Incorporating credibility in forward-looking models: some examples with QPM

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Introduction

Countries are increasingly implementing monetary policy in a manner designed to build credibility. While the empirical evidence on whether or not credibility is greater is still inconclusive, changes in credibility could potentially have far-reaching consequences for the dynamics of the economy. The most obvious changes directly involve inflation expectations. If credibility is high, a reduction in the inflation target will quickly be reflected in expectations. This in turn will help bring inflation down to the new target, reducing the output losses associated with a disinflation. Similarly, if expectations are anchored by policy, the monetary authority will not have to react as aggressively to temporary inflation shocks. In addition, with increased credibility, agents will likely be willing to place greater weight on longer term forecasts. This in turn may be associated with increased contract lengths. All these changes may alter the speed with which policy can influence inflation, and thus the manner in which policy should be conducted.

Given the importance of issues surrounding credibility, explicit credibility effects need to be incorporated into models used for policy analysis and projections. This paper describes the development and calibration of a credibility effect using the Bank of Canada's Quarterly Projection Model (QPM). A methodology for incorporating credibility effects is developed, which uses a "perceived target" which captures agents medium-term inflation expectations. The model is calibrated taking a cautious approach, given the lack of conclusive empirical evidence which can be used to benchmark the degree of credibility. The perceived target is calibrated to ignore short-term changes in inflation, but to look forward to the medium term inflation profile, but it is given a relatively low weight in the overall calibration of expectations. Given the absence of other benchmarks, some of the key stylized facts to which the model is calibrated are left unchanged, such as the cumulative output gap associated with a disinflation. Nevertheless, the new model does incorporate changed characteristics. In particular, it decreases the variability of inflation in non-policy shocks, and reduces the degree of response needed by the monetary authority to offset such shocks.

The calibration presented in this paper should be viewed as an initial attempt to incorporate credibility effects. Above all, it highlights the need for further empirical work on such areas as whether expectations formation has undergone a structural change in the 1990s associated with credibility, and whether or not key stylized facts such as sacrifice and benefit ratios have changed. It will also be important to simulate the new model using real data. An interesting check of the current calibration will be to simulate the model over history and see how changing the weight on the perceived target alters the extent to which model expectations track other measures of expectations such as those coming from the Conference Board Survey of Forecasters.

The next section provides a brief overview of the nature of credibility and the expected changes associated with increased credibility. Section 2 gives an overview of QPM, particularly those aspects of the model which affect the degree to which the inflation target is incorporated into expectations, and thus the implicit level of credibility. Section 3 considers two alternative ways of more explicitly incorporating credibility effects into price expectations. Section 4 both reviews empirical evidence and presents two calibrations of QPM.

^{*} The views expressed in this paper are solely those of the author. No responsibility for them should be attributed to the Bank of Canada.

1. Credibility

Credibility is generally interpreted as the extent to which agents believe the policy maker. In Canada, where the Bank of Canada and the Minister of Finance began announcing inflation targets in 1991, credibility can be defined as the extent to which people believe inflation will remain within the target bands.

We distinguish between two aspects of credibility: the "announcement" effect and the process of learning or gaining credibility over time. The announcement effect captures the extent to which a policy announcement immediately changes people's expectations and behaviour. This announcement effect will increase as the monetary authority gains credibility. If credibility in the targets has been growing in Canada in the 1990s, for example, then an announced change in the target should alter agents' inflation expectations. The size of the announcement effect is determined by the degree to which credibility is transferable from one policy to another. Moreover, an announcement effect may occur whether or not the announcement of a policy change coincides with a consistent policy action by the central bank. The second aspect of credibility deals with how quickly credibility is gained or lost over time, or the learning process during which agents alter the extent to which they incorporate the policy into their expectations. Over time the monetary authority may build up or lose credibility, depending on its success in achieving the targets.

Both the announcement effect and the process by which agents incorporate a target into expectations over time will be dependent on the dynamics of the economy. For example, in an economy where it is known that the monetary authority has little impact on inflation in the near term, it would be unreasonable for near-term expectations to adjust immediately to a new target. Similarly, if it is known that adjustment is costly and prices are sticky, this will affect the speed with which people expect inflation to move to the target, even when credibility in the monetary authority's commitment to the policy is high.

Changes in credibility can potentially have a large impact on the dynamics of the economy, and the extent to which various shocks are reflected in inflation. In general these changes are likely to make it easier for a monetary authority to maintain a stable rate of inflation, or implement a change in policy regime. Consider, for example, the case of a policy change such as a decrease in the inflation target. If credibility in the current policy is high, this will likely carry over to credibility in the new policy. Expectations will incorporate the new target much more rapidly than if expectations are more backward-looking. With faster adjustment of expectations, actual inflation will fall more quickly and/or the monetary authority will need to act less in order to achieve the new target. This in turn implies that the cumulative output loss associated with a disinflation, will be less with higher credibility.

Increased credibility has similar implications for a non-policy shock. In the case of an inflationary shock, for example, such as a depreciation in the exchange rate or a positive shock to demand, credibility will help to anchor inflation expectations. Expectations will not vary as much when people anticipate that the monetary authority will act to bring inflation back to the target. As a result, the monetary reaction does not need to be as great. The cumulative output losses in a deflationary shock will tend to be greater than in the case of less credibility, since less of the shock is offset directly by policy. Similarly, cumulative output gains from a positive shock will be greater.

While there is considerable agreement about the gains from greater credibility, far less is known about the process of building credibility. A wide variety of factors that likely influence credibility have been identified in the literature, such as the clarity of the goals of monetary policy, the extent to which policy is understood, the central bank's degree of autonomy and accountability, and the consistency of monetary and fiscal policies. There is no precise mapping, however, between different settings of say fiscal policy or institutional arrangements and a specific degree of credibility. Nevertheless, given the potential benefits from increased credibility for the monetary authority, an increasing number of countries are implementing monetary policies designed to increase credibility. Since increased credibility could have potentially large implications for adjustment in the economy, it

is also important to incorporate credibility into economic models. The next section provides a brief overview of the Bank of Canada's Quarterly Projection Model (QPM) and in particular the expectations within the model. The remaining sections then look at ways of incorporating specific credibility effects, and review issues associated with the calibration of credibility effects.

2. Credibility and QPM

QPM is a forward-looking model, with expectations which are partly backward-looking, and partly based on model consistent values. While there are no explicit credibility effects within QPM, credibility is still embodied in the model as the degree to which the inflation target is imbedded in expectations. Initially, this comes through the model consistent component of expectations, and subsequently becomes embodied in the backward-looking component. This behaviour depends on such things as the exact structure of expectations formation and the way in which expectations feed through into the price equations. The degree of credibility is also embodied in many properties chosen in the overall calibration of the model and thus affects the model's response to a range of shocks. To assess the appropriateness of any approach, therefore, requires that a broad range of model properties needs to be considered. This section provides a short overview of QPM then considers the main parts of QPM which affect or incorporate assumptions about credibility. It also provides an illustration of a model change which intuitively may seem consistent with increasing the degree of credibility in the model, but does not produce model properties which are consistent with theory.

QPM consists of two models: a well-defined, neo-classical steady-state model and a dynamic model which traces the adjustment path between the starting conditions and the steady-state. There are three key groups of agents who determine the steady state conditions: consumers, firms and government. Consumers have a desired level of wealth and make decisions on savings and consumption over time to reach that level. Their behaviour is modelled on the Blanchard-Weil model of overlapping generations. 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 taxation. These stocks, together with the rest-of-world economy, determine the level of net foreign assets. The exchange rate adjusts so as to ensure the current account balance is consistent with the flows needed to service any foreign debt. QPM is based on the "Almost Small Economy Assumption", which means that given unchanged conditions in the rest of the world, in order to export a greater quantity, the price of exports must fall.

There are three main sources of dynamics which determine the short and medium term adjustment in QPM: intrinsic dynamics, expectational dynamics and policy adjustment. The intrinsic dynamics capture the idea that adjustment is costly and therefore occurs over time rather than all at once. In making decisions, agents must balance the cost of being away from their desired levels against the costs of adjusting variables. Agents follow decision rules where variables such as prices are combinations of both backward and forward-looking elements. The forward-looking elements are based on expectations equations which are also a combination of backward looking and model consistent values, and in some cases steady-state variables.

There are two policy equations within QPM. A fiscal policy rule determines government expenditure and taxation based on an exogenously determined path for the debt-to-GDP ratio. There is also a monetary policy rule, where the monetary authority reacts to shocks by altering nominal short-term interest rates in order to bring inflation back to the target in the medium-term. The monetary policy rule is written in terms of the yield curve gap, or the difference between the slope of the nominal term structure and its risk-adjusted steady state value. The desired value of the yield curve gap is a function of a lagged value and the deviation of year-on-year inflation in consumer prices excluding food and energy (*CPI*) and the target rate of inflation, 6 to 7 quarters in the future:

 $YCG = a1^{*}(YCG)_{t-1} + ((CPI_{t+6} - CPITARG_{t+6}) + (CPI_{t+7} - CPITARG_{t+7}))/2$

where YCG is the yield curve gap and $(CPI_{t+i} - CPITARG_{t+i})$ is the difference between the year-onyear increase in the CPI and the annual inflation target *i* periods ahead.

2.1 Calibrated properties – Sacrifice and benefit ratios

The dynamic structure of QPM is not directly estimated; rather it is calibrated to reflect empirical evidence and established stylized facts. For example, currently, the model is calibrated to ensure that there is sacrifice ratio of 3 in a disinflation shock (i.e. in a 1% disinflation shock, the cumulative output gap is 3%), and a benefit ratio of 1 in an inflation shock. In contrast to the disinflation and inflation shocks where the sacrifice ratios are always restored, changes to the model often result in changes to cumulative output gains and losses in other shocks. The cumulative output losses and gains from other shocks are not specifically calibrated and there is generally less empirical evidence to help determine what they should be.

The properties of the disinflation and inflation shocks are based on non-linear Phillips Curve estimations by Laxton, Rose and Tetlow (1993) for the period 1975 to 1991. As mentioned above, the degree of lost output that the monetary authority needs to generate to offset temporary shocks to inflation or to implement policy changes, is greatly affected by the degree of credibility of policy. The current calibration, therefore, reflects the "average" degree of credibility in the period over which the equation was estimated. It is hard to assess how high this average credibility is. The rising rates of inflation over the 1970s likely eroded credibility while the relatively more stable and lower rates in the 1980s likely restored some of the lost credibility. In the 1990s, the announcement of inflation targets and the success in keeping inflation within the range is likely to have raised credibility further.

Any attempt to incorporate increased credibility, must include a re-assessment of the sacrifice and benefit ratios. In particular, if credibility is incorporated in such a way that the current target helps to anchor expectations, but changes in the target are not immediately believed, the cumulative output losses/gains in shocks where the target remains unchanged will alter, but the sacrifice ratio in a disinflation shock need not fall. Alternatively, if credibility effects also include rapid assimilation of a newly announced target into expectations, the sacrifice and benefit ratios in the disinflation and inflation shocks may fall. Choosing new values for these is problematic, however, particularly given the lack of any empirical evidence supporting a decline in the sacrifice ratio in Canada.

2.2 Expectations formation

Price expectations in QPM are in terms of price levels rather than inflation. Price levels are a combination of a backward and a forward-looking component. For example, the expected level of the log of consumer prices excluding food and energy in period T (*LCPI_ET*) is the combination of a backward element including 5 lags of the past price level, and the model consistent value for period T:

$LCPI_ET = BW*Backward + MC*Modelconsistent(T)$

where BW is the weight on the backward-looking component and MC is the weight on the model consistent component.

Currently, the weights on the backward and forward components of consumer price expectations are 0.8 and 0.2 respectively. The weights chosen for the backward and model consistent components obviously have a major impact on the speed with which expectations change given a change in the target, and the extent to which shocks to inflation flow through into expectations. Since the monetary policy rule is acting to move inflation in the medium term to the target, model consistent expectations in future periods increasingly incorporate the target rate of inflation.

2.3 Incorporation of expectations into prices

The effects of varying the weights on the backward and forward components of expectations are partly a function of the way in which expectations are incorporated into the price equation. Expectations feed into prices through the forward-looking component of the price equation, which is a weighted average of expectations of both marginal cost and the price up to eight periods ahead. For example, the forward-looking component of the *CPI* is:

$LPCPIFOR = F(LCPI_E0...E8, LMC_E0...8)$

where $LPCPI_ET$ is the expectation of LPCPI in period T and LMC_ET is the expectation of the log of marginal cost in period T.

The expectations are weighted so that the most weight is placed on the near-term expectations, and the weights decline the further into the future are the expectations. This reflects the assumption that people are less certain about expectations of events further into the future, and therefore, base their behaviour more on shorter term expectations.

2.4 Examples of model properties – a disinflation and a demand shock

Figures 1 and 2 show the adjustment of key variables in a 1% disinflation (i.e. a reduction in the inflation target of 1 percentage point) and a 1% negative demand shock (i.e. total demand is reduced by 1 percentage point). In a disinflation, the model is calibrated to ensure that the monetary authority must raise real short-term interest rates by around 100 basis points in the first year. In nominal rates, this corresponds to an increase of 80 basis points in nominal short-term interest rates. The tighter yield curve acts directly to reduce consumption and investment. Higher interest rates also lead to an appreciation of the exchange rate, which further reduces inflationary pressures. CPI inflation falls 0.13 percentage points by the end of the first year, and takes 4-5 years to reach the new target. As mentioned above, the coefficients of the output gap within the price equations are adjusted to ensure a cumulative output gap of 3%.

In a negative demand shock, the monetary authority responds by reducing short-term interest rates in order to loosen the slope of the yield curve. Nominal short-term interest rates fall 80 basis points in the first year. CPI inflation troughs at a rate 0.4 percentage points below control. Output returns to control at the end of the second year following the shock, but there is some secondary cycling for the next few years. The cumulative output gap is just over 1%.

2.5 Increasing the model consistent component of expectations

Increasing the weight on the forward-looking or model consistent component at first seems very close to increasing the degree of credibility in the model, and gives results consistent with increased credibility when considering a change in the inflation target. In the case of a non-policy shock such as a demand shock, however, increasing the weight on the model consistent component gives results which are the opposite of those expected from increased credibility.

The effects in a disinflation shock of increasing the weight on the model consistent component of expectations are illustrated in Figure 3. Figure 3 shows the effects of a 1 percentage point decline in the inflation target, with a range of models where the weight on the model consistent component of expectations for both the CPI and the GDP deflator range from 0.1 up to 0.7. (Note that the legend only shows every other line.) The models with a larger weight on the model consistent component show a more rapid decline in inflation in a disinflation shock, since the forward-looking component pulls expectations down while the backward component slows the adjustment in expectations. Similarly, the monetary authority does not have to tighten the yield curve gap (the policy instrument) as much as when greater weight is placed on backward-looking expectations and the resulting cumulative output loss is reduced. In this case, the results from equations where more weight is placed on the model consistent component are equivalent to those expected from a greater



1% disinflation



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1% negative demand shock





Figure 3 1% disinflation – varying weights on model consistent component



1% negative demand shock - varying weights on backward component



degree of credibility – faster adjustment of expectations and a smaller output loss associated with moving to a lower target.

Figure 4 shows for the same models, the effect of a 1% decline in demand. In the standard shock, a decrease in demand leads to excess supply and puts downward pressure on inflation. Expectations of inflation also fall putting further downward pressure on the price level. Initially, the fall in expectations comes through the model consistent component, then over time as inflation falls, through the backward-looking component. The changes in expectations feed directly through into inflation. The monetary authority responds by decreasing interest rates which boosts consumption and investment. Decreased interest rates also lead to a depreciation in the exchange rate which helps generate demand for exports and import-substitution, as well as having direct pass-through effects on the price level.

In theory, where there is increased credibility, inflation expectations should act as more of an anchor in such a shock, since people believe the monetary authority will act to bring inflation back to the target. Having less of a fall in expectations will put less downward pressure on inflation and will reduce the degree to which the monetary authority must act. Figure 4 shows, however, that the opposite is true when the weight on the model consistent component is increased. In the first few years of a demand shock, the model consistent component actually pulls expectations away from the target whereas it is the backward component which provides inertia. This is because the value generated by QPM for inflation in a specific quarter, puts greater weight on short run model dynamics, since greater weight is placed on near-term expectations. Agents are responding more to the short run dynamics of the shock, thereby causing greater, not less variation in expectations. Increasing the weight on the model consistent component, therefore, leads to a greater trough in inflation and more need initially for the monetary authority to offset the shock. The greater the weight on the model consistent component, the smaller the cumulative output gap in a negative demand shock, since the monetary authority offsets more of the negative shock to output.

It is also important to note that changing the calibration of expectations, changes the monetary response needed for a given shock, and thus the output losses and gains associated with that shock. Moreover, as described above, theory suggests that greater credibility should be associated with less need for the monetary authority to respond to a shock and decreased costs of disinflating. This implies that incorporating a greater credibility effect in a model, should be accompanied by a decrease in the sacrifice ratio. Unfortunately, however, given that the sacrifice ratio is a result of the calibration of the model, it is not obvious how to determine a new benchmark for the value of the sacrifice ratio, since empirical work has not yet shown any evidence of declining inflation/output tradeoffs.

3. Incorporating the target into expectations

The goal of monetary policy in QPM is to keep inflation in the CPI close to the target. The easiest way of incorporating credibility effects more explicitly in QPM, therefore, is to introduce the target into price expectations. As shown below, though, this also introduces an announcement effect which is both inconsistent with the intrinsic dynamics within QPM and an undesirable feature for a projection model. An alternative formulation is tried, therefore, where expectations include a perceived target. This reduces the problems associated with the announcement effect and also provides greater flexibility for calibrating the model. The perceived target is based on the formulation of expectations in Black and Rose (1997).¹

¹ See also Black, Macklem and Rose (1998).

3.1 Introducing the target

Price expectations are a combination of a backward component and the model consistent value. The target was initially incorporated by introducing a third term – the price level implied by the inflation target.

The equation for expectations of the log level of the CPI (*LCPI*) in period T is:

$LCPI_ET = XBW*DC*(BACKWARD) + XMC*LCPI(T) + (1-XMC-XBW*DC)*LCPITAR_ET$

where XBW is the weight on the backward component, XMC the weight on the model consistent value, (1-XMC-XBW*DC) is the weight on the target, and LCPITAR_ET is the price level implied by the target in period T. DC is a decay factor which takes a value between zero and one. The value of DC can be fixed, implying a fixed weight on the target, or it can decline over time implying a greater weight on the target for longer term expectations.² This discussion focuses on the results of the constant decay model.

LCPITAR_Ei becomes a new endogenous variable, which is created using the specified year-over-year inflation target. The expected target level in the first period is the previous period's price level, plus the quarterly rate of change implied by the inflation target:

$LCPITAR_E1 = LCPI(-1) + LOG(CPITAR(i))$

Expectations for the target level in subsequent periods are calculated as the target level expectation of the previous period plus the quarterly rate of change implied by the inflation target:

$LCPITAR_Ei = LCPITAR_E(i-1)+LOG(CPITAR(i))$

Expectations of the target were incorporated into both expectations of the GDP deflator and expectations of the CPI.

To explore the implications of introducing the target directly in price expectations, two shocks were introduced: a disinflation shock, and a negative demand shock. The models were simulated with three different values of the decay parameter: 0.95, 0.8 and 0.6. The results are shown in Figures 5 and 6.

The results for the horizon-dependent model are shown in Appendix 1.

In the disinflation shock, the greater the weight on the target, the larger the initial announcement effect. This can be seen in the five-year ahead inflation expectations which start out at a much lower rate than the base model, the higher the weight on the target. The immediate impact that a change in the target has on expectations is also very evident in the initial decline in nominal long-term interest rates. The decline in expectations in turn puts downward pressure on the actual rate of inflation. In the first quarter of the shock, when the decay is set at 0.95 (i.e. only a small weight on the target) CPI inflation falls 0.02 percentage points, compared to 0.08 percentage points with a decay of 0.6. In the base model there is essentially no announcement effect in the first quarter. By the fourth quarter, CPI inflation has fallen 0.27 percentage points with a 0.95 decay, compared to 0.4 percentage points (almost half of the movement to the new target) in the model with a decay of 0.6, and 0.13 percentage points in the base model.

Earlier, credibility effects were divided into announcement effects, and the speed which which agents "learn" over time. In QPM, however, these learning effects are not very clear, because the path expectations take over time is greatly affected by the reaction of the monetary authority. This is evident by comparing the time it takes the five-year ahead expectations of inflation and actual inflation to reach the target. Expected inflation over the first four years is lower the greater the weight

² This is the form currently used for expectations which decay to the steady state, for example, expecations of output and the real exchange rate.

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1% disinflation – fixed coefficients



Figure	6
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on the target. However, the length of time it takes expectations to reach the new target is not greatly affected by the weight placed on the target. This is because the monetary authority, seeing a smaller gap between actual inflation and the target, makes less of an adjustment to interest rates. Consistent with this, the total length of time it takes for inflation to reach the new target is not altered significantly. The greater the weight on the target, the smaller the change in short-term interest rates in a disinflation shock, and thus the lower the cumulative output gap. With a 0.8 decay, nominal short-term interest rates peak at 5.3%, compared to 4.5% with a decay of 0.6.

In a negative demand shock, the greater the weight on the target, the more expectations act as an anchor. Inflation expectations do not exert as much downward pressure on inflation and therefore, it does not trough as low. With expectations acting as an anchor, the monetary authority does not have to respond as much. There is also less secondary cycling with greater weight on the target. While the cumulative output loss is greater in the early part of the demand shock, with greater weight on the target, the reduction in secondary cycling results in the total cumulative output loss remaining largely unchanged.

While these results are consistent with what is expected from an increase in credibility, the large impact which a change in the target can have on expectations is troubling, particularly since expectations will alter given an announced change in target, even if the monetary authority does nothing to implement its announced policy. This is illustrated in Figure 7, which shows a disinflation shock with a 1-year delay in the response of the monetary authority. In other words, the target rate of inflation was reduced by 1 percentage point, but the yield curve gap and nominal interest rates were set to remain unchanged until the end of four quarters.

It can be seen that even when the monetary authority does not follow a policy consistent with the target, inflation expectations fall immediately, causing in turn a fall in inflation. When the decay is 0.95, inflation falls only marginally (0.02 percentage points in the first quarter and 0.06 percentage points by the fourth quarter). With a greater weight, however, the effect is more pronounced. With a decay of 0.6, inflation falls 0.08 percentage points in the first quarter and 0.36 percentage points (or a third of the way to the new target) by the fourth quarter, before the monetary authority has begun to act. With a decay of only 0.8, the announcement effect is sufficiently strong that essentially no increase in short-term interest rates is necessary. In the base model, inflation and inflation expectations, do not adjust until the monetary authority starts to increase interest rates.

It was argued above that incorporating short-term expectations which are inconsistent with the underlying dynamics of the model is inappropriate. It is even less appropriate when expectations are highly inconsistent with the actions of the monetary authority. Incorporating excessive announcement effects could lead to an underestimation of the costs of reducing the target. As can be seen in these results, the pure announcement effect of a policy change can do much of the work towards bringing expectations in line with the new target, without any action needed on the part of the monetary authority. This decreases the onus on the monetary authority to try to adjust monetary conditions. The projection process, however, is one in which the Staff try to present a scenario where the risks are balanced. On such questions as the degree to which credibility will help the monetary authority the model should if anything err on the side of caution. (For similar reasons, steady-state QPM does not include real benefits from a lower rate of inflation, even though the Staff believe such benefits occur.) Incorporating the target directly into price expectations is not, therefore, a satisfactory way of introducing increased credibility effects into QPM.

3.2 Introducing the perceived target

An alternative to introducing the target directly into price expectations is to introduce a "perceived target", a variable which reflects what agents believe to be the actual target being used by

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Delayed 1% disinflation – fixed coefficients



the monetary authority.³ The perceived target is a mechanism through which expectations are sensitive to the action of the monetary authority but allow expectations to "look through" the short run price dynamics in the model.

The perceived target is calculated as a combination of a forward-looking component (model consistent inflation four and five years ahead) and a backward-looking component:

$PCPITAR_E=1.35*PCPITAR_E(-1)-0.425*PCPITAR_E(-2)+0.0375*(PCPI_DA(16)+PCPI_DA(20))$

where $PCPITAR_E$ is the perceived target inflation rate and $PCPI_DA(T)$ is the model consistent inflation rate in period T.

The forward-looking component of the perceived target provides a measure of where people expect inflation will go over the medium to long term, once adjustment to current shocks has occurred. If the monetary authority is expected to keep inflation close to the target over the mediumterm the model consistent inflation rate will be close to the target. If the monetary authority does not act in a manner consistent with its announced target, however, the perceived target may differ from the actual target.

Credibility can now be thought of as having two components. The perceived target is the policy which agents believe is being followed by the monetary authority, which may or may not be equivalent to the announced target. In other words, one measure of credibility is the difference between the perceived and announced target. The weight which the perceived target has within the expectations equation can be thought of as either the proportion of agents who use their perception of policy to form expectations, or the degree to which agents think policy will determine inflation outcomes.

This structure for expectations is very flexible for incorporating alternative assumptions about credibility. The perceived target can easily be replaced by other expectations processes, tying long-term expectations to real long-term bond rates, for example. The coefficient on the perceived target could also be made endogenous, providing another means of gaining or losing credibility over time.

Incorporating a perceived target also provides considerable flexibility for calibrating different effects associated with credibility. This can be seen by reviewing changes to model properties given changes to the values of the key components within the perceived target framework: the choice of time horizon for the forward-looking component, the weights on the forward and backward components within the perceived target, and the overall weight on the perceived target within price expectations.

Time horizon for the forward-looking component

The choice of time horizon for the forward-looking component is based on the idea that it reflects people's medium-term inflation expectations. The horizon 4-5 years ahead was selected because it is far enough ahead not to be greatly affected by the short-term effects of shocks to the economy. This can be seen in Figure 8, which shows a demand shock with time horizons for the forward-looking component of 2-3 years, 3-4 years and 4-5 years. A high weight has been given to the perceived target in price expectations in these simulations (0.56) so as to clearly illustrate the effects of varying the time horizon. The perceived target shows much greater variation when a shorter time horizon is used. It should be noted that in a negative demand shock, the perceived target increases rather than decreases, since it is picking up the secondary cycling which occurs after 2002. The 4-5

³ This is the approach used in CPAM, where a "perceived" target is included in inflation expectations. Richard Black, Tiff Macklem and David Rose, "On Policy Rules for Price Stability", Bank of Canada Conference 3rd-4th May, forthcoming, p. 13.





1% demand shock – varying time horizon for forward-looking component

Figure 9



1% disinflation – varying time horizon for forward-looking component

year time horizon shows relatively little variation since it looks beyond the effects of the shock. Clearly, it would not be appropriate to have a large positive increase in the perceived target during a negative demand shock, thus the 4-5 year time horizon is the most appropriate. The path of the output gap is similar in all three cases. The cumulative output gap is slightly smaller with the 4-5 year time horizon, however, due to less secondary cycling.

Figure 9 shows a disinflation shock for the same time horizons. In the disinflation shock the 3-4 and 4-5 year horizons give very similar results since both are looking ahead to the new target almost immediately. The 2-3 year time horizon, however, causes inflation expectations to adjust more slowly. For this reason, the policy response in the 2-3 year scenario is greater, resulting in a larger sacrifice ratio.

Weighting of components within perceived target

Credibility is lost initially if the forward-looking component varies from the actual target. This may be due to the actions of the monetary authority, or it may be due to the impact of shocks to the economy if the time horizon for the perceived target is too short. The coefficients on the two lags of the perceived target then determine the speed with which a change in the forward-looking component leads to further loss of credibility. The greater the coefficient on the first lag, the faster the change in the perceived target. For CPAM the coefficients were chosen so that the roots of the equation are 0.85 and 0.50.⁴

The overall weighting on the backward as compared to forward elements of the perceived target has no impact on shocks to the economy where the target does not change. (This result assumes, of course, that the time horizon chosen for the forward component looks beyond the shock.) The relative weighting on backward and forward elements does, however, have a large impact on shocks where the target changes, since it determines the speed with which a change in the target is reflected in the perceived targets, and thus the monetary response and cumulative output gap in a disinflation or inflation shock.

The effects of changing these weights can be seen in Figure 10 which shows a disinflation shock for different weights on the backward and forward components. Again, a relatively large weight (0.56) was chosen for the perceived target within expectations, to illustrate the impact of the coefficient changes. Increasing the weight on the forward-looking component within the perceived target increases the speed with which it reaches the new target. With a weight of 0.075 on the forward component, the perceived target falls around two-fifths of the way to the new target by the end of the first year. By the end of the third year it has almost reached the target, but does not fully converge until the fifth year. By contrast, with a weight of 0.445 on the forward component the perceived target has reached the actual target by the end of the first year.

Consistent with the change in the perceived target, the greater the weight on the forward component, the faster inflation falls, and the less the monetary authority has to alter interest rates. With a weight of 0.445 on the forward component, short-term nominal interest rates do not increase at all. The effect of increases in the forward-looking component on the cumulative output gap is highly non linear and decreases as the weights increase i.e. increasing the weight from 0.075 to 0.1675 causes the cumulative output gap to fall to 2.2% as compared to about 3% when the weights are increased from 0.168 to 0.445.

The implications of different weights within the perceived target are even more obvious if real data are used. Figure 11 shows the values of the perceived target, along with actual year-on-year inflation, calculated over history. There is a considerable difference between the different

⁴ The coefficient on the first term is the sum of the two roots, whereas the coefficient on the second lag is the product of the two roots.

Figure 10



1% disinflation – varying backward for forward-looking components

Figure 11

The perceived target over history



calibrations of the perceived target, particularly in periods when inflation moves down or up for 2-3 years then returns back. The calibration which places a smaller weight on the forward-looking component (0.075) appears to do a better job of looking through the short-term shocks and focussing on medium term inflation.

Weight on the perceived target within price expectations

While the relative weights on the forward and backward components of the perceived target affect policy shocks, the weight on the perceived target within price expectations affects all shocks. Figures 12 and 13 show the impact of varying the weight on the perceived target in the disinflation and demand shocks. These results are very similar to those resulting from incorporating the target directly into price expectations. In a disinflation shock, expectations adjust more quickly and inflation falls more in the first year. Inflation also locks into the target is not, however, greatly changed. The degree to which the monetary authority needs to adjust interest rates decreases the greater the weight on the perceived target, particularly in the first year, and the cumulative output gap falls. In the demand shock, the variability of expectations and inflation falls, with both a shallower trough and less secondary cycling. Again, the monetary authority needs to do less to offset the shock, and thus the cumulative output gap increases.

Incorporating the perceived target reduces, though does not entirely eliminate, the problem of a "pure" announcement effect where expectations adjust even when the monetary





Disinflation, the perceived target – varying the weight within expectations

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Delayed response disinflation – with perceived target

authority is not acting consistently with the stated target. This is illustrated in Figure 14, which shows the impact of a disinflation shock where the monetary authority does not react for one year. When the perceived target has a low weight, expectations and inflation do not decline until the monetary authority starts to increase interest rates. When the perceived target has a high weight, however, there is the potential for an announcement effect. This is because given the reaction function in QPM, once the monetary authority starts to act, it does so very fast and still brings inflation down to the target by the 4-5 year time horizon being used in the forward-looking component. The longer the period over which the monetary authority fails to act, however, the less likely that expectations will adjust. If the monetary authority fails to act for four years, for example, there is no announcement effect with the perceived target. With the actual target in expectations, there would still be an announcement effect in such a case.

While building in an effect which forces expectations to move towards the target independent of the actions of monetary policy, is not appropriate, it must be remembered that incorporating an announcement effect is an implication of credibility. Increased credibility implies that the announcement of a new policy will have a greater immediate impact on expectations. The size of the announcement effect is a calibration issue.

The above analysis shows, therefore, that the perceived target framework offers considerable flexibility in incorporating credibility effects in QPM. Consistent with what one would expect from increased credibility, the perceived target acts as an anchor for price expectations in non-policy shocks, and increases the speed with which expectations adjust when the target adjusts. In both kinds of shock, this reduces the extent to which the monetary authority must adjust interest rates. The greater the weight on the perceived target within expectations, the greater the impact it has on both kinds of shocks. The relative impact on policy and non-policy shocks can be altered by varying the weights on the backward and forward-looking components within the perceived target.

4. Calibration of the model

Having decided on a framework for incorporating a specific credibility effect within QPM, it is necessary to calibrate the equations. In other words, weights must be chosen so that the dynamics of expectations reflect empirical evidence on the formation of expectations in recent years. Values must also be chosen for other key elements which are calibrated such as the sacrifice and benefit ratios. This section provides an overview of empirical evidence on the effects of credibility and some preliminary empirical work to establish a set of stylized facts to be used for the calibration. An initial calibration of the model is chosen and the implications are assessed for changes in model properties. Since the data on expectations and the effects of credibility are sparse, there are perhaps more questions raised than substantive answers given. These provide a useful guide, however, for future research.

4.1 Empirical evidence of increased credibility

Despite widespread acceptance of the benefits of credibility and adoption in many countries of low-inflation policies designed to build credibility, empirical evidence about credibility is very inconclusive.⁵ There are two main ways in which people have tested for changes in credibility: analysing changes in the inflation/unemployment or inflation/output trade-off, and identifying and modelling changes in inflation expectations. The literature on sacrifice ratios has uncovered little evidence of increased credibility, while studies focussing more directly on inflation expectations have produced some results which are consistent with growing credibility.

⁵ For reviews of the empirical literature see Blackburn and Christensen (1989), Amano et al. (1996) and St. Amant (1997).

Blackburn and Christensen (1989) start with the hypothesis that increased credibility will reduce the inflation/unemployment trade-off. They calculate these trade-offs for disinflations in three countries, all of which made a commitment to some nominal target and many announcements about new anti-inflation policy designed to influence expectations. They found no declines in the inflation/unemployment trade-off, suggesting that the policies did not affect expectations. Debelle (1996) finds no reduction in the inflation/output trade-off in the recent disinflation in Australia, New Zealand and Canada. He finds, for example, that the sacrifice ratio in Canada was the highest ever in the last disinflation.

Changes in sacrifice ratios over time may be a misleading indicator of monetary policy credibility. In Canada, for example, it can be argued that the high sacrifice ratio in the early 1990s, was in part related to good credibility: inflation was generally below the mid-point of the target bands thus if policies were credible, people would have been expecting inflation to rise back up to the mid-point. The disinflation also came at a time of considerable restructuring in the economy, which may have contributed to short-term declines in output.

There is also some doubt as to what implications increased credibility in a low inflation environment will have for the real economy. A number of models of price behaviour imply nonlinearities in the Phillips Curve which, by decreasing the coefficient on the output gap, would tend to increase output/inflation trade-offs in regimes with a lower level and/or less volatile inflation, unless there was a significant change in the process generating inflation expectations (for example, through increased credibility). Signal extraction models, for example, suggest that the coefficient on the output gap is lower when inflation volatility is lower, because agents are better able to distinguish between relative price and aggregate price shocks. Adjustment cost models suggest a similar relationship between the coefficient on the output gap and the level of inflation. In low inflation regimes, for example, agents may negotiate longer contracts in order to save on adjustment costs, which will would tend to slow adjustment. Dupasquier and Ricketts (1997a, b) test for a variety of such non-linearities in the Phillips curve. For Canada they find evidence of non-linearities. While the strongest evidence appears to support non-linearities with respect to the output gap, they are unable to rule out effects coming from the level and the volatility of inflation. To the degree that the volatility of inflation falls when credibility is increased, therefore, there may be an offsetting impact on the beneficial influence of credibility on the sacrifice ratio.

An alternative way of trying to gauge the degree of credibility is to determine whether survey data on inflation forecasts change over time in a manner consistent with the policy objective. With increased credibility, survey expectations will likely show less variability since they will be more anchored to the target, and the dispersion of individual forecasts will be lower. Expectations should also adjust more quickly to changes in policy. Debelle (1996), for example, models inflation expectations as an autoregressive process and searches for evidence of a structural break in recent years. He finds evidence consistent with increased credibility for New Zealand, no evidence of increased credibility for Australia, and mixed evidence in Canada. Bachelor and Orr (1991) and Fischer and Orr (1994) look at measures of uncertainty based on the variance of inflation expectations across forecasters for the United Kingdom and New Zealand. While their results show declining uncertainty, this seems largely to be due to lower rates of inflation.

Johnson (1997) uses survey data from professional forecasts across 18 countries for the period 1984 to 1995. He finds that in most cases, in both inflation targeting and non-targeting countries alike, the disinflations of the 1990s were unanticipated which led him to conclude that inflation targets were not instantly credible. He does find evidence of decreased variance of forecast errors in recent years, but is unable to differentiate between the effects of targets and the effect of a period of more stable inflation. Perrier (1997) applies and extends Johnson's methodology to data on inflation expectations in Canada from the Conference Board Survey of Forecasters. He finds that explicit targets contributed to reducing the mean and variance of forecast errors, and concludes from this that the targets did increase credibility.

Work on inflation expectations and regime switching models also provides evidence that the inflation process has changed, and that these changes are consistent with improvements in credibility.⁶ Fillion and Léonard (1997), for example, estimate a Phillips Curve for Canada using inflation expectations based on a Markov switching model estimated by Ricketts and Rose (1995). In the model there are three possible inflation regimes: low and stable inflation, moderate inflation and very high (unit root) inflation. The model suggests that since 1991 a very high probability is placed on being in a low inflation regime (over 90%). This supports the idea that expectations are in line with the current target, but it does not give clear indications about changes in credibility over time. In the second half of the 1980s a similar probability was attached to being in a moderate inflation regime with a mean inflation rate of around 4%. Similarly, the transitions from one regime to another do not suggest expectations are adjusting more quickly to policy changes than in the past. On average transitions take about 2 years. The transition to the low inflation regime of 1990s took only 6 quarters, but the fastest transition was the adjustment to a high inflation regime in 1974.

Overall, therefore, while the empirical evidence based on expectations is consistent with increased credibility it does not provide any quantitative benchmarks which can be used in model calibration. Similarly, empirical work provides no evidence on changes in sacrifice ratios. This is not surprising given that the use of low inflation policies specifically designed to build credibility is relatively recent. It is quite possible that the period has not yet been long enough to build significantly greater credibility or for credibility effects to show up in the data. It nevertheless presents a problem for modellers trying to incorporate credibility effects.

4.2 Overview of measures of expectations for Canada

Survey-based expectations

The main source of survey-based inflation expectations in Canada is the Conference Board Survey of Forecasters. The survey covers from 8 to 17 private sector forecasters and collects forecasts of annual average inflation in the current year and one year ahead, for both the CPI and the GDP deflator. It is available on a quarterly basis from 1984 and on an annual basis from 1975.

Figure 15 shows consensus (mean) one-year-ahead inflation expectations of the CPI from the Conference Board Survey, compared to actual annual average inflation at the time the forecast was made. It is evident that these forecasts closely track contemporaneous inflation.⁷ In the disinflations of the early 1980s and 1990s, expectations were generally below actual inflation, but above realised inflation. In the 1990s, expectations have also closely followed the current mid-point of the target range and have been around 2% since 1993.

Consensus Economics also provides quarterly forecasts of inflation. They survey a very similar group to the Conference Board, but provide forecasts over a greater range of time horizons, up to ten years ahead.⁸ Unfortunately, the data only begin in 1991. Figure 16 shows CPI inflation forecasts one, two, five and ten years ahead. Not surprisingly, given the similar pool of forecasters used, the one-year-ahead forecast is almost identical to that from the Conference Board. These data suggest that longer term inflation expectations adjust at a similar speed as shorter term expectations. Despite their very different time horizons, the two-year, five-year and ten-year ahead forecasts show a very similar evolution over the 1990s, again closely related to the contemporaneous mid-point of the target range and to the contemporaneous rate of inflation.

⁶ In particular see Laxton, Ricketts and Rose (1993), Ricketts and Rose (1995) and Fillion and Léonard (1997).

⁷ The fall in annual average inflation in 1994 is largely associated with a decline in the indirect tax on tobacco, which was unanticipated.

⁸ Forecasts are published in *Consensus Forecasts*. Longer term horizons are available semi-annually.

Figure 15





Figure 16

Consensus forecasts of CPI inflation (plotted against date forecast was made)



Given that the first announcement of a path for inflation targets was made in February 1991, in theory the adjustment of expectations in 1991 compared to 1990 should reveal something about the announcement effect, perhaps provide a lower bound since credibility was likely to be lower rather than higher than currently. In practice, however, it is hard to gain much information from the evolution of expectations over this period. The one-year ahead expectations held in 1990 were greatly affected by the pre-announced introduction of GST for 1991, thus a large decline in expected inflation would be expected even in the absence of inflation targets. (On the positive side, though, it is clear that people did expect GST to have only a one-off impact on inflation.) Two-year ahead expectations fell a full percentage point from 4.1% in the second half of 1990 to 3.1% by the second half of 1991. This could be taken to suggest a very substantial announcement effect. Alternatively, it could be seen as following the path of underlying inflation. Moreover, the five and ten-year ahead expectations adjusted slightly more slowly than the two year-ahead expectations, which is less consistent with high credibility.

Real return bonds

Another source of data on long-term inflation expectations is the differential between conventional and real return bond yields. Real return bonds were first issued in December 1991. They are 30-year bonds, for which both the coupon payments and the principal are indexed to the CPI. The difference between the real return yields and the yield from a conventional bond of the same maturity is strongly associated with inflation expectations.

The differential between the two may not be identical to inflation expectations, since there are a number of things which may cause people to want different real returns on different



Figure 17 Differential between nominal and real long-term bonds

bonds.⁹ For example, currently the secondary market for real return bonds is much smaller than that for conventional bonds, thus the real return bond is not as liquid. Agents may demand a premium on the real return bond as compensation for the greater liquidity risk, in terms of a higher real return relative to that expected from conventional bonds. If this is the case, the differential between the two will underestimate inflation expectations. Similarly, if there is considerable uncertainty over the future rate of inflation, investors in conventional bonds may demand a premium over and above that needed to compensate them for the average rate of inflation. In this case the differential between the two would overestimate inflation. Moreover, moving towards a situation of reduced uncertainty about inflation would cause a greater fall in the differential than can be accounted for by changes in inflation expectations.

Figure 17 shows the differential between the real return and conventional bonds, along with the announced path of inflation targets. Since 1992 the differential has fallen from over 4% to under 2%. The differential increased in 1994, but this was related to concerns over fiscal policy. Over this period long-term nominal rates increased in the United States, and rates in other industrialized countries followed suit. In those countries with high indebtedness, including Canada, greater increases occurred than elsewhere.

As mentioned above, the level of the differential is not necessarily a good representation of the level of inflation expectations, but the change in the differential is certainly consistent with declining expectations. Moreover, expectations have on average declined at a very similar speed to the actual path of announced targets, but with much greater variance than the Consensus Economics forecast. As before this evidence is not conclusive, particularly since inflation uncertainty likely declined over this period. Nevertheless, it provides another source of information on inflation expectations which is clearly suggestive that the targets have considerable credibility.

4.3 Establishing a benchmark calibration of QPM

Given the lack of conclusive empirical evidence, a cautious approach was taken in calibrating the credibility effect into QPM. Clearly, incorporating a large effect, which would imply a very large change in model properties such as the degree of monetary response needed in the face of shocks or policy changes and the resulting output gains and losses, cannot be justified. The weights chosen for the perceived target were those which provided the smoothest path for the perceived target over history: a weight of 0.075 on the forward-looking component, and of 1.35 and -0.425 on the first and second lags of the backward component (as discussed in Section 3.2). This path most closely reflects the idea that the perceived target reflects agents' medium-term inflation expectations. A decay of 0.8 was chosen, which gives a weight of 0.16 on the forward-looking component of the CPI.

As shown above, changing expectations in this manner would, all else equal, reduce the sacrifice and benefit ratios in a disinflation and an inflation. It is not clear, however, whether such an adjustment is appropriate. As described in Section 4.1, particularly in the discussion of Dupasquier and Ricketts (1997a, b), there are questions as to whether offsetting changes in the relationship between output and inflation may partly or fully counteract the gains from the faster adjustment of expectations, perhaps leading to no significant changes in sacrifice and benefit ratios associated with policy changes.¹⁰ If this is the case, it may not be appropriate to let these ratios adjust in the absence of a new benchmark established on the basis of empirical work, rather than model simulations.

⁹ For more information see Coté et al. (1996).

¹⁰ It is important to distinguish between two experiments i) where only credibility changes and ii) where both credibility and the level of inflation have changed.

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Disinflation shock – with perceived target





Demand shock – with perceived target



Given this uncertainty, two calibrations of the model are shown below: one in which the sacrifice and benefit ratios associated with a disinflation and inflation respectively, are restored to those in the base model;¹¹ and one where they are allowed to fully adjust with the introduction of the perceived target.

Figure 18 shows the implications of these two calibrations for a disinflation. Both models which include the perceived target give very similar results. The predominant change is the initial decline in inflation expectations compared to the base model, which reduces the initial monetary response needed to bring about the disinflation. In the model where the sacrifice ratio is allowed to adjust, monetary policy eases a little more quickly in the second and third years of the disinflation since the negative output gap has a slightly greater affect on the inflation rate than in the model where the original sacrifice ratio is restored. This results in a smaller trough in output and a decreased cumulative output gap. If left unchanged, with the introduction of the perceived target the cumulative output gap declines by around 0.2 percentage points (from 3.0 to 2.8).

The changes to model dynamics introduced by the inclusion of the perceived target are more evident in a demand shock. This is shown in Figure 19. In both calibrations, inflation does not trough as low, and the monetary response needed to offset the shock is again reduced. For this reason, the cumulative output gap associated with a negative demand shock is greater, since less of it is offset by the monetary authority. This result carries over to other non-policy shocks: the perceived target acts as an anchor to expectations and in general inflation is less affected by shocks to the economy. Output gaps (whether positive or negative) tend to be sustained for longer, however, since the monetary authority does not need to offset as much of the shock.

Unlike the disinflation, in a demand shock the model where the sacrifice ratio associated with a disinflation has been restored shows a greater difference from the base model than the calibration in which no further adjustments are made. This is because the sacrifice ratio is adjusted in the former calibration by reducing the coefficient on the output gap within the price equations. This means that a given shock to demand has less of an impact on inflation.

These calibrations should be regarded as a preliminary attempt at incorporating credibility. Considerably more empirical work is needed to try and identify whether there has been a structural change in the way in which expectations are formed in the 1990s, and to identify changes in key stylized facts used in the calibration of the model, such as the cumulative output loss associated with a disinflation. It is also very important to study the implications of the perceived target using real-world data, rather than in the artificial environment. A good test of the model, will be to simulate the model over history and see how changing the weight on the perceived target alters the extent to which model expectations track other measures of expectations such as those coming from the Conference Board Survey of Forecasters. Another area of research will be to simulate the model in a stochastic environment. In such simulations, factors such as the variance of forecast errors over time can be compared to those from survey data. This will help establish the suitability of different calibrations. It will also be important to conduct sensitivity analyses based on different benchmarks of credibility in order to better define what we would expect to see in terms of factors such as altered trade-offs between unemployment and inflation or output and inflation. These will help to determine how credibility is changing over time.

¹¹ This is done by altering the coefficients on the output gap terms within the price equations.

Conclusion

Many aspects of QPM affect the degree to and speed with which price expectations incorporate changes in the inflation target and deviations from the target due to temporary shocks or inconsistent monetary policy. These include the weights on the model consistent and backward components of expectations and the way in which expectations are incorporated into prices. The characteristics chosen in the overall calibration for such things as the sacrifice and benefit ratios in disinflation and inflation shocks, and the degree of monetary response needed to offset shocks or change the target are also crucial determinants of credibility. If credibility has increased in the 1990s, the current calibration can be characterized as incorporating too few credibility effects.

More explicit credibility effects can be incorporated into QPM by introducing a "perceived target" into price expectations based on the lagged perceived target and model consistent inflation in the future. This approach is preferred to one where the target is introduced directly into expectations, since it provides greater flexibility for calibrating different aspects of credibility and reduces problems associated with inconsistency between the announcement effect and both the monetary authority's actions and the intrinsic dynamics of the model. The perceived target can be thought of as agents' assessment of the policy target being used by the monetary authority, which may or may not be equivalent to the announced policy target. The weight on the perceived target within price expectations captures the proportion of agents who base expectations on policy, or the degree to which the average agent believes policy will determine the price outcome.

Unfortunately, calibrating a credibility effect in the model raises more questions than can currently be answered, based on empirical work. The weights in the perceived target were chosen so that when simulated over history, the perceived target does not fully incorporate short-term movements in inflation, but provides a smooth track which acts as a proxy for agents' medium term inflation expectations. Given the lack of evidence currently available, however, a cautious approach was taken to the overall weighting of the perceived target within expectations. It was given a weight of 0.14, which implies a small decline in the cumulative output gap associated with a disinflation. Given the absence of other benchmarks, it is very unclear what should happen to the cumulative output gap/gain associated with a disinflation/inflation. For this reason two calibrations are shown, one in which these cumulative gaps are allowed to adjust fully with the incorporation of the perceived target, and one in which the original values used to calibrate the base model are restored. Above all, this exercise highlights the need for further empirical research on inflation expectations, and the testing of different calibrations with both real world data, and in a stochastic environment.

Appendix 1: Results of horizon-dependent weights on the target





Disinflation shock – time dependent coefficients







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