# Price-Level Targeting—The Role of Credibility

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## Introduction

In the early literature on price-level targeting, the main rationale for considering such a policy was to reduce price-level uncertainty. If agents are better able to predict future prices, this simplifies intertemporal comparisons, encourages longer contracts, and avoids redistribution of income arising from incorrect price-level expectations. The main cost of following such a policy is assumed to be the greater variability of output needed to restore prices to their target path.

More recently, price-level targeting has been proposed as a desirable policy, even if the central bank does not have a specific preference about price-level uncertainty, but rather wants to minimize the variability of inflation, output, and interest rates. Incorporating a price-level target into a monetary rule can reduce fluctuations in these variables, compared with a purely inflation-targeting rule, if the price-level target is completely credible.

To illustrate the effects a credible price-level target has on expectations, consider an inflation-targeting central bank faced with a positive shock that pushes inflation above target. The central bank needs to tighten policy to get inflation back to the target. Agents' expectations of future inflation are therefore likely to be above or at the target rate. Contrast this

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with the case of a price-level-targeting central bank where the price-level target grows over time at a constant rate of 2 per cent. This central bank, when faced with a positive shock that pushes inflation over 2 per cent, and thus pushes the price level above the target path, must not only return inflation to 2 per cent, but must also induce a secondary cycle with lower inflation, in order to restore the price level. If agents understand this policy, and believe the central bank is fully committed to the price-level target, their expectations will be for inflation to dip below 2 per cent. In other words, inflation expectations will be lower with price-level targeting than with inflation targeting. Thus, more of the necessary adjustment in real interest rates can come about through changes in expectations rather than changes in nominal interest rates.

The assumption that price-level targeting is fully credible is, however, a strong assumption to make. The aim of this paper is, therefore, to explore how crucial this is to the results and whether reductions in the variability of inflation, output, and nominal interest rates are possible under different assumptions about how expectations are formed. The impact of adding price-level targeting to a policy rule is considered with backward-looking expectations, model-consistent expectations, and with credibility effects tied more specifically to inflation and price-level targets. The sensitivity of results to different rules is also considered. More generally, the work provides an examination of whether results in the literature based on small, analytical models can also be obtained in a larger model with far more complex dynamics—in this case, the Bank of Canada's Quarterly Projection Model (QPM).

We find that it is possible to replicate key results from the literature using QPM, and that the assumptions made about expectations are very important in determining the final results. When agents are highly backward-looking, introducing a price-level target into a Taylor rule results in increased output and interest rate variability. With highly model-consistent expectations, however, it is possible to reduce the variability in inflation, output, and nominal interest rates. Incorporating credibility effects specifically tied to the price-level target leads to even greater reductions in these variabilities. But above all, it illustrates the dangers of making expectations exogenous: the results are driven by the assumptions, and it makes little difference what monetary rule is used.

While some credibility is needed for price-level targeting to generate reductions in the variabilities of inflation, output, and nominal interest rates, the results suggest that complete credibility is not required. When expectations were based on the assumption of a mixed process where agents are partly backward-looking and partly forward-looking, adding a price-level target can reduce variabilities if those agents who based their expectations on an inflation target switch to immediately basing expectations on the price-level target. In other words, some degree of credibility is essential, but it is considerably less than complete credibility.

Experimentation with different rules suggests that in QPM, price-level targeting gives more beneficial results (in terms of reducing key variabilities) if introduced into an explicitly forward-looking rule. Acting early to anticipate the future effects of shocks on the price level gives a smoother policy response and less cycling in interest rates and output.

Given that the effects on medium-term expectations are very important in determining the effects of price-level targeting, results may be sensitive to assumptions about the monetary transmission mechanism. In QPM, for example, while the monetary instrument is the short-term interest rate, the link to real activity is via the yield spread. The monetary authority, therefore, must primarily influence the short-term real rate to alter real output.[1] It is unlikely, however, that the introduction of a price-level target will have a large impact on such near-term inflation expectations. A credible price-level target will have a greater impact on longer-term expectations and thus longer-term real rates of interest. Thus, the degree to which price-level targeting will reduce the need for the monetary authority to alter nominal rates of interest will likely be sensitive to assumptions made about the role of long- versus short-term interest rates in the transmission mechanism.

Section 1 describes the methodology, including a brief overview of QPM and outlines the different assumptions made about expectations, and the rules to be considered. Section 2 presents the results based on a contemporaneous Taylor-type rule. Section 3 considers whether the results from the Taylor rule are robust for other types of monetary rule, and the final section concludes.

## 1 Methodology

The principal means of evaluating price-level targeting in this paper is to incorporate a price-level gap into different inflation-targeting rules within QPM and to run stochastic simulations to compare the resulting variabilities of inflation, output, and interest rates. Unlike many studies in this area, no loss function is specified. Rather, we are interested in seeing what trade-offs occur when price-level targeting is introduced. If all three variabilities fall, this is assumed to be an unambiguously better result. Similarly, we are not considering the broader question of welfare gains from price-level targeting.

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1. In QPM, the real 90-day interest rate is defined as the nominal 90-day rate deflated by an average of expectations of this quarter's inflation in the consumer price index (CPI), excluding food and energy, and in the GDP deflator.

To do this properly would require specifying utility functions for consumers and considering the costs of price-level uncertainty, which are beyond the scope of this project. Our aim is limited to answering the following question: Under what assumptions about expectations can price-level targeting reduce the variabilities of inflation, output, and nominal interest rates?

Since the analysis is based on QPM, an overview of the model is given below, followed by a review of the assumptions used regarding expectations and a brief description of the methodology for performing stochastic simulations.

## 1.1 The Quarterly Projection Model

QPM is a system composed of two models: a well-defined, neo-classical, steady-state model (SSQPM), which determines the long-run equilibrium, and a dynamic model that traces the adjustment path between the starting conditions and the steady state.[2]

Within SSQPM are three key groups of agents: consumers, profit-maximizing firms, and government. Consumer behaviour is modelled on the Blanchard-Weil model of overlapping generations. Consumers have a desired level of wealth and make decisions on savings and consumption over time to reach that level. Firms determine the capital stock and associated rates of investment. The government sector determines the level of debt and associated levels of government expenditure and taxes. These decisions take place in the context of an open economy, where the exchange rate must adjust to ensure that the current account balance is consistent with the flows needed to service any foreign debt.

Within the dynamic model (QPM), a number of important features affect the path of the economy over the short and medium terms. Adjustment of both prices and quantities is assumed to be costly, so there is an intrinsic element to the dynamics. Agents are forward-looking, and their expectations are modelled as a combination of a backward-looking/adaptive component and forward-looking, model-consistent values. QPM also incorporates endogenous fiscal and monetary policy reaction functions. The fiscal policy rule determines government expenditures and taxation based on an exogenously determined target debt-to-GDP ratio. The objective of monetary policy is to control inflation. In the base model, monetary policy is

2. For detailed documentation on QPM and SSQPM, see Black, Laxton, Rose, and Tetlow (1994); Armstrong, Black, Laxton, and Rose (1995); and Coletti, Hunt, Rose, and Tetlow (1996). For a less technical review of QPM and its use at the Bank of Canada, see Poloz, Rose, and Tetlow (1994).

implemented through a forward-looking reaction function that adjusts the policy instrument to bring inflation into line with the inflation target. The instrument of monetary policy is the short-term interest rate, which affects domestic spending through the yield curve.

A key feature of QPM is that it is dynamically stable and the key stocks in the model (government bonds, capital, and net foreign assets) are consistent with the economic theory in SSQPM. The necessary flows are supported by relative price movements, and if a shock affects a stock, the required flows are generated to return the model to its steady state.

QPM is not an estimated model; rather, it is calibrated to reflect empirical evidence and established stylized facts. For example, the model is calibrated to ensure a sacrifice ratio of 3:1 in a disinflation (i.e., in a 1 percentage point disinflation the cumulative output gap is 3 per cent), and a benefit ratio of 1 in an inflation shock. These properties are based on estimations of an asymmetric Phillips curve for the period 1975 to 1991, by Laxton, Rose, and Tetlow (1993).

## 1.2 Expectations

Price expectations in QPM are modelled in level terms as a function of three components: a backward-looking component, the model-consistent price level, and the "perceived target." The perceived target can be thought of as a credibility effect, which captures agents' views about the inflation target being used by the monetary authority. (It is based on model-consistent inflation four to five years ahead.)

The expectation of the log level of the CPI excluding food and energy in period *t* is:

$$\text{LCPI\_}Et = BW\text{*Backward} + MC\text{*Modelconsistent}(t) + (1-BW-MC)\text{*Perceivedtarget}(t), \quad (1)$$

where *BW* is the weight on the backward component, *MC* is the weight on the model-consistent price level in period *t*, and the remainder of the weight goes on the perceived target, i.e., the price level implied by the inflation rate that agents believe the monetary authority is targeting. In other words, some people are backward-looking, some people have a very sophisticated view of the economy, while others put weight on what they think is the inflation target being used by the monetary authority. While the weight on the credibility effect is exogenous, the value of the perceived target is endogenous and reflects how well the monetary authority is succeeding in keeping inflation near the target. If the monetary authority is following a policy that is successfully keeping inflation close to the target, the perceived target will be the same as the actual target. If the monetary authority is not following such a policy, however, the perceived target will drift away from the announced target.

Using this framework, the effects of inflation and price-level targeting are considered under three alternative specifications of price expectations:

(i) Highly backward-looking expectations, where 80 per cent of the weight within CPI expectations is on the backward component, 20 per cent of the weight is on the model-consistent component, and no weight is placed on the perceived target.

(ii) Highly forward-looking expectations, where 90 per cent of the weight is on the model-consistent component of price expectations and 10 per cent is on the backward-looking component. No weight is placed on the perceived target.

(iii) Credible inflation target, where 80 per cent of the weight is on the perceived target. The backward-looking and model-consistent components each have a 10 per cent weight.

In addition, a fourth specification of expectations is tried, which incorporates price-level credibility. The target price level is incorporated directly into expectations with a weight of 0.8:

$$\text{LCPI\_}Et = 0.1*\text{Backward} + 0.1*\text{Modelconsistent}(t) + 0.8*\text{Priceleveltarget}(t). \quad (2)$$

## 1.3 Monetary rules

Initially, price-level targeting is added into a simple Taylor rule. As described above, the monetary instrument in QPM is the short-term nominal interest rate, which affects activity through the yield spread (the difference between the nominal 90-day rate and the nominal 10-year rate). The Taylor rule is written, therefore, in terms of the yield spread gap, i.e., the difference between the slope of the nominal term structure and its risk-adjusted steady-state value:

$$\text{Yieldspreadgap}(t) = \alpha*\text{Outputgap}(t) + \beta*\text{Inflationgap}(t) + \lambda*\text{Pricelevelgap}(t), \quad (3)$$

where Outputgap($t$) is the contemporaneous output gap, Inflationgap($t$) is the gap between year-over-year inflation of the CPI and the target rate of inflation, and Pricelevelgap($t$) is the difference between the level of the CPI minus the target price level, normalized by the target price level, i.e., (cpi($t$) – cpitarget($t$))/cpitarget($t$).

The main version of QPM uses an inflation-forecast-based (IFB) rule. Previous work at the Bank by Armour and Maclean found that contemporaneous Taylor rules do not seem to perform as well as IFB rules in QPM, since they are generally associated with higher variabilities of inflation, output, and interest rates. This is partly because of greater secondary cycling. Nevertheless, Taylor rules are more robust to model changes than IFB rules. With an IFB rule, both the coefficient values and the optimal degree of forward-lookingness will likely alter, given changes in assumptions about expectations. In other words, when an IFB rule is used, the appropriate degree of forward-lookingness of both the inflation and price-level gaps needs to be reestablished for each different assumption about expectations. The time needed to perform such simulations raises severe practical difficulties.[3] For this reason, the analysis focuses initially on contemporaneous Taylor rules. The robustness of these results across other rules is considered in section 3.

Within the Taylor rule, it is assumed that the central bank is targeting an inflation rate of 2 per cent. The target price level is also assumed to increase by 2 per cent a year. Thus, any difference in results is not due to a different implied target rate of inflation, but is purely a result of the weight on price-level targeting. For the stochastic simulations, the coefficients on the inflation and price-level gaps are varied ($\beta$ and $\lambda$ in Equation (3)). The coefficient on the output gap is kept constant at 0.5.[4]

## 1.4 Stochastic simulations

Stochastic simulations are based on shocks that are calibrated to be broadly representative of the historical distribution of shocks affecting the Canadian economy. (A brief review of the calibration technique is given in the Appendix.) For each set of Taylor-rule coefficients, 100 replications are performed, each replication a simulation of 109 quarters.[5]

When looking at the results of the stochastic simulations, three measures of variability are examined: the root-mean-squared deviation (RMSD) of inflation from target, the RMSD of the output gap from zero,[6] and the standard deviation of interest rates. The RMSD calculations have two components: the standard deviation and the bias. The fact that QPM incorporates an asymmetric Phillips curve means that under an inflation-targeting regime, the mean of inflation is generally higher than 2 per cent in

3. For example, running 100 replications of 109 quarters each, for 15 different rules, requires 50 Sun Ultra workstations running simultaneously for 10 hours.
4. The coefficient is based on previous work at the Bank by Armour and Maclean, where Taylor rules were evaluated within QPM and the most appropriate coefficients chosen.
5. The results from the first 8 quarters are ignored to ensure that the summary statistics are not affected by the starting-point values.
6. This is equivalent to the square root of the sum of squares of the output gap.

stochastic simulations, i.e., there is a positive bias. (Given random shocks, if excess demand feeds into inflation more strongly than excess supply, on average, inflation will tend to be above 2 per cent.) Under price-level targeting, however, no such bias exists, since inflation must average 2 per cent for price levels to return to their target path. Due to the asymmetric Phillips curve, the average output gap will be negative under both regimes.[7]

# 2 Results for Taylor Rules

## 2.1 Backward-looking/adaptive expectations

Price-level targeting is introduced into a Taylor rule when price expectations are assumed to be highly backward-looking and the weights on both the inflation and price-level gaps are varied. The results for inflation and output variability and inflation and nominal interest rate variability are shown in Figures 1 and 2, respectively. In each figure, the lines show points where the weight on the inflation gap ($\beta$ in equation (3)) is held constant. The line furthest to the right in Figure 1, for example, has a weight of 0 on the inflation gap. The highest weight used is 4. Moving down the points on a given line shows the impact of increasing the weight on the price-level gap ($\lambda$), given a constant weight on the inflation gap. Note that the lowest weight shown on the price-level gap is not the same for all lines. For example, for weights of 2 and higher on the inflation gap, the first point shows a zero weight on the price-level gap. Thus, the difference between no price-level targeting and a small weight on the price-level target can be compared. With lower weights on the inflation target it was not possible to simulate the model with a zero weight on the price-level target, therefore the first point on the lines already includes a positive $\lambda$ coefficient.

The results suggest that if private agents are largely backward-looking, the introduction of an element of price-level targeting at best leads to a trade-off between inflation variability and the variabilities of output and nominal interest rates. For very low weights on the inflation gap, there is a greater reduction in inflation variability when price-level targeting is added. However, this largely reflects the fact that they are poor rules to begin with. For coefficient values on the inflation gap that give more desirable results—2 and 3—there is very little reduction in inflation variability when a price-level target is added. There are, however, increases in output and interest rate variability. For all the weights on the inflation gap, once the weight on the

7. The average output gap can increase or decrease when price-level targeting is introduced, depending on the extent to which changes in expectations help the monetary authority in achieving its inflation and/or price-level target.

**Figure 1**
**Backward expectations**

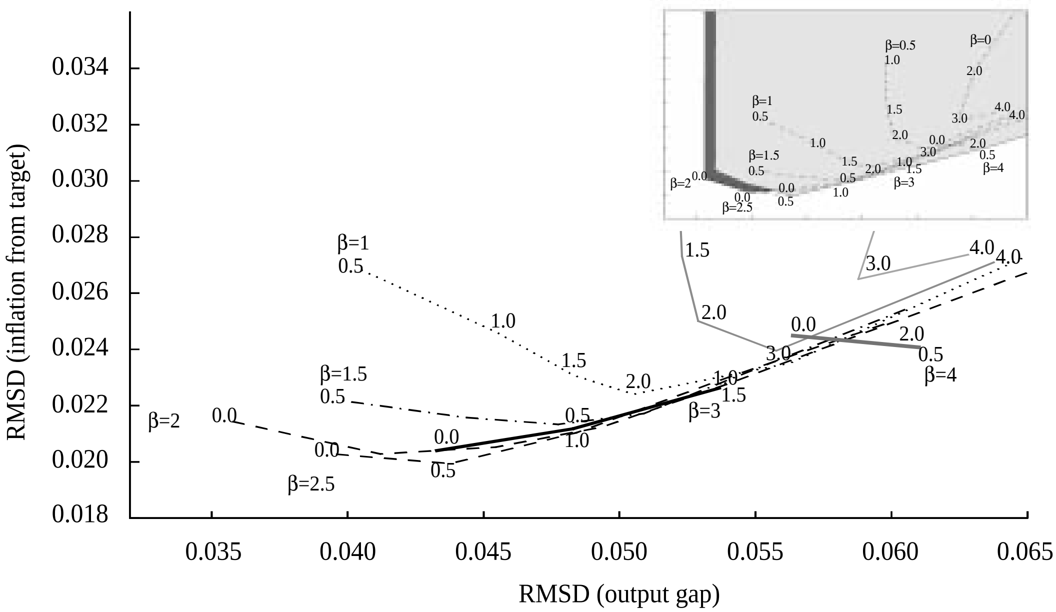
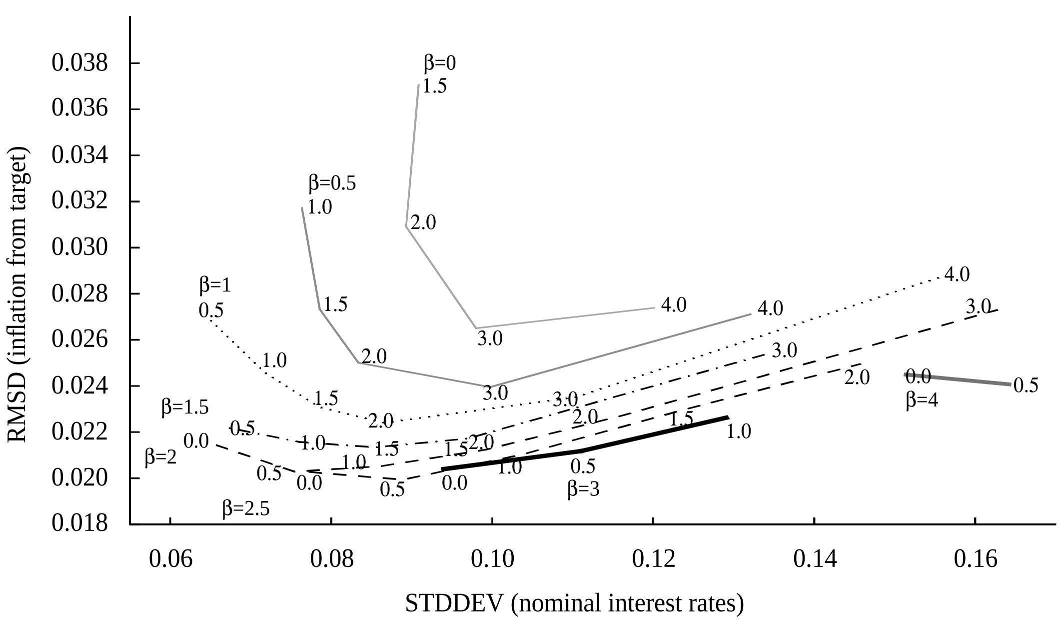



**Figure 2**
**Backward expectations**



price-level target increases beyond a certain point, inflation, output, and interest rate variability increase.

The inset graph in Figure 1 shows the frontiers for the rules with and without price-level targeting. The lightly-shaded area shows the variabilities that can be achieved with those rules that include a price-level target. The dark line indicates the extra points that can be achieved with those rules that do not include price-level targeting. Again, it is evident that lower output variability can be obtained with rules that do not include price-level targeting.

There are two main reasons why price-level targeting leads to increases in output and interest rate variability with largely backward-looking expectations. First, a secondary cycle must be induced to restore price levels, which is unnecessary under an inflation-targeting regime; second, there is continual overshooting of the price-level target so that the cycling continues for much longer than just a secondary cycle. The first reason is the traditional cost cited in the early literature on price-level targeting. The second may be more model- or rule-specific. The over-shooting occurs because both the backward-looking expectations and other lags in the model mean that when the price-level gap closes after the monetary authority has, for example, been trying to increase inflation, inflationary pressures continue to push inflation above the 2 per cent target for a number of quarters. The monetary authority therefore misses its target and must then induce a cycle of below-target inflation. Part of the problem may be, therefore, that a rule based on contemporaneous data is not adequately forward-looking. For this reason, more forward-looking versions of the rule are considered in section 3.

## 2.2 Model-consistent expectations

The second major assumption made for expectations is that they are based largely on model-consistent values of future inflation. This assumes that agents have a full understanding of the shocks hitting the economy, a full understanding of the model of the economy, and that they know the rule being followed by the monetary authority. This assumption is used in many of the key papers that have found a role for price-level targeting, such as Svensson (1996), Vestin (2000), and Dittmar, Gavin, and Kydland (1999). The results of simulating the same rules as previously are shown in terms of inflation and output variability (Figure 3), inflation and nominal interest rate variability (Figure 4), and inflation and real interest rate variability (Figure 5).

In a world of highly model-consistent expectations, introducing a small weight on the price-level target can unambiguously improve model

**Figure 3**
**Model-consistent expectations**

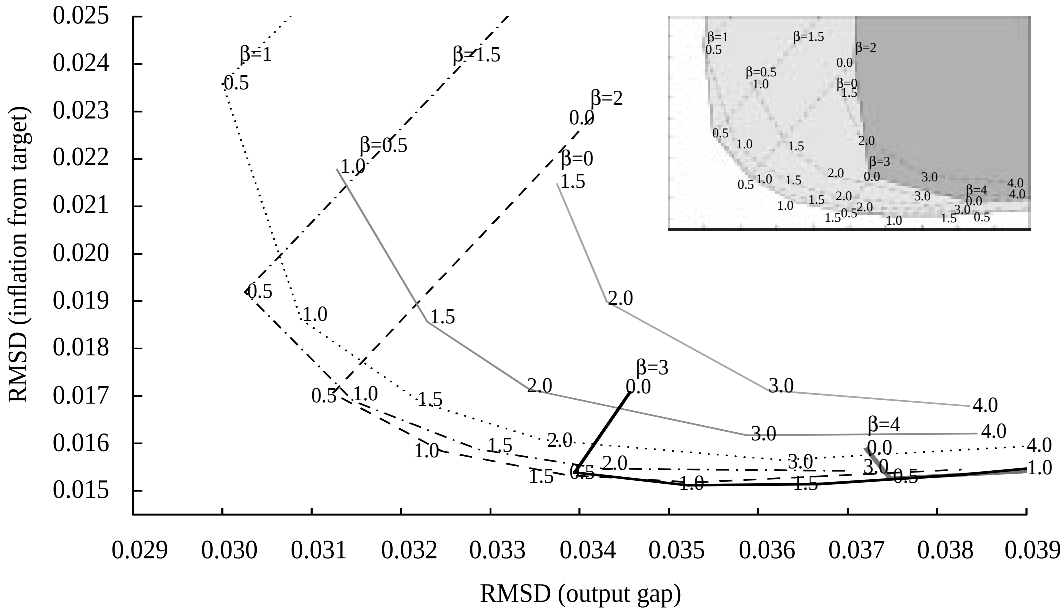



**Figure 4**
**Model-consistent expectations**

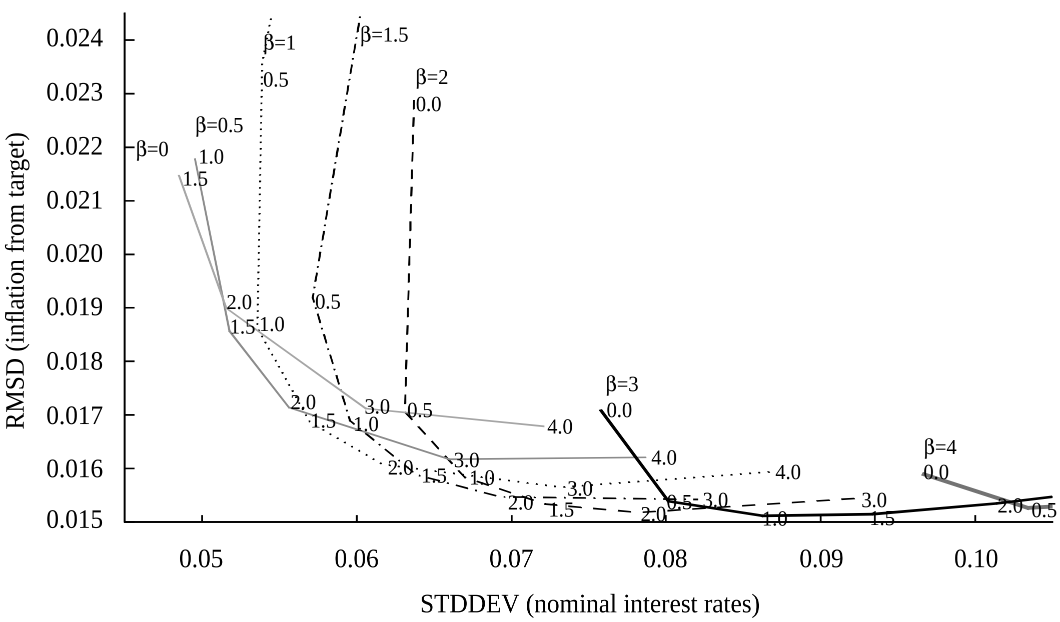
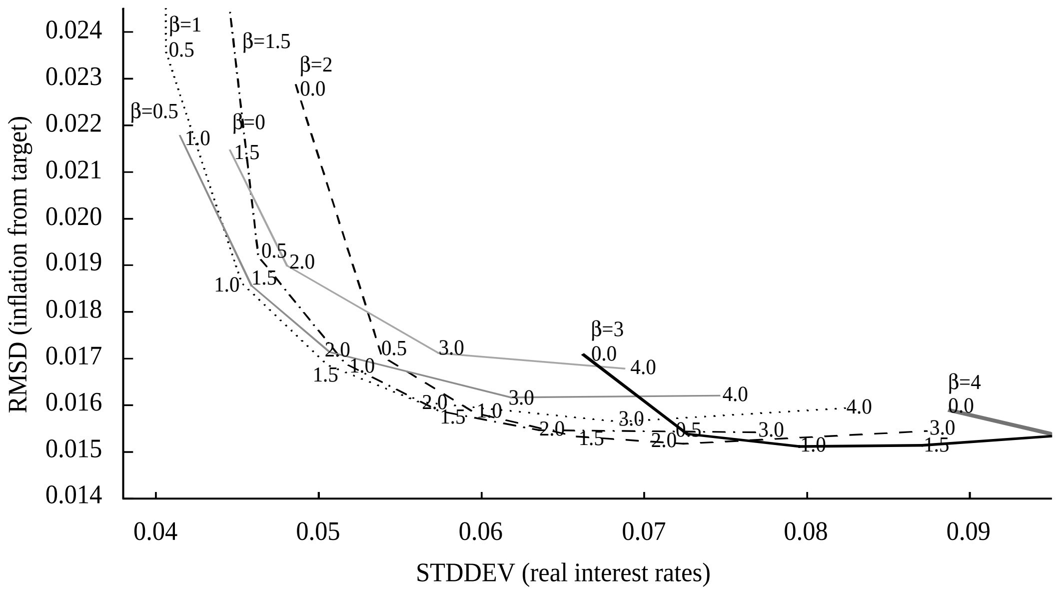


**Figure 5**
**Model-consistent expectations**




properties, with the variabilities of inflation and output declining and nominal interest rate variability remaining largely unchanged. This can be seen, for example, in Figure 3, where the weight on the inflation gap is held constant at 2, and a small weight of 0.5 is introduced on the price-level gap. (Remember that for weights on the inflation gap of 0 and 0.5, it was not possible to simulate a zero weight on the price-level target, so we cannot see the impact of moving from no price-level targeting to a small weight on the target.) Inflation and output variability both fall. Introducing the price-level gap causes no significant change in nominal interest rate variability (Figure 4), but real interest rate variability increases. This is consistent, therefore, with the idea that price-level targeting affects expectations in a manner that is beneficial to the monetary authority, i.e., above-target inflation will be expected to be followed by below-target inflation. Therefore, there is less need for the monetary authority to adjust nominal interest rates to generate the required real interest rate variability.[8] The result of unchanged nominal interest rate variability is not robust across all weights, however. For example, if the weight on the inflation gap is 3, nominal interest rate variability clearly increases with the addition of a price-level target.

8. Examination of the results of individual replications shows that the gains occur most in those simulations where the draws of shocks lead, with an inflation-targeting rule, to sustained periods of inflation outside the inflation-target bands of 1 to 3 per cent. In these situations, adding a small weight on the price-level target has a significant impact on expectations and helps bring inflation back within the bands much more quickly. Moreover, it does so with less need for nominal interest rate variability.

It is interesting to note that further increases in the weight on the price-level target create the same trade-offs as in the backward-looking example, where inflation variability falls initially, but output and interest rate variability increase. This is because the key benefits come from changes in expectations, and the main benefits from these accrue even with only a small weight on the target. Similarly, even with model-consistent expectations, the rules that have no weight on the inflation gap and only weights on the output and price-level gaps (the line marked $\beta = 0$) are associated with generally higher variabilities of inflation, output, and interest rates than those that have a weight on the inflation gap. Thus, while these results do suggest a role for some weight on a price-level target, they do not support a pure price-level-targeting rule.

The inset graph in Figure 3 again provides a good summary of the effect of price-level targeting on output and inflation variability when expectations are highly model-consistent. The frontier of the darkly-shaded area shows the best points achievable with no weight on the price-level target. The lightly-shaded area shows the extra points that are attainable with the inclusion of a price-level target. Clearly, both inflation and output variability can be reduced.

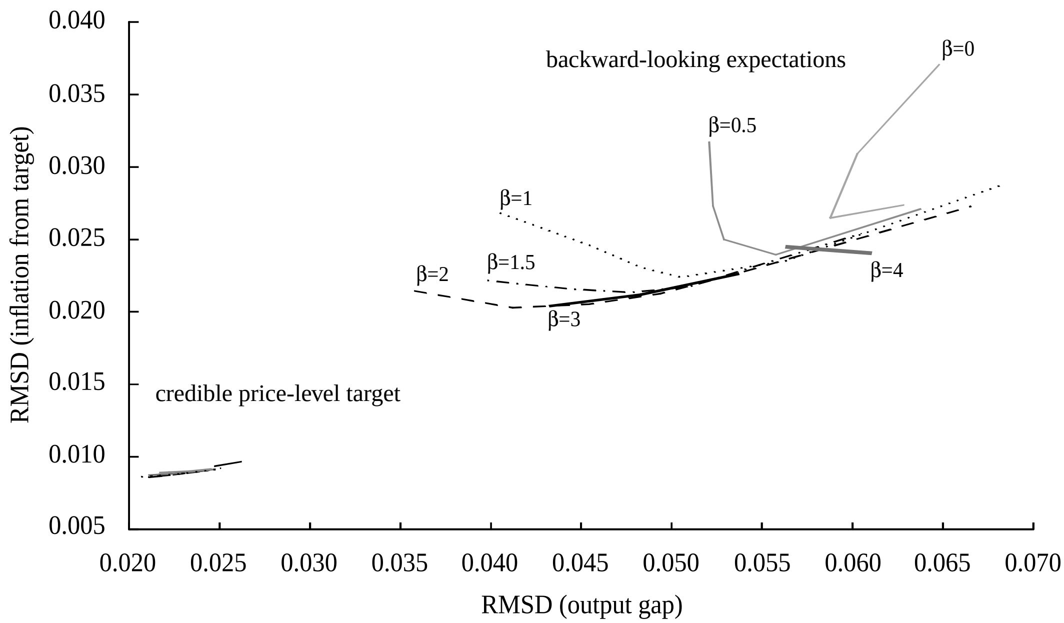
## 2.3 A highly credible price-level target

Making expectations model-consistent introduces a form of credibility, since agents implicitly know the rule being followed by the monetary authority. A much stronger assumption about price-level credibility can be made, however, by putting the price-level target directly into expectations. This assumes less sophisticated agents than the model-consistent agents, who do not necessarily understand the model of the economy or the nature of the shocks, but believe the monetary authority is fully committed to maintaining the target, and thus base their expectations on this target path.

Incorporating the price-level-target path directly into expectations with a high and completely exogenous weight is, of course, a very strong assumption to make. This becomes obvious when looking at the results from varying the monetary rule under such an assumption. These are shown in terms of inflation and output variability, in Figure 6. Also shown in this graph, for comparison, are the results from the same rules when agents were assumed to be backward-looking (i.e., the results from Figure 1).

Compared with the case of backward-looking expectations, a highly credible price-level target is clearly associated with much lower variabilities of inflation and output. Varying the weights within the rule, however, makes little difference. The results are being completely driven by the assumptions made about expectations. In other words, if expectations are determined by

**Figure 6**
**Highly credible price-level target**




an exogenous assumption, it makes little difference what rule is used. The outcomes will be very similar, regardless. Clearly, this is not a desirable assumption to make. Incorporating endogenous credibility, where the "credibility coefficient" perhaps responds to deviations of the price level from target, would be an interesting path for future research.

## 2.4 A highly credible perceived inflation target

One final form of credibility is considered: a highly credible inflation target. It may seem a little odd to incorporate a credible inflation target when price-level targeting is being considered. But conceivably, if a monetary authority has been following a successful inflation-targeting regime, agents may place a high weight on the target in their expectations. If they do not completely understand the shift to a new regime of price-level targeting, they may continue to place weight on what they think of as the inflation target. This combination could, therefore, capture the transition period from one regime to another. As described above, the credibility effect for an inflation target in QPM is incorporated by including a term capturing agents' perceptions of the target being used by the monetary authority. This "perceived target" is endogenous and will diverge from the actual target if the monetary authority is not keeping inflation close to the target.

The results are shown in Figures 7 and 8, again compared to the results with backward-looking expectations (i.e., the results from Figure 1).

**Figure 7**
**High credibility of inflation target**

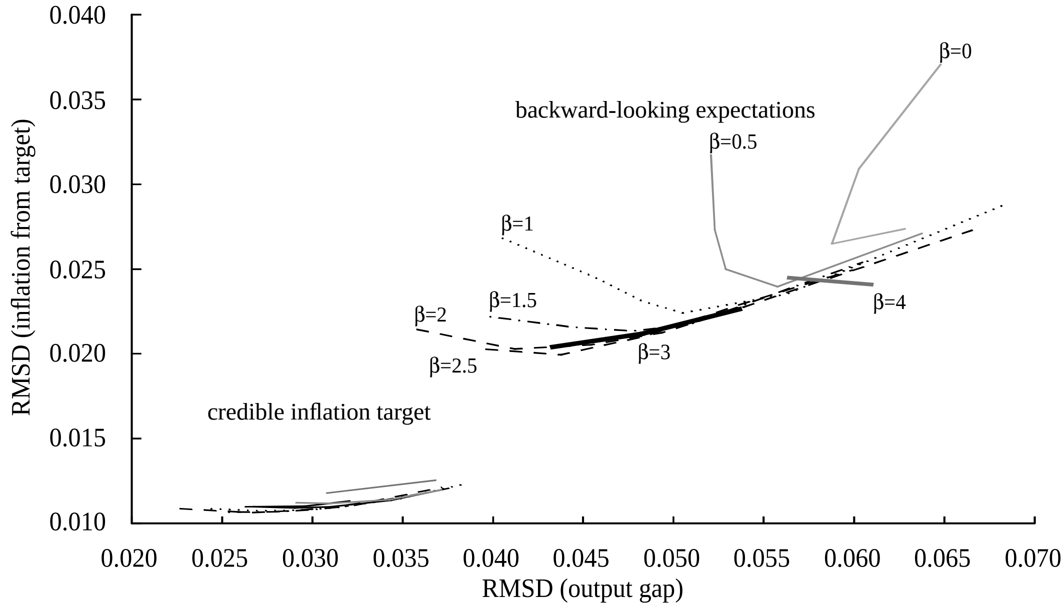
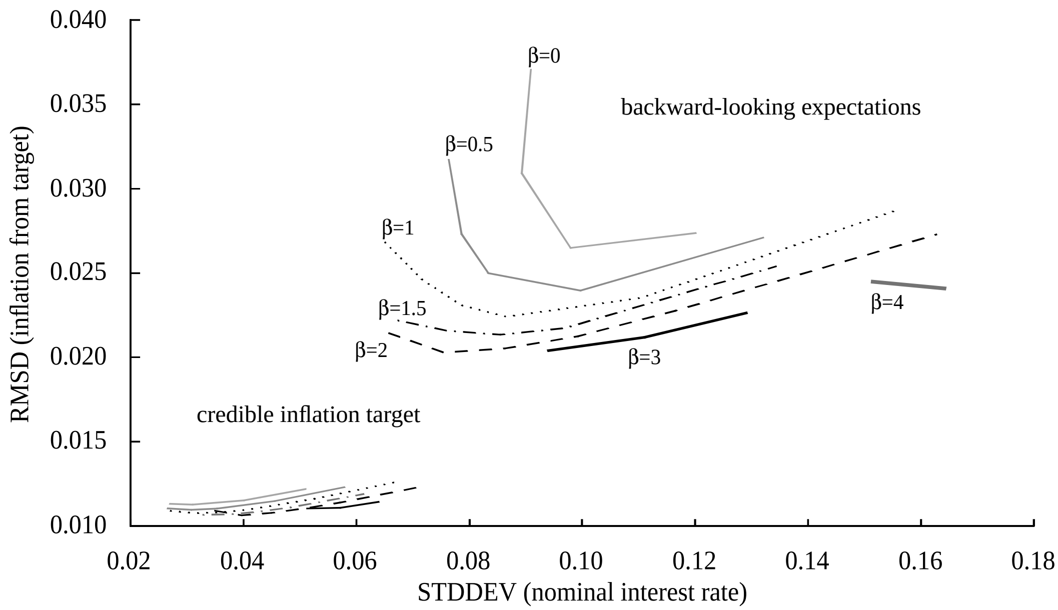



**Figure 8**
**High credibility of inflation target**



Placing a small weight on the price-level target at best decreases the variability of inflation, but increases output and interest rate variabilities. This is not surprising, since the benefits of price-level targeting that are derived from changes in expectations do not occur if agents are still basing expectations on a perceived inflation target. The changes in all variabilities are extremely small, however. Again, making expectations exogenous in this manner is clearly a strong assumption.

## 2.5 Expectations based on a mixed process

The above results support the general idea that price-level targeting can improve inflation, output, and nominal interest rate variability if agents incorporate targeting behaviour into their expectations. These results are based, however, on extreme assumptions about expectations—price-level targeting appears to have a role if it is highly credible, or if agents are almost all forward-looking and understand how the economy works and the policy being followed. This raises the question of what would happen if we made some less extreme assumptions, where expectations are based on a mixed process incorporating elements of backward-looking and model-consistent expectations.

To answer this question, the same rules were simulated, but this time with two sets of expectations, very similar to those used in the base case of QPM, i.e., the version used for doing projections at the Bank of Canada. In base-case QPM, expectations have a weight of around 0.7 on the backward component, a weight of around 0.2 on the model-consistent component, and a weight of around 0.1 on the perceived target. The rules were simulated based on this formulation of expectations. In addition, it was assumed that the .10 weighting on the inflation target in the base-case formulation switches to a weight on the price-level target. Figures 9, 10, and 11 show the results of both sets of simulations for inflation and output variability, inflation and nominal interest rate variability, and inflation and real interest rate variability. In each graph, the dot-dash line shows the results using base-case expectations (i.e., including a .10 weight on the perceived inflation target), and the solid lines show the results using the same weights on components for expectations, but this time with a credibility effect based on the price-level target.

The results from the base-case expectations show that, in such an environment, adding a weight on the price-level target in the policy rule causes the same trade-off seen in the backward-looking examples: inflation variability may fall, but at the cost of increased output and nominal interest rate variability. Clearly, the smaller weight on the model-consistent element is not enough to generate unambiguously beneficial effects. If, however, the

**Figure 9**
**Price level (solid) and inflation (dash) expectations close to base-case QPM**

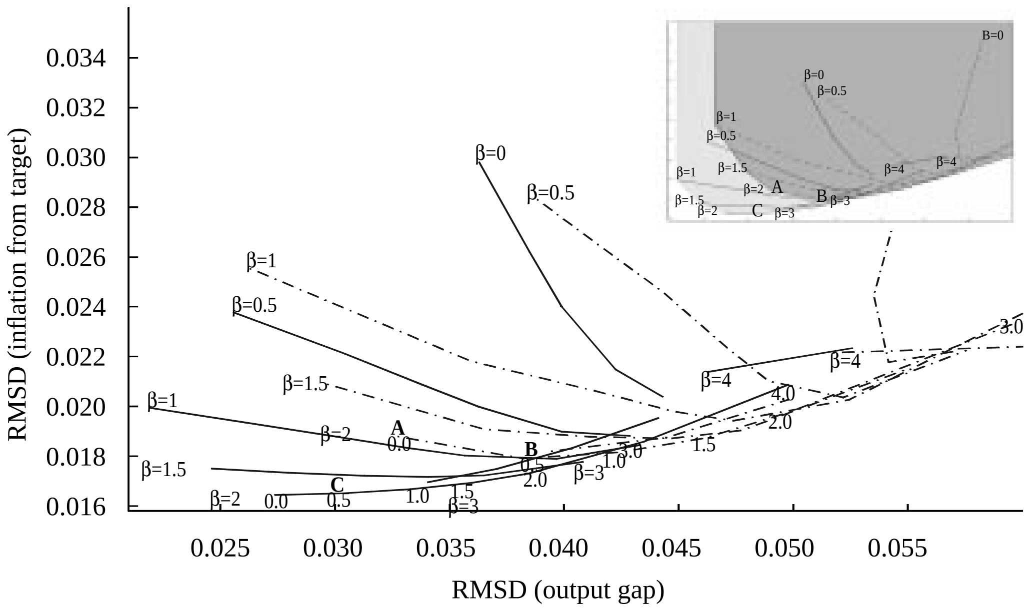



**Figure 10**
**Price level (solid) and inflation (dash) expectations close to base-case QPM**

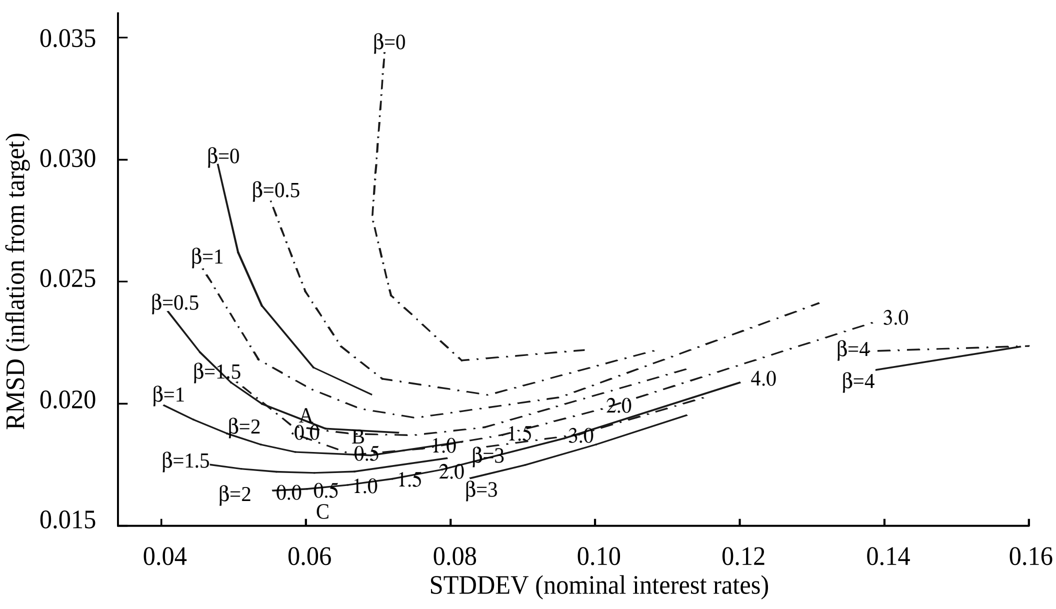
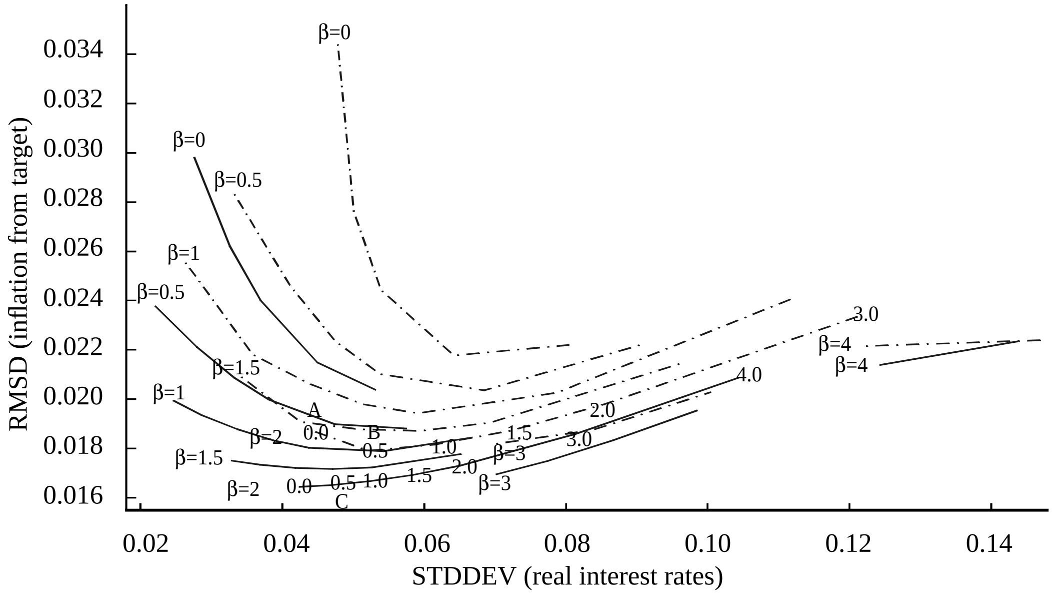


**Figure 11**
**Price level (solid) and inflation (dash) expectations close to base-case QPM**




10 per cent of people who base their expectations on the inflation target switch to basing their expectations on the price-level target, this is enough to generate declines in inflation and output variability. This can be seen in the shift between the dot-dash and solid lines. Point A, for example, indicates a point with no weight on the price-level target, a weight of 2 on the inflation target, and base-case expectations. Adding a weight on the price-level target in the policy rule with no changes in assumptions about expectations, represents a movement along the line to point B. Adding a weight on the price-level target in the policy rule and assuming the credibility effect switches to the price level, represents a movement to point C. At this point, the variabilities of output and inflation have fallen compared with A, and nominal interest rate variability is almost unchanged.

Another way of looking at this information is to consider the frontiers for price-level- and non-price-level-targeting rules, as shown in the inset graph in Figure 9. The frontier of the darkly-shaded area shows the best points attainable with only an inflation target, when about 10 per cent of people base their inflation expectations on the perceived target. The lightly-shaded region shows the extra area achievable with price-level targeting, if credibility switches from the perceived inflation target to the price-level targets.[9] This area includes rules associated with both lower inflation and output variability.

Thus, the introduction of price-level targeting can induce a lower variability of output with little increase in interest rate variability, under considerably less restrictive assumptions than complete credibility or completely model-consistent expectations. Moreover, it is worth stressing that the assumptions made about expectations and credibility of the inflation target in base-case QPM are not purely arbitrary. They are carefully calibrated to try and reflect empirical evidence on the behaviour of expectations and the costs of disinflation. A number of studies suggest that credibility has increased in the last few years, and in light of these results, the weight given to credibility within QPM can be viewed as a relatively cautious one.[10] It is not completely clear, however, whether credibility is linked to the Bank of Canada or more specifically to the inflation targets. If it is the former, then the assumption that those directly incorporating the perceived target into their expectations switch to using the price-level target path is not unreasonable. If it is the latter, however, with credibility linked to the inflation target, price-level targets would not necessarily have the same degree of credibility, particularly when newly introduced. The above results suggest that in this case, introducing price-level targets would lead to higher variability in output and interest rates.[11]

## 3 Sensitivity of Results to the Taylor Rule

For largely practical reasons, the analysis of price-level targeting described above was made using contemporaneous Taylor-type rules. Past work, however, has found that such rules do not give model properties in QPM as desirable as those resulting from explicitly forward-looking IFB rules. They are generally associated with higher variabilities of output and interest rates, partly because of considerable secondary cycling. There is concern, therefore, that the results may be sensitive to the fact that the starting-point rule is

9. The frontier of the lightly-shaded area is notional in that it shows points where some people place weight on a price-level target, but the policy rule has a zero weight on the price-level gap. All points to the right of the frontier, however, are associated with both some price-level credibility and a non-zero weight on the price-level gap in the policy rule.

10. For a good review of recent studies on the credibility of monetary policy in Canada, see Perrier and Amano (2000).

11. The result that some adjustment in expectations must occur for price-level targeting to lower variabilities is also consistent with that found in Black, Macklem, and Rose (1998). This is encouraging as regards the robustness of the result, since although they were using a model similar to QPM (the Canadian Policy Analysis Model), they incorporated credibility in a very different manner and used very different shocks in the stochastic simulations.

not a good rule to begin with. For this reason, we reconsider some of the key results using IFB rules. The above analysis also keeps the weight on the output gap unchanged. Conceivably, however, a price-level-targeting rule may perform better with different weights on the output gap. The sensitivity of results to changes in the output gap coefficient is, therefore, also considered (see section 3.2). Finally, within the Taylor-rule framework, adding a small weight on a price-level gap is sometimes beneficial, but the results do not support completely replacing the inflation gap with a price-level gap. This may be because a Taylor-rule framework is not the most appropriate one for price-level targeting. Consideration is given, therefore, to formulating a rule that is more explicitly oriented to a purely price-level-targeting regime.

## 3.1 Inflation-forecast-based rules

To check the robustness of the results obtained using the Taylor rules, price-level targeting is introduced into IFB rules under the assumptions of largely backward-looking and highly model-consistent expectations. The IFB rule used is again in terms of the yield spread, with weights on a forward-looking inflation gap (where the degree of forward-lookingness is $t+i$) and a forward-looking price-level gap (where the degree of forward-lookingness is $t+j$):[12]

$$\text{Yieldspreadgap}(t) = \beta * \text{Inflationgap}(t+i) + \lambda * \text{Pricelevelgap}(t+j). \quad (4)$$

As well as varying these weights, the appropriate degrees of forward-lookingness for both the inflation and price-level gaps have to be found for the two different assumptions about expectations. They were chosen by first selecting the degree of forward-lookingness for the inflation gap, assuming a zero weight on the price-level target. The selection was made on the basis of trying to minimize inflation, output, and interest rate variabilities. Once selected, a range of positive coefficient values on the inflation and price-level gaps were considered, with different degrees of forward-lookingness on the price-level gap.

In the case of highly backward-looking expectations, the appropriate degree of forward-lookingness for the inflation gap is 6 to 7 quarters ahead (the time horizon used in the base-case QPM rule). When searching for the appropriate lead on the price-level gap, a greater degree of forward-lookingness always appears better. (We tried up to 8 to 9 quarters ahead.) This can be seen in Figures 12 and 13, which show the results of varying the weight on the inflation and price-level gaps, given different degrees of forward-lookingness of the price-level gap. The solid lines show 4 to 5

12. Unlike the base-case IFB rule in QPM, no weight was placed on either the output gap or the lagged-yield spread gap.

**Figure 12**
**IFB rules, BW expectations: Leads on the price level**

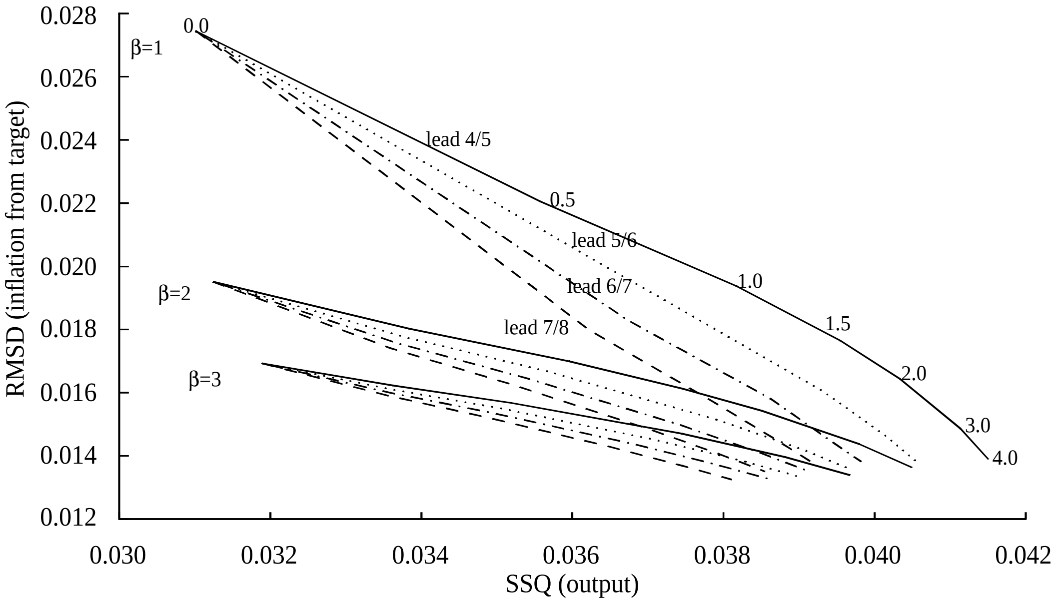
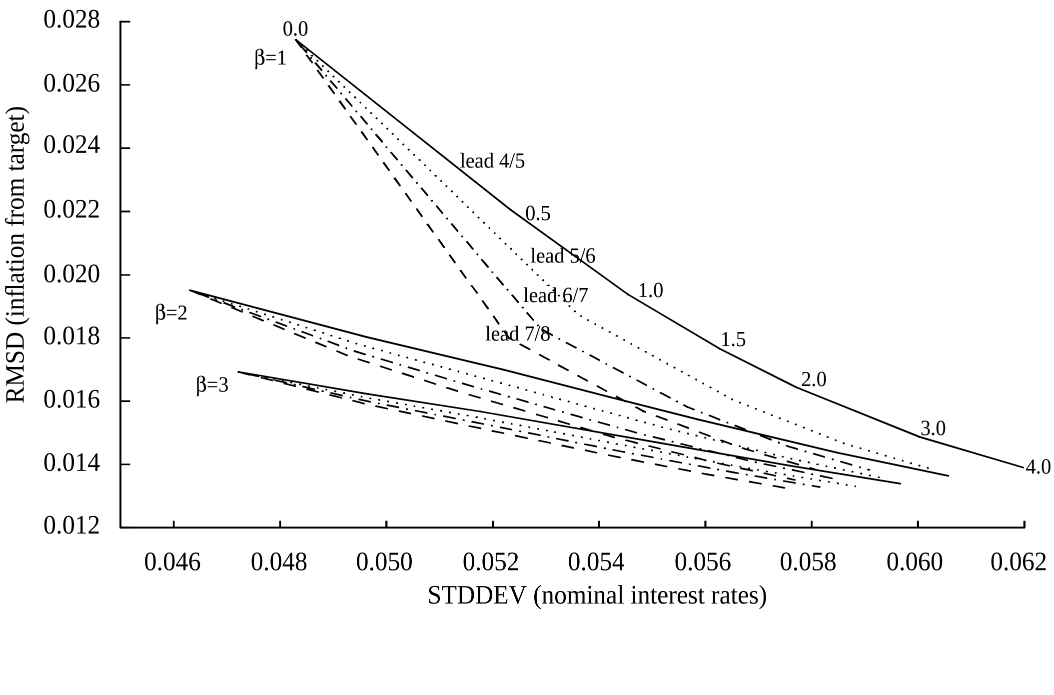



**Figure 13**
**IFB rules, BW expectations: Leads on the price level**



periods ahead, the dotted 5 to 6, the dot-dash line 6 to 7, and the dash line 7 to 8 periods ahead. A greater degree of forward-lookingness is generally associated with lower inflation and interest rate variability. Varying the weights on the inflation and price-level gaps makes a bigger difference to the variabilities, however, than varying the degree of forward-lookingness. Moreover, for all degrees of forward-lookingness, adding a price-level target still creates a trade-off between lower inflation variability but higher output and interest rate variability.

Under the second assumption of highly model-consistent expectations, the most appropriate lead on the inflation gap was found to be 5 to 6 quarters ahead.[13] Figures 14, 15, and 16 show the results for different leads on the price-level gap. Again, a more forward-looking price-level gap gives lower output and inflation variability but higher interest rate variability.

For all degrees of forward-lookingness, the general results obtained with the Taylor rule appear robust, but the gains from adding a small weight on a price-level target are considerably greater. Not only do inflation and output variability decline, there are also significant declines in nominal interest rate variability. The gains are also evident for a greater range of weights on the inflation gap term. In some cases, additional gains also occur not just with the initial introduction of the price-level target, but when the weight increases from 0.5 to 1.

The fact that price-level targeting does better in an IFB rule is broadly consistent with previous work in QPM comparing IFB and Taylor rules. In QPM, in the context of an inflation-targeting rule, it is always better to anticipate the effects of shocks. When the monetary authority acts early, the policy response can be much smoother. Acting later requires a sharper initial response and is associated with greater secondary cycling of interest rates and output. In the context of price-level targeting, looking ahead and anticipating the effects of shocks to allow a smoother response is even more important. This can be seen in the above results, where the most appropriate horizon for the price-level gap is found to be more forward-looking than that of the inflation gap.

A question remains about how specific the results for the effects of price-level targeting in the Taylor and IFB rules are to QPM. In particular, one feature of QPM that may be important is that monetary policy affects activity through the yield spread. To affect real activity, therefore, the monetary authority must influence real short-term interest rates.[14] The real

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13. This is consistent with Amano, Coletti, and Macklem (1999), who found that the optimal lead on the inflation gap in an IFB rule declines when credibility is increased.
14. This contrasts, for example, with models of the U.S. economy where activity is generally tied to longer-term rates of interest.

**Figure 14**
**IFB rules, MC expectations: Leads on the price level**

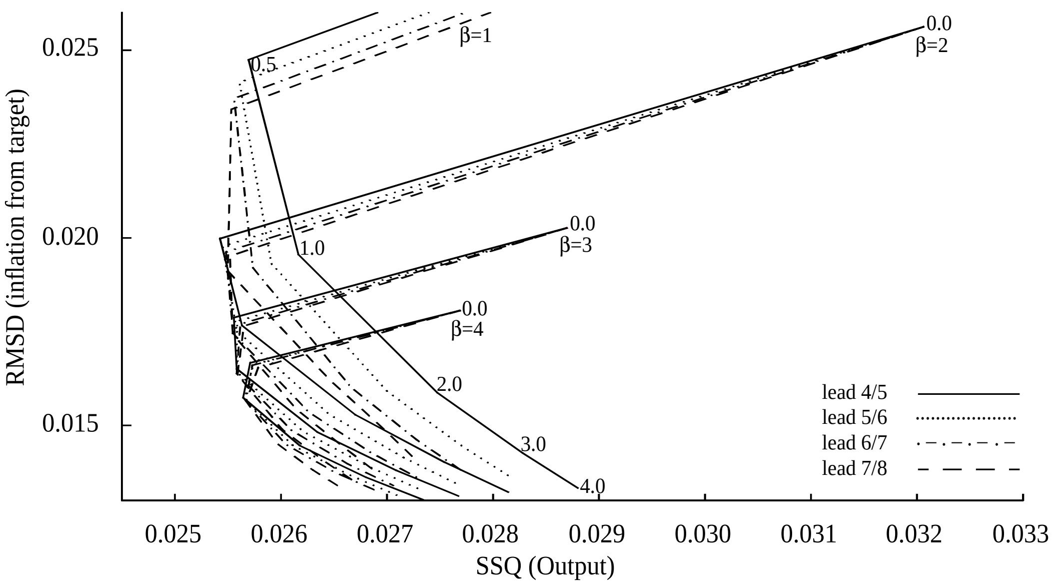



**Figure 15**
**IFB rules, MC expectations: Leads on the price level**

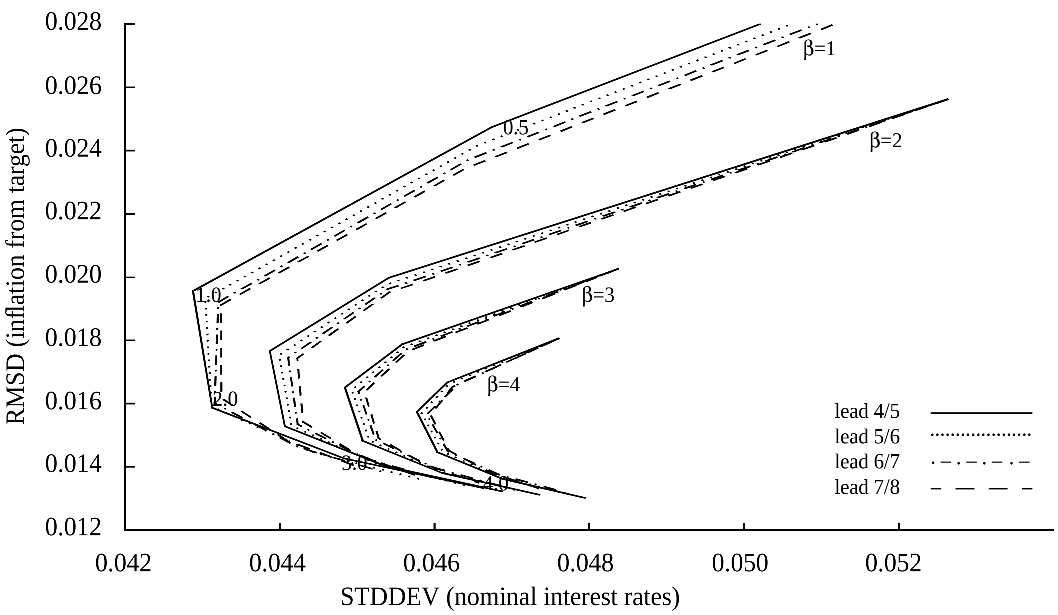
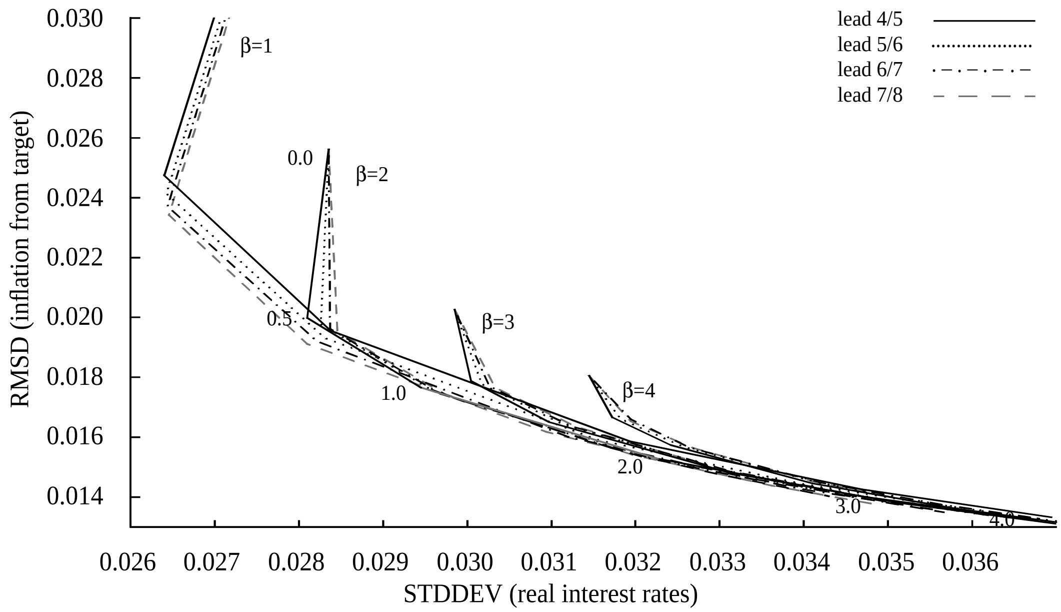


**Figure 16**
**IFB rules, MC expectations: Leads on the price level**




short-term rate is defined as the nominal rate deflated by expectations of current inflation. Even if agents believe that the monetary authority is committed to returning to a price-level target, they will hardly expect the effects of a shock to be reversed in the next quarter. Thus, changes in the short-term real rate will not be large. Price-level targeting may therefore do better in models where the transmission mechanism depends on longer-term rates of interest. Changes in medium-term expectations stemming from the price-level target would then have a greater impact on those rates that affect real activity.

This has interesting implications for the probable effect of price-level targeting in the presence of binding zero nominal interest rate floors. Many authors have proposed price-level targeting as a means of avoiding problems associated with a zero nominal interest rate floor in a low-inflation economy.[15] During a period of disinflation, nominal interest rates cannot fall below zero, but if agents expect a period of higher inflation in the future to restore the price-level-target path, real interest rates can still adjust through changes in expectations. The above results suggest, however, that in a model such as QPM, where short-term real rates are important in the monetary transmission mechanism, incorporating price-level targeting may not greatly reduce problems with zero nominal interest rate floors, because the main

15. Papers dealing with this issue include Wolman (1998), Woodford (1999), and Reifschneider and Williams (1999).

changes to expectations occur in the medium term and do not directly affect the short-term real rate.

## 3.2 Varying the weight on the output gap

In the above simulations where the price level is added to a Taylor rule, the weight on the output gap is kept constant at 0.5. To determine whether varying the weight on the output gap could lead to better results with price-level targeting, the rules were simulated with weights of 1, 2, and 3 on the output gap under the assumption of highly model-consistent expectations. These results are shown in Figures 17 and 18. (Although not specifically marked, the coefficient values for the inflation gap are the same as those used in the previous simulations.) In Figure 17, it can be seen that increasing the weight on the output gap generally decreases output and inflation variability, but makes no real difference to the comparison of rules with and without price-level targeting.[16] Similarly, increasing the weight on the output gap leads to generally higher nominal interest rate variability, but, as before, adding a small weight on the price-level target is generally associated with little change in nominal interest rate variability.

## 3.3 A contemporaneous price-level-targeting rule

Much of the above work involves adding a price-level target into a Taylor rule. Remember that a Taylor rule has an inflation-gap term (since the monetary authority is assumed to be targeting inflation) and an output-gap term, which largely plays the role of providing forward-looking information about future inflation. Incorporating a price-level target into this framework is in some ways a little strange. After a positive shock to inflation, for example, the inflation- and price-level-gap terms will both be positive initially. But at some point, to restore the price-level target, inflation must fall below “target” while the price-level gap is still positive. Thus, the two components will have opposite signs. An alternative idea is to try to develop a specifically price-level-targeting rule, in the same spirit as the Taylor rule, i.e., which includes the price-level gap and a term that provides information about the future price level.

Three different rules were tried: a rule consisting of the price-level gap and a cumulative output gap; a rule consisting of the price-level gap, the

16. While weights on the output gap greater than 0.5 reduce output variability in stochastic simulations, they result in some undesirable model properties in deterministic shocks. The policy response to a negative demand shock, for example, is so extreme that the shock appears inflationary.

**Figure 17**
**MC expectations using traditional Taylor rule, varying weight on output gap**

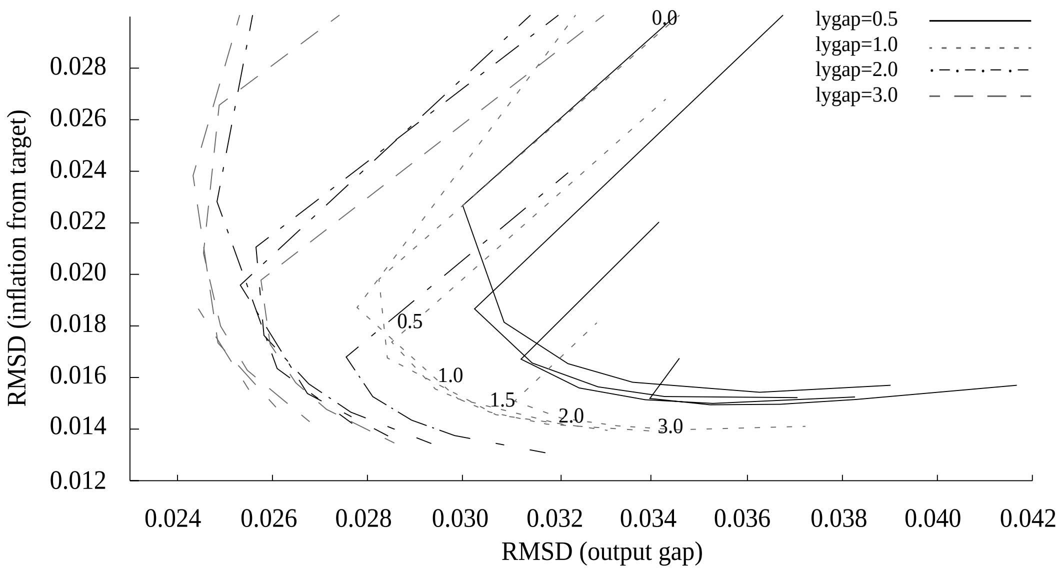
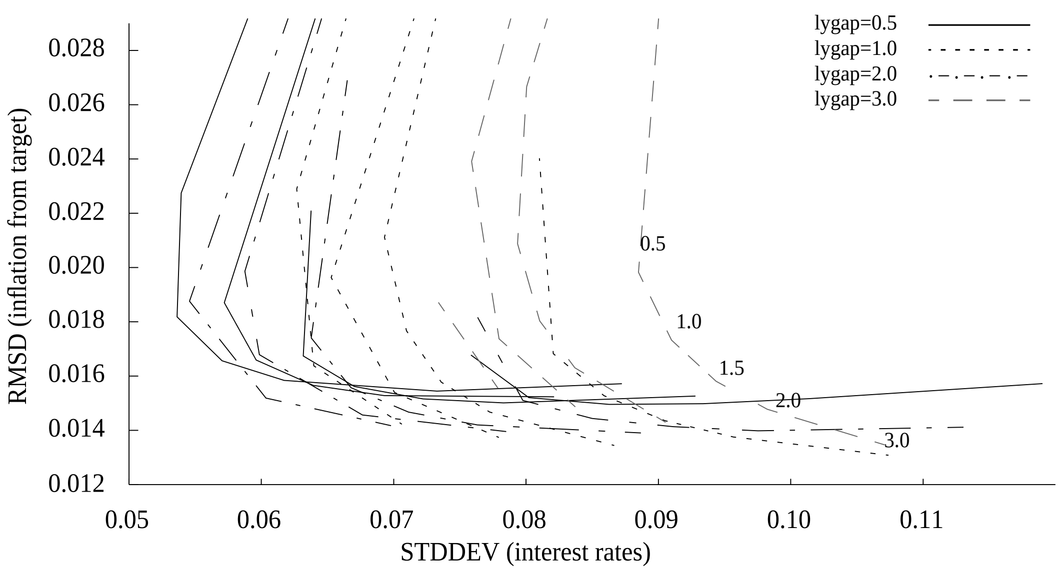



**Figure 18**
**MC expectations using traditional Taylor rule, varying weight on output gap**



output gap, and the change in the output gap; and a rule consisting of the price-level gap, the output gap, and a moving average of past output gaps.[17]

$$\text{Yieldspreadgap}(t) = \alpha{*}\text{CumulativeOutputgap}(t) + \lambda{*}\text{Pricelevelgap}(t) \quad (5)$$

$$\text{Yieldspreadgap}(t) = \alpha{*}\text{Outputgap}(t) + \beta{*}\text{Changeinoutputgap}(t) + \lambda{*}\text{Pricelevelgap}(t) \quad (6)$$

$$\text{Yieldspreadgap}(t) = \alpha{*}\text{Outputgap}(t) + \beta{*}\text{MAoutputgap}(t{-}1 \text{ to } j) + \lambda{*}\text{Pricelevelgap}(t) \quad (7)$$

The first formulation, with the cumulative output gap, was in many ways the most intuitive of the three sets of rules. It did not produce good results, however, in that it was associated with generally higher variabilities of inflation, output, and interest rates, and in many cases the models never settled to their steady state in deterministic simulations. The failure of the rules to incorporate exchange rate pass-through effects may be one reason for their poor performance. Their performance was also very sensitive to the exact measure used for the cumulative output gap.[18] The rules that included the moving average of lagged output gaps were also associated with significantly higher variabilities of inflation, output, and interest rates compared with the traditional Taylor rules with price-level targeting.

The rules that performed the best were those that included the output gap and the change in the output gap. Including the change in the output gap increases the initial response to a demand shock (and decreases the initial response to a price-level shock), but then causes a faster turnaround in interest rates once the trough or peak in output is passed.

The results of the “change” rules are shown in Figures 19 and 20, compared with the results from the traditional Taylor rules with price-level targeting (the light grey dash lines). As before, moving down the lines shows the effect of increasing the weight on the price-level gap. The different sets of lines show different weights on the output gap, and each line within the set shows a different weight on the change in output. Initially, increasing the weight on the price-level gap reduces both inflation and output variability. Beyond some point, however, further increases in the weight lead to a deterioration in these variabilities. Interestingly, the best coefficient values

17. Averages of the past two and five years were tried.

18. The measures tried for the cumulative output gap were: the total cumulative output gap dating from the beginning of the simulation, the addition of output gaps over the past five years, and the addition of output gaps over the past two years. The non-linearity of the Phillips curve was taken into account when calculating the cumulative output-gap measures.

**Figure 19**
**MC expectations using change rule, varying weight on output**

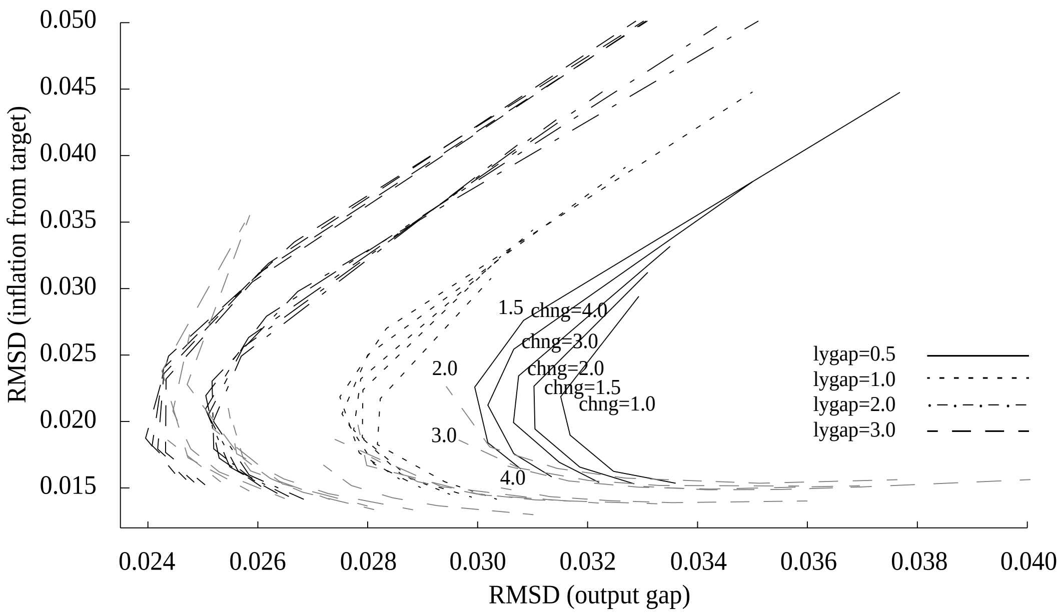
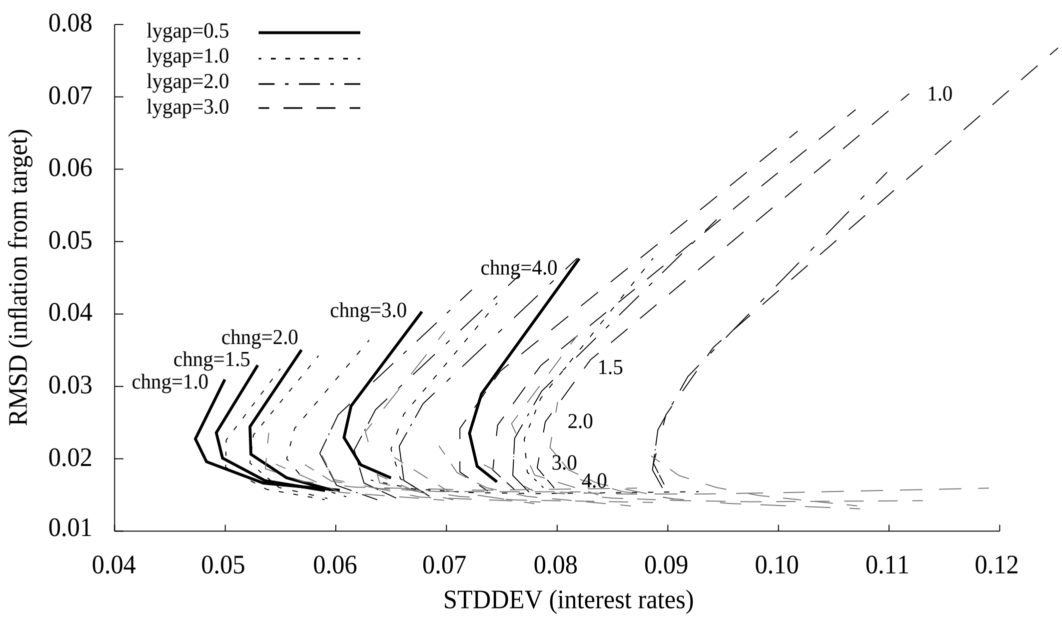



**Figure 20**
**MC expectations using change rule, varying weight on output**



for the price-level gap (around 3) are similar to the best coefficient values for the inflation-gap term in the traditional Taylor rules. Increasing the weight on the change in output gap shifts the lines to the left, i.e., leads to a reduction in output variability, at the expense, however, of slightly increased inflation variability.

There is a range of weights over which the new rules give very similar results to the Taylor rules with price-level targeting, in terms of the variabilities of inflation and interest rates.[19] For example, with a weight on the output gap of 0.5, change rules with a weight of around 3 on the price-level gap and 3 and 4 on the change, give similar variabilities to Taylor rules with a weight of 0.5 on the price-level gap and 2 or 3 on the inflation gap. These rules are associated, however, with higher nominal interest rate variability. As can be seen in Figure 20, as the weight on the change in the output gap is increased, interest rate variability also increases. These results are thus consistent with those in section 2, which suggest that in terms of inflation, output, and nominal interest rate variabilities, pure price-level-targeting rules do not give results as desirable as those that still contain an inflation target.

## Conclusion

We find that the assumptions made about expectations are crucial in determining the results from adding price-level targeting into a Taylor rule. If agents are highly backward-looking, there are no clear gains from adding a price-level gap. Rather, there is a trade-off between slightly decreased inflation variability and significantly increased output and interest rate variability. If agents' expectations are highly model-consistent, however, the introduction of a small weight on a price-level gap can reduce inflation and output variability, without significantly changing the variability of nominal interest rates. In addition, we find that gains from adding a price-level target can occur with considerably less than fully model-consistent expectations. In particular, using the version of expectations calibrated to reflect Canadian data, price-level targeting improves the variabilities of inflation and output if the price-level targets have the same credibility as is currently placed on the inflation target. Nevertheless, some degree of credibility is required to generate lower variabilities.

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19. While the overall variabilities for the two different models appear similar for some points, the model properties are quite different. The rules that include the change in the output gap and no inflation gap are characterized by a more aggressive initial reaction to demand shocks, followed by a faster reversal of interest rates and a less aggressive but longer reaction in price-level shocks.

Introducing an exogenous credibility effect, while giving desirable results in terms of the impact of price-level targeting, is found to be a dangerous modelling strategy. It is too strong an assumption and can give desirable results in terms of variabilities even when relatively poor rules are being followed by the monetary authority.

While gains are found from adding in a small weight on a price-level gap, the results do not support completely replacing an inflation target with a price-level target. A number of different specifications of a contemporaneous price-level-targeting rule were tried, but none could outperform adding a small weight on a price-level gap within a traditional Taylor rule.

When introduced into an explicitly forward-looking IFB rule, the gains from price-level targeting are more significant. Even in an inflation-targeting regime in QPM, the policy response is much smoother when the monetary authority is forward-looking and anticipates the future effect of shocks. With price-level targeting, being forward-looking appears to be even more important, to avoid unnecessary cycling in interest rates and output.

An important caveat to these results is that we are unsure how specific they may be to QPM. They may be sensitive to assumptions about the monetary transmission mechanism, in particular, the role of short- versus longer-term interest rates. The potential benefits from price-level targeting rely on the effect that changes in medium-term expectations have on the real interest rate, which in turn affects real activity. Medium-term expectations can, therefore, have a more direct impact if the monetary transmission mechanism relies on a longer-term interest rate. For example, this may limit the extent to which our results can be applied to U.S. models, where activity is linked to longer-term rates.

## Appendix

The shocks used in the stochastic simulations are calibrated using an estimation-by-simulation approach. We start with a simple AR(1) representation of innovations, then re-parameterize them until QPM produces standard deviations and autocorrelation coefficients that match approximately those in the data. In other words, we are trying to match both the mix of shocks and their persistence. In particular, we try to match the variability and autocorrelation of the change in real output, inflation, and the change in interest rates to those values calculated for the period from the first quarter of 1973 to the first quarter of 1998.[1] Shocks are introduced on eight behavioural variables[2] and one exogenous variable (the level of steady-state productivity). Shocks are also introduced for four variables capturing activity in the rest of the world. These are generated using an estimated VAR. For more details on the estimation-by-simulation approach, and the VAR used to generate the rest-of-world shocks, see Amano, Coletti, and Murchison (1999).

Table A-1 shows the variability and autocorrelation measures from the base-case calibration and over history for output, inflation, and interest rates. It can be seen that the variability of output is higher than historically, whereas the variability of inflation is a little below the historical measure. This reflects the fact that QPM now has a more aggressive rule than that followed over the historical period.

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1. The choice of sample period is open to the criticism that variabilities may have altered over time, for example that output variability has fallen. This calibration is viewed as preliminary. Sensitivity analysis performed to check the robustness of results suggests, however, that the main qualitative conclusions regarding changes in variabilities as rules differ are robust to reasonable variations in the variabilities of output and inflation.

2. Shocks are included for the GDP deflator, the CPI, real consumption, real investment, real exports, real imports, the total direct tax rate, and wages.

**Table A-1**
**Standard deviations and autocorrelation coefficients with their corresponding 95 per cent confidence intervals for selected variables.**

| Variables* | Standard Deviation | AR(1) Coefficient |
|---|---|---|
| Output | | |
| Quarterly | 3.0 < 3.4 < 3.9 < **4.8** | 0.24 < **0.36** < 0.43 < 0.63 |
| Annual | 2.1 < 2.4 < 2.6 < **3.0** | 0.67 < **0.82** < 0.87 < 1.06 |
| CPI less food and energy | | |
| Quarterly | **1.9** < 3.1 < 3.5 < 4.1 | 0.61 < **0.56** < 0.80 < 1.00 |
| Annual | **1.5** < 2.8 < 3.2 < 3.7 | 0.76 < **0.89** < 0.96 < 1.16 |
| Yield spread | 1.2 < 1.4 < **1.5** < 1.6 | 0.54 < 0.74 < **0.85** < 0.93 |
| 10-year interest rate | 1.9 < **2.2** < 2.5 | 0.73 < **0.91** < 0.93 < 1.12 |
| 90-day interest rate | 3.0 < 3.4 < 4.0 < **4.9** | 0.72 < **0.88** < 1.11 |

Notes: QPM sample moments are shown in bold.
* Quarterly indicates quarterly growth at annual rates. Annual indicates year-over-year growth.

# References

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

Amano, R., D. Coletti, and S. Murchison. 1999. "Empirical Estimation and the Quarterly Projection Model: An Example Focusing on the External Sector." Sveriges Riksbank Working Paper No. 104.

Armstrong, J., R. Black, D. Laxton, and D.E. Rose. 1995. *The Bank of Canada's New Quarterly Projection Model. Part 2: A Robust Method for Simulating Forward-Looking Models*. Technical Report No. 73. Ottawa: Bank of Canada.

Black, R., D. Laxton, D.E. Rose, and R. Tetlow. 1994. *The Bank of Canada's New Quarterly Projection Model. Part 1: The Steady-State Model: SSQPM*. Technical Report No. 72. Ottawa: Bank of Canada.

Black, R., T. Macklem, and D. Rose. 1998. "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 1997. Ottawa: Bank of Canada.

Coletti, D., B. Hunt, D.E. Rose, and R. Tetlow. 1996. *The Bank of Canada's New Quarterly Projection Model. Part 3: The Dynamic Model: QPM*. Technical Report No. 75. Ottawa: Bank of Canada.

Dittmar, R., W.T. Gavin, and F.E. Kydland. 1999. "The Inflation-Output Variability Tradeoff and Price-Level Targets." *Federal Reserve Bank of St. Louis Review* 81 (1): 23–31.

Laxton, D., D.E. Rose, and R. Tetlow. 1993. "Is the Canadian Phillips Curve Non-Linear?" Bank of Canada Working Paper 93–7.

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

Poloz, S., D. Rose, and R. Tetlow. 1994. "The Bank of Canada's New Quarterly Projection Model (QPM): An Introduction." *Bank of Canada Review* (Autumn): 23–38.

Reifschneider, D. and J.C. Williams. 1999. "Three Lessons for Monetary Policy in a Low Inflation Era." Working Paper No. 44. Board of Governors of the Federal Reserve System.

Svensson, L.E.O. 1996. "Price-Level Targeting vs. Inflation Targeting: A Free Lunch?" NBER Working Paper No. 5719.

Vestin, D. 2000. "Price-Level Targeting Versus Inflation Targeting in a Forward-Looking Model." Unpublished manuscript. < URL: http://www.iies.su.se/~vestin/html/price.htm >.

Wolman, A.L. 1998. "Real Implications of the Zero Bound on Nominal Interest Rates." Paper presented at NBER Universities Research Conference: Formulation of Monetary Policy.

Woodford, M. 1999. "Commentary: How Should Monetary Policy Be Conducted in an Era of Price Stability?" In *New Challenges for Monetary Policy,* 277–316. A symposium sponsored by the Federal Reserve Bank of Kansas City, August.

# Discussion

*Jerzy D. Konieczny*

It is a pleasure to discuss the important paper by Maclean and Pioro. They explore the effect of adopting price-level targeting in Canada on the variability of inflation, output, and interest rates, using the Bank of Canada Quarterly Projection Model (QPM).

It has been known, since the pioneering work by Svensson (1999), that even when society prefers the control of inflation, adopting a price-level target may be better than adopting an inflation target. This goes against the conventional view that price-level targets raise inflation and output variability. Svensson showed, however, that when expectations are forward-looking and output is persistent, adopting price-level targets lowers the variability of inflation and does not affect the variability of output; hence, he called the result "a free lunch." The benefits of such *history-dependent* (Woodford 1999) policy arise as the policy affects agents' expectations. An increase in the inflation rate creates expectations of a future inflation reduction, and thus reduces current price increases. This result is surprising, since the monetary authority, to be credible, must actually deliver a lower rate of inflation in the future. The best intuition for understanding this is provided by Michael Parkin in the last paper of this volume. While the rate of inflation responds to the output gap in the case of inflation targeting, under price-level targeting it responds to *changes* in the output gap. If output is sufficiently persistent, the change in output gap is less variable than the output gap itself; therefore, inflation variability is lower under a price-level target. The free-lunch result has been shown to be quite general, by Black, Macklem, and Rose (1998) and Dittmar and Gavin (2000), among others.

## The Paper's Goals and a Summary of the Results

The goal of the paper, as I see it, is to transform the free lunch from a theoretical proposition into a practical solution. And that is commendable.

The paper concentrates on two issues. First, with the exception of Williams (1999), the free-lunch result in the literature comes from small, analytical models. As a practical question, the authors ask whether it holds in a more complex model, the QPM, used by the Bank of Canada. They also determine whether it is robust to changes in assumptions about the nature of the policy and the way expectations are formed. Second, a major issue in the literature is that for the free-lunch result to hold, complete credibility is assumed. This is a requirement of high order. Hence, the authors examine how much credibility is needed for the variabilities of inflation, output, and interest rates to fall when price-level targets are introduced. In particular, they are interested in whether the result holds for the expectations specifications used in the QPM, which are calibrated for the Canadian economy. If it does, then it may be said with some confidence that price targeting could be useful in the Canadian case.

The answers are, generally speaking, positive. Maclean and Pioro find that the results in the literature do hold in the more complex QPM. A combination of an inflation target and a price-level target leads, for some weights on the price-level target, to lower variability of inflation, output, and prices, and this result is robust. Most important, while credibility is crucial, full credibility is not needed. In particular, the result does hold for the expectations specifications used in the QPM.

The main question for a reviewer of a simulation paper of this type is whether it provides sufficient evidence to make price-level targeting a practical proposition, i.e., to determine whether we will, in fact, get the free lunch. In my opinion, the paper can be viewed as work in progress.

## Results Under Taylor-Policy Rules

Maclean and Pioro are careful not to make welfare comparisons and thus examine only the effect on variabilities of output, inflation, and interest rates. They start their analysis by simulating the effect of adding a price-level target to Taylor-type policy rules in which the monetary authority reacts to deviations of inflation and output from target. More specifically, they consider (see their equation (3)) the effects of increasing $\lambda$ from zero to a small number in the following rule:

$$\text{Yieldspreadgap} = 0.5 * [(\text{Outputgap}) + 4 * (\text{Inflationgap}) + \lambda * (\text{Pricelevelgap})]. \quad (1)$$

Their results are summarized in Table 1 of this discussion. The rows of Table 1 show the assumptions and results of various simulation experiments. The crucial difference between experiments is in the assumptions about agents' expectations. The basic idea, used in QPM, is that there are three types of agents in the economy. The first type has backward-looking expectations, the second has model-consistent expec-tations, while agents of the third type believe (with some modifications) in whatever the Bank of Canada announces. The experiments vary the weights on the three types of expectations (i.e., the proportions of agents of each type).

As the first two rows of Table 1 show, results obtained in the literature hold in the QPM under some assumptions. With backward-looking expectations (row 1: 80 per cent of agents with backward-looking expectations, 20 per cent with model-consistent expectations), introducing a price-level target raises the variability of output and interest rates; the variability of inflation falls or, with some parameter values, does not change. When expectations are forward-looking (row 2: 10 per cent of agents with backward-looking expectations, 90 per cent with model-consistent expectations), the variabilities of inflation and output fall as $\lambda$ increases (as long as $\lambda$ is small); the effect on the interest rates is small. Note that, in these simulations, agents with model-consistent expectations realize that the central bank is using a combination of inflation and price-level targeting, i.e., they know the form of the rule (1) and the value of $\lambda$.

In the next experiment, called a highly credible price-level target, and shown in row 3 of Table 1, Maclean and Pioro assume that 10 per cent of agents are backward-looking, 10 per cent have model-consistent expectations, and 80 per cent believe that the Bank of Canada is following a price-level target. They then consider the effect of increasing $\lambda$ from zero to a small number in this environment. Output and inflation variability increase as $\lambda$ is raised, but their values are much lower than in previous experiments. As Maclean and Pioro admit, this is an odd experiment. A vast majority of agents are assumed to believe that the weight on the inflation gap is zero, while, in fact, it is much larger than the weight on the price-level target. This example, in my view, usefully stresses the crucial role of expectations: when most agents believe in a price-level target, variabilities of inflation and output are very low.

Row 4 of Table 1 summarizes the effects of introducing price-level targeting when most agents believe the Bank of Canada targets inflation. Not surprisingly, this makes things worse. Variabilities in this case are somewhat smaller than with model-consistent expectations. This is an interesting result: variability is lower when agents blindly believe in the Bank of Canada's announcements than when their expectations are rational.

**Table 1**
**The effect of introducing a price-level target with a small weight**

| Expectations assumptions | | Weight on: backward-looking expectations | Weight on: model-consistent expectations | Weight on: perceived inflation-target expectations | Weight on: price-level-target expectations | The effect on the variability of: $\pi$ | The effect on the variability of: $Y$ | The effect on the variability of: $i$ |
|---|---|---|---|---|---|---|---|---|
| **Row** | **Column** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 1 | Highly backward-looking | 0.8 | 0.2 | | | – or 0 | + | + |
| 2 | Highly forward-looking | 0.1 | 0.9 | | | – | – | 0 or + |
| 3 | Credible price-level target | 0.1 | 0.1 | | 0.8 | + | + | |
| 4 | Credible inflation target | 0.1 | 0.1 | 0.8 | | – or + | + | + |
| 5 | QPM weights, inflation target | 0.7 | 0.2 | 0.1 | | – or + | + | + |
| 6 | QPM weights, price target | 0.7 | 0.2 | | 0.1 | –* | –* | 0* |

* The effect of simultaneously introducing a price-level target and replacing a credible perceived inflation target with a credible price-level target.

My first question concerns the choice of weights on various forms of expectations. They appear largely arbitrary. In particular, the weights in the first two rows are not symmetric. The same issue arises in other parts of the paper. The arguments would be more convincing if the choice of weights was explained. This is especially important in a simulation exercise where it is difficult to assess the effect of a change in parameter values on the results. Similarly, inflation beliefs and price-level beliefs are treated differently. Following the practice in the QPM, Maclean and Pioro assume that, whenever agents believe that the central bank is targeting inflation, it is a "perceived target": the announced target corrected on the basis of past performance. On the other hand, when agents are assumed to believe in the price-level target, it is the actual target. Hence, inflation and price-level targets are not treated symmetrically, and this asymmetry may significantly affect results.

The weights in the last two rows are not arbitrary, but are based on weights similar to those used in the basic QPM: 70 per cent of agents are backward-looking, 20 per cent have model-consistent expectations, and 10 per cent believe whatever the Bank of Canada says.

The main result of the paper occurs when the Taylor rule changes from:

$$\text{Yieldspreadgap} = 0.5(\text{Outputgap} + 4 * \text{Inflationgap})$$

to:

$$\text{Yieldspreadgap} = 0.5(\text{Outputgap} + 4 * \text{Inflationgap} + \text{Pricelevelgap}),$$

and, *simultaneously*, the 10 per cent of agents who believe whatever the central bank says, switch to believing that the target has changed from inflation to price level.[1] The results of this experiment, which are described in detail in section 2.5 of the Maclean-Pioro paper, are summarized in row 6 of table 1 of this discussion. Variability of output and inflation both fall; the effect on the variability of interest rates is small. These effects arise even though credibility of monetary policy is quite limited: 70 per cent of agents have backward-looking expectations. It is important to stress that these are the actual expectations weights calibrated in the QPM. Thus, it can be argued that full credibility is not needed, and that the free-lunch result holds in the Canadian economy.

The assumption about expectations changes is puzzling. The 10 per cent of agents who believe whatever the Bank of Canada says are assumed to believe that the central bank follows a price-level target. In the simulation summarized in row 6 of Table 1, it, in fact, targets both inflation *and* the

1. This switch is crucial, as can be seen from row 5 of Table 1.

price level; but, the weight on the inflation gap is four times greater than the weight on the price-level gap. I am not sure how such expectations can be formed. If agents believe in Bank announcements because of credible behaviour in the past, they may, of course, initially trust the Bank's announcement of the new policy. But, given the relatively high weight on the inflation gap in the Bank's Taylor rule, it will miss the price-level target systematically and, over time, the believers will realize that the Bank target is different from the one announced. Bank credibility will be eroded. Therefore, a switch to price-level targeting will result in only temporary improvement and, in the long run, the central bank will have to return to inflation targeting, as can be seen from row 5 (Table 1), which summarizes the results when agents believe an inflation target is followed.

## Robustness Under Alternative Assumptions About Policy Rules

The contemporaneous Taylor rules used in these simulations are dominated in the QPM by inflation-forecast-based (IFB) rules. While not as robust, IFB rules result in lower variability of inflation and output. The authors recognize that and thus do simulations under the IFB assumptions. The assumptions are, however, different than before: they put zero weight on the output gap and use only expectations rules from rows 1 and 2 in Table 1. The results are similar to those obtained under Taylor rules, but the reductions in variability are larger than before. It is not clear, however, whether the main result holds with IFB rules and limited credibility. The problem is that, if the goal is to minimize variabilities, the Bank of Canada would like to use *the best policy*; this may be IFB rules with a mix of inflation and price-level targeting. So, the next step should be to determine whether the main result holds under these assumptions.

As previously mentioned, monetary policy is assumed to react both to deviations of inflation, as well as of the price level, from their respective targets. Maclean and Pioro recognize that this is a bit unusual; in particular, under some circumstances, the gaps may point in the opposite direction. They therefore consider three Taylor-type rules that do not include inflation targeting. Under these rules, the monetary authority reacts to some measure of current and past output gaps, as well as a price-level gap. The best performing rule is one that includes the output gap, as well as the change in output gap. It would be interesting to know why these particular rules have been tried. The results are similar to those obtained before but, again, cannot be directly compared, because of different treatment of output and the fact that only forward-looking expectations are used.

As I understand, some simulations were not done because they are very time-consuming. In a simulation study of a complex model, however, it is sometimes difficult to assess the effect of changing assumptions on the results. Therefore, it is essential that assumptions be chosen on the basis of theoretical or practical considerations. If neither theory nor empirical results provide guidance regarding what assumptions should be used, then it is advisable to proceed in a systematic fashion. So, again, I view the paper as work in progress.

## The Credibility of the Stable Price-Level Target

Let us assume that a subsequent paper shows that a price-level target is superior to targeting inflation. What target should then be chosen? Maclean and Pioro consider a path of prices increasing at 2 per cent per year; the choice of a particular value for the price-level target is, to a large extent, beyond the scope of their paper.

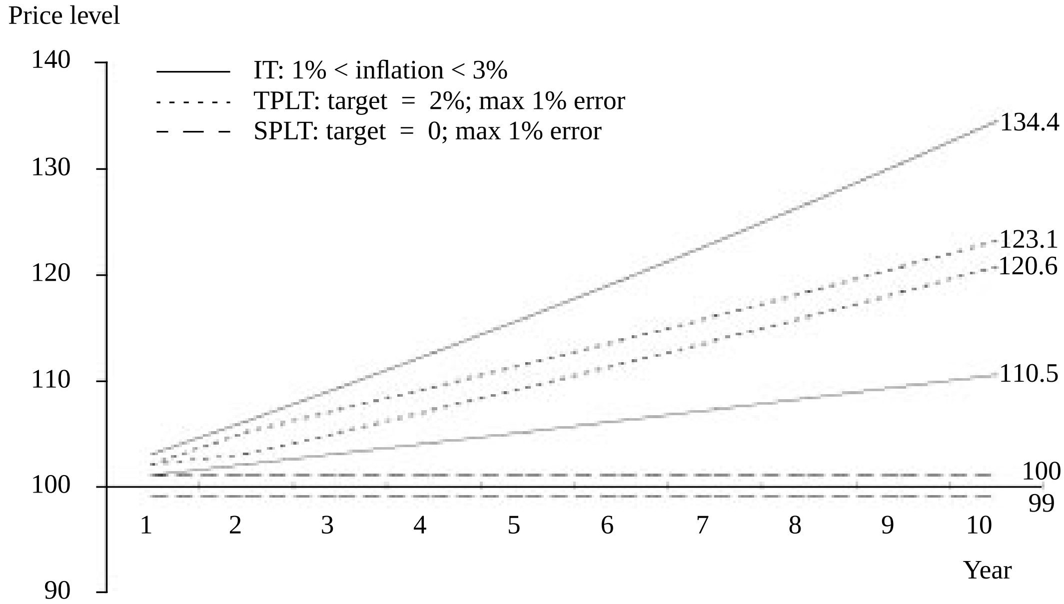
I think this question should be addressed, and for two reasons. First, the QPM includes a non-linear Phillips curve, and thus simulation results are likely to depend on the choice of a particular rate of price change. Second, the fact that credibility is crucial makes most price-level targets less attractive, and one more attractive.

I will call any non-zero price-level target a *trend price-level target* (TPLT) and a zero price-level target a *stable price-level target* (SPLT). Price stability is ensured by SPLT. Figure 1 illustrates the evolution over time of the maximum and minimum values of the price level under TPLT, under SPLT, and under inflation targeting, assuming a 2 per cent trend and a 1 per cent bound on errors each year.

For a target to be credible, it has to be communicated to the public; agents must be able to understand it and verify that it has been met. That is difficult to achieve for any TPLT. Assume that the trend is 2 per cent per year and errors are no greater than 1 per cent. Consider now the task of communicating to the public the monetary policy goal for year 10. The rate of inflation can be between 0 and 4.1 per cent,[2] therefore this is not helpful. The price level has to be between two exponential bands, changing at the rate of 2 per cent per year. In year 10, the public must verify that the price level is between 120.6 and 123.1, as illustrated in Figure 1. This is a difficult task. The more difficult it is to communicate the goal, the less credible the goal is likely to be. On the other hand, the stable price-level target is easy to understand and to verify: agents need to check whether the consumer price index is between 99 and 101; the only problem is to persuade them to look at

2. I assume that errors are proportional.

**Figure 1**
**Maximum and minimum values of price level under various targets**




the price level and not at the rate of inflation.[3] Hence, a TPLT is likely to be less credible than a SPLT, and the transition period during which agents modify their expectations will be longer. The paper's main result holds only if the price-level target becomes immediately credible; otherwise, the variabilities of inflation, output, and interest rates all rise.

Credibility considerations clearly promote a stable price-level target over a trend price-level target.

## Computational Benefits of Stable Prices

It is difficult to add to the excellent analysis of the (absence of significant) costs of price stability by Michael Parkin (2001) in this volume, so let me conclude with a brief discussion of one important benefit that is rarely studied. It is the fact that price stability makes intertemporal calculations, as well as intratemporal choices, easy.

Why is stabilizing inflation important? As stressed by Fischer and Modigliani (1978), among others, when inflation is highly variable, long-term contracts, as well as long-term planning, are risky, since the real terms of such contracts or plans are difficult to assess. As Maclean and Pioro state,

3. An inflation target, of course, is easy to verify. The figure for the rate of inflation is widely available, and it is easy to verify that the published number is in the promised range (say, 1 per cent to 3 per cent).

"the main rationale for considering [price-level targets] was to reduce price-level uncertainty" (p. 153).

The difference between SPLT (i.e., price stability) and TPLT is that, while both reduce price-level uncertainty to the same extent, the latter forces agents to recompute prices to obtain real values. Long-term contracts and long-term planning become difficult, and may be risky *if agents make computational mistakes*. Economists assume that computing real prices is a task economic agents can do at no cost. But, there is plenty of evidence that many people in Canada have problems with simple calculations, let alone logarithms (ask any math teacher). The typical economist's response is that agents operate near-rationally. For short horizons or small transactions, they use nominal accounting, since the consequences of possible errors are small. If the potential consequences of errors are substantial, they make sure to do the right calculation.

The following example makes me wonder whether this approach is justified. Let me quote NASA (my emphasis):

> **Mars Climate Orbiter Team**
> **Finds Likely Cause of Loss**
>
> A failure to recognize and correct an error […] led to the loss of the spacecraft last week…
>
> "*People sometimes make errors*," said Dr. Edward Weiler, NASA's Associate Administrator for Space Science. "The problem here was not the error, it was the failure of NASA's systems engineering, and the checks and balances in our processes to detect the error. That's why we lost the spacecraft."
>
> The peer review preliminary findings indicate that one team used English units (e.g., inches, feet and pounds) while the other used metric units for a key spacecraft operation. *This information was critical to the maneuvers required to place the spacecraft in the proper Mars orbit.*
>
> "*Our inability to recognize and correct this simple error has had major implications*," said Dr. Edward Stone, director of the Jet Propulsion Laboratory.

In this example, potential consequences of an error were very substantial. Together with the failure of the Mars Polar Lander a few months later, it put NASA's Mars project, and the jobs of those involved, in jeopardy. Few financial decisions of a typical household can have a similar impact on its well-being.

I do not claim, of course, that the people involved were not able to convert one set of units into another. Rather, the reason for the error was a coordination failure between different teams of scientists. Note, however, that those involved were the proverbial "rocket scientists" (some of the best in the world, in fact), and no household and few private companies can match NASA's system of checks and balances. If the task of coordinating operations so that there is no confusion between two units of account is (sometimes) too hard for rocket scientists, this leaves only brain surgeons and, perhaps, economists, to be able to always correctly convert nominal into real numbers. The average household is continually confounded with this task. Errors they make lead to suboptimal consumption structure. For example, overestimating the increase in the price level since the last house purchase means that the household would spend too much on a new one. A monetary policy rule, which simplifies the computational task, would be clearly beneficial.

The significance of the consequences of private computational errors is very difficult to assess. We do not know how large these errors may be, or how painful their consequences. One way of evaluating the welfare losses from computational errors is as follows. Start with a timeline of a typical household's spending. Assume that the household makes multiplicative errors in assessing the price level and ask how large these errors must be to generate significant welfare losses.[4] The result of such an exercise, which is beyond the scope of this discussion, would depend on the form of the utility function. A low value of the trend in the price-level target ensures that the consequences of errors in the conversion of nominal into real variables are small for frequent transactions. But, in 1999, spending on new and resale housing alone was Can$130 billion, or about 20 per cent of total expenditure. Adding retirement savings, purchases of durable goods, and infrequent purchase of perishable goods (e.g., overseas trips, university education) means that, for a typical Canadian household, at least one-third of expenditure is on infrequent, or long-horizon, transactions. It seems to me that even relatively small errors in estimating the value of the price level since the last similar transaction may result in large welfare losses.

4. The value of welfare loss can be evaluated as the percentage of income needed to provide the household with the same level of utility it would have obtained if it had made no errors and had chosen the optimal consumption bundle.

Note that the consequences of computational errors need not show in GDP statistics (except for participation rate, since the errors reduce the utility of consumption relative to the utility of leisure). The benefit of avoiding computational errors under price stability may be purely subjective and, consequently, very difficult to assess.

Economists are uneasy with arguments based on phenomena that they cannot measure.[5] A theory based on subjective costs runs the risk of being untestable, and thus vacuous. It is, however, possible to find some evidence of computational costs, as well as other subjective costs of inflation. In particular, Shiller's (1997) survey points to computational problems as the main reason for public dislike of inflation. Another example is the literature on downward nominal-wage rigidity (for example, Akerlof, Dickens, and Perry 1996 or Fortin 1996). The essence of the argument is this: under inflationary conditions, agents make different decisions than they would make under price stability. This means that inflation undermines the allocative role of the price system[6] and thus reduces welfare. Finally, Di Tella, MacCulloch, and Oswald (2001) use data from a large-scale survey of quality of life in 12 European countries, from 1975 to 1991, as well as from a happiness study in the United States, from 1972 to 1994. They find that, after controlling for personal characteristics, there is a significant negative relationship between reported life satisfaction or happiness, and the rate of inflation. The result is striking, since the surveys ask straightforward questions about happiness or about life satisfaction and do not mention inflation at all.

While arguments about subjective costs of inflation are often treated with skepticism, they can potentially explain the fact, observed by Shiller, that the public seems more averse to inflation than do professional economists.

## Conclusions

Assume it is decided that the most important of all units of account should be stable. Is the potential benefit of a stable price-level target worth the cost of achieving it, or is it better to choose a *trend* price-level target? Di Tella et al. estimate that an extra 1 per cent of unemployment reduces reported happiness by as much as an extra 1.7 per cent of inflation. While the surveys cover a relatively high inflation period and are not available for Canada, these numbers suggest that, under any reasonable estimate of the sacrifice

5. See, however, an interesting paper by Ragan (1998).
6. This was argued some time ago by Friedman (1977).

ratio, going from a trend price-level target to price stability will increase happiness.

In light of these findings, I think that Maclean and Pioro are on the right track. However, I suggest that they analyze the effect of introducing a stable price-level target into QPM under IFB rules and limited credibility, as calibrated in the QPM.

## References


Akerlof, G.A., W.T. Dickens, and G.L. Perry. 1996. "The Macroeconomics of Low Inflation." *Brookings Papers on Economic Activity* 1: 1–59.

Black, R., T. Macklem, and D. Rose. 1998. "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 1997. Ottawa: Bank of Canada.

Di Tella, R., R.J. MacCulloch, and A.J. Oswald. 2001. "Preferences over Inflation and Unemployment: Evidence from Surveys of Happiness." *The American Economic Review* 91 (1): 335–41.

Dittmar, R. and W.T. Gavin. 2000. "What Do New-Keynesian Phillips Curves Imply for Price-Level Targeting?" *Federal Reserve Bank of St. Louis Review* 82 (2): 21–30.

Fischer, S. and F. Modigliani. 1978. "Towards an Understanding of the Real Effects and Costs of Inflation." *Weltwirtshaftliches Archiv* 114 Heft (4): 810–30.

Fortin, P. 1996. "The Great Canadian Slump." *Canadian Journal of Economics* 29 (4): 761–87.

Friedman, M. 1977. Nobel Lecture: "Inflation and Unemployment." *Journal of Political Economy* 85 (June): 451–72.

"Mars Climate Orbiter Team Finds Likely Cause of Loss." NASA (September 1999). < URL: http://mars.jpl.nasa.gov/msp98/news/mco990930.html >.

Parkin, M. 2001. "What Have We Learned About Price Stability?" In *Price Stability and the Long-Run Target for Monetary Policy*, 223–59. Proceedings of a seminar held by the Bank of Canada, June 2000. Ottawa: Bank of Canada.

Ragan, C. 1998. "On the Believable Benefits of Low Inflation." Bank of Canada Working Paper No. 98–15.

Shiller, R.J. 1997. "Why Do People Dislike Inflation?" In *Reducing Inflation: Motivation and Strategy*, edited by C.D. Romer and D.H. Romer, 13–65. NBER Studies in Business Cycles, Vol. 30. Chicago: University of Chicago Press.

Svensson, L.E.O. 1999. "Price-Level Targeting versus Inflation Targeting: A Free Lunch?" *Journal of Money, Credit and Banking* 31 (3) Part 1: 277–95.

Williams, J.C. 1999. "Simple Rules for Monetary Policy." Finance and Economics Discussion Series Paper No. 1999–12, Federal Reserve Board.

Woodford, M. 1999. "Commentary: How Should Monetary Policy Be Conducted in an Era of Price Stability?" In *New Challenges for Monetary Policy*, 277–316. A symposium sponsored by the Federal Reserve Bank of Kansas City, August 1999.

# General Discussion*

Allan Crawford began the general discussion on a light note, enquiring whether, in light of Konieczny's remarks regarding the problems rocket scientists have with measurement issues, there were any nuclear physicists who might have something to add.

Paul Beaudry asked Jerzy Konieczny to identify the errors he had mentioned. For example, if we were to commit to a price-level target with no trend growth for a long period of time, and people start to believe it, they might enter into long-term nominal contracts. However, we don't know what will happen: perhaps there will be some reason to move away from price-level targeting. Then, if people are locked into long-term nominal contracts, substantial costs will result. With 2 per cent inflation, we may have the right amount of protection against future changes. If we are implicitly encouraging people to get into real contracts or short-term nominal ones, they make fewer big mistakes.

Tiff Macklem agreed with Konieczny that anyone seriously considering price-level targeting comes up against a considerable communications challenge: if the price level contained trend growth, the population would have to understand logs. However, there could be simpler ways to obtain the benefits of price-level targeting, while remaining in a framework that people are more accustomed to. For example, the current target is defined in terms of year-over-year inflation. Alternatively, quarter-over-quarter or month-over-month could have been used. Some smoothing has been built into the target, which is like putting weight on the price level or limiting its volatility. However, a two-year-over-two-year inflation rate, or some longer term could

* Prepared by James Yetman.

be considered, which could yield some of the benefits of a price-level target while minimizing the communications challenges.

Frederic Mishkin suggested that using a 10-year average inflation rate as a target would be closer to an error-correction set-up rather than a narrow band, as Konieczny had shown. This may be an argument for a hybrid-type policy, where instead of having a price-level target with 2 per cent drift, you have an intermediate target of 2 per cent each year, with an average over 10 years of 2 per cent. That would be different from a price-level target, but would still tie down the price level to a substantial degree. When thinking about the kind of framework one could use to move towards price-level targeting, one must consider how it is to be communicated. Communications issues may argue for moving from pure price-level targeting towards an error-correction framework.

Kevin Clinton stated that rules that place any weight on the deviations of the price level from some target ("hybrid rules"), no matter how small the weight, are ultimately price-level-targeting rules, since the price level will ultimately converge to the desired path.

Responding to Konieczny, Dinah Maclean agreed that the weights on the different components in the inflation expectations equation are arbitrary. They capture the general idea of mostly backward-looking and mostly model-consistent expectations, and variations in the weights should not have much impact on the results. Whether 10 per cent of agents would believe in price-level targeting is a good question, but what is interesting is that this is significantly less than the standard assumption in the literature of complete credibility. Provided a price-level target were well communicated, there is little reason to believe that it would result in loss of credibility over time, although it would be interesting to address such issues in a model with endogenous credibility. As far as robustness of the IFB rules is concerned, more simulations would be required to verify this. Nevertheless, one would generally expect price-level targeting to look better with such rules. More generally, it is very important to look at the costs of price-level uncertainty in order to justify the choice of a price-level target. Also, it would be possible to sell a hybrid rule as an average rate of inflation over a longer period of time.

Konieczny, in response to Beaudry, commented that what we are trying to do is protect people from themselves. In principle, contracts should be indexed. Perhaps higher inflation would induce people to enter such contracts.

Pierre Duguay responded that, with the exception of wage contracts, most contracts are not indexed even with high inflation when errors are costly. Instead, nominal contracts typically become shorter in length. Debt contracts involve larger economic costs, and these are typically not indexed. The evidence from the optimal indexation literature is that it is optimal to index when the shocks are nominal shocks, but not when they are real shocks. If a central bank had a price-level target, that could be interpreted as reversing revealed preference on the part of people who choose not to index contracts in the face of real shocks.