Another Look at the Inflation-Target Horizon

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- *The inflation-target horizon is the period during which monetary policy actions are expected to return inflation to target. Policy-makers have an interest in communicating this horizon, since it is likely to help anchor inflation expectations.*
- *Bank researchers have recently conducted two studies of the appropriate horizon for returning inflation to target. The choice of the inflation-target horizon balances the costs of volatility associated with the output gap and interest rates against the benefits of keeping inflation close to its target.*
- *Research results indicate that the duration of the optimal inflation-target horizon varies widely, depending on the combination of shocks to the economy. On average, however, it is marginally shorter than eight quarters. Bearing in mind the inherent uncertainty in this type of analysis, the current target horizon of six to eight quarters appears to remain an appropriate guide to the speed with which inflation should return to target in response to economic shocks.*
- *In rare cases when the financial accelerator is triggered by a persistent shock such as an asset-price bubble, it may be appropriate to take a longer view of the inflation-target horizon.*

The inflation-target horizon is the time it takes inflation to return to target in response to monetary policy actions designed to offset the effects of a shock on the economy. Inflation does not immediately return to target because frictions (for example, wage contracts) in the economy cause movements in inflation to persist, and because there are lags in the effect of a monetary policy action on inflation.

The inflation-target horizon is the time it takes inflation to return to target.

A short horizon would be consistent with a vigorous change in interest rates in order to return inflation to target quickly, but could result in excessive volatility in interest rates and the real economy, since the lagged effects of vigorous interest rate changes need to be cancelled by subsequent actions in the other direction. A long horizon would be consistent with a more sluggish change in interest rates that could result in less real volatility, but would cause deviations of inflation from target to be more persistent. Thus, there is an optimal inflation-target horizon that balances these two opposing considerations. Moreover, each type of shock to the economy will have its own optimal inflation-target horizon because each shock leads to a different trade-off between output and inflation volatility. The target horizon as discussed by the Bank of Canada refers to the typical length of time required to return inflation to target in response to various combinations of shocks.

This article draws on two Bank of Canada studies that subject a pair of state-of-the-art dynamic stochastic general-equilibrium models of the Canadian economy to an array of shocks that mimic the typical shocks experienced over the past 25 years. Both models contain well-articulated explanations of the monetary policy transmission mechanism. In one study, the model focuses on nominal and real frictions (e.g., nominal wage contracts, costs of adjusting capital) to explain the lag between a monetary policy action and the subsequent movement of inflation. The model in the other study additionally incorporates financial frictions (often referred to as financial accelerators) that, when triggered, can change the relationship between a monetary policy action and the subsequent movement of inflation.

Inflation does not immediately return to target because of frictions in the economy.

To determine the optimal inflation-target horizon, a quantitative measure of the loss the economy suffers from volatility in output, inflation, or interest rates from following a monetary policy rule that returns inflation to target either too quickly or too slowly is included in the models. The parameters of the monetary policy rules in the models—which relate changes in the policy interest rate to predicted future deviations of inflation from target and the current state of the output gap—are then varied to determine the inflation-target horizon that minimizes the loss to the economy.[1] This exercise is repeated for a wide array of potential shocks in order to obtain the range of optimal inflation-target horizons.

The results from these studies support the thesis that different shocks are associated with different horizons, indicating that the optimal inflation-target horizon varies over time, just as shocks hitting the economy vary. Nevertheless, in most instances, the studies support the conclusion that the Bank's policy since 1991, which has aimed to return inflation to target within a six-to-eight-quarter target horizon, remains appropriate. In rare cases when the financial accelerator is triggered by a large and persistent shock, it may be appropriate to take a longer view of the inflation-target horizon.

Methodology

Because of the complexity of the frictions present in the economy, the two studies examined the issue of the inflation-target horizon through the lens of two different models of the Canadian economy.

The first study, by Cayen, Corbett, and Perrier (2006, henceforth CCP), uses a preliminary version of the Terms-of-Trade Economic Model (TOTEM), a new multi-sector, open-economy dynamic general-equilibrium model of the Canadian economy designed to analyze monetary policy issues and to conduct economic projections (Murchison and Rennison, forthcoming). Nominal-wage rigidity is the most important friction used in TOTEM to generate persistent real short-run effects of monetary policy actions. Significant, but less important, are price rigidities. Also important are habit formation,[2] costly adjustment of physical capital, and variable capital utilization. In addition, TOTEM features a separate commodity-production sector that permits rich terms-of-trade dynamics and uses a wide range of exogenous shocks to provide the initial impulses for the model's dynamics.

The second study, by Basant-Roi and Mendes (2006, henceforth BRM), uses an experimental model that features a financial accelerator in the housing market.[3] This model shares many of the features of TOTEM, including nominal-wage rigidities in both the labour and product markets and real rigidities, such as habit formation, that slow the speed of the real economy's adjustment to shocks. Although the model used in BRM is not as well developed in certain areas as TOTEM, it features financial frictions not incorporated in TOTEM and can therefore provide insight into how the interaction between the real economy and the financial sector might affect economic outcomes.[4] The financial frictions in the model result from variations in the value

1. See Armour and Côté (1999–2000) and Black, Macklem, and Rose (1997) for a review of feedback rules for inflation control.

2. Habit formation refers to the assumption that consumers care not only about their level of consumption but about the change in consumption from one period to the next.

3. The current version of this model does not account for a financial accelerator that may also exist in the business sector and affect business investment through, say, large swings in equity prices. However, given the structure of the Canadian economy, large swings in housing prices are likely to be of more concern to policy-makers (Selody and Wilkins 2004).

4. For example, BRM does not allow for commodity-price shocks or shocks to the inflation target.

of collateral used to secure mortgage financing. For example, in the face of a positive shock to housing prices, the initial increase in the price of houses raises the value of mortgage collateral, which reduces the cost of borrowing. This stimulates borrowing and aggregate demand, including housing demand, and sets off a financial accelerator by causing a further increase in housing prices. The financial accelerator is set off by shocks that are quite similar to those in TOTEM; in addition, the inclusion of housing prices in the model provides an opportunity to study the effect of asset-price bubbles on the optimal inflation-target horizon.

Both models were assigned parameters to replicate key characteristics of the Canadian macroeconomic data over the period 1980 to 2004. Matching the key relationships found in the data is essential to correctly characterizing the inherent trade-offs between inflation, the output gap, and interest rate stabilization that are a feature of the economy.

Well-anchored expectations create a strong tendency for actual inflation to revert to the inflation target.

One of the key determinants of the persistence of inflation in the economy is the credibility of monetary policy. If policy is highly credible, inflation expectations will remain well anchored to the inflation target over the medium term. For the purpose of this article, both models assume that monetary policy is highly credible, which is consistent with recent evidence (see box).

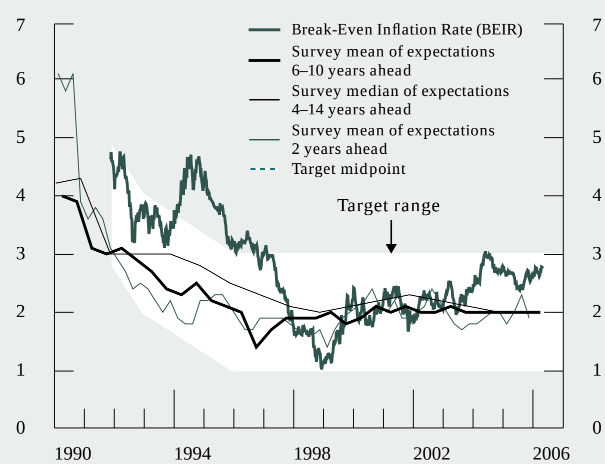
Monetary Policy Credibility

There is considerable evidence that the credibility of monetary policy has increased significantly with the introduction of the inflation-targeting regime in Canada. Chart B1 shows several measures of inflation expectations at various horizons. For example, the difference between the yield on Government of Canada long-term Real Return Bonds and nominal bonds of comparable maturity (labelled the Break-Even Inflation Rate, BEIR), may be considered a very crude proxy for long-term inflation expectations. (For a thorough discussion of the usefulness of the BEIR as an indicator of inflation expectations, see Christensen, Dion, and Reid 2004). The evolution of bond-yield differentials suggests that there has been a decline in the premium for inflation expectations. Longer-term inflation forecasts reported by Consensus Economics surveys of private sector forecasters show a similar convergent trend. These forecasts suggest that longer-term inflation expectations (two, five, and 10 years ahead) converged on the 2 per cent inflation target after its introduction and have remained in line with the target since then. Johnson (1998), Perrier (1998), and Amano and Perrier (2000) use statistical analysis based on the survey data to conclude that the credibility of monetary policy in Canada has increased over the inflation-targeting period.

Drawing inferences about monetary policy credibility from surveys of expected inflation is hindered by the possibility that expectations of inflation may be low simply because of recent business-cycle developments, including past inflation itself. A more compelling analysis can be found in Levin, Natalucci, and Piger (2004), who find that, for the period 1994 to 2003, private sector long-run inflation forecasts fail to exhibit significant correlation with lagged inflation for the five countries (including Canada) that maintained explicit inflation objectives over this period, indicating that the monetary policy followed by these central banks has been reasonably credible.

Chart B1

Four Measures of Long-Term Inflation Expectations



Well-anchored expectations create a strong tendency for actual inflation to revert to the inflation target and, all else being equal, indicate that monetary policy needs to be less active (Svensson 2002) and that interest rates and output need to move less to counter movements in inflation away from target.

The CCP and BRM studies apply the same general methodology to determine the optimal target horizon (see Batini and Nelson 2000). In both studies, the central bank is assumed to adjust policy interest rates to minimize the overall costs arising from three sources: inflation volatility around the target inflation rate, output volatility around potential output (the output gap), and the volatility of interest rates. Stabilizing inflation is desirable in part because variable inflation makes it harder for the market to achieve efficient resource allocation, and the ensuing uncertainty makes it more difficult for firms, consumers, and savers to make the right decisions (Svensson 2002). Minimizing output variability around potential is an objective because households generally prefer a smooth future consumption stream. The volatility of interest rates is included because policy-makers are assumed to care about financial stability, which might be impacted by excessive volatility in interest rates (Cukierman 1990), or about the risk of hitting the zero bound on nominal interest rates (Rotemberg and Woodford 1997; Woodford 1999).

More formally, the models used in the two studies incorporate the assumption that the central bank sets the optimal inflation-target horizon to minimize the quadratic loss function:

$$\bar{L} = \sigma_{\pi}^2 + \sigma_{ygap}^2 + 0.5 \cdot \sigma_{\Delta R}^2 , \qquad (1)$$

where σ_{π}^2, σ_{ygap}^2, and $\sigma_{\Delta R}^2$ are the unconditional variances of the gap between inflation (π) and the target inflation rate (π^T), the output gap (*ygap*), and the change in the policy interest rate (ΔR).[5]

The function captures the notion that all future deviations of these variables from target are costly to the economy.[6] The weights on the various elements in the function imply that the central bank cares equally about inflation and the output gap but less about smoothing interest rate movements.[7]

Both studies also characterize the behaviour of the central bank through the use of a simple monetary policy rule:

$$R_t = \rho R_{t-1} + (1-\rho)R^* + \varphi_{\pi}(E_t\pi_{t+k} - \pi^T) + \varphi_y(ygap_t) , \qquad (2)$$

where R^* is where interest rates eventually settle and E_t denotes expectations made in period t.[8] A simple rule was used because it is more likely to be robust across models than a more complex rule optimized for a particular model (Levin, Wieland, and Williams 1999; Armour and Côté 1999–2000; and Côté et al. 2002). The specific rule used here is an inflation-forecast-based (IFB) rule in that the inflation term uses the difference between the expected future inflation rate and the target. In general, IFB rules are simple, intuitive, and parsimonious, and have reasonable properties over a wide range of disturbances (see Amano, Coletti, and Macklem 1999; and Black, Macklem, and Rose 1997).

The variables in this hypothetical monetary policy reaction function are the same as those in the objective function. The central bank chooses the weight on interest rate smoothing (ρ), the degree to which it reacts to expected deviations of inflation from target (φ_{π}), the degree to which it reacts to the output gap (φ_y), and the degree to which policy is forward looking (k). These parameters are chosen separately for each of the models in the CPP and BRM studies to minimize the objective function (1) when the economy is subject to an array of random shocks similar to those seen over history. The resulting inflation-target horizon is deemed to be an optimal horizon, at least within the confines of a simple feedback rule.

Results from Shocks Occurring in Normal Times

Table 1 quantifies the inflation-target horizon associated with the optimal rule if we again faced the typical macroeconomic shocks observed over the 1980 to 2004

5. The intertemporal loss function is: $\bar{L}_t = E_t\left((1-\beta)\sum_{i=0}^{\infty} \beta^i L_{t+i}\right)$, where E_t denotes expectations based on information that is available in time t, and β is the rate at which central banks discount the future. As the discount rate approaches one $\mathrm{Lim}_{\beta \to 1}\bar{L}_t = \bar{L}$. Tables 1 and 2 provide estimates of the variances of inflation, the output gap, and the change in interest rates under the optimized monetary policy rules.

6. Note that the deviations are represented quadratically, indicating that substantial deviations from the targets are thus assessed as considerably more costly than slight variations.

7. Some recent research focuses on choosing monetary policy rules that maximize the welfare of the representative consumer. One advantage of this strategy is that it avoids specifying arbitrary central bank loss functions, as is done in the work discussed here. Since this new approach is computationally quite demanding, it remains challenging in more realistic larger-scale models.

8. The complexity of monetary policy decision making means that these simple reaction functions should not be thought of as precise characterizations of the behaviour of policy-makers.

Table 1

Optimal Target Horizons in the Absence of Housing-Price Bubbles

	CCP	BRM
Feedback horizon (*k*)	2.0	2.0
Smoothing parameter (ρ)	0.8	0.6
Inflation variance (σ^2_π)	0.9	0.7
Output gap variance (σ^2_{ygap})	5.1	4.3
Variance of the change in interest rate ($\sigma^2_{\Delta R}$)	1.7	1.6
Mean target horizon	7.0	6.0
Range of target horizons*	4–11	2–9

Note: Horizons are expressed as the number of quarters required to return inflation to within 0.1 percentage point of the target.
* Based on a 90 per cent confidence band

Table 2

Optimal Target Horizons in the Case of Housing-Price Bubbles

	Rule 1: ignoring bubbles	Rule 2: optimized with bubbles
Feedback horizon (*k*)	2.0	2.0
Smoothing parameter (ρ)	0.6	0.6
Inflation variance (σ^2_π)	0.8	0.8
Output gap variance (σ^2_{ygap})	4.3	4.4
Variance of the change in interest rate ($\sigma^2_{\Delta R}$)	1.6	1.6
Mean target horizon	14.0	13.0
Range of target horizons*	3–51	4–48

Note: Horizons are expressed as the number of quarters required to return inflation to within 0.1 percentage point of the target.
* Based on a 90 per cent confidence band

period.[9] For these calculations it is deemed that inflation has returned to target if it is within 0.1 percentage point of the target. The average target horizon is the mean of the distribution built from making repeated draws from the distribution of shocks that were estimated to have hit the economy over that period.

There are three main points to be drawn from the table. First, the CCP and BRM studies find a similar mean inflation-target horizon of 6 to 7 quarters. Second, the range of target horizons is also quite similar in the two studies. The CCP study estimates that, in the event of a shock that pushes inflation away from the target, it should be returned to within 0.1 percentage point of the target within 4 to 11 quarters 90 per cent of the time. The BRM study finds a similar range of 2 to 9 quarters. Third, these results suggest that the optimal inflation-target horizon is, on average, at the lower end of the 6-to-8-quarter range. This may reflect, in part, increased credibility since the targeting regime was introduced, which has acted to reduce the lag between monetary policy actions and inflation outcomes and has thereby reduced the cost of returning inflation to target.

Results Including Housing-Price Bubbles

BRM also simulated an exogenous asset-price bubble in the housing market to see what effect it might have on the optimal inflation-target horizon. The bubble, which is defined as a sustained and growing gap between the market price of a house and its fundamental economic value, is modelled along the lines of Bernanke and Gertler (2000). In this exercise, it is assumed that the probabilities of the bubble arising and bursting are fixed and are known to all of the agents in the model.[10] Bubbles are assumed to arise, on average, every 10 years. The probabilities are calculated such that, on average, the bubble grows to a maximum of 30 per cent of fundamental value, and the bubble-boom period spans a maximum of three years.[11] These simulations are conducted using the same policy rule as in the no-bubble case considered above (Rule 1), along with another rule that is optimized given the possibility of bubbles (Rule 2).

Introducing the possibility of bubbles has little effect on the parameters of the optimized simple feedback rule from the BRM study reported in Table 1, since asset-price bubbles are assumed to be low-probability events. In the event that a housing-price bubble actually hits the economy, the average time it takes for inflation to return to target lengthens significantly (Table 2). The horizon is substantially longer because such a shock triggers large financial-accelerator effects, which are very costly for monetary policy to counteract. In particular, a housing-price bubble has a direct effect on asset prices and the financial accelerator, whereas all of the other shocks have only an indirect effect.

9. The horizon is somewhat sensitive to different sample periods, with the horizon varying as much as two quarters in the samples considered in the CCP study. While a variation of two quarters is enough to push the average inflation horizon outside the six-to-eight-quarter range in some circumstances, the deviation is not large enough to significantly affect expectations. In the CCP study, there are five demand shocks (e.g., consumption shock), six price or mark-up shocks (e.g., wage shock), a domestic technology shock, a shock to the country risk premium, and four foreign shocks (world commodity prices, foreign output, foreign prices, and the foreign interest rate).

10. This assumption is made for simplicity, since, in reality, agents do not have this much information.

11. This is roughly consistent with stylized facts for housing-price bubbles found in the International Monetary Fund's World Economic Outlook for April 2003.

This result occurs whether or not housing prices are specifically added to the monetary policy rule. Sensitivity analysis shows that there is little to be gained by including housing prices directly in the rule, likely because it already considers their effects on inflation and output volatility. This result is consistent with Bernanke and Gertler's (2000) finding that monetary policy can deal appropriately with bubbles by reacting to expected inflation. Policy does not have to respond directly to housing prices to be effective.[12]

The results are therefore no more than an indication of what might happen if the Canadian economy were to experience an asset-price bubble.

The simulations in BRM are highly stylized, and the results are therefore no more than an indication of what might happen if the Canadian economy were to experience an asset-price bubble. It is difficult to be precise about the real impact of large housing-price shocks, the effect of monetary policy actions on a housing-price bubble, and the degree to which the target horizon may need to be extended, given how rarely these situations have occurred in Canada in the past.[13] Moreover, the model does not account for the full extent of financial disruption that may accompany such events. For example, while the cost of mortgage financing increases in response to falling asset prices, quantity restrictions that may occur in the event of a "credit crunch" are not modelled. Tkacz and Wilkins (2006) find evidence in the Canadian data of important threshold effects in the relationship between housing prices and real activity, suggesting that the bias from ignoring such quantity restrictions may be important.

A target horizon of six to eight quarters remains appropriate.

Conclusions

The choice of the inflation-target horizon is a balancing act. A shorter horizon keeps inflation closer to the target but at the cost of more volatility in output and interest rates; a longer horizon allows the central bank to miss its inflation target for a longer period in the interest of greater stability in output and interest rates. Our studies show that the optimal inflation-target horizon varies with each shock and suggest that, on average, the optimal horizon is marginally shorter than previously thought. However, because of several important sources of uncertainty inherent in the analysis, the point estimates of the optimal inflation-target horizon should be interpreted as merely indicative. In particular, the structure and calibration of the models studied are imperfect approximations of the actual economy. As well, the pattern of future shocks could be quite different from historical experience. Finally, these studies rely on concepts that are not easy to put into practice with great precision. For example, it is difficult to accurately specify the preferences of policy-makers using a simple objective function. In light of this uncertainty, we conclude that a target horizon of six to eight quarters remains appropriate in most instances. In the context of the models examined, a few rare shocks, such as an asset-price bubble, have unusually long inflation-target horizons. In these rare circumstances, the results suggest that it may therefore be appropriate for monetary policy to take a longer view of the inflation-target horizon.

12. For a more recent example, see Tetlow (2005).

13. In the BRM experiments, monetary policy actions affect the fundamental component of housing prices, but not the bubble process.

Literature Cited

Amano, R., D. Coletti, and T. Macklem. 1999. "Monetary Rules When Economic Behaviour Changes." Bank of Canada Working Paper No. 99–8.

Amano, R. and P. Perrier. 2000. "Credibility and Monetary Policy." *Bank of Canada Review* (Spring): 11–17.

Armour, J. and A. Côté. 1999–2000. "Feedback Rules for Inflation Control: An Overview of Recent Literature." *Bank of Canada Review* (Winter): 43–54.

Basant-Roi, M. and R. Mendes. 2006. "Should Central Banks Adjust Their Target Horizons in Response to Housing-Price Bubbles?" Bank of Canada Working Paper (forthcoming).

Batini, N. and E. Nelson. 2000. "Optimal Horizons for Inflation Targeting." Bank of England Working Paper No. 119.

Bernanke, B. and M. Gertler. 2000 "Monetary Policy and Asset Price Volatility." NBER Working Paper No. 7559.

Black, R., T. Macklem, and D. Rose. 1997. "On Policy Rules for Price Stability." In *Price Stability, Inflation Targets and Monetary Policy*, 411–61. Proceedings of a conference held by the Bank of Canada (May). Ottawa: Bank of Canada.

Cayen, J.-P., A. Corbett, and P. Perrier. 2006. "An Optimized Monetary Policy Rule for TOTEM. " Bank of Canada Working Paper (forthcoming).

Christensen, I., F. Dion, and C. Reid. 2004. "Real Return Bonds: Monetary Policy Credibility and Short-Term Inflation Forecasting." *Bank of Canada Review* (Autumn): 15–26.

Côté, D., J. Kuszczak, J.-P. Lam, Y. Liu, and P. St-Amant. 2002. "The Performance and Robustness of Simple Monetary Policy Rules in Models of the Canadian Economy." Bank of Canada Technical Report No. 92.

Cukierman, A. 1990. "Why Does the Fed Smooth Interest Rates?" In *Proceedings of the 14th Annual Economic Policy Conference of the Federal Reserve Bank of St. Louis*, 114–47. Norwell, MA: Kluwer Academic Publishers.

Johnson, D. 1998. "The Credibility of Monetary Policy: International Evidence Based on Surveys of Expected Inflation." In *Price Stability, Inflation Targets, and Monetary Policy*, 361–95. Proceedings of a conference held by the Bank of Canada (May). Ottawa: Bank of Canada.

Levin, A., F. Natalucci, and J. Piger. 2004. "Explicit Inflation Objectives and Macroeconomic Outcomes." European Central Bank Working Paper No. 383.

Levin, A., V. Wieland, and J. Williams. 1999. "Robustness of Simple Monetary Policy Rules under Model Uncertainty." In *Monetary Policy Rules*, 263–99, edited by J.B. Taylor. Chicago: University of Chicago Press.

Murchison, S. and A. Rennison. 2006. "TOTEM: The Bank of Canada's New Projection Model." Bank of Canada Technical Report (forthcoming). Ottawa: Bank of Canada.

Perrier, P. 1998. "Un examen de la crédibilité de la politique monétaire au Canada." Bank of Canada Working Paper No. 98–12.

Rotemberg, J. and M. Woodford. 1997. "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy." NBER Macroeconomics Annual.

Selody, J. and C. Wilkins. 2004. "Asset Prices and Monetary Policy: A Canadian Perspective on the Issues." *Bank of Canada Review* (Autumn): 3–14.

Svensson, L. 2002. "Monetary Policy and Real Stabilization." In *Rethinking Stabilization Policy, A Symposium Sponsored by the Federal Reserve Bank of Kansas City*, 261–312. Jackson Hole, Wyoming, 29–31 August.

Tetlow, R. 2005. "Monetary Policy, Asset Prices and Misspecification." Presented at the Bank of Canada conference on "Issues in Inflation Targeting," 28–29 April.

Tkacz, G. and C. Wilkins. 2006. "Linear and Threshold Forecasts of Output and Inflation with Stock and Housing Prices." Bank of Canada Working Paper (forthcoming).

Woodford, M. 1999. "Optimal Monetary Policy Inertia." NBER Working Paper No. 7261.