest rates based on inflation considerations, taking into account growth developments as well. This standard approach to monetary policy implies that stock prices only enter the deliberations of central banks insofar asset prices affect inflation or GDP. An alternative policy approach is that the central bank actively tries to stabilize asset prices around fundamental values or attempts to prick certain asset price bubbles. To contribute to this discussion, we ask whether the basic Taylor rule could instead be augmented with an alternative variable that collects and synthesises the information from the asset and financial markets, i.e. whether central banks are targeting the relevant economic information contained in a group of financial variables and not simply targeting each financial variable.

The role of asset prices is an important issue considered in some studies. However, no consensus was reached about whether the central bank should or not target this kind of variables. Cecchetti et al. (2000), Borio and Lowe (2002), Goodhart and Hofmann (2002), Chadha et al. (2004) and Rotondi and Vaciago (2005) consider important that central banks target asset prices and provide strong support and evidence in that direction. On the contrary, Bernanke and

Gertler (1999, 2001) and Bullard and Schaling (2002) do not agree with an exante control over asset prices. They consider that, once the predictive content of asset prices for inflation has been accounted for, monetary authorities should not respond to movements in assets prices. Instead, central banks should act only if it is expected that they affect inflation forecast or after the burst of a financial bubble in order to avoid damages to the real economy. Morever, Driffill et al. (2006) analyse the interactions between monetary policy and the futures market in the context of a linear reaction function. They find evidence supporting the inclusion of futures prices in the central bank's reaction function as a proxy for financial stability. The issue of financial stability is also investigated by Montagnoli and Napolitano (2005). They build and use a financial conditional indicator that includes the exchange rate, share prices and housing prices in the estimation of a Taylor rule for some central banks. Their results show that this indicator can be helpful in modelling the conduct of monetary policy.

To empirically analyze the role of asset prices, these authors used either the standard Taylor rule or augmented Taylor rule, which describes how the central bank adjusts interest rates in response to inflation, the output gap, and stock prices. The use of this Taylor rule to draw inferences about the behaviour of the central bank is not without criticism (Judd and Rudebusch, 1998; Dennis, 2006). An important issue concerns the interpretation of the Taylor rule. A Reaction policy rule may be observed, following Sevensson (1997), as the result of an optimization of an intertemporal loss function subject to two equations describing the structure of the economy. In general, the arguments of the loss function are the gap between expected and target inflation, and the output gap. The important issue in this context is that the parameters of the reaction function rule are convolutions of the original parameters associated to the preferences of the central bank and the structure of the economy.

In light of the above problem Dennis (2006) advocates modelling the Fed's behaviour by specifying its objective function and then deriving its optimal interest rate rule, conditional on a particular model for the US economy. The Fed's interest rate rule can be estimated jointly with the structural model, imposing any cross-equation restrictions. This approach allows the Fed's preference parameters to be identified and to examine whether they actually change over time. Dennis uses the structural approach to examine if there has been a change in Fed preferences. He considers two sub-periods (1961:1 to 1979:3) and (1982:1 to 2000:2) The central bank is assumed to have a quadratic loss function characterized by three parameters: an inflation target (π^*) ; a weight on output gap stabilization (λ) and a weight on interest rate stabilization (μ). Favero and Rovelli (2003) also use the structural framework to examine the Fed preferences. However, rather than solving for the optimal interest rate rule, Favero and Rovelli use the Fed's first-order condition - its Euler equation- along with a structural model of the economy, to estimate Fed preferences. They argue that estimate an interest rate rule in a single equation specification is not a good advise, except if the researcher is only interested in the behaviour of the coefficient associated to the gap between expected and inflation target. Following this recommendation, Rodriguez (2008) estimated in case of Canada a three equations system, allowing for the possibility to retrieve the structural parameters associated to the preferences of the monetary authority and the structure of the economy.

Considering these developments, our contribution is simply to estimate a reaction function rule for the Canada, where the information from some financial variables is accounted for to shed some more light on its importance. In this paper we adopt the basic approach recommended by Favero and Rovelli (2003) in modelling the behaviour of the Bank of Canada for the period 1961:1 to 2008:4. In others words, to estimate a Taylor rule augmented, this paper considers a system of equations that takes into account not only the structure of the economy and the parameters of the central bank loss function but also a stock market variable. We approximate the preferences of the Bank of Canada with a quadratic loss function. We assume that the Bank of Canada only cares not only about deviations of inflation around some target, in deviations in the output gap and smoothing the nominal interest rate but also consider a loss function which take into account the fluctuations of asset prices. The mains difference between our analysis and the previous work lies with the structure of our model for the Canadian economy. In their studies both Dennis, Favero and Rovelli and Rodriguez use a purely backward-looking model of economy (aggregate demand and supply) without effect of stock prices. In contrast our model of economy contains three equations (aggregate demand, supply and dynamic equation of asset price). In seeking to estimate the Bank of Canada's preferences (and other structural parameters) we follow Favero and Rovelli and work with the Euler equation for optimal policy, the aggregate demand curve, the Phillips curve and dynamic Euler equation of asset price.

This paper proceeds as follows. Section 2 presents the model. The empirical results are presented and discussed in section 3. Section 4 offers the main findings of this paper and concludes.

2 The Model: Structural Estimates of Central Bank Preferences

We use a structural backward-looking model of a closed economy that allows for the effect of asset prices on aggregate demand. The model augments the standard Ball (1999) and Svensson (1997) specification by taking into account asset prices. Aggregate supply is the result of firms that set the prices for their products so as to maximize profits in a monopolistic competition setting. The setup of the New-Keynesian model in this study is rather standard and follows largely well-known expositions such as McCallum and Nelson (1999) and is similar, e.g., to Giordani (2004), Muscatelli, Tirelli, and Trecroci (2004), Svensson (2000), Leitemo, Roisland, and Torvik (2002), Jensen (2002), Moons et al. (2007) and others.

2.1 The Structure of the Economy

Following standard assumptions in the New-Keynesian literature [see among others Gali and Gertler (1999); Gali, Gertler and Lopez-Salido (2005); Moons, C. et al. (2007)], we assume the following specifications for aggregate demand :

$$x_{t+1} = \eta_1 x_t - \eta_2 (i_t - \pi_{t+1}) + \eta_3 s_t + \varepsilon^x_{t+1} \tag{1.1}$$

where x denotes the output gap, i the short-term nominal interest rate, π the inflation rate, s the stock market price index (asset prices) and ε^x is an aggregate demand shock. All variables are in logarithms and refer to deviations from an initial steady state. The structural parameters can be interpreted as partial elasticities. Equation (1.1) is consistent with the specification employed by Walsh (1998), Ball (1999), and Svensson (1997) with one important difference: aggregate demand depends positively on the past level of asset prices via consumption wealth effects and investment balance sheet effects. For example, a persistent decrease in the level of stock prices increases the perceived level of households' financial distress causing a reduction in consumption spending. The balance sheet channel implies a positive relationship between the firms' ability to borrow and their net worth, which in turn depends on asset valuations. There is a vast amount of empirical evidence indicating that asset price movements are strongly correlated with aggregate demand in most major economies[1]. In our model, the central bank takes into account the effect of wealth on aggregate demand, that is, it is fully aware of the effect of s_{t-1} on x_t and

[1] See among others, Kontonikas and Montagnoli (2005) for relevant empirical evidence considering the UK economy, and Goodhart and Hofmann (2000) for international evidence. A recent study by the IMF (2003) points out that equity price reductions are associated with heavy GDP losses.

its magnitude. Futhermore, parameter η_3 in the aggregate demand equation is of crucial interest since it indicates the magnitude of the effects of asset price movements on output. If there are no wealth effects/balance sheet effects then $\eta_3 = 0$ and Eq. (1.1) resembles a traditional dynamic IS curve.

The specification of aggregate supply is given by:

$$\pi_{t+1} = \phi x_t + \theta \pi_t + \varepsilon^{\pi}_{t+1} \tag{1.2}$$

where the supply shock ε^{π} may be interpreted as a shift of the degree of substituability between inputs in the production of final goods, or an exogenous cost push shocks. Equation (1.2) is a backward-looking NAIRU type Phillips Curve where the change in inflation is a positive function of the lagged output gap and the inflation shock. Such a specification has also been adopted by Ball (1999), Svensson (1997) and Rudesbusch and Svensson (1999). The presence of inflation inertia in the inflation equation implies that disinflations will be costly in terms of output losses, thus there is a short-run trade-off between inflation and output. However, since lagged inflation enters equation (1.2) with unity coefficient, the model implies a vertical long-run Phillips curve. This process is also consistent with the empirical finding that inflation in the major industrialised countries is so highly persistent that it may indeed contain a unit root as some studies have shown (see e.g. Grier and Perry, 1998). Equation (1.2) posits no role for expected future inflation in the inflation adjustment equation. The parameter ϕ is a positive constant which measures the sensitivity of inflation to excess demand[2].

In empirical applications, more lags of output and asset prices (in the case of the IS curve) and output and inflation (for the Phillips curve) are often included to improve the empirical fit. Adding these lags will also induce a more persistent and therefore more realistic adjustment to shocks. In empirical studies and monetary policy analysis sometimes concepts of equilibrium and/or core inflation are added to (1.2), to distinguish short-run fluctuations of inflation from longer term, equilibrium inflation. In our analysis this issue is not dealt with and inflation (as all other variables) is defined in terms of deviations from (possibly non-zero inflation) steady-state (see Vega and Wynne, 2003).

Following the current monetary policy analysis framework, one possible shortcoming of equa-

[2] As Clark, Goodhart, and Huang (1999) point out, there are good reasons to believe that a is not constant. However, the assumption of linearity in the Phillips curve helps to obtain a closed-form solution for the optimal feedback rule.

tions (1.1) and (1.2) is their relevance in the context of open economies, where international trade is an important part of the economic activity and therefore, the exchange rate should be considered as a significant argument in policy function of open economies. However, using modified versions of equations (1.1) and (1.2), Ball (1999) does not find important changes in the interest rate movements for open and closed economies. On the other hand, using a forward-looking perspective, Svensson (2000) finds varied benefits of including the exchange rates in the monetary rule in comparison with the original Taylor rule. In a similar way, Taylor (2001) finds weak evidence for the exchange rate channel. Clarida et al. (1998, 2000) attempt to re-specify Taylor-type rules for small economies using foreign variables. For the cases of Japan and Germany, they use the US interest rate and the exchange rates in the interest rate rule and the results show that the coefficients may be small and significant but in some cases, as for Germany, the inflation coefficient is negative. Taylor (2001) suggests that the inclusion of the exchange rate is not crucial for the monetary policy rule. As Rodriguez (2008), we consider the role of the exchange rate explicitly in the empirical part in the Phillips curve. Futhermore, the role of asset prices in the conduct of monetary policy has been recently controversial among economists and central bankers. In fact, taking into account asset prices could be justified by the increasing importance of securities in the financial wealth of households and the high volatility of stock prices in recent years. Unanticipated movement of asset prices may affect the forecasts of the central bank (Bernanke and Gertler 1999, Smets, 1997) because changes in asset prices can have a direct impact on aggregate demand for goods. From the point of view of the household's hand, changes in stock prices and real estate prices may affect expenditures on private consumption . They can influence saving decisions and modify the capacity of households to borrow and spend. On the firm's side, changes in stock prices and real estate prices can the ability of companies to raise funds on the stock market or to borrow from banks. We add, in this study, a stock market variable to analyze whether asset prices have an impact on the interest rate policy of the Bank of Canada. Asset price changes also impact on real economic activity and, therefore, influence the output gap variable. Following Kontonikas and Montagnoli (2005) and Nisticò (2006), an asset price equation is given by:

$$s_t = \gamma_1 E x_{t+1} - \gamma_2 (i_t - E\pi_{t+1}) + \gamma_3 \Delta s_{t-1} + \varepsilon_t^s \tag{1.3}$$

where ε^s represents exogenous random shocks to asset prices. It can be interpreted as a shock to the equilibrium real stock price value. Equation (1.3) can be separated into an asset price non-fundamental component and the fundamentals, where the asset price is fundamentals plus variations of previous asset prices. Moreover equation (1.3) represents the Euler equation displaying the dynamic evolution of asset prices and their underlying fundamentals. We assume a partial adjustment mechanism of actual asset prices towards their fundamental value that allows for the appearance of a bubble buildup. As equation (1.3) indicates, if asset prices have increased in the past ($\Delta s_{t-1} > 0$) there is a positive 'momentum' effect on their current level ($\gamma_3 > 0$). In essence, investors bid up the demand for asset holdings in the expectation that past capital gains will persist in the future. The higher the value of γ_3 the stronger the effect from past asset price changes, therefore s_t can diverge significantly from its fundamental value. But once asset prices revert, at an unknown future date, the downward effect on aggregate demand could be large. Stability of the asset price path requires that the parameter γ_3 satisfies: $0 \leq \gamma_3 < 1$. Note that $\gamma_1, \gamma_2 > 0$.

2.2 The Policy Objective Function

Following standard assumptions in the empirical literature of monetary policy, the policymaker's preferences are modeled as an intertemporal loss function in which, at each period, the loss function depends on both inflation and output in relation to their target values, as well as the smoothing interest rate and other potential variables (e.g., asset prices). Future values are discounted at rate β, and the weights λ, μ, and δ are nonnegative. As usual, we assume that monetary policy is conducted by a central bank that chooses the sequence of short-term nominal interest rates in order to minimize the present discounted value of its loss function. Rather than assuming a quadratic form as is usual in the literature (see Svensson, 1997; Favero and Rovelli, 2003 and Rodriguez, 2008), we use a more general specification of the monetary authorities objectives.

$$Loss = E_t \sum_{\zeta=0}^{\infty} \beta^{\zeta} \left[\left(\pi_{t+\zeta} - \pi^*\right)^2 + \lambda \widehat{x}_{t+\zeta}^2 + \mu \left(i_{t+\zeta} - i_{t+\zeta-1}\right)^2 + \delta s_{t+\zeta}^2 \right] \tag{1.4}$$

In summary, the intertemporal optimization problem is then to minimize (1.12) subject to the restrictions (1.9), (1.10) and (1.11). The problem is, then,

$$\underset{i_t}{Min}\ E_t \sum_{\zeta=0}^{\infty} \beta^{\zeta} \left[\left(\pi_{t+\zeta} - \pi^*\right)^2 + \lambda \widehat{x}_{t+\zeta}^2 + \mu \left(i_{t+\zeta} - i_{t+\zeta-1}\right)^2 + \delta s_{t+\zeta}^2 \right] \tag{1.5}$$

$$
\begin{aligned}
\text{subject to } x_t &= \eta x_{t-1} - \alpha(i_t - \pi_{t+1}) + \tau s_t + \varepsilon_t^{ad} \\
\pi_t &= \phi x_t + \theta \pi_{t+1} + \varepsilon_t^{as} \\
s_t &= a x_{t+1} + b\left(s_{t-1} - s_{t-2}\right) - c\left(i_t - \pi_{t+1}\right) + \varepsilon_t^{s}
\end{aligned}
$$

After finding the first-order conditions for optimality and after some manipulations, it is possible to obtain an interest rate rule. The parameters of this monetary rule are convolutions of the coefficients associated with the restictions under which the loss function has been intertemporally optimized; that is they are convolutions of the parameters associated with the preferences of the central bank (λ, μ, δ, π^*) and the structure of the economy ($\eta, \phi, \theta, \alpha, \tau, a, b, c$).

Adopting the method of Optimal Control to solve this problem (see Chiang, 1992), we calculate the first-order conditions for the minimization of the loss function, which leads to the following Euler equation:

$$
0 = \left[\begin{array}{c} E_t \sum_{\zeta=0}^{\infty} \beta^{\zeta} \left[\left(\pi_{t+\zeta} - \pi^*\right) \frac{\partial \pi_{t+\zeta}}{\partial i_t} \right] + E_t \sum_{\zeta=0}^{\infty} \beta^{\zeta} \lambda \left[\left(x_{t+\zeta}\right) \frac{\partial x_{t+\zeta}}{\partial i_t} \right] \\ + E_t \sum_{\zeta=0}^{\infty} \beta^{\zeta} \delta \left[\left(s_{t+\zeta}\right) \frac{\partial s_{t+\zeta}}{\partial i_t} \right] + \left[\mu\left(i_t - i_{t-1}\right) - \mu\beta E_t\left(i_{t+1} - i_t\right)\right] \end{array} \right] \tag{1.6}
$$

Because of the persistence in the structural equations of the economy, the Euler equation has an infinite horizon, and thus cannot be used directly in empirical work. To estimate this equation it is necessary to truncate its lead polynomials at some reasonable temporal horizon. As Favero and Rovelli (2003), we use a 4 quarters lead horizon. Two reasons stand in favour of the lead truncation of the Euler equation: First, as Favero and Rovelli (2003) have argued, a natural cutting point for the future horizon of the Euler equation emerges anyway, even if we consider a theoretical infinite horizon loss function. In fact, the weight attached to expectations of future gaps and inflation decreases as the time-lead increases, meaning that expectations of the state of the economy carry less relevant information for the present conduct of policy as they relate to periods further away in the future. Second, expanding the horizon in the Euler equation would complicate it and bring collinearities to the system, causing great difficulties in making estimations. It is worth noting that our option is consistent with the standard practice in the estimation of forward-looking policy reaction functions. Boivin and Giannoni (2003) truncate the forecast horizon at 1 quarter for output and 2 quarters for inflation, while Muscatelli et al. (2002), and Orphanides (2001 b) truncate the inflation forecast horizon at 4 quarters. Rodriguez (2008) shows that estimated backward-looking policy reaction functions for US and Canada, strongly indicate that actual policy decisions involve forecast horizons of inflation not beyond 4 quarters ahead.

Once the Euler equation is truncated at 4 quarters ahead, its partial derivatives components can be expressed as functions of the aggregate demand and aggregate supply parameters, thus building into the Euler equation the cross-equation restrictions. This ensures that the loss function is being properly minimized subject to the constraints given by the economy's structure.

$$0=\left[\begin{array}{c} E_t\sum_{\zeta=0}^{4}\beta^{\zeta}\left[\left(\pi_{t+\zeta}-\pi^*\right)\frac{\partial\pi_{t+\zeta}}{\partial i_t}\right]+E_t\sum_{\zeta=0}^{4}\beta^{\zeta}\lambda\left[\left(x_{t+\zeta}\right)\frac{\partial x_{t+\zeta}}{\partial i_t}\right] \\ +E_t\sum_{\zeta=0}^{\infty}\beta^{\zeta}\delta\left[\left(s_{t+\zeta}\right)\frac{\partial s_{t+\zeta}}{\partial i_t}\right]+\left[\mu\left(i_t-i_{t-1}\right)-\mu\beta E_t\left(i_{t+1}-i_t\right)\right] \end{array}\right] \tag{1.7}$$

Expanding the partial derivatives, (1.6) turns into

$$0=\left[\begin{array}{c} \beta E_t\left(\pi_{t+2}-\pi^*\right)\left[\frac{\partial\pi_{t+2}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right]+\beta^2E_t\left(\pi_{t+3}-\pi^*\right)\left[\frac{\partial\pi_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right] \\ +\beta^3E_t\left(\pi_{t+4}-\pi^*\right)\left[\frac{\partial\pi_{t+4}}{\partial x_{t+3}}\left(\frac{\partial x_{t+3}}{\partial i_t}+\frac{\partial x_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right)+\frac{\partial\pi_{t+4}}{\partial\pi_{t+3}}\left(\frac{\partial\pi_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right)\right] \\ +\lambda\beta E_t\left(x_{t+2}\right)\left[\frac{\partial x_{t+2}}{\partial i_t}+\frac{\partial x_{t+2}}{\partial s_{t+2}}\times\frac{\partial s_{t+2}}{\partial i_t}\right]+\lambda\beta^2E_t\left(x_{t+3}\right) \\ \left[\frac{\partial x_{t+3}}{\partial i_t}+\frac{\partial x_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}+\frac{\partial x_{t+3}}{\partial s_{t+2}}\times\frac{\partial s_{t+2}}{\partial i_t}\right]+\lambda\beta^3E_t\left(x_{t+4}\right) \\ \left[\frac{\partial x_{t+4}}{\partial x_{t+3}}\left(\frac{\partial x_{t+3}}{\partial i_t}+\frac{\partial x_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right)+\frac{\partial x_{t+4}}{\partial s_{t+3}}\left(\frac{\partial s_{t+3}}{\partial i_t}+\frac{\partial s_{t+3}}{\partial s_{t+2}}\times\frac{\partial s_{t+2}}{\partial i_t}\right)\right] \\ +\delta\beta E_t\left(s_{t+2}\right)\left[\frac{\partial s_{t+2}}{\partial i_t}+\frac{\partial s_{t+2}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right]+\delta\beta^2E_t\left(s_{t+3}\right) \\ \left[\frac{\partial s_{t+3}}{\partial i_t}+\frac{\partial s_{t+3}}{\partial s_{t+2}}\times\frac{\partial s_{t+2}}{\partial i_t}+\frac{\partial s_{t+3}}{\partial x_{t+3}}\times\frac{\partial x_{t+3}}{\partial x_{t+2}}\times\frac{\partial x_{t+2}}{\partial i_t}\right]+\delta\beta^3E_t\left(s_{t+4}\right) \\ \left[\frac{\partial s_{t+4}}{\partial s_{t+3}}\left(\frac{\partial s_{t+3}}{\partial i_t}+\frac{\partial s_{t+3}}{\partial s_{t+2}}\times\frac{\partial s_{t+2}}{\partial i_t}\right)+\frac{\partial s_{t+4}}{\partial x_{t+4}}\left(\frac{\partial s_{t+4}}{\partial x_{t+4}}\left(\frac{\partial x_{t+4}}{\partial x_{t+3}}\times\frac{\partial x_{t+3}}{\partial i_t}\right)\right)\right] \\ +\left[\mu\left(i_t-i_{t-1}\right)-\mu\beta E_t\left(i_{t+1}-i_t\right)\right] \end{array}\right] \tag{1.8}$$

Then, the IS curve equation, Phillips curve equation and Euler equation can be jointly estimated as a system, generating estimates of the structural parameters c_1 through c_{14}, as well as of the policymakers structural preferences parameters λ, μ, δ, π^*:

$$\begin{aligned} x_{t+1} &= c_1+c_2x_t+c_3x_{t-1}+c_4\left(i_{t-1}-\pi_{t-1}\right)+c_5\left(i_{t-2}-\pi_{t-2}\right)+c_6s_t+\varepsilon_{t+1}^{ad} \qquad (1.9) \\ \pi_{t+1} &= c_7\pi_t+c_8\pi_{t-1}+c_9x_t+c_{10}\triangle w_t+\varepsilon_{t+1}^{as} \\ s_{t+1} &= c_{11}x_{t+1}+c_{12}\left(i_{t-1}-\pi_{t-1}\right)+c_{13}\left(i_{t-2}-\pi_{t-2}\right)+c_{14}\left(s_t+s_{t-1}\right)+\varepsilon_{t+1}^{s} \end{aligned}$$

We rearranged Equation (1.7) and substituted derivatives with coefficients from equation (1.8) to obtain

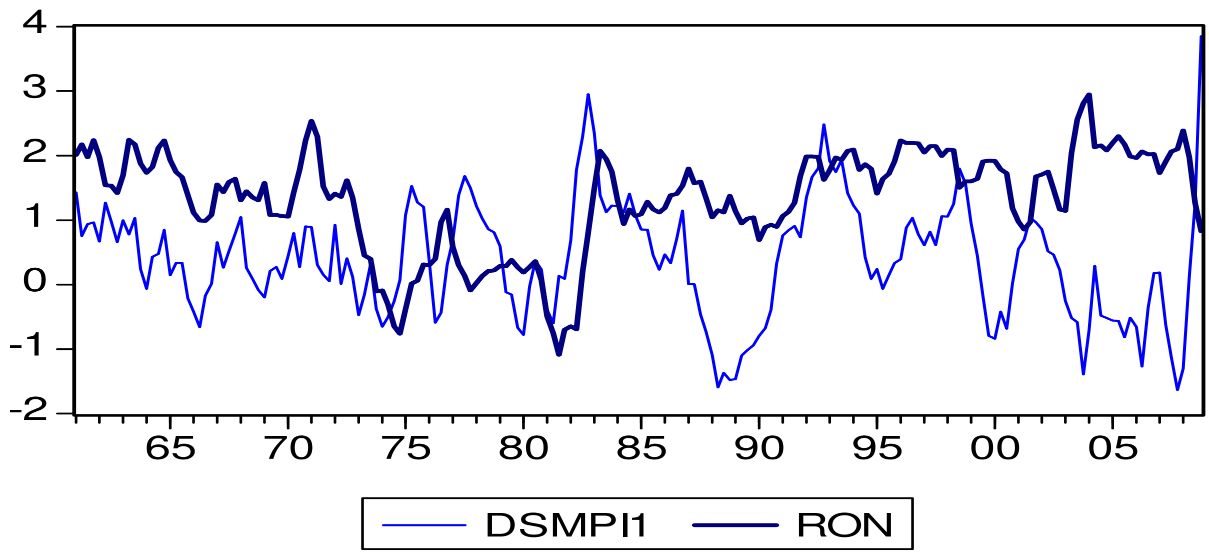
$$
0 = \left[\begin{array}{c}
\left[\mu\left(i_t - i_{t-1}\right) - \mu\beta E_t\left(i_{t+1} - i_t\right)\right] + \beta^2 E_t\left(\pi_{t+3} - \pi^*\right)\left[c_9 c_4\right] \\
+\beta^3 E_t\left(\pi_{t+4} - \pi^*\right)\left[c_9\left(c_5 + c_2 c_4\right) + c_7 c_9 c_4\right] \\
+\lambda\beta E_t\left(x_{t+2}\right)\left[c_4\right] + \lambda\beta^2 E_t\left(x_{t+3}\right)\left[c_5 + c_2 c_4 + c_{12} c_6\right] \\
+\lambda\beta^3 E_t\left(x_{t+4}\right)\left[c_2\left(c_5 + c_2 c_4\right) + c_6\left(c_{12} + c_{12} c_{14}\right)\right] \\
+\delta\beta E_t\left(s_{t+2}\right)\left[c_{12} + c_4 c_{11}\right] + \delta\beta^2 E_t\left(s_{t+3}\right)\left[c_{13} + c_{12} c_{14} + c_{11} c_2 c_4\right] \\
+\delta\beta^3 E_t\left(s_{t+4}\right)\left[c_{14}\left(c_{13} + c_{12} c_{14}\right) + c_5 c_9 c_{11}\right]
\end{array} \right] \tag{1.10}
$$

Following Favero et Rovelli (2003), the parameters of the structural equations and the loss function are estimated jointly from a system formed by system (1.8) and the Euler equation (1.9). As we want to obtain the preferences implied by the coefficients from the threshold regression model, the dependent variable in the interest rate is the fitted interest rates from the threshold regression model including the lagged interest rates. Furthermore, to cover the different types of asymmetry in the policymaker's preferences identified in the literature, estimation is carried out sequentially allowing each of the loss function weights λ, μ and δ to vary with the state of the corresponding target variable, and then concludes with a joint test. Statistical inference is based on individual significance tests and Wald tests.

2.3 The Data Set

The estimation is conducted on quarterly data for the Canadian economy, obtained from Statistics Canada and the Bank of Canada, that spans the period from 1961:Q1 to 2008:Q4. Several different methods have been proposed to measure the output gap (see Rodriguez, 2008). Our aim is not to ascertain the way that real output evolves over the long-run. Instead, the goal is to obtain a reasonable measure of the pressure felt by the Bank of Canada to use monetary policy to affect the level of output. Potential output is obtained from the Hodrick-Prescott (HP) trend of the Canadian real GDP. The output gap is then constructed as the percentage difference between the logarithm of real GDP and its HP trend. We also consider a second measure of the output gap construct by quadratic trend approach. Annual inflation is measured as $100 \times (p_t - p_{t-4})$, where p_t denotes logarithms of the Consumer Price Index (CPI). The nominal interest rate is the annual percentage yield on 3-month Treasury bills. Financial variables represent another group of variables that have been recently considered in the specification of the Taylor rule for the analysis of the behaviour of the Central Bank. In this paper, we consider the effects of S&P/TSX. In fact, the S&P/TSX composite index is an index of the stock prices of the largest companies on the Toronto Stock Exchange as measured by market capitalization. We choose this index because TSX listed companies in this index comprise about 70% of the market capitalization for all Canadian based companies listed on the TSX, thus it is the best financial index which contains the information that can help the Bank of Canada when making policy decisions.

To gain insight into the relatively history of monetary policy carried out by the Bank of Canada, we take a look at stock prices (DSMPI1), interest rates (RON) in the Canada since 1961. The evolution of stock prices and interest rates during the period cover our study is shown in figure 1. We show the stock prices level in deviation from its average over the sample period, to get an idea of the size of peaks and troughs. The stock market peaked in 1983 with 2.9 points deviations from the sample average and reached its trough in the end of 2007 with -1.8 points deviation from average. Thus a boom as well as a bust in stock prices occurred. Volatility in stock prices was considerable during the period of this research. The question is how did the Bank of Canada respond to these stock price fluctuations? Figue 1 also shows the interest rates in the Bank of Canada that are effectively targeted by Bank of Canada. The interest rate moves closely around the refinancing rate (overnight rate), which is the policy rate of the Bank of Canada. It is apparent that the central bank raised interest rates in the beginning of 1981, while interest rates decreased from the end of 2004 until 2008. This implies that monetary policy was tightened during the stock market boom while it was eased afterwards. This behaviour of the Bank of Canada is consistent with the alternative policy approach that includes stabilizing stock prices.



Stock prices and interest rates

The literature on monetary rules has suggested an estimation by subsamples, where the break point is considered exogenous. In a recent paper, Rodríguez (2004) has estimated interest rate rules for Canada and the US using endogenous break points selected by the approach suggested by Bai and Perron (1998, 2003). In general, his results show that the selected break dates are consistent with what previous research has used for the US. Since in our paper we have a system of three equations, while the Bai and Perron's approach is adequate for single equations, the adequacy or possible modification of the approach to the system case is beyond the scope of this empirical paper. Unlike Rodriguez (2008), we decided to use one break date selected for Canada (1991:1). Note that an explicit inflation target has been announced by the Canadian government since 1991:1. The breakdown of the sample into two subperiods is meant to capture potential differences in the reaction function between the first period, in which there was no explicit target, and the second one which was characterized by an explicitly announced inflation target. For the whole sample period, as well as for both subperiods, the implicit inflation target is estimated along with the other parameters.

3 Empirical Evidence and implications

3.1 The statistical validity of the model

The descriptive statistics are presented in table (1.1) of the appendix. In short, data vary enough so that one can apprehend relevant correlations between the dependent variable and explanatory variables. Moreover the matrix of correlations between explanatory variables (Table (1.2) of the appendix) suggests that the inclusion of all these variables in the same model poses no problem of multicollinearity. Indeed, coefficients of correlation appear quite low on the whole.

Knowledge of the integrational properties of the variables is important for the specifications of the econometric model. Given the implications for econometric modelling, we formally test for unit roots, a necessary conditions for the use of the approach of Caner and Hansen (2004). In order to investigate the stationarity of each time series that we are considering in this study, many tests exist. Apart from the conventional augmented Dickey and Fuller (1979, 1981) there is the nonparametric test proposed by Phillips and Perron (PP) test (1988), the ADF statistic based on the Generalized Least Squares detrending procedure proposed by Elliott, Rothenberg and Stock (1996), and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test (1992). In contrast with previous studies, we decide to run ADF and KPSS tests.

Since considerable evidence exists that data-dependent methods to select the value of k are superior to choosing a fixed k a priori, we follow the recursive t-statistic procedure suggested by Campbell and Perron (1991) and Ng and Perron (1995). Starting from a maximal order of k (say $kmax$), the method tests if the last lag included is significant, and if not, the order of the autoregression is decreased by one and the coefficient of the last lag is again examined. This is repeated until a rejection occurs or the lower bound 0 is reached. In our case, we use a sequential procedure suggested by Perron (1989). So we consider our $k\max = integer\left(12\frac{T}{100}\right)^{\frac{1}{4}}$.

It is well known that ADF tests have low power with short time spans of data, and so we also use the KPSS test developed by Kwiatkowski et al. (1992). Unlike the ADF and PP tests, the KPSS test has stationarity as the null hypothesis and a unit root as the alternative hypothesis. As with the ADF and PP tests, the version of the KPSS test used here allows for drift but not trend.

The results of the ADF, PP and KPSS tests for the variables, reported in Table 1.1 provide evidence against the unit root hypothesis. For all the variables, we estimated the ADF, PP and KPSS tests using only an intercept. With the ADF and PP tests, the unit root null can be rejected at least at the 10% level for all variables. With the KPSS test, we cannot reject the null hypothesis of stationarity for the output, the stock market price index and the exchange rate at the 1% level, for the inflation rate, and the nominal interest rate at 10% and 5% respectively. These findings are consistent with the work of other researchers, and constitute a benchmark consistent with a unit root in the variables.

Table 1.1: Unit root and stationarity tests

	ADF		PP		KPSS	
	Test	P-value	Test	P-value	Test	Level
Interest rate	-1.814	0.373	-2.066	0.259	0.414	10%
Inflation rate	-2.032	0.273	-1.919	0.323	0.492	5%
Output gap	0.787	0.994	1.119	0.998	1.668	1%
Exchange rate	-1.977	0.297	-1.870	0.346	0.966	1%
Stock Market Index	-0.814	0.813	-0.815	0.812	1.678	1%
1% critical value	-3.465		-3.465		0.739	
5% critical value	-2.877		-2.877		0.463	
10% critical value	-2.575		-2.575		0.347	

3.2 Estimates: Derivation of the preference parameters

Equation (1.10) is jointly estimated with the system (1.9), generating estimates of the coefficients describing the monetary policy regime -μ, λ, δ and π^*- as well as of the aggregate demand, the aggregate supply and the dynamic evolution of the stock market prices coefficients. To estimate our model specifications for the Canada, we use the GMM procedure. The latter appears highly adequate for our purposes because at the time of its interest rate setting decision, the central banks cannot observe the ex-post realized right hand side variables. That is why the central banks have to base their decisions on lagged values only (Belke/Polleit 2007). We decided to use the first eight lags of inflation, the output gap and the stock prices and - whenever it is added to the regression equation - the first eight lags of the additional variable as instruments. Moreover, we perform a J-test to test for the validity of over-identifying restrictions to check for the appropriateness of our selected set of instruments. As the relevant weighting matrix we choose, as usual, the heteroskedasticity and autocorrelation consistent HAC matrix by Newey and West (1987). For comparison, in each estimation table, we include the estimation using the total sample. The discount factor β is set to 0.975 for quarterly data, as is common in the literature (see Dennis, 2001; Favero and Rovelli, 2003; Rodriguez, 2008)[3]. Notice that the sample size constraints the number of instruments used in these cases and the estimates obtained are the best considering these restictions.

Table 1.2 summarizes the results of estimation. Firstly, the change observed in the value of π^* among subperiods reflects a successful monetary policy. The inflation target varies between 4.95% and 2.02%. On the other hand, the value of the coefficient μ indicates an increase in the smoothing of interest rate between the pre-inflation targeting period (1961:1-1990:4) and the targeting inflation period. The value of λ implies a significant decrease between the subperiods. The value of δ indicates a significant reduction of the weight assigned to the financial market in the conduct of monetary policy for the second subperiod. This means that the central bank uses an indirect mechanism, that of aggregate demand, to take into account the stock market in its decision making. Moreover, the standard deviations of aggregate demand and supply suggest that the economic conditions related to aggregate demand have been favourable in comparison with those related to aggregate supply in pre-inflation targeting period. In contrast, under inflation

[3]Estimating β together with the model parameters leads to a slightly lower value between 0.94 and 0.96 without changing the results. This accords with Favero and Rovelli (2003) who also found that qualitative results are not sensitive to variations in the discount factor.

targeting period, we observed reverse situation. The standard deviations of the monetary rules indicates that monetary policy has been more successful in the inflation targeting period. In particular, observing this parameter, it seems that the pre-inflation targeting period has been characterized by a bad conduct of monetary policy. Better macroeconomic conditions are observed from the side of aggregate demand in comparison with those from aggregate supply in the case of full sample and pre-inflation targeting period. The reverse situation is observed when the inflation targeting period. The empirical evidence suggests, without any doubt, that monetary policy has been conducted efficiently in the last subperiod.

The intuition and policy implications become clearer if aggregate demand is affected by the evolution of asset prices; then the monetary authorities should include asset price fluctuations in their optimal feedback rule and there should be a change in the distribution of the relevant interest rate weights. This allows for asset prices to be considered as an element of the authorities' reaction function without necessarily implying, overall tighter than before, policy since the response to inflation and output will be less aggressive. In other words, our results imply that first, asset prices should have an independent role instead of being considered as instruments to help forecast output and inflation; and second, there should be a shift in the magnitude of reaction, away from the traditional variables (inflation, output gap) and towards a direct response to financial instability.

Despite the highly stylized structure of the model, the results reveal several practical monetary policy lessons. First, a monetary authority should generally respond to asset prices as long as asset prices contain reliable information about inflation and output. Second, this finding holds even if a monetary authority cannot distinguish between fundamental and bubble asset price behavior. Third, a monetary authority's desire to respond to asset prices falls dramatically as its preference to smooth interest rates rises. Finally, a monetary authority should not respond to asset prices if there is considerable uncertainty about the macroeconomic role of asset prices.

Table 1.2: Estimates of the preferences of monetary policy

	No Breaks		Two subperiods			
	1961:1-2008:4		1961:1-1990:4		1991:2-2008:4	
	Coefficient		Coefficient		Coefficient	
c_1	0.025^a	(0.008)	0.101^a	(0.013)	-0.074^a	(0.015)
c_2	1.081^a	(0.008)	0.911^a	(0.009)	1.417^a	(0.029)
c_3	-0.261^a	(0.007)	-0.189^a	(0.006)	-0.568^a	(0.028)
c_4	0.026^a	(0.001)	0.059^a	(0.002)	0.034^a	(0.004)
c_5	-0.044^a	(0.003)	-0.071^a	(0.004)	-0.010^c	(0.005)
c_6	0.026^a	(0.009)	0.128^a	(0.018)	0.033^c	(0.018)
c_7	1.133^a	(0.011)	1.175^a	(0.008)	1.069^a	(0.017)
c_8	-0.143^a	(0.011)	-0.180^a	(0.009)	-0.148^a	(0.019)
c_9	0.166^a	(0.004)	0.127^a	(0.003)	0.152^a	(0.009)
c_{10}	0.009^a	(0.001)	0.011^a	(0.001)	0.011^a	(0.002)
c_{11}	-01.07^a	(0.004)	-0.100^a	(0.003)	-0.446^a	(0.012)
c_{12}	0.026^a	(0.002)	0.042^a	(0.0.001)	0.084^a	(0.008)
c_{13}	0.049^a	(0.002)	0.064^a	(0.001)	-0.008	(0.008)
c_{14}	0.783^a	(0.005)	0.749^a	(0.006)	0.427^a	(0.017)
β	0.9750^e		0.9750^e		0.9750^e	
π^*	4.029^a	(0.007)	4.946^a	(0.047)	2.019^a	(0.021)
μ	0.024^a	(0.010)	0.017^b	(0.009)	0.051^c	(0.015)
λ	0.015^a	(0.001)	0.029^a	(0.001)	0.002^a	(0.001)
δ	0.336^a	(0.050)	0.664^a	(0.042)	0.236^a	(0.046)
$\sigma\left(u^d\right)$	0.719		0.839		0.378	
$\sigma\left(u^o\right)$	0.641		0.603		0.652	
$\sigma\left(u^s\right)$	0.433		0.370		0.632	
$\sigma\left(u^m\right)$	0.067		0.098		0.022	
J-Statistic	25.001		14.446		9.439	

^{a,b,c} denotes significance levels at 1%, 5.0% and 10%, respectively. ^{e} indicates that the coefficient has been imposed in the estimation. Standard errors robust to serial correlation (up to 6 lags) in parentheses. J -statistic reports Hansen's test for over-identifying restrictions.

3.3 Sensitivity to the approach in calculating the output gap

We now examine how the policy regime estimates change as the approach used to calculate the output gap changed. Here we re-estimate the model while using the quadratic trend approach to calculate the output gap. As before, the sample period is 1961:1 to 2008:4. Results are shown in Table 1.3; standard errors are in parentheses.

Table 1.3 shows that qualitatively the results are not sensitive to the assumed approach used to calculate output gap. In each case the weight on parameters stabilization are fallen between the subpériods. The inflation target varies between 4.41 % and 1.94 %. As in table 1.2, similar observations are obtained. The values of the coefficients μ, λ and δ seem to suggest that reduced smoothing of the interest rates is assigned by the central bank and slight weight to the output gap and stock prices is also attributed. For example, the value of π^* indicates that the implicit target has been reduced significantly in the second subperiod. The value of λ indicates a significant decrease of the weight assigned to the output gap in the conduct of monetary policy between subperiods. What is more interesting is that the standard deviations of the monetary rule is close to zero in the last subperiod, indicating that monetary policy has be successful in this subperiod. Furthermore, the value of δ goes from greater weight to a small one indicating that, in the pre-inflation targeting period, the monetary authority has given an important weight to the stock market index price in the conduct of monetary policy, while, in the inflation targeting period, the evidence suggests that the monetary authority does not give directly any weight to the stock market index price. This analysis demonstrates the extreme sensitivity of the estimates to the different approaches in calculating the output gap. It is particularly the cases for the parameters μ, λ and δ. Another point is the fact that preferences of the monetary authorities have changed drastically in the inflation targeting period. It is clearly reflected in the estimates of π^*.

In general, the results of the estimation are very interesting. The estimation results give new relevant insights into the influence of stock market index prices on monetary policy in Canada. These findings about the role of stock market index prices for the Bank of Canada provide relevant insights regarding the opportunities and limitations of incorporating financial indicators in monetary policy decision making. They also give financial market participants, such as analysts, bankers and traders, a better understanding of the impact of stock market index prices on the Bank of Canada policy. We find that over time, the Bank of Canada has assigned changing weights to inflation, the output gap and the stock market index price.

Table 1.3: Estimates of the preferences of monetary policy

	No Breaks		Two subperiods			
	1961:1-2008:4		1961:1-1990:4		1991:2-2008:4	
	Coefficient		Coefficient		Coefficient	
c_1	0.193^a	(0.010)	0.190^a	(0.014)	0.089^b	(0.039)
c_2	1.181^a	(0.007)	1.142^a	(0.007)	1.546^a	(0.049)
c_3	-0.222^a	(0.006)	-0.203^a	(0.006)	-0.561^a	(0.050)
c_4	0.062^a	(0.007)	0.077^a	(0.003)	0.009^b	(0.004)
c_5	-0.142^a	(0.005)	-0.150^a	(0.004)	-0.041^a	(0.013)
c_6	0.116^a	(0.007)	0.206^a	(0.012)	0.061	(0.046)
c_7	1.167^a	(0.010)	1.224^a	(0.007)	1.066^a	(0.045)
c_8	-0.188^a	(0.010)	-0.241^a	(0.001)	-0.139^a	(0.053)
c_9	0.041^a	(0.002)	0.047^a	(0.002)	0.020^b	(0.009)
c_{10}	-0.012^b	(0.001)	0.014^a	(0.001)	-0.007	(0.007)
c_{11}	-0.006^a	(0.001)	-0.003^b	(0.001)	-0.007	(0.011)
c_{12}	-0.048^a	(0.002)	-0.062^a	(0.003)	-0.023	(0.021)
c_{13}	0.059^a	(0.002)	0.074^a	(0.004)	0.029	(0.020)
c_{14}	0.874^a	(0.004)	0.855^a	(0.005)	0.912^a	(0.050)
β	0.9750^e		0.9750^e		0.9750^e	
π^*	3.447^a	(0.053)	4.411^a	(0.030)	1.937^a	(0.066)
μ	0.028^a	(0.001)	0.033^a	(0.001)	0.002^b	(0.001)
λ	0.002^b	(0.001)	0.003^a	(0.001)	0.000^a	(0.000)
δ	0.265^a	(0.014)	0.254^a	(0.0013)	0.002	(0.004)
$\sigma\left(u^d\right)$	0.757		0.873		0.403	
$\sigma\left(u^o\right)$	0.656		0.613		0.677	
$\sigma\left(u^s\right)$	0.479		0.424		0.555	
$\sigma\left(u^m\right)$	0.035		0.045		0.001	
J-Statistic	37.909		14.455		15.911	

^{a,b,c} denotes significance levels at 1%, 5.0% and 10%, respectively. ^{e} indicates that the coefficient has been imposed in the estimation. Standard errors robust to serial correlation (up to 6 lags) in parentheses. J -statistic reports Hansen's test for over-identifying restrictions.

4 Conclusion

What have we learned from this paper? There is strong evidence that Bank of Canada should take into account asset price fluctuations when setting interest rates. In other words, Bank of Canada should care about the financial instability associated with large asset price fluctuations when setting interest rate. This remark gives new relevant insights into the influence of stock market index prices on monetary policy in Canada. These findings about the role of stock market index prices on Canadian monetary policy provide relevant insights regarding the opportunities and limitations of incorporating financial indicators in monetary policy decision making. They also give financial market participants, such as analysts, bankers and traders, a better understanding of the impact of stock market index prices on Bank of Canada policy. This is not the case in the U.S. (see Castro, 2008). Indeed, it would seem that the Fed leaves those markets free from any direct control. This difference in the behaviour of the two central banks might be one of the causes for the credit crunch that arose recently in the US housing market and that affected the real economy, with important repercussions in the world economy, but to which Canada remained less exposed. Thus, the first main contribution of this paper is that targeting financial conditions might be a solution to avoid the financial and asset market instabilities and, consequently, to help to avoid sharp economic slowdowns. However, we acknowledge that it may be difficult to interpret asset price movements and distinguish between fundamental and non-fundamental components, but the same type of uncertainty exists when policymakers are faced with stochastic trend output. Hence, there is scope for the monetary authorities to take into account asset price fluctuations in the conduct of monetary policy despite the measurement errors that they might face.

There is strong evidence of change in the central bank's target rate of inflation towards the end of the 1970s. In the pre-inflation targeting period, we estimate the target rate of inflation to be 6.26 percent per annum. Since the inflation targeting period, the target rate of inflation seems to be 1.96 percent per annum. This implies, without any doubt, that monetary policy has been conducted efficiently in the last subperiod. We find strong statistical support for this decline and the result is consistent with previous findings by Rodriguez (2008). Whether the relative weight that the Bank of Canada gives to output stabilization has fallen since the inflation targeting period becomes certain. Unlike Rodriguez we do find sizeable (and significant) estimate for λ and δ leading us to conclude that the Bank of Canada does care about output and stock market price stabilization (in addition to inflation stabilization). Better macroeconomic conditions are also observed from the side of aggregate demand in comparison with those from aggregate supply only in the pre-inflation targeting period (1961:1 to 1990:4), while, the reverse situation is observed in the targeting period (1991:2 to 2008:4).

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Appendix 1.1: Descriptive statistics

	Interest rate	Inflation rate	Stock Market Index price	Output gap	Exchange rate
Mean	7.0457	4.1552	6.5498	0.0000	-0.2128
Std. Dev	3.6075	2.9879	17.1211	1.3724	5.1067
Minimum	0.9450	-0.0387	-54..6668	-5.4295	-20.7438
Maximum	21.0167	11.9524	58.2378	2.7919	17.8876
Jacques Bera	36.4621	32.1990	17.6103	15.6266	28.6247
Prob.	0.0000	0.0000	0.0002	0.0004	0.0000
Obs.	192	192	192	192	192

Appendix 1.2: Correlation Matrix

	Interest rate	Inflation rate	Stock Market Index price	Output gap	Exchange rate
Intrest rate	1.0000				
Inflation rate	-0.9088	1.0000			
Stock Market Index Price	0.3922	-0.1295	1.0000		
Output gap	-0.2687	0.0907	0.0892	1.0000	
Exchange rate	0.3241	-0.0955	0.1808	0.1387	1.0000