WP/16/192

IMF Working Paper

How to Improve Inflation Targeting in Canada

by Maurice Obstfeld, Kevin Clinton, Ondra Kamenik,
Douglas Laxton, Yulia Ustyugova, and Hou Wang

INTERNATIONAL MONETARY FUND

 WP/16/192

IMF Working Paper

Research Department and Western Hemisphere Department

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September 2016

Abstract

Routine publication of the forecast path for the policy interest rate (i.e. "conventional forward guidance") would improve the transparency of monetary policy. It would also improve policy effectiveness through its influence on expectations, particularly when there is a risk of low inflation, and the policy rate is constrained by the effective lower bound. Model simulations indicate that a potent macroeconomic strategy, for returning the Canadian economy to potential, combines conventional forward guidance with a fiscal stimulus. As a response to the effective lower bound constraint, and the decline in the world equilibrium real interest rate, this strategy is preferable to raising the inflation target.

JEL Classification Numbers: E31; E39; E52; E62

Keywords: Canada; inflation targeting; monetary policy; fiscal policy

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* Kevin Clinton and Ondra Kamenik are visiting scholars in the Research Department. We thank Cheng Hoon Lim for useful comments as well as participants at seminars at the IMF and the Department of Finance Canada. We also thank Yiqun Li for his excellent research assistance.

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Preamble to the Bank of Canada Act

WHEREAS it is desirable to establish a central bank in Canada to regulate credit and currency in the best interests of the economic life of the nation, to control and protect the external value of the national monetary unit and to mitigate by its influence fluctuations in the general level of production, trade, prices and employment, so far as may be possible within the scope of monetary action, and generally to promote the economic and financial welfare of Canada.

I. INTRODUCTION AND SUMMARY

For a quarter century, the Bank of Canada has pursued flexible inflation targeting (FIT).[1] The inflation-control targets, defined in agreements between the Bank of Canada and the Government of Canada, put into an operational form the broad, multiple, objectives defined by the preamble to the Bank of Canada Act. The mandate includes objectives for stabilizing output and inflation. FIT, which takes account of the lagged effects of monetary policy on inflation and output, and the short-term trade-offs between these goal variables, is squarely in line with this mandate.

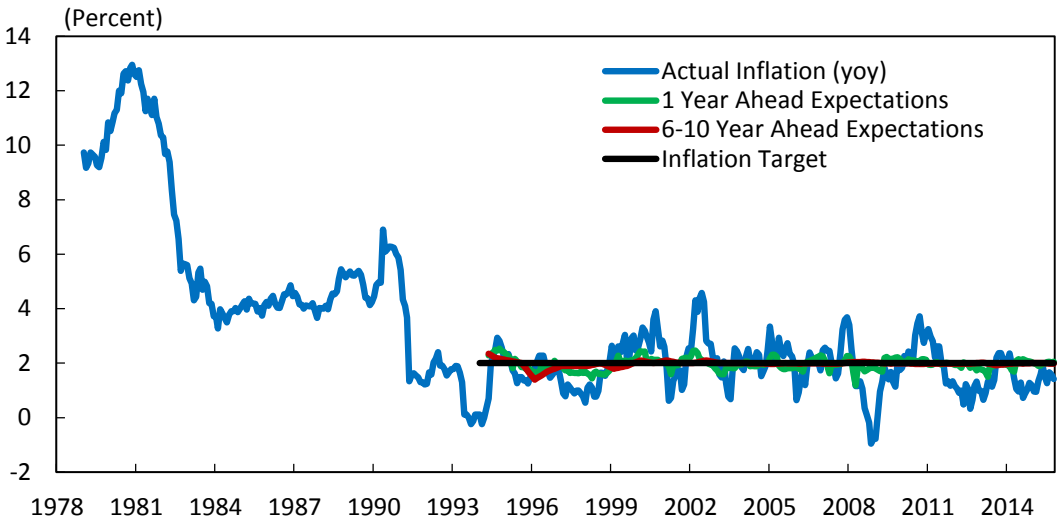
The Canadian monetary framework is well tested and, without question, sound.[2] And like any good arrangement for economic policy, the 5-year inflation-target agreements between the government and the central bank have enshrined a process for periodic review, assessment, and possible revision. The current agreement is up for renewal in 2016, and the Canadian authorities are considering how it might be modified, or not. This paper acknowledges the success of the existing regime, but argues that the framework could be improved with increased transparency with respect to the future path of the policy rate—a step that we call *conventional forward guidance* (CFG). CFG would involve a routine publication of the forecast path of the policy rate and other relevant macroeconomic variables (e.g., output gap and inflation) following the Bank's policy decision meetings.

Before going further, we draw attention to the outstanding record of inflation control. Since 1994 headline CPI inflation has averaged just less than the target of 2 percent, and expectations have been firmly anchored there, through the ups and downs of the business cycle, and through exogenous price shocks that have occasionally driven the actual inflation rate off-target. Thus, in 2016 the outlook for inflation remains remarkably stable despite the large impact of the recent oil price shock (Figure 1 and Table 1).

The most transparent FIT central banks are inflation-forecast targeting (IFT) central banks. Under IFT, the central bank's forecast represents an ideal intermediate target that is used to communicate how it is managing the short-run output-inflation trade-off (Svensson, 1997). That is, monetary policy targets the path of the central bank's inflation forecast, which gradually

[1] See Bank of Canada (2012).
[2] For a discussion of the history of inflation targeting in Canada, see Lane (2015).

Figure 1. Inflation and Consensus Inflation Expectations for Canada



Source: Consensus Economics.

Table 1. Inflation Expectations Better Anchored in IFT Countries

	2016	2017	2018	Cumulative Deviations from Inflation Objectives (2017-2018)[1]	IFT Central Bank[2]
Canada	1.7	2.1 (0.1)	2.0 (0.0)	**0.1**	Yes (1994)
Czech Republic	0.6	1.7 (-0.3)	2.1 (0.1)	**-0.2**	Yes (2002)
New Zealand	0.7	1.7 (-0.3)	2.0 (0.0)	**-0.3**	Yes (1997)
Sweden	1.0	1.5 (-0.5)	2.2 (0.2)	**-0.3**	Yes (2007)
United States[3]	1.3	2.3 (0.0)	2.3 (0.0)	**0.0**	Yes (2012)
Euro Area	0.3	1.3 (-0.7)	1.5 (-0.5)	**-1.2**	No
Japan	-0.1	0.6 (-1.4)	0.9 (-1.1)	**-2.5**	No

[1] We calculate the cumulative deviations from inflation objectives starting in 2017 to remove some of the temporary factors driving inflation (such as low global oil prices).

[2] IFT central banks use consistent macro forecasts to explain how they are adjusting their instruments to achieve their output-inflation objectives.

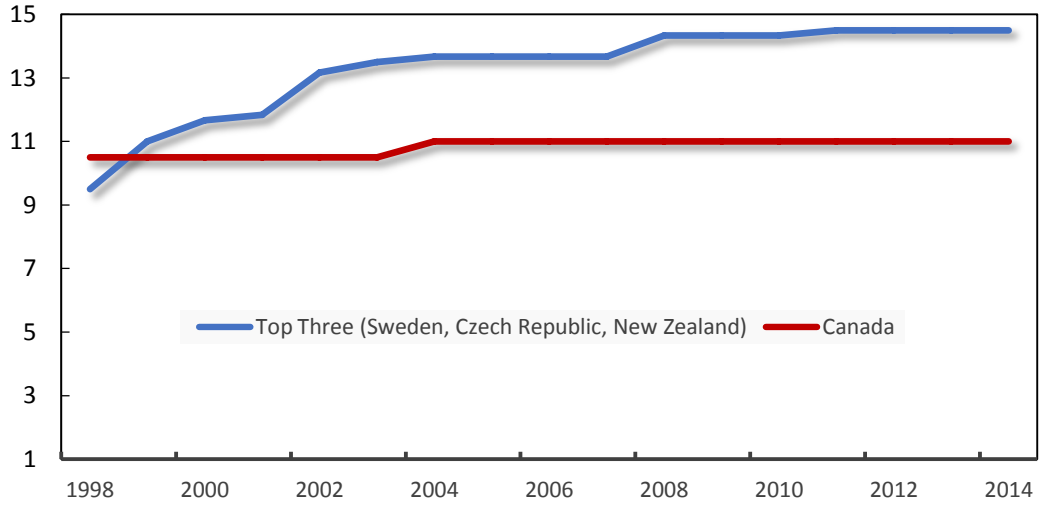
[3] The implicit CPI inflation objective for the U.S. is estimated by the authors at about 0.3 percentage points above the Fed's official PCE inflation objective of 2.0 percent. This is based on the difference in long-term CPI and PCE inflation forecasts from Philadelphia Fed's Survey of Professional Forecasters.

Source: Consensus Economics, July 2016.

converges to the 2 percent long-term target. The rationale is that this forecast embodies all relevant factors known to the central bank that may affect the future course of inflation. These factors include the policymakers' own preferences regarding the output-inflation trade-off, their assessments of the state of the economy, and their views on the transmission of monetary policy to output and inflation. Thus, the forecast embodies policymakers' views of the best feasible path of the inflation rate, from its current level to the long-term target rate. From this perspective, the central bank's inflation forecast is itself an ideal operational target for monetary policy, over the medium term as well as the long term. Table 1 indicates, in an international comparison, that the IFT approach has had superior results in terms of anchoring long-term inflation expectations to the announced targets.

IFT central banks, such as the Sveriges Riksbank, the Czech National Bank, and the Reserve Bank of New Zealand ranked as the top three in the Dincer-Eichengreen index of central bank transparency (Figure 2). On this measure, they have overtaken the Bank of Canada, which was an early pioneer of inflation targeting, and which, in conjunction with the IMF, provided advice on implementing the regime to several of them.

Figure 2. Dincer-Eichengreen Central Bank Transparency Index



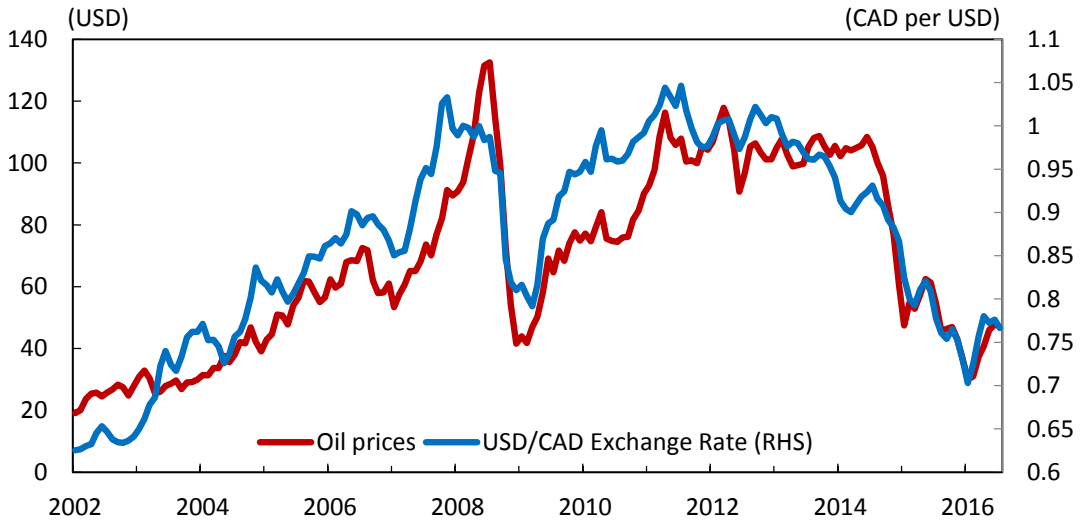
Source: Dincer and Eichengreen (2014).

Several factors have contributed to the marked success of the IFT framework in Canada.

First, the exchange rate against the U.S. dollar has been allowed to vary over a wide range, absorbing large shocks to the terms of trade, and thereby buffering their impact on domestic output and inflation (Figure 3).

Second, fiscal policy has mainly played a supportive role, with surpluses during the pre-2008 expansion switching to large deficits post-global-crisis, which reflect endogenous effects of the recession, and the 2009-10 fiscal stimulus. The budgetary consolidation over the period 2012-15,

Figure 3. Oil Price and Canadian Exchange Rate



Source: Haver Analytics.

with smaller deficits, eventually restored a declining government debt-to-GDP ratio. Fiscal policy in 2016 has adopted a stimulative stance—appropriately in view of the macroeconomic circumstances, as we discuss in Section IV.

Third, in the first half of this decade, Canada benefited from booming demand for oil and other commodities, driven by the expansion in China and other emerging markets, which stimulated domestic investment and output. This fortuitous development largely shielded Canada from the negative effects of the large drop of the global equilibrium real interest rate in the wake of the 2008 global financial crisis. In many advanced economies, chronic excess capacity, and unduly low inflation rates, have persisted despite extremely low interest rates. The global level of nominal rates consistent with maintaining output at its potential level given inflation targets is well below the pre-2008 level; in 2016 the neutral rate may be around zero. Since 2014, the drop in world oil prices, the recession in the energy sector, and the weakness of other commodities markets, has confronted Canadian monetary policy with the sharp end of the issue.

Fourth, a sound system of financial regulation and supervision, which includes a regular 5-year updating of banking legislation, helped the Canadian financial system avoid the excesses that preceded the global financial crisis. As a result, Canada was one of the few advanced countries to escape severe financial-sector stress during the 2008-09 global crisis. The banks were well-capitalized, and did not need public sector support. The post-crisis tightening of credit, due to heightened risk aversion, was less severe in Canada than in other countries.

The core measure of CPI inflation has remained near 2 percent, but the widening of the negative output gap since 2014 portends further reductions in inflation. In response, the Bank of Canada has reduced the overnight interest rate. With the overnight interest rate now at 0.5 percent, some

room remains for cuts—the Bank has revised its estimate of the effective lower bound (ELB) on the overnight rate down to -0.5 percent, from the previous 0.25 percent (Witmer and Yang, 2015). However, the global equilibrium real interest rate has declined considerably since the global financial crisis, and is likely less than 1 percent (Box 1).[3] This means that policy rate cuts, even of the maximum feasible extent, might not give much of a boost to the economy—unless, that is, they are supplemented by other measures. The Bank, drawing on the experiences of other central banks, has signaled that it is prepared to adopt unconventional monetary policy measures, e.g., large-scale asset purchases, and funding for credit. While these less conventional options remain open for future contingencies, their efficacy is uncertain (Poloz, 2015). And questions have been raised about the implications of negative rates maintained over an extended period for the efficiency and stability of the financial system (Bech and Malkhozov, 2016).

CFG would strengthen an already strong framework, by making the interest rate instrument more effective—a strategic modification that would pay off in good as well as bad times. The change would move Canada back to the forefront of the IFT economies in terms of transparency. It would improve the Bank of Canada's ability to manage the medium-term trade-offs as shocks drive the economy off course. In the current situation, it might obviate the need to consider a negative policy rate, or the increased use of unconventional monetary instruments. And CFG would be preferable to the suggestion to raise the inflation target from 2 percent, which raises issues of credibility (long-term inflation expectations have been very firm at 2 percent), effectiveness (a mere announcement would not do the job, the Bank would have to raise the actual inflation rate), and economic efficiency (e.g., inflation distortions caused by confusion between real and nominal changes, and by interactions with accounting and tax systems).

The essence of the argument is simple. In and of itself, the Bank of Canada's setting of the overnight rate for the next 6 weeks (the interval between policy meetings) has no material impact on inflation or output. The policy rate has an effect only insofar as it moves the longer-term interest rates at which households and firms borrow and invest. In effect, the Bank has to ensure that public expectations of the future overnight rate move in line with the current setting.[4] Conversely, the central bank must have a view of how its policy decisions will affect the medium-term path of the short-term rate, because the transmission to inflation and output depends on this path. Thus, underlying every interest rate policy decision is a forecast—indeed, the best-informed forecast—of the rate path that will get inflation back to the 2 percent target over the medium term. The forecast rate path, moreover, is endogenous—in the literal sense that

[3] Mendes (2014) estimates the neutral real interest rate in Canada at 1-2 percent, which translates to 3-4 percent in nominal terms. A neutral rate as high as 4 percent would imply that monetary conditions have been extremely expansionary since 2009, because the actual policy rate has not been above 1 percent. But this is difficult to square with the subdued growth and inflation. If the latter are attributed to long-lasting economic headwinds, for operational purposes it would be simpler to regard these as part of the environment, rather than shocks, and to reduce the estimate of the neutral rate correspondingly.

[4] Theory supporting this assertion can be found in, e.g., Eggertsson and Woodford (2003) and Woodford (2005).

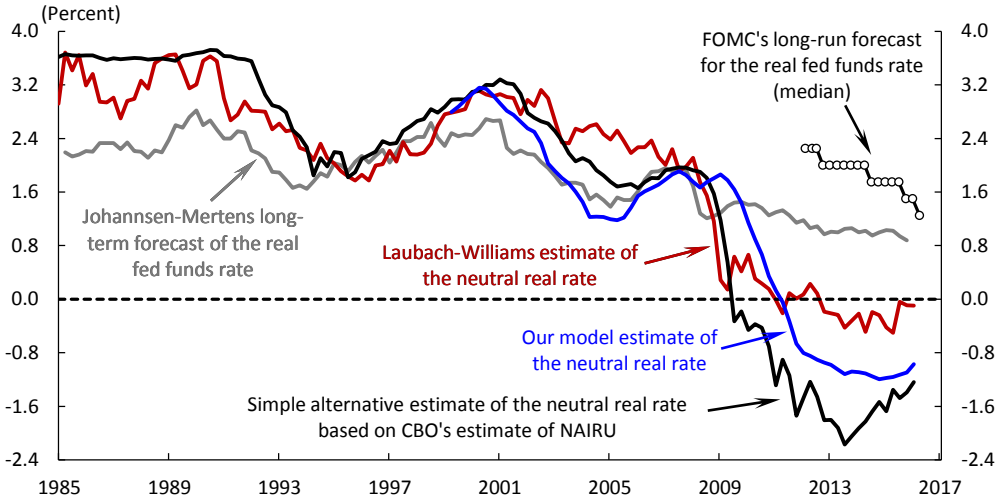
Box 1. Downward Trend in Global Equilibrium Real Interest Rate

For present purposes, the equilibrium real interest rate is the rate that would be consistent with equality between actual output and potential (full employment) output in the absence of any short-run or cyclical shocks. In a standard macroeconomic model, an inflation-targeting central bank would vary the rate from this level only to return inflation to the target rate after some disturbance. This involves a medium-term concept of equilibrium. For Canada, a very open economy, with high capital mobility, the global (or as an approximation, the U.S.) equilibrium rate drives the domestic rate.

Inflation-adjusted bond yields have seen a trend decline since the early 1980s (Rachel and Smith, 2015). A renewed drop after the onset of the 2008-09 global financial crisis, accompanied by low inflation and weak output growth has led to substantial downward revisions of the equilibrium real interest rate. But there is no consensus on how far the rate may have declined since the crisis. CEA (2015) and Holston, Laubach, and Williams (2016) discuss the causes of the decline. Summers (2015) cites a -3 to 1.75 percent range from a survey of U.S. studies. Mendes (2014) puts the range at 1-2 percent for Canada. The main difference arises from definitions of shocks. Higher estimates, above 1 percent, classify as shocks the repeated headwinds that have resulted in a systematically disappointing recovery. Lower estimates, near or below zero, classify these headwinds as a permanent part of the medium-term environment, rather than shocks.

We are inclined to favor the second approach. At some point, if negative headwinds persist, they are no longer shocks. Repeated downgrades of forecasts (Table 3), and below-target inflation, along with declines in actual real rates, suggest that monetary policy has been confronting a decline in the neutral rate that can be perceived only with a recognition lag. In the meantime, policymakers overestimating the equilibrium real interest rate would attribute persistent surprisingly weak output to unexpected headwinds.

Box Figure 1. Equilibrium Real Interest Rate for the United States



Source: Authors' calculations; Johannsen and Mertens (2016), Laubach and Williams (2015), Federal Reserve and Nomura.

IFT central banks use forecasting models with an endogenous policy rate, as well as in the logical sense that with an inflation target the policy rate must vary so as to keep inflation on target within the forecast horizon. The policy rate path therefore responds to observed economic conditions so as to get the inflation rate back on target. If markets have the same rate forecast as the central bank, longer-term interest rates, the exchange rate, and asset prices generally, are likely to move in support of the objectives of monetary policy.

This point has been long accepted with respect to publication of the forecast inflation rate path. There is a duality, in that expected inflation, and the actual nominal interest rate, are the two components of the real interest rate. The published inflation rate forecast generally influences the expected real interest rate in support of monetary policy. When nominal interest rates are constrained by the ELB, this is of increased importance.[5] The central bank might well envisage a strategy in which there is a temporary overshoot of inflation, over and above the target. This would reduce the real interest rate, and help move the economy away from a deflation or low inflation dark corner. Under CFG the central bank would communicate the whole story underlying the strategy, allaying any risk to the credibility of the target that the planned overshoot might otherwise create.

The main objection to CFG is the conditionality of the interest rate forecast. Monetary policy has to allow the interest rate to vary to offset shocks. It cannot commit to a forecast path for the rate. Central bankers have worried that if it becomes necessary to deviate from a given path their credibility might be impaired. However, with effective communications, this issue need not arise: markets have readily adjusted in those countries where the central bank publishes its interest rate forecast (e.g., the Czech Republic, New Zealand, Norway, Sweden). Indeed, with a deeper understanding of the intentions of policymakers, markets are more likely to perform a strong buffering role against shocks. Model-derived confidence bands, and alternative forecasts based on shocks to the baseline forecast, are useful tools for communicating the conditionality of the projection, and the impact of shocks should they materialize.

The paper is organized as follows. Section II provides a rationale for conventional forward guidance in terms of its effect on expectations and the effectiveness of monetary policy. Section III reviews the experience with forward guidance in the U.S. and the U.K., as well as Canada. Section IV contains policy simulations of a new-Keynesian model for Canada. These indicate that a strong policy framework for avoiding macroeconomic quagmires would be provided by: a loss-minimizing monetary policy, with a quadratic loss function, which puts an increasingly heavy penalty on deviations from the inflation target and from potential output; and full publication of the central bank forecast. In addition, in 2016, near the ELB, there is a clear role for a fiscal stimulus. These features could be more effective than unconventional monetary policy measures, or negative interest rates, or raising the target inflation rate, for avoiding the dark corner of the ELB-deflation trap. Concluding comments are in Section V.

[5] In Canada, the ELB has not been tested in practice, but a recent Bank of Canada estimate puts it at about -0.5 percent (Witmer and Yan, 2015).

II. EXPECTATIONS AND A THREATENING DARK CORNER

In normal times, following a contractionary shock, policy would react with an interest rate cut which has its effects on inflation and output via the usual transmission mechanism. At the ELB a somewhat weakened version of the mechanism could still apply, through real interest rates and the real exchange rate. That is, expected inflation provides a channel through which forward guidance can stimulate the economy. If monetary policy is active, and credible, it could persuade the public that it will eventually get inflation back up to the long-run target. With the promise of a sufficiently vigorous policy, which commits to holding the interest rate at the ELB for an extended future period, the public—financial market participants in particular—would expect increased inflation in the future. This would reduce longer-term real rates of interest even if the nominal rate were stuck at the ELB. These movements serve as a buffer to the shock. Under such circumstances, in order to respond strongly to the initially very weak economy, the central bank might show a stimulative forecast in which, over the medium term, inflation overshoots before returning to the long-run target.

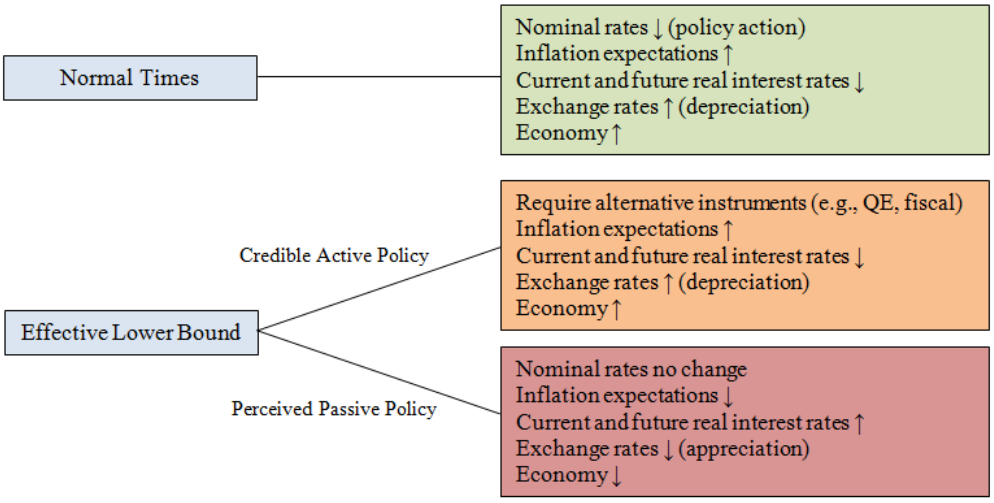
Moreover, the real exchange rate would depreciate, and asset prices would rise immediately in line with the drop in the real interest rate. And the longer the expected period for the policy rate at the floor, the larger are these effects (Appendix I). This equilibrating response of the real price of foreign exchange is a normal aspect of the transmission mechanism. Thus, the real interest rate channel would be amplified in the open-economy case by the real exchange rate channel.[6] A very similar argument to that for the real exchange rate applies to asset prices. An increase in the expected medium-term rate of inflation that reduces real interest rates would boost asset prices through the lower real discount rate, and through the positive impact of exchange rate depreciation on profits. Increased asset prices would stimulate spending.

To achieve this result, the central bank has to persuade people: that the nominal interest rate will remain at the floor for an extended period; and that the rate of inflation will rise over the medium term, possibly above the long-run target; but that the rate of inflation will eventually return to target. Is this a realistic prospect? The exchange rate policy used by the Czech National Bank since 2013, which has relied heavily on influencing expectations, suggests that, under a transparent IFT framework, it can be (Alichi and others, 2015a).

If, however, monetary policy were passive, and not credible, the real exchange rate and asset prices would amplify a contractionary shock, because the expected rate of inflation would fall (equivalently, the expected rate of deflation would rise). At the ELB, real interest rates would rise, the real exchange would appreciate, and asset prices would fall. This is the classic deflation trap. The flowchart in Figure 4 illustrates the difference between the two policy regimes.

[6] Svensson (2001) emphasizes these expectations mechanisms as a way to jump start the economy in Japan.

Figure 4. Expectations as Shock Absorbers or Amplifiers



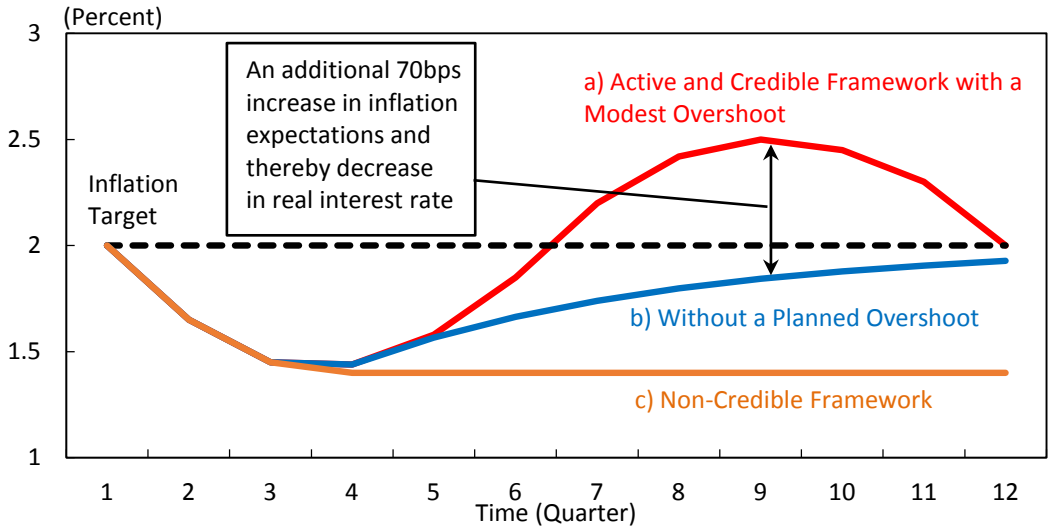
Source: Adapted from Clinton and others (2015).

Figure 5 provides an illustration. The economy is hit by some contractionary shocks which cause inflation to be below the target. The orange line indicates a passive policy, with actual inflation well below a non-credible target of 2 percent, and the interest rate stuck at the ELB. The blue line is for a credible framework: starting in period 4, policy smoothly achieves the 2 percent target in period 12. But policy could be more aggressive. With conventional forward guidance, monetary policy deliberately causes inflation to overshoot the target for several quarters—at the peak, inflation reaches 2.5 percent. The medium-term increase in the inflation rate (over the blue line), which peaks at 0.7 percentage point, translates into temporarily higher inflation expectations, and hence a decrease in real interest rates of 70 basis points. This positive feedback is part of the boost provided by the more aggressive policy, which achieves the inflation target at a lower overall cost: it involves a smaller cumulative output gap, and provides better risk management, in that it moves the economy more quickly from the deflation-ELB dark corner.

During a period in which the ELB is binding, and where the main danger is on the deflation side, the forecast endogenous interest rate would be at the ELB long enough to get inflation back on track (Eggertsson and Woodford, 2003, with a different model, reach the same conclusion). To the extent that this forecast affects market expectations, it will result in medium- and long-term rates that are lower than their long-run equilibrium values. In this sense, publication of the forecast becomes an additional instrument, helping policy achieve its objectives, in the same way as the Fed's forward guidance since 2008. CFG emerges from a systematic framework, but it so happens that its advantages become most clear in the ELB zone. A transparent lower-for-longer interest rate strategy would have the positive impact of reducing real interest rates by more than the actual cut in the overnight rate. A published forecast would encourage a desirable movement in medium-term expectations for both the nominal interest rate (down) and for inflation (up).

Thus, longer-term market interest rates, the exchange rate, and asset prices would play a reinforced shock-absorber role in support of the economy.

Figure 5. Inflation Paths for Different Policy Frameworks



Source: Authors' calculations.

Moreover, encounters with the ELB are likely to become more frequent, and longer lasting. This is because the equilibrium real interest rate has fallen substantially since the global crisis. Some estimates put the current global equilibrium real rate near zero (Box 1).

III. Different Kinds of Forward Guidance

III.1. Conventional Forward Guidance

Monetary policy works by affecting expectations about the future interest rate. It is the entire interest rate path that is important for future inflation and resource utilization, not merely the interest rate over the coming weeks. The Riksbank has therefore come to the conclusion that the only right thing is to explicitly discuss the interest rate path and to choose a particular path as the main forecast, as well as publishing the interest rate path and justifying its selection. This is in my opinion the most effective way of conducting monetary policy. Not to discuss and select a particular interest rate path as a main forecast would be an incomplete decision-making process. Not to publish the interest rate forecast would be to hide the most important information. (Svensson, 2007)

CFG as practiced in the Czech Republic, New Zealand, Norway and Sweden, is a systematic part of the policy framework. It derives from the publication of a complete central bank macroeconomic forecast, with an endogenous interest rate path, and confidence bands around key variables. The endogenous policy rate moves to achieve the announced inflation target over a medium-term horizon in a way that reflects the policymakers' preferences with respect to the

short-run trade-offs between output, inflation and interest rate variability. The policy rate path is clearly conditional on a range of assumptions, and subject to a range of uncertainty as indicated by the confidence bands. In general, publication of the path should help steer public expectations in a way that is helpful to the attainment of policy objectives, in particular through the effect on medium- and longer-term interest rates.

Under IFT, forward guidance of a more or less explicit form always takes place on an ongoing basis, in that the central bank provides a regular flow of information on its current policy actions, and on its view of the medium-term macroeconomic outlook. The principle is that markets are more likely to operate in support of monetary policy objectives if they are well-informed about the central bank's view of the forces affecting inflation and output. At a minimum, under IFT, forecast paths for inflation and the output gap or growth are published, just after interest rate policy decisions are announced—i.e. 8 times per year in Canada.

Systematic publication of the forecast interest rate path too would provide market participants with a seamless flow of information on how the changing state of the economy is likely to affect the monetary policy actions aimed at returning inflation to the target. This approach is robust in the sense that CFG is a regular part of the policy framework—forward guidance is continuous, in the routine format of the published forecast, not just in cases of major economic instability (Clinton and others, 2015).

Publishing the path for the endogenous policy rate underlines that the policy action at any point in time involves more than just setting an interest rate until the next monetary policy meeting. In making any particular decision, the policymakers must have in mind some view of the future interest rate path that will be necessary for the efficient achievement of the target over the medium term. A priori, releasing that path, along with a discussion of how it might change in response to new information that changes the outlook, would be the single most obvious way of clarifying for the public the central bank's view of the policy implications of the economic outlook, and, more generally, for revealing how it intends to manage the short-run output-inflation trade-off.[7] In contrast, a published forecast that shows a smooth return of inflation to target and output to potential, without the interest rate path, does not provide the public with a clear idea of the central bank's perception of, e.g., how strong the economic headwinds may be, or how it intends to deal with them.

It is important, however, that communication on the policy rate path should avoid creating the false perception that the path is a promise rather than a conditional forecast. In practice, this has not proved to be an insuperable difficulty in the Czech Republic, New Zealand, Norway and Sweden, where the central banks publish their forecasts for the short-term interest rate (Clinton and others, 2015). It would be appropriate in this regard for the central bank to communicate to the public not just a forecast path for the future policy rate (and for unconventional instruments

[7] This has been described by some policymakers as finding a path that "looks good" (Svensson, 2002, and Qvigstad, 2005).

where these are a factor), but also a sense of how and why this path might change in response to a variety of developments. At the same time the central bank should make clear its evaluation of the risks and uncertainties that lie ahead. Effective communications are the key to avoiding false perceptions about the precision of the forecast. To underline the degree of uncertainty in the projections, CFG central banks publish confidence bands, as well as the central tendency, for the path of the policy interest rate. In addition, the publication of alternative scenarios to the baseline, embodying large shocks for which the probability cannot be calculated from historical data, can indicate the "non-normal" range of uncertainty perceived by the central bank.

A central bank using CFG does not have to give special guidance as to when any particular policy approach will switch on and off, or as to the threshold values of inflation and unemployment (or the output gap) that might trigger a policy move. In contrast, forward guidance as practiced in the U.S. has involved ad hoc central bank statements about when in the future—at which calendar date—the policy interest rate might be changed, or about thresholds for the inflation rate and unemployment that might trigger a change in the rate (Alichi and others, 2015b).

CFG would generally influence expectations for the future policy rate, and for medium-term inflation, in a way that helps monetary policy—in good times as well as in times of heightened economic instability.[8] That is, it would encourage the longer-term real market interest rates that affect business and household demand to move in line with developments in the state of the economy and the Bank of Canada's output and inflation objectives. It would also improve the process of accountability, in that published forecast paths, confidence bands, and alternative scenarios, provide a quantitative framework by which to account for central bank actions. Policymakers should be able to explain the events that caused deviations from the forecast path transparently, in terms of the specific deviations from forecast assumptions.

III.2. Unconventional Forward Guidance

Forward guidance on the policy interest rate was employed by the Bank of Canada, the Federal Reserve, the Bank of England and the Bank of Japan, among others, after the global financial crisis. These central banks used forward guidance to talk down the expected policy rate path and term premium, and thereby to reduce longer-term interest rates. In this respect, it did succeed (Engen, Laubach and Reifschneider, 2015; Charbonneau and Rennison, 2015). We call this *unconventional forward guidance* (UFG), because it was introduced along with other unconventional measures, as an ad hoc tool when the ELB put constraints on reductions in the policy rate.

[8] This corresponds to the observation by Eggertsson and Woodford (2003): "In fact, the management of expectations is the key to successful monetary policy at all times, not just in those relatively unusual circumstances when the zero bound is reached." See also Woodford (2005).

UFG has encountered communication difficulties with respect to the conditionality aspect, in particular with respect to the time horizon over which the guidance is to apply. In the immediate aftermath of the global financial crisis, with elevated risk premiums, central banks wanted to assure markets that the policy rate would remain at the floor for at least as long as it took to restore a semblance of order. Thus, from April 2009 to April 2010, the Bank of Canada emphasized that the policy rate would be kept at the floor (estimated at the time to be 0.25 percent) for about a year, but that this commitment was conditional on the outlook for inflation. As the economy recovered and inflation returned to the 2 percent target the Bank exited from the UFG (more or less as initially planned). This experience therefore turned out quite well. Canada avoided difficulties that surfaced in other advanced economies, as discussed below. However, this was in large part fortuitous, in that after 2009 Canada benefited from the favorable shock of booming demand for oil and other commodities from China and other emerging markets.

In the United States and the United Kingdom, things were more complicated. As these economies emerged, sluggishly and unevenly, from the post-crisis recession, their central banks tried to communicate when, and under what conditions, the policy rate would rise from the floor (and quantitative easing would taper off). For this purpose, they announced threshold values for the unemployment rate and the inflation rate.

A risk in this kind of announcement is over-simplification. Policymakers do not themselves use a simple threshold rule for decision making. Their view of the future path of the policy rate depends on a much more complex assessment of what may be necessary to return the inflation rate to target: they have a clear perception of the objectives of policy, which are given, and the conditional nature of their projections for the policy instrument. Within central banks, such assessments are informed by forecasts derived with macroeconomic models that take account of numerous factors influencing the outlook, and the judgment of the forecasters. Announcing thresholds for inflation and unemployment risks misguiding financial markets about the scope of other considerations that may influence policymakers' outlook for the interest rate. This could lead financial market participants to underestimate the degree of uncertainty in the outlook, and hence make financial markets vulnerable to the arrival of unexpected news. For example, the strategy might misrepresent the amount of uncertainty in future long-term interest rates: in the short run it might convince financial markets that short-term interest rates will stay low; there will, however, come a point at which the interest rate has to be raised, upsetting market expectations, and creating market volatility (as in the 2013 taper tantrum). Thus, the Governor of the Bank of Canada has expressed a concern that a conditional commitment to hold rates low might artificially reduce two-way rate volatility, and prevent markets from properly assessing risks in the interest rate outlook, especially with respect to potential shocks of a size and nature in the distant tails of the statistical distributions (Poloz, 2014). This risk is reduced with CFG, which presents the central bank forecast as a conditional projection, and is transparent about the underlying assumptions, and their uncertain nature.

III.3. Country Experiences with Unconventional Forward Guidance

III.3.1. United Kingdom

The Bank of England announced a threshold rule (August 2013), declaring that it would not raise its policy interest rate (or reduce its quantitative easing) until

- the unemployment rate fell below 7 percent, or
- CPI inflation 18 to 24 months ahead rose above 2.5 percent, or
- inflation expectations became unhinged, or
- the low interest rate threatened financial stability.

Within a few months the unemployment rate had fallen below the threshold, yet there was no economic case for a rate increase: inflation was below 2 percent and falling, and the financial system looked stable. In February 2014 the central bank reverted to qualitative guidance, with no numerical thresholds.

III.3.2. United States

The Federal Reserve has changed the form of its UFG several times since its inception in 2008 (Table 2). Until 2013 the guidance succeeded in the operational objective of reducing the term premium, and expected future short-term rates—and hence bond yields (Figure 6). These changes nevertheless look like improvisation, rather than following a consistent strategy. In 2013, a change in perceptions about policy triggered the taper tantrum, an outbreak of financial market volatility. Bond yields and term premiums rose sharply, to an extent way out of line with the modest eventual tightening envisaged in the cautious public statements of the central bank. Continuing communication difficulties with UFG are illustrated by this clarification from Fed Chair Yellen (March, 2015): "just because we removed the word 'patient' … doesn't mean we are going to be impatient…"

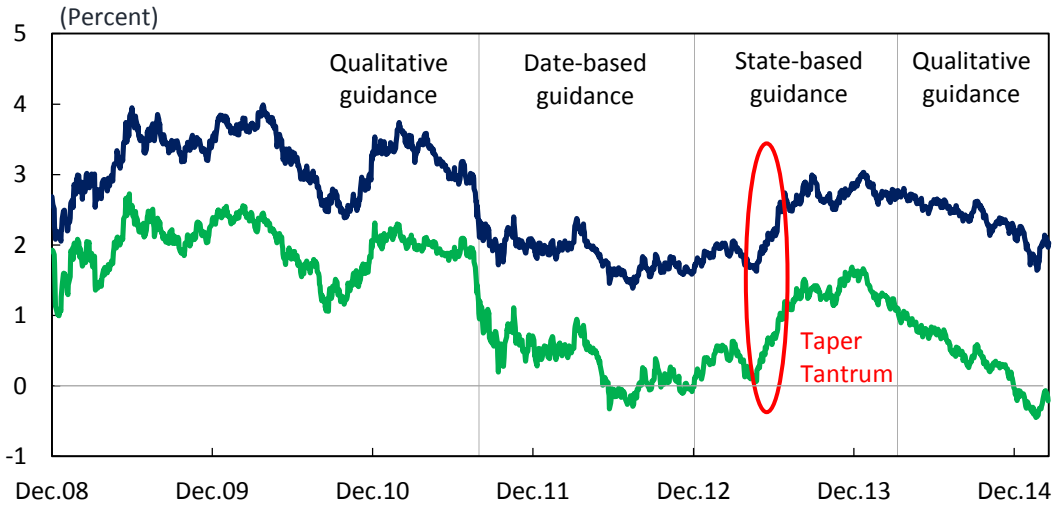
There is evidence that the communications difficulties have had material macroeconomic costs. The empirical study by Engen, Laubach, and Reifschneider (2015) concludes that if the public had understood beforehand the willingness of the FOMC to accommodate, the recession would have been less severe and the subsequent recovery more rapid (Figure 7). Since January 2012 the Fed has released FOMC members' interest rate projections following each meeting. But it is difficult to "connect the dots" from the individual projections to form a single consistent forecast (Alichi and others, 2015b).

Table 2. Guidance of the Fed after the Global Financial Crisis (November 2008-March 2015)

Date	Action	Description
December 2008 to March 2015	Forward guidance	Qualitative (Dec 2008-Aug 2011), date-based (Aug 2011-Dec 2012), threshold-based (Dec 2012-Mar 2014), qualitative (Mar 2014-Mar 2015)
November 2008 to March 2015	Balance sheet guidance	Volume of purchases, pace of purchases, assets purchased, criteria for revising asset purchases, reinvestment and shrinking of the balance sheet
April 2011	Post-meeting press conference	More comprehensive and timely information on the FOMC policy decision and views, including Summary of Economic Projections
January 2012	Statement on longer-run goals and policy strategy	Clarify the Federal Reserve's objectives and policy strategy, including the introduction of a long-run 2 percent inflation goal
January 2012	Policy rate projections	Individual FOMC members' policy rate projections were added to the quarterly Summary of Economic Projections published following FOMC meetings

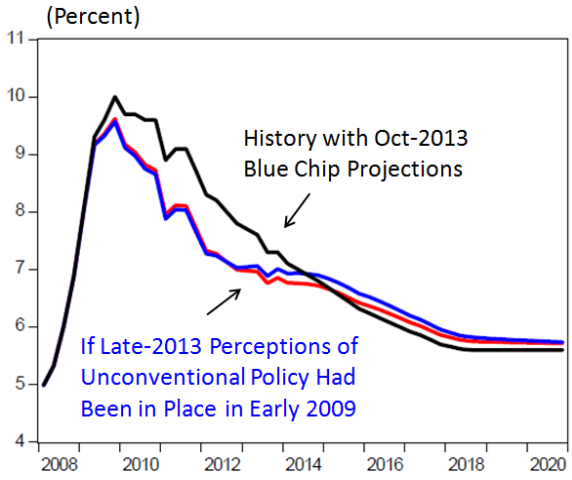
Source: Adapted from Alichi and others (2015b).

Figure 6. 10-Year U.S. Treasury Yield and Term Premium



Source: Alichi and others (2015b).

Figure 7. Predicted U.S. Unemployment Rate



Source: Adapted from Engen, Laubach, and Reifschneider (2015).

Filardo and Hoffmann (2014) look at experience in the U.S., Japan, and the U.K. They find that forward guidance has had moderately beneficial results. Charbonneau and Rennison (2015) provide a somewhat more favorable assessment of the international experience (including Canada), finding: lower expectations of the future path of policy rates; improved predictability of short-term yields over the near term; and reduced sensitivity of financial variables to economic news. Engen, Laubach, and Reifschneider (2015) suggest the net stimulus to real activity and inflation was limited by the gradual nature of the changes in expectations for the interest rate and term premiums. In view of the limited sample size, and of the shifts in the nature of forward guidance, the lack of a strong positive macroeconomic effect should not be surprising. More systematic, and more explicit, interest rate guidance might well yield material gains.

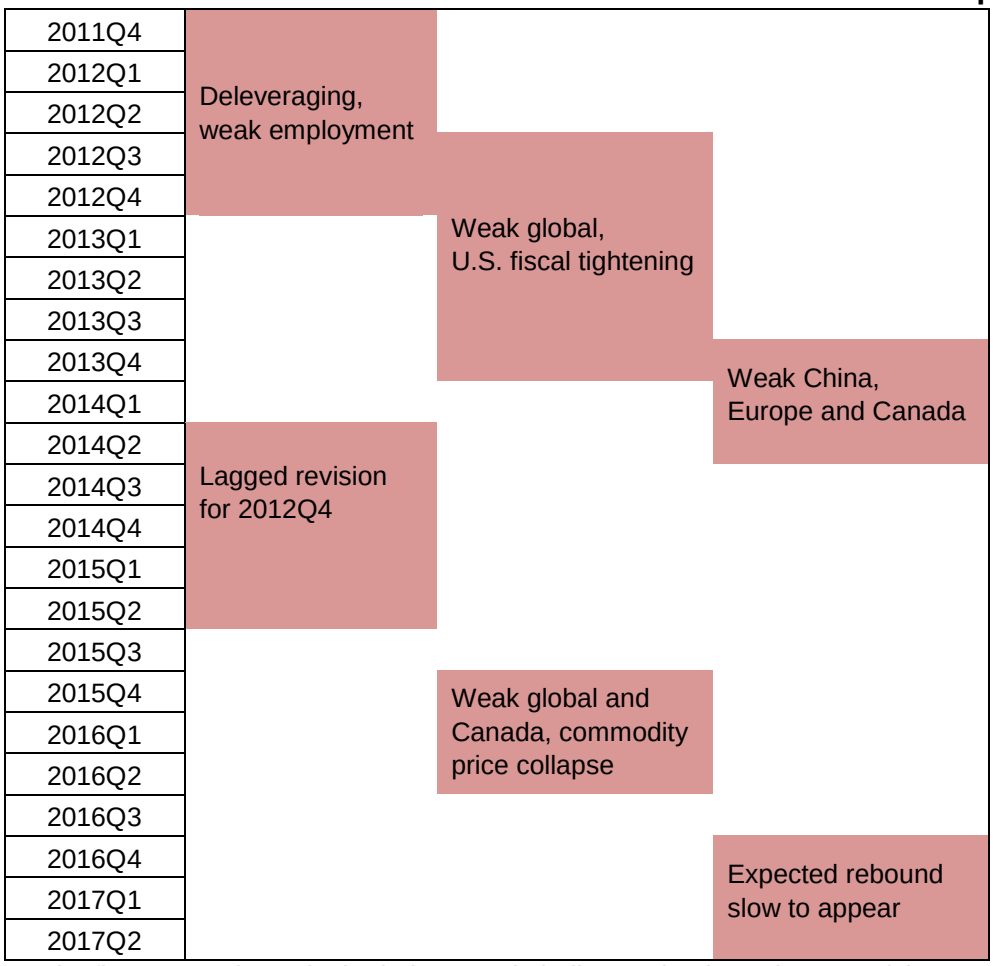
III.3.3. Canada

The rate of inflation when the crisis broke out was about 2 percent, and the Bank of Canada's policy rate was above 4 percent. Over the next 2 years, the ample room for action was exploited by the Bank, which cut the policy rate to near zero. The Canadian dollar depreciated. Exports fell sharply with the drop in U.S. demand, but the decline in GDP was limited to 2.7 percent, as domestic demand held up quite well. Inflation remained positive. In the Canadian case, policy actions helped keep expectations up, and the exchange rate acted as a shock absorber. Despite the proximity of Canada to the U.S. epi-center of the crisis, and the drop in commodity prices, the Canadian recession was relatively mild.

By 2010 the Canadian economy was recovering. Rising global oil prices gave output as well as inflation a boost, as investment and output in the energy sector began to expand strongly. Even so, a considerable degree of slack, with weak employment, persisted. One might question the management of the output-inflation trade-off. The Bank's forecasts for output were consistently overoptimistic. Over time, the forecasts in Monetary Policy Reports repeatedly put back the date at which output was expected to reach potential, from 2011Q4 in the July 2010 Report, to

2017Q3 in the April 2016 Report (Table 3). In retrospect at least, such long-lasting headwinds, or negative output shocks, imply that the Bank was overestimating the equilibrium real interest rate. An overestimate was to some extent inevitable, because this rate is not directly observable, and it would be impossible in real time to recognize a decline of the magnitude that now seems likely to have occurred.

Table 3. Revisions to BoC Forecast for Attainment of Potential Output



Note: The first quarter in each shaded rectangle indicates the time when a revision was made. The last quarter in each shaded rectangle indicates the date when output gap was expected to close according to that revision. Rectangles do not always overlap exactly 1 quarter because small revisions are omitted.

Source: Bank of Canada Monetary Policy Reports, 2009-2016.

IV. Model Simulations of Alternative Policy Strategies

Simulation results based on a new-Keynesian model illustrate how CFG might operate. The model that we use for Canada bears similarities to those used at many central banks for forecasting and policy analysis. It has a standard core structure, with equations for the output gap, core inflation, the policy interest rate, and the exchange rate. Expectations are forward

looking, consistent with the projections of the model itself, but the behavioral equations also embody lagged adjustments. In addition, the model has equations for headline inflation, food and energy inflation, the commodity terms of trade, trade and financial linkages with the rest of the world, and bond yields of various maturities.[9] Nonlinearities are in the Phillips curve, which becomes quite flat when there is a negative output gap, the ELB constraint, and the monetary policy reaction function.

Monetary policy follows a loss-minimizing strategy, in which the loss function has a weight 1 on the squared inflation gap (the deviation from 2 percent), and the squared output gap; there is a weight of 0.5 on the squared change in the policy interest rate, which implies a smoothed interest rate policy response—such smoothing is justified on theoretical grounds, and is a well-observed feature of actual central bank behavior. The quadratic loss function imposes an increasingly heavy loss as deviations from target increase; the loss-minimizing strategy would therefore be very averse to dark corners, in which the economy gets stuck in a bad equilibrium that is resistant to conventional policy instruments. In other words, the strategy takes a risk-avoidance approach to risk management.

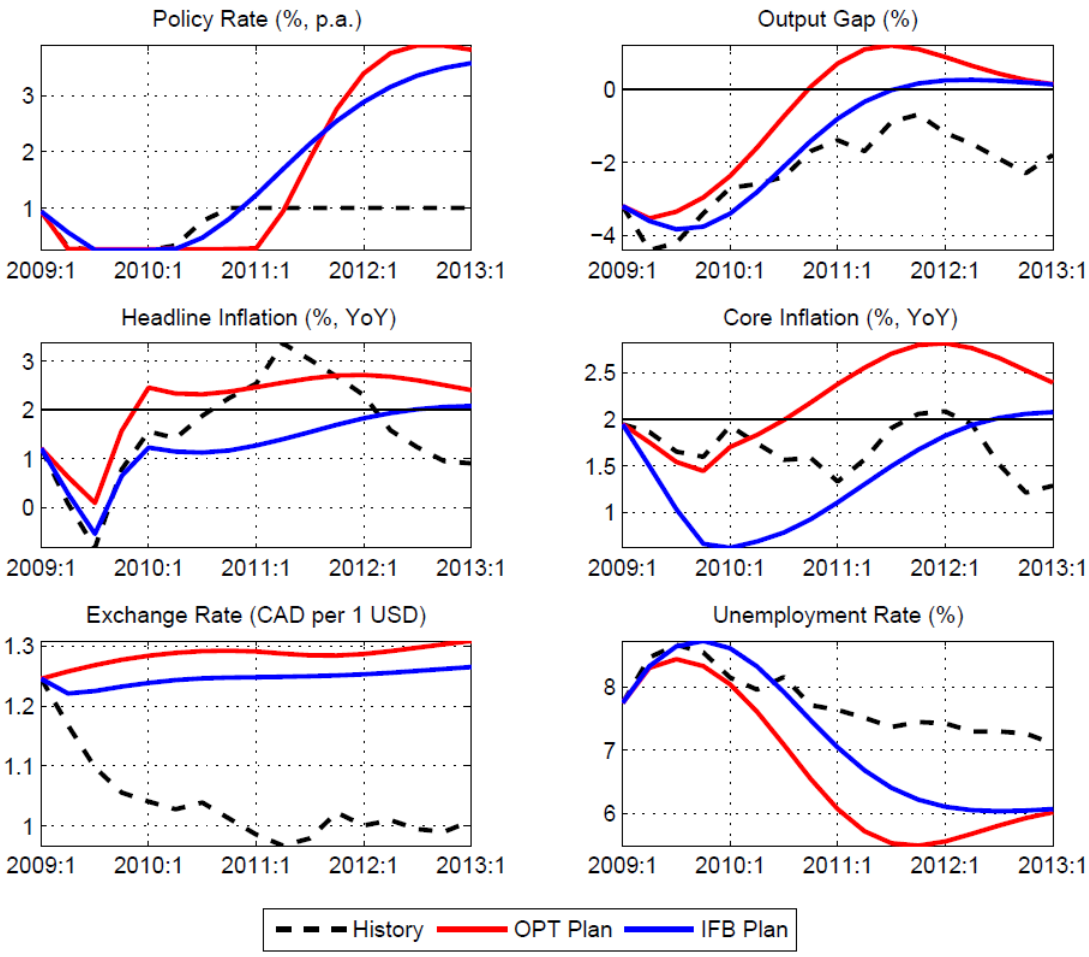
We are interested to see how a strategy of this nature, using CFG, would have performed following the extreme event of the global financial crisis. We start in 2009Q2. The dire situation unambiguously called for maintaining the policy rate at the floor for some time, and in fact the Bank of Canada provided forward guidance to this effect:

With monetary policy now operating at the effective lower bound for the overnight policy rate, it is appropriate to provide more explicit guidance than is usual regarding its future path so as to influence rates at longer maturities. Conditional on the outlook for inflation, the target overnight rate can be expected to remain at its current level until the end of the second quarter of 2010 in order to achieve the inflation target. (Press Release, April 9th, 2009).

The Bank forecast that this policy would return inflation to the target of 2 percent in 2011, was not far off (Figure 8, dashed line). However, this was largely due to the one-off effect of a rise in global energy and food prices, 2010-11. The forecast that the output gap would be closed in 2011 was overoptimistic. Core inflation languished below 2 percent, and within a couple of years headline inflation fell back below target. One might ask whether monetary policy should have maintained an easier stance, especially after 2010 as the post-crisis fiscal stimulus was being withdrawn. More productive questions, however, concern systematic strategy, rather than the particular response to the circumstances of the time.

[9] Appendix II outlines the model structure.

Figure 8. Optimal Control versus IFB Reaction Function



Source: Authors' simulations.

What would the macro forecast—the expected results—have looked like if the CFG-loss minimizing strategy had been in place at the outset in 2009Q2? How would the post-crisis economy, affected as it was by unexpected developments, have looked? What are the implications of other unconventional or supporting tools, such as a negative policy rate, and fiscal backstop?

In the simulations that follow, policymakers operate in quasi-real time: i.e., the information available to them in any quarter is limited to what could have been available at the time. However, as we do not use vintage data sets, the series that we employ contain revisions to the historical data. In other words, in our counterfactual re-runs of history, the current historical dataset unrolls one quarter at a time. The starting point, in 2009Q2, had a large output gap, assumed to be -4.5 percent, an inflation rate of 1 percent, and a policy interest rate at the (then) assumed effective ELB of 0.25 percent (Figure 8). As for the real equilibrium interest rate, for

the starting point, we assume an estimate, based on historical information available at the time, of 1.7 percent; it is revised downward thereafter on the basis of incoming new data.[10]

Forecast as per 2009Q2 plan

Figure 8 compares a plan made in 2009Q2 under the loss-minimization strategy (OPT, red line) with one based on a linear inflation-forecast-based reaction function (IFB, blue line). Under both illustrative plans the central bank practices CFG, so the forecast interest rate path has a direct impact on interest rate expectations. The red and blue lines—for the policy rate, output gap, inflation, exchange rate and unemployment—can be interpreted as the forecasts the policymakers would have before them in 2009Q2. They would of course differ from subsequent actual outcomes because of unexpected changes: the counterfactual comparison of policies is purely a model-based exercise. The dashed lines in the figure show the realized historical paths of the variables. Monetary policy is constrained by an ELB of 0.25 percent, which the Bank of Canada at that time viewed as the effective floor.

Key aspects of these policy simulations are:

1. The derived loss-minimizing strategy (OPT) keeps the policy rate at the floor for two years, 2009Q2-2011Q2. The expectation under this plan, with the nominal interest rate held at the ELB, is for the exchange rate to rise (the Canadian dollar to depreciate) about 4.5 percent, 2009Q1-2012Q4. The wide output gap is closed quite quickly, to zero by 2010Q4, and an excess demand gap opens. The unemployment rate comes down at the same pace. Inflation overshoots. Year-on-year core inflation peaks at 2.8 percent, 2011Q4-2012Q2, before it goes back to 2 percent. Headline peaks slightly lower. One of the reasons for the strong stimulative impact of the policy is that the anticipated medium-term increase in inflation reduces real interest rates and causes the real exchange rate to rise (i.e. a real depreciation).

2. The IFB strategy implies that the policy rate stays at the floor for only about a year, 2009Q3-2010Q2. The medium-term rise in the exchange rate (depreciation of the Canadian dollar) is relatively modest. The output gap is closed more slowly than with the OPT strategy, reaching zero in 2011Q3, and staying there. Unemployment at 2011Q3 point is 1 percentage point higher than under OPT. Inflation (core and headline) does not get back to target until 2012Q3. By most standards, OPT would be regarded as the better strategy.

OPT wants inflation to overshoot, and the output gap to close fast, because given the initial conditions, the below-target inflation and the wide negative output gap in 2009Q2, a quadratic loss function implies at the margin relatively high benefits from increases in both inflation and output. The constraint of the ELB is an additional reason for the stimulative policy: given the loss function, forward-looking policymakers would be very averse to the bad equilibrium where

[10] A rolling filter determines the estimates of latent variables.

deflation meets the ELB. The idea is to put distance between the economy and that dark corner, fast.

Counterfactual history with loss-minimizing strategy

The global financial crisis in fact had deeper and longer-lasting effects than anticipated in 2009. On top of this, additional negative shocks were to hit the Canadian economy. As a result, the history presents a much weaker picture than either of our two illustrative 2009Q2 policy strategies envisaged, and the negative output gap never was completely closed.

We can repeat the simulations, allowing the unanticipated shocks to affect the outcomes, including the loss-minimizing policy response (Figure 9).[11] The quasi-real time results can be compared with the history, since the hypothetical central bankers are dealing with the same shocks as the real ones.

Key aspects of the results are:

1. The loss-minimizing response to the historical shocks results in the policy rate at the ELB until 2013Q1 (the whole period shown in the figure). In contrast, the Bank of Canada raised the policy rate to 1 percent in 2010. The Canadian dollar appreciates less with the counterfactual strategy.

2. Under OPT, inflation overshoots the target by a substantial margin. Core inflation peaks above 3.5 percent in 2010, and headline inflation, driven by energy and food price shocks, peaks above 4 percent. The output gap closes to zero in the second half of 2011, before further negative shocks in 2012 re-open a gap.

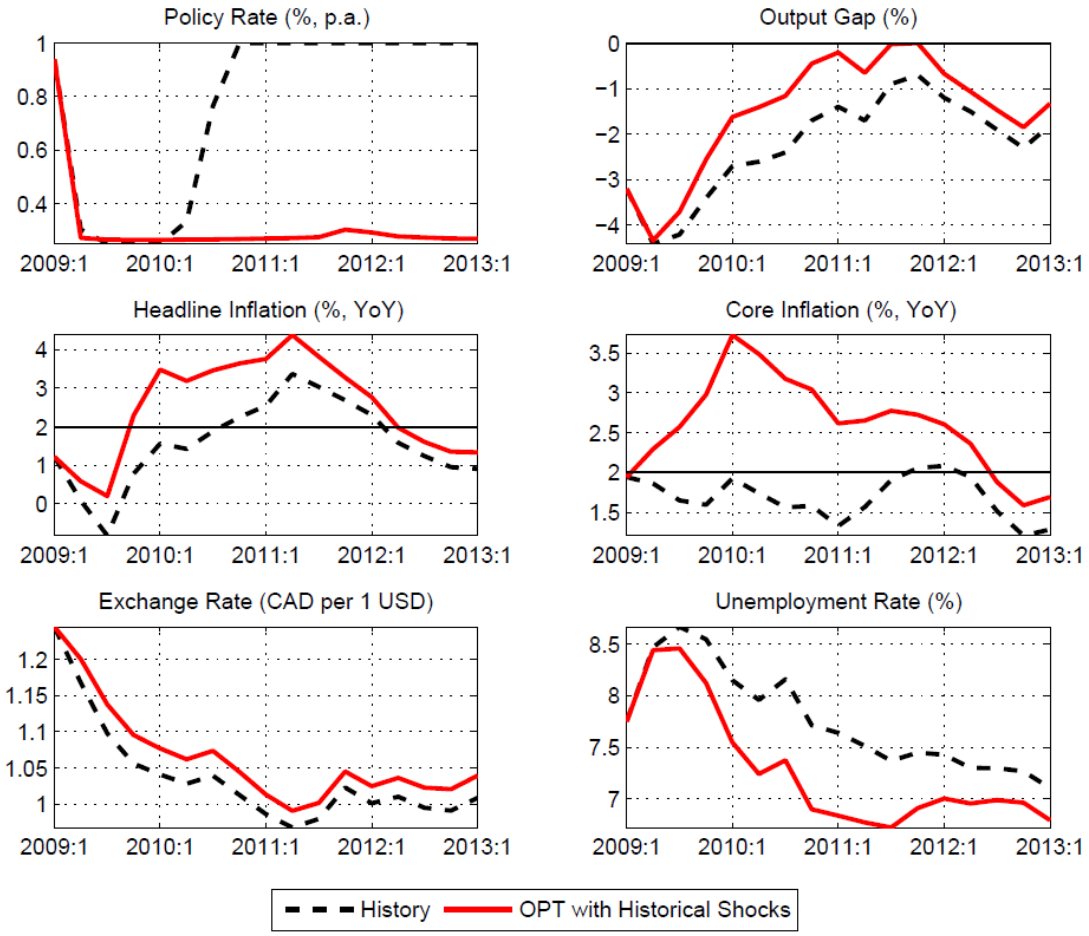
3. OPT delivers a considerably narrower output gap than the historical output gap, and an unemployment rate consistently below the historical rate—as much as 0.8 percentage points lower in 2010 and 2011.

4. In summary, OPT involves an aggressive response to the negative shocks, in terms of the length of time the policy rate forecast is at the ELB. It would get the economy quickly away from the deflation dark corner, and get the economy closer to potential output and full employment.

5. The overshoot in the inflation rate with OPT may be regarded as a drawback. And the 2010-11 increase in the prices of oil and food exacerbates the cycle in headline inflation. In our view, the prospect of a medium-term overshoot is acceptable, as over time the strategy would involve deviations on both sides of the target. Such a pattern is evident in Figure 9, and is in line with the Canadian experience of inflation targeting, and the maintenance of a firm nominal anchor (see Kamenik and others, 2013).

[11] The shocks are estimated from historical filtration of the model.

Figure 9. Predicted Outcomes under Optimal Control with Historical Shocks

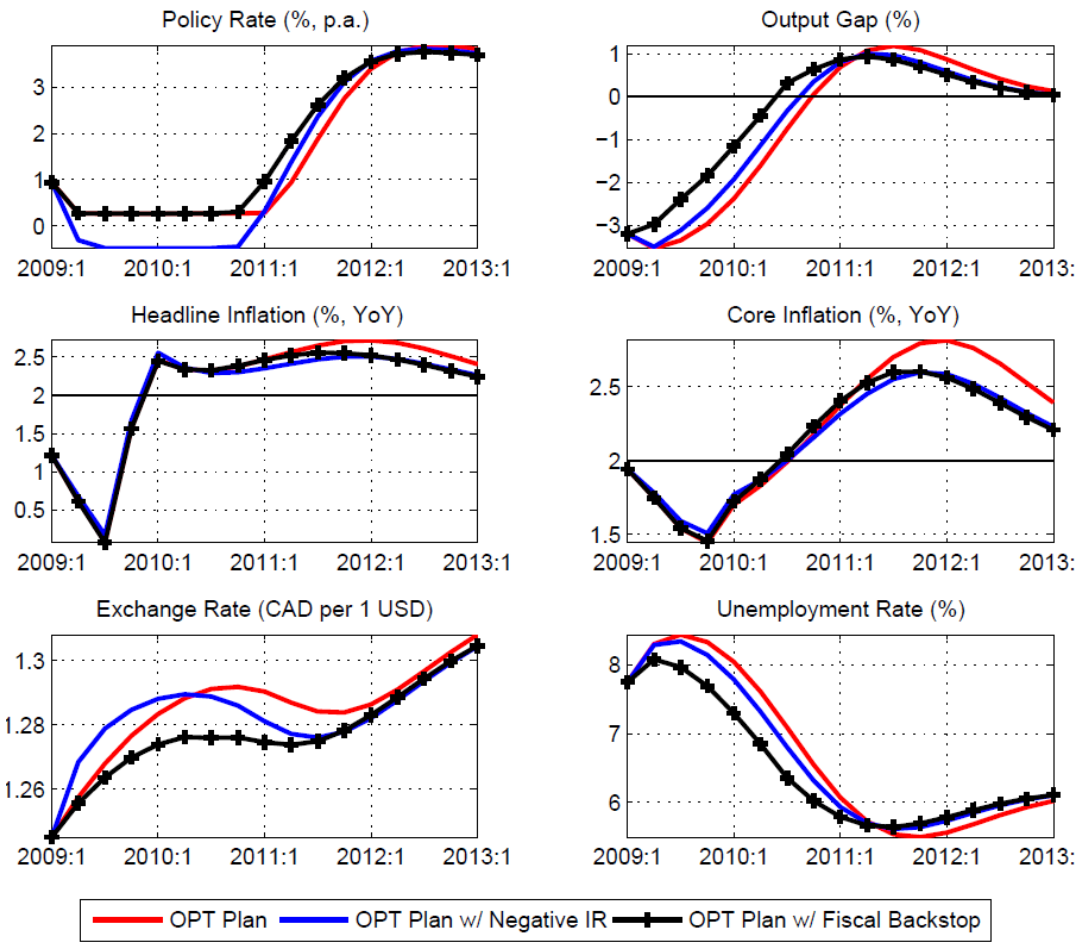


Source: Authors' simulations.

Fiscal stimulus

The simulations in Figure 10 are to investigate the extent to which more expansionary policies in the aftermath of the global financial crisis might have helped in the achievement of policy objectives. The assumed shock involves a fiscal stimulus equivalent to 1 percent of GDP, and a cut in the policy rate from 0.25 to -0.5 percent (reflecting the Bank of Canada's latest estimate of the ELB). As before, each policy simulation refers to a forecast as of 2009Q2. All cases considered are under the loss-minimizing strategy.

Figure 10. Optimal Control with Negative Interest Rate or Fiscal Backstop



Source: Authors' simulations.

Key aspects are:

1. Under the negative interest rate case (blue line), the policy rate is cut to the new floor, and stays there a little less time than the base case with the 0.25 percent ELB (red line). The lower rate causes a quick rise in the price of foreign exchange; these 2 changes close the output gap faster than the control. Because the nominal rate declines more, the decline in the real interest rates requires a smaller overshoot of inflation than in the base case. These changes are relatively modest compared to those achieved at the positive ELB.

2. Fiscal policy has a more direct impact on the economy than monetary policy. The results are shown in the cross-hatched lines. Because fiscal policy works through the demand channel more directly, and is less reliant on the expectations channel, the implied inflation overshoot is smaller than in the baseline. The fiscal stimulus does appreciate the Canadian dollar relative to the base case—in line with the classic Mundell-Fleming result

for fiscal policy in a small economy with perfect capital mobility. However, in this model, unlike in Mundell-Fleming, fiscal policy is effective in increasing output, because monetary policy keeps its focus on the objectives for inflation and the output gap, and holds the interest rate at the ELB. The exchange rate decrease relative to control is not large enough to choke off the stimulus.

Alternative scenario: linear policy reaction function, backward-looking expectations

In this illustrative case, we investigate a situation where monetary policy places less emphasis on the avoidance of large risks, and where credibility of the inflation target is not strong. The specific assumptions are:

- that monetary policy follows an IFB reaction function; and
- that expectations put a high weight on lagged inflation, e.g., because of imperfect credibility of the inflation target (Appendix II provides detailed assumptions behind this exercise).

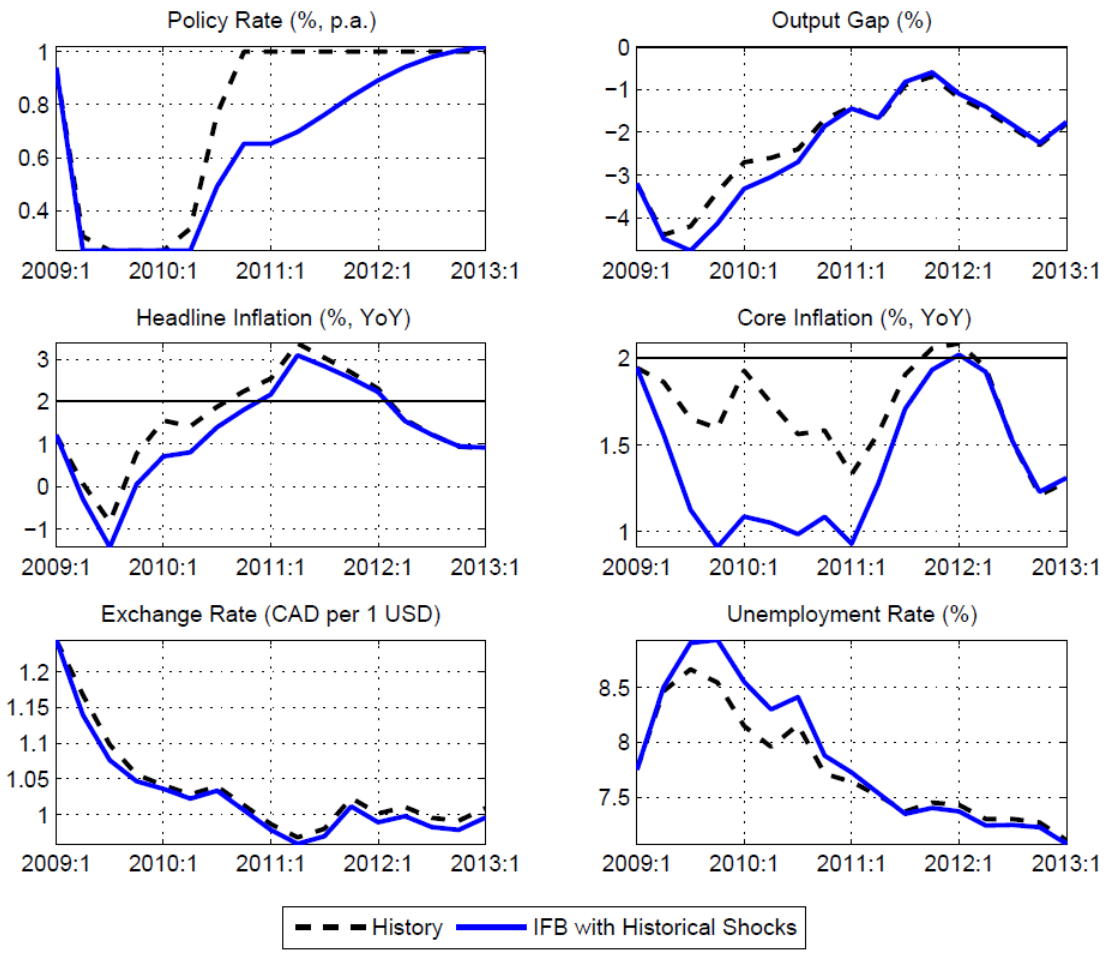
The IFB reaction function does not have the same aversion to dark corners as the quadratic loss function, and will not lead to especially sharp corrective actions against negative shocks in the vicinity of deflation/ELB. Backward-looking expectations would reflect imperfect credibility of the announced inflation objective. If the target is not hit for a prolonged period, people are more likely to believe the rate they observe than the rate the central bank would like.

Negative shocks in this situation have bad results (Figure 11). Relative to history, starting in 2009Q2, the output gap would have been wider, unemployment higher, and inflation lower. The counterfactual policy interest rate is lower for a couple of years. This does not reflect a more aggressive policy, but an endogenous response to the weaker economy.

V. CONCLUSIONS

Canada has a strong and well-proven IFT regime. Inflation expectations have been stable at the target rate of 2 percent for more than two decades. Core elements of this achievement have been the credibility of the target, which has been reinforced by sound monetary policy decisions, and the flexible exchange rate, which has helped stabilize the economy in the face of foreign disturbances, including large fluctuations in the commodity terms of trade. We argue, however that the framework could be strengthened, especially in its capacity for avoiding dark corners. There is a strong case for the Bank of Canada to use CFG—i.e., to publish its forecast of the short-term interest rate path as part of the information it releases following each of the 8 annual policy decision meetings. Such an increase in transparency would strengthen the monetary policy framework for good times, as well as times of heightened economic instability. It would also improve accountability for monetary policy, in that the Bank would be able to account openly for its interest rate decisions, against the guideline of the forecast path, justifying divergences from the path in terms of specific unexpected developments.

Figure 11. IFB Reaction Function and Backward-Looking Inflation Expectations



Source: Authors' simulations.

Since the 2014-15 collapse of the boom in oil and other commodities, and the subsequent recession in the domestic energy industry, the Bank of Canada is leaving open the options of unconventional policy instruments and a negative policy interest rate. However, these options have their own limitations, and as yet uncertain effectiveness. Estimates of the equilibrium world real interest rate have been falling since the global financial crisis, in view of the lack-luster performance of global output, and low inflation. Various recent estimates are about zero (Summers, 2015). This has implications for the framework of monetary policy, and for fiscal policy.

As regards monetary policy, the question may be asked: if the 2 percent inflation target was right when the equilibrium real interest rate was 2 percent, is it still right when the equilibrium rate is near zero? The ELB on the nominal interest rate would then impose a floor of about -2 percent on the gap between the actual and equilibrium real interest rate, which would not represent strong resistance to a downturn of typical cyclical amplitude. An increase of 1 percentage point

in the inflation target, to 3 percent, would provide that much more space, which is still not a lot, for expansionary monetary policy. However, merely announcing a higher target would not be enough; actions would be needed to get there; and the issue of how to achieve the more ambitious target remains to be confronted, especially given the firmness of expectations in Canada at 2 percent. Moreover, considering the price stability mandate for monetary policy, and the general performance of the Canadian economy over the past quarter century, the policymakers would reasonably be loath to recommend such a step. From this viewpoint, an expansionary fiscal policy offers a better alternative for dealing with below-par activity. It would raise output, and at the same time make monetary policy more effective in managing the short-run output-inflation trade-off.

In 2016, CFG for monetary policy combined with a well-designed fiscal stimulus would be a potent combination for getting the economy back on track, ELB notwithstanding. Such a strategy would avoid the financial stability issues that could arise over time with negative interest rates, and have a stronger effect than unconventional monetary interventions, such as quantitative easing which operate through bond yield term or risk premiums that are of relatively small size in Canada. And it would avoid any questioning of the 2 percent inflation target, which has served the Canadians well, as a firm nominal anchor to the economy.

REFERENCES

Alichi, A., J. Benes, J. Felman, I. Feng, C. Freedman, D. Laxton, E. Tanner, D. Vavra, and H. Wang, 2015a, "Frontiers of Monetary Policymaking: Adding the Exchange Rate as a Tool to Combat Deflationary Risks in the Czech Republic," IMF Working Paper No. 15/74.

Alichi, A., K. Clinton, C. Freedman, M. Juillard, O. Kamenik, D. Laxton, J. Turunen, and H. Wang. 2015b, "Avoiding Dark Corners: A Robust Monetary Policy Framework for the United States," IMF Working Paper No.15/134.

Bank of Canada, 2012, "Monetary Policy," Backgrounders.

Bank of England, 2013, "Monetary Policy Trade-Offs and Forward Guidance," August.

Bech, M. and A. Malkhozov, 2016, "How Have Central Banks Implemented Negative Policy Rates?" BIS Quarterly Review, March.

Blagrave, P., P. Elliott, R. Garcia-Saltos, D. Hostland, D. Laxton, and F. Zhang, 2013, "Adding China to the Global Projection Model," IMF Working Paper No. 13/256.

Carabenciov, I., I. Ermolaev, C. Freedman, M. Juillard, O. Kamenik, D. Korsunmov, D. Laxton, and J. Laxton, 2008, "A Small Multi-Country Global Projection Model with Financial-Real Linkages and Oil Prices," IMF Working Paper No. 08/280.

Charbonneau, K. and L. Rennison, 2015, "Forward Guidance at the Effective Lower Bound: International Experience," Bank of Canada Staff Discussion Paper 2015–15.

Clinton, K., C. Freedman, M. Juillard, O. Kamenik, D. Laxton, and H. Wang, 2015, "Inflation-Forecast Targeting: Applying the Principle of Transparency." IMF Working Paper No.15/132.

Council of Economic Advisers, 2016, "Long-term Interest rates: A Survey."

Dincer, N. and B. Eichengreen, 2014, "Central Bank Transparency and Independence: Updates and New Measures," International Journal of Central Banking, Vol. 10, No. 1, pp. 189–259.

Eggertsson, G. B., and M. Woodford, 2003, "The Zero Bound on Interest Rates and Optimal Monetary Policy," Brookings Papers on Economic Activity, 1:2003.

Engen, E., T. Laubach, and D. Reifschneider, 2015, "The Macroeconomic Effects of the Federal Reserve's Unconventional Monetary Policies," Finance and Economic Discussion Series 2015-005, Federal Reserve Board.

Filardo, A. and B. Hoffmann, 2014, "Forward Guidance at the Zero Lower Bound," BIS Quarterly Review, March.

FOMC, 2012, Board of Governors of the Federal Reserve Press Release, January 25.

Holston, K., T. Laubach, and J. Williams, 2016, "Measuring the Natural Rate of Interest: International Trends and Determinants," Federal Reserve Bank of San Francisco Working Paper 2016-11.

Kamenik, O., H. Kiem, V. Klyuev, and D. Laxton, 2013, "Why is Canada's Price Level So Predictable?" Journal of Money Credit and Banking, 45(February), pp. 71–85.

Johannsen, B. K. and E. Mertens, 2016, "The Expected Real Interest Rate in the Long Run: Time Series Evidence with the Effective Lower Bound," FEDS Notes.

Lane, T., 2015, "Inflation Targeting—A Matter of Time," Bank of Canada. Conference presentation, Halifax, Nova Scotia October.

Laubach, T. and J. C. Williams, 2015, "Measuring the Natural Rate of Interest Redux," Federal Reserve Bank of San Francisco Working Paper 2015–16.

Mendes, R.R., 2014, "The Neutral Rate of Interest in Canada," Bank of Canada Discussion Paper 2014–5.

Poloz, S. S., 2014, "Integrating Uncertainty and Monetary Policy-Making: A Practitioner's Perspective," Bank of Canada Discussion Paper 2014-6.

----------, 2015, "Prudent Preparation: The Evolution of Unconventional Monetary Policies," Bank of Canada, December.

Qvigstad, J. F., 2005, "When Does an Interest Rate Path 'Look Good'? Criteria for an Appropriate Future Interest Rate Path – A Practician's Approach," Norges Bank Staff Memo No. 2005/6.

Rachel, L. and T. D. Smith, 2015, "Secular Drivers of the Global Real Interest Rate," Bank of England Staff Working Paper No. 571.

Summers, L. H., 2015, "Low Real Rates, Secular Stagnation, and the Future of Stabilization Policy," Speech, Bank of Chile, November.

Svensson, L. E. O., 1997, "Inflation Forecast Targeting: Implementing and Monitoring Inflation Targets," European Economic Review, Vol. 41.

----------, 1999, "Price Level Targeting vs. Inflation Targeting: A Free Lunch?" Journal of Money, Credit and Banking, 31, pp. 277-295.

----------, 2001, "The Zero Bound in an Open Economy: A Foolproof Way of Escaping from a Liquidity Trap," Monetary and Economic Studies (Special Edition), February.

----------, 2002, "Monetary Policy and Real Stabilization," in *Rethinking Stabilization Policy, A Symposium Sponsored by the Federal Reserve Bank of Kansas City*, Jackson Hole, Wyoming.

----------, 2007, "Monetary Policy and the Interest Rate Path," Sveriges Riksbank, August.

Witmer, J. and J. Yang, 2015, "Estimating Canada's Effective Lower Bound," Bank of Canada Staff Analytical Note 2015–2.

Woodford, M., 2005, "Central-Bank Communication and Policy Effectiveness," presented at the Federal Reserve Bank of Kansas City Symposium, Jackson Hole, Wyoming, August 25–27.

Yellen, J., 2015, Transcript of Chair Yellen's FOMC Press Conference, March 18.

APPENDIX I. POLICY CREDIBILITY: EXCHANGE RATE AND ASSET PRICES AS SHOCK ABSORBERS OR AMPLIFIERS

The risk-adjusted uncovered interest parity (UIP) condition

This condition, under perfect foresight, may be written as

$$i_t - (i_t^f + u_t) = s_{t+1} - s_t,$$

where i_t is domestic interest rate, i_t^f is foreign interest rate, u_t is domestic risk premium, s_t is nominal price of foreign exchange. That is, the future change in the exchange rate compensates for any interest differential, such that the return adjusted for change in the exchange rate and the risk premium is the same in either currency.

One period ahead we have

$$i_{t+1} - (i_{t+1}^f + u_{t+1}) = s_{t+2} - s_{t+1}.$$

Going forward we have

$$i_{t+2} - (i_{t+2}^f + u_{t+2}) = s_{t+3} - s_{t+2},$$

$$\dots$$

such that this holds for any time t

$$i_{t+k} - (i_{t+k}^f + u_{t+k}) = s_{t+k+1} - s_{t+k}.$$

Summing up all the equations, from time t to $t+k$, yields

$$i_t + i_{t+2} \dots + i_{t+k} - (i_t^f + u_t) - \dots - (i_{t+k}^f + u_{t+k}) = (s_{t+1} - s_t) + (s_{t+2} - s_{t+1}) + \dots + (s_{t+k+1} - s_{t+k}),$$

or equivalently,

$$\sum_{j=0}^{k} i_{t+j} - \sum_{j=0}^{k} (i_{t+j}^f + u_{t+j}) = s_{t+k+1} - s_t.$$

Rearranging the equation, we get

$$\sum_{j=0}^{k} i_{t+j} = s_{t+k+1} - s_t + \sum_{j=0}^{k} (i_{t+j}^f + u_{t+j}).$$

The same condition holds in real terms,

$$\sum_{j=0}^{k} r_{t+j} = z_{t+k+1} - z_t + \sum_{j=0}^{k} (r_{t+j}^f + u_{t+j}),$$

where r_t is real interest rate, and z_t is real exchange rate defined as nominal exchange rate adjusted for the foreign (p_t^f) and domestic (p_t) price differential,

$$z_t = s_t + p_t^f - p_t.$$

Real exchange rate as shock absorber

Under normal times with active policy, a negative demand shock reduces inflation in the short run, but does not affect the long-run real exchange rate (z_{t+k+1}). An IFT central bank is expected in normal times to reduce the policy rate sufficiently to steer inflation back to target. This expectation would, through the UIP condition, lead to an immediate depreciation of the currency: the spot price of foreign exchange has to rise to the point that the expected decrease from then on compensates for the lower domestic interest rate.

Under a credible regime of aggressive policy responses, the expected medium-term inflation rate would also increase.[12] The decline in real interest rates would be greater than that in nominal rates. At the ELB, the current nominal interest rate cannot go any lower, but under the aggressive regime people would expect that the future nominal interest would be at the ELB for longer, and because of the anticipated increase in inflation, real interest rates would decline. Thus in both normal times, and during the ELB, we have ($\downarrow \sum_{j=0}^{k} r_{t+j}$). Given that the long-run real exchange rate (z_{t+k+1}) and expected paths for foreign real interest rates and domestic risk premium $\sum_{j=0}^{k}(r_{t+j}^{f} + \mu_{t+j})$ do not change, this would result in a real depreciation ($\uparrow z_t$),

$$\downarrow \sum_{j=0}^{k} r_{t+j} = z_{t+k+1} - \uparrow z_t + \sum_{j=0}^{k}(r_{t+j}^{f} + \mu_{t+j}) .$$

This helps support demand, through both exports and domestic expenditure switching (from foreign goods to domestic goods).

Real exchange rate as shock amplifier

At the ELB, the exchange rate can act as a shock amplifier. If policy is passive, and not credible, following a negative demand shock, people would expect the inflation rate in the future to be lower. Current and future short-term real interest rates could increase ($\uparrow \sum_{j=0}^{k} r_{t+j}$), resulting in a real appreciation ($\downarrow z_t$):

$$\uparrow \sum_{j=0}^{k} r_{t+j} = z_{t+k+1} - \downarrow z_t + \sum_{j=0}^{k}(r_{t+j}^{f} + \mu_{t+j}) .$$

This would reduce net exports and further deepen the recession.

[12] A regime that targets the path of the price level would systematically produce this kind of response (Svensson, 1999).

Asset prices as shock absorber or amplifier

A similar argument holds for other asset prices such as equity prices. A credible aggressive policy response would cause increases in equity prices (through the positive impact on profits of currency depreciation, and the effect of lower real discount rate on asset valuations). A non-credible, passive response would do the reverse. Thus depending on the policy regime, asset prices too may act as an absorber or an amplifier for the impact of shocks.

APPENDIX II. THE NEW-KEYNESIAN MODEL FOR CANADA

A.II.1. IS Equation

The output gap (y_t) is defined as the difference between the log-level of output (y_t) and potential output ($\bar{y}_t$). The IS equation relates Canada's output gap (y_t) to past and expected future output gaps, the deviations of the lagged one-year real interest rate ($r4_t$) and the real effective exchange rate ($reer_t$) from their equilibrium values, and the-rest-of-the-world output gap (y_t^{World}). The terms-of-trade gap (tot_t) also affects the output gap in a significant way.

$$y_t = \bar{y}_t + y_t$$

$$y_t = \underset{(0.65)}{\beta_1 y_{t-1}} + \underset{(0.15)}{\beta_2 y_{t+1}} + \underset{(-0.15)}{\beta_3 (r4_{t-1} - \bar{r}4_{t-1})} + \underset{(0.05)}{\beta_4 (reer_{t-1} - \overline{reer}_{t-1})} + \underset{(0.3)}{\beta_5 y_t^{World}} + \underset{(0.5)}{\beta_6 tot_t} + \varepsilon_t^y$$

$$r4_t = (r_t + r_{t+1} + r_{t+2} + r_{t+3}) / 4$$

A.II.2. Phillips Curve

In the Phillips curve, the core inflation rate (π_t^C) depends on inflation expectation ($E\pi_t^C$) and past year-on-year core inflation ($\pi 4_{t-1}^C$), with coefficients on both terms adding up to one. The lagged term reflects the intrinsic inflation inertia, resulting from contracts, costs of changing list prices, etc. Inflation expectation is pinned down by both the model-consistent solution of the year-on-year inflation one year ahead ($\pi 4_{t+4}^C$), as well as the inflation target (π^*), with the latter one having a small weight.[13] Core inflation depends on lagged output gap in a non-linear way. Core inflation also depends on the rate of real effective exchange rate depreciation, as well as the deviation of the real effective exchange rate from its equilibrium value, as a real depreciation raises the domestic cost of imported intermediate inputs and final goods, creating upward pressure on prices. Finally, we allow some small pass-through from oil and food price inflation to core inflation. This is captured by adding the two terms on the real price of oil and food adjusted for real exchange rate effects.

[13] In the sensitivity analysis (Figure 11), we look at the implications of more inertia in the inflation process, in other words, a case where λ_1 is reduced from 0.75 in the base case to 0.65, and at the same time the weight on the inflation target $(1 - \lambda_7)$ is reduce to 0.

$$\pi_t^C = \lambda_1 E\pi_t^C + (1-\lambda_1)\pi 4_{t-1}^C + \lambda_2 \frac{5y_{t-1}}{5-y_{t-1}} + \lambda_3 \Delta reer_t + \lambda_4 reer_t + \lambda_5 (rp_t^{Oil} + \hat{z}_t) + \lambda_6 (rp_t^{Food} + \hat{z}_t) + \varepsilon_t^{\pi^C}$$

(0.75) (0.25) (0.05) (0.05) (0.01) (0.01)

$$E\pi_t^C = \lambda_7 \pi 4_{t+4}^C + (1-\lambda_7)\pi^*$$

(0.8)

A.II.3. Policy Interest Rate: Reaction Function Options

Linear inflation-forecast-based (IFB) reaction function

The equation is a fairly standard IFB reaction function:

$$i_t = \gamma_1 i_{t-1} + (1-\gamma_1)[\bar{r}_t + \pi 4_{t+3}^C + \gamma_2(\pi 4_{t+3}^H - \pi^*) + \gamma_2 y_t] + \varepsilon_t^i$$

(0.75) (1.5) (0.5)

In contrast to the conventional Taylor rule, the inclusion of the three-quarter-ahead inflation projection ($\pi 4_{t+3}^C$ and $\pi 4_{t+3}^H$) in the IFB reaction function implies that it discounts shocks to the system that are expected to reverse within the three-quarter policy horizon. More generally, the reaction function allows the central bank to take account of all relevant information available to it on future developments over the three-quarter forecast horizon.

Loss minimizing strategy—risk management

This strategy chooses the interest rate path to minimize the discounted current and future losses from inflations deviation from the target, output gaps, and changes in the policy rate. The loss function incorporates the principal objectives of the central bank–expressing an aversion to deviations of output and inflation from desired values that grows ever larger as these deviations increase.

$$Loss_t = \sum_{i=0}^{\infty} \beta^i [\omega_1 (\pi 4_{t+i}^H - \pi^*)^2 + \omega_2 y_{t+i}^2 + \omega_3 (i_{t+i} - i_{t+i-1})^2]$$

(0.98) (1.0) (1.0) (0.5)

The quadratic formulation, implies that large errors or deviations are more important in the thinking of central banks than small errors or deviations. The term with the squared change of the policy interest rate prevents very sharp movements in the policy interest rate, which would otherwise occur in the model on a regular basis in response to chocks. Central banks in practice do not typically change interest rates in large steps, and there are sound theoretical reasons for this. By taking account of both current and expected future values of output and inflation, this

formulation has the central bank incorporate into its decisions any information currently available that may affect its objectives over the next few quarters.

ELB

Under both cases, the interest rate is subject to an effective lower bound constraint (i^{floor}), which is assumed to be 0.25 percent in the historical simulation.[14]

$$i_t \geq i^{floor}$$
$$(0.25)$$

A.II.4. Real Interest Rates and Real Exchange Rates

The real interest rate (r_t) is defined as the nominal interest rate minus the expected core inflation (π^C_{t+1}).

$$r_t = i_t - \pi^C_{t+1}$$

The bilateral real exchange rate between Canada and the United States (z_t) is defined in terms of Canadian core CPI (p^C_t), and in such a way that an increase means a depreciation in the Canadian dollar. The real exchange rate is broken down into an equilibrium trend ($\bar{z}_t$) and deviation from that trend ($\hat{z}_t$). The equilibrium real exchange rate is assumed to be determined by the equilibrium terms of trade ($\bar{z}^{tot}_t$).

$$z_t = s_t + p^{US}_t - p^C_t$$
$$z_t = \bar{z}_t + \hat{z}_t$$
$$\bar{z}_t = \bar{z}^{tot}_t$$

The real effective exchange rate that enters the output gap equation is the trade-weighted bilateral real exchange rates of Canada versus seven regions in the world (U.S., Euro Area, Japan, China, Emerging Asia, Latin America, and the rest of the world). The breakdown of the regions is consistent with the Global Projection Model (GPM).[15]

[14] Historically the effective lower bound is assumed to be 0.25 percent. Recently the Bank has revised down its estimate of the effective lower bound to be -0.5 percent. In simulations we look at the implications of the new effective lower bound.

[15] See Carabenciov and others (2008) and Blagrave and others (2013) for the GPM model.

$$reer_t = \underset{(0.68)}{w^{Trade,US}}\hat{z}_t^{US} + \underset{(0.07)}{w^{Trade,EU}}\hat{z}_t^{EU} + \underset{(0.02)}{w^{Trade,JA}}\hat{z}_t^{JA} + \underset{(0.08)}{w^{Trade,CH}}\hat{z}_t^{CH} + \underset{(0.04)}{w^{Trade,EA}}\hat{z}_t^{EA} + \underset{(0.05)}{w^{Trade,LA}}\hat{z}_t^{LA} + \underset{(0.05)}{w^{Trade,RC}}\hat{z}_t^{RC}$$

Risk-adjusted UIP Condition

The risk-adjusted uncovered interest parity condition links the bilateral exchange rate between Canada and the U.S. with the interest rates in the two economies (i_t and i_t^{US}).

$$i_t - i_t^{US} = 4(Es_{t+1} - s_t) + \sigma_t^{ctry} + \sigma_t^{tot} + \varepsilon_t^s$$
$$Es_{t+1} = \underset{(0.84)}{\phi s_{t+1}} + (1-\phi)\{s_{t-1} + 2[\Delta\bar{z}_t - (\pi^{*,US} - \pi^*)/4]\}$$

The equation allows the expected exchange rate (Es_{t+1}) to be a linear combination of the model-consistent solution (s_{t+1}), and backward-looking expectations (s_{t-1}) adjusted for the trend exchange rate depreciation ($2[\Delta\bar{z}_t - (\pi^{*,US} - \pi^*)/4]$). The factor ¼ which multiplies the inflation differential ($\pi^{*,US} - \pi^*$) de-annualizes the inflation rates which are expressed in annual terms, while the factor 2 is necessary as we extrapolate the nominal exchange rate in the past period (s_{t-1}) two periods into the future using the steady-state growth rate in the nominal exchange rate ($\Delta\bar{z}_t - (\pi^{*,US} - \pi^*)/4$). Conversely, in the condition that links Canadian and U.S. interest rates, the factor 4 before the expected depreciation ($Es_{t+1} - s_t$) annualizes the expected quarterly depreciation rate, making it consistent with the interest rate quoted on the annual basis. A time-varying variable (σ_t^{ctry}) is included to account for shocks to country risk premium. Terms-of-trade shifts (σ_t^{tot}) is also an important factor that affects movements in the nominal exchange rate.

As the terms-of-trade premium should disappear when the economy is in the equilibrium, the following condition holds:

$$\bar{r}_t - \bar{r}_t^{US} = 4(\bar{z}_{t+1} - \bar{z}_t) + \sigma_t^{ctry}$$

A.II.5. Relative Prices

Headline inflation is affected by the dynamics of relative price movements (core CPI (p_t^C) relative to headline CPI (p_t^H)). In the long run the overall (headline) inflation is assumed to be equal to the underlying (core) inflation, though it can diverge over prolonged periods of time,

when there is a trend in the relative prices of non-core items (mortgage interest rates, unprocessed food, energy). The dynamics of relative prices (rp_t) are modeled as the sum of the relative price trend ($\overline{rp}_t$) and the relative price gap (rp_t). The relative price gap depends on the real price of oil and food in the international markets adjusted for exchange rate effects, while the relative price trend growth is assumed to be an autoregressive process with mean zero. The parameters in the relative price gap equation are calibrated based on various information, such as the weights of energy and food in the CPI basket, and the degree and time profile of the pass-through from energy and food inflation to headline inflation.

$$rp_t = p_t^C - p_t^H$$

$$rp_t = \overline{rp}_t + rp_t$$

$$rp_t = \underset{(0.43)}{\rho^{rp}} rp_{t-1} - \underset{(0.012)}{c_1^{rp}}(rp_t^{Oil} + \hat{z}_t) - \underset{(0.02)}{c_2^{rp}}(rp_t^{Food} + \hat{z}_t) + \varepsilon_t^{rp}$$

$$\Delta\overline{rp}_t = \underset{(0.9)}{\rho^{\Delta\overline{rp}}}\Delta\overline{rp}_{t-1} + \varepsilon_t^{\Delta\overline{rp}}$$

A.II.6. Term Structure of Interest Rates

The model allows for long-term bond yields to shed light on the equilibrium real interest rates. Let $i_t^{Gov,k}$ be the nominal government bond yield with a maturity of k quarters, where k could be 4, 8, 20 or 40. The bond yield is equal to the average expected short-term interest rates k quarters into the future plus a term ($\sigma_t^{Term,k}$) that captures both government bond premium (same for bonds with all maturity) and term premium (a premium which increases with the maturity). A shock at the end of each equation ($\varepsilon_t^{Gov,k}$) reflects measurement errors.

$$i_t^{Gov,4} = i4_t + \sigma_t^{Term,4} + \varepsilon_t^{Gov,4}$$

$$i_t^{Gov,8} = (i4_t + i4_{t+4})/2 + \sigma_t^{Term,8} + \varepsilon_t^{Gov,8}$$

$$i_t^{Gov,20} = (i4_t + i4_{t+4} + i4_{t+8} + i4_{t+12} + i4_{t+16})/5 + \sigma_t^{Term,20} + \varepsilon_t^{Gov,20}$$

$$i_t^{Gov,40} = \sum_{i=0}^{9} i4_{t+4i}/10 + \sigma_t^{Term,40} + \varepsilon_t^{Gov,40}$$

$$i4_t = (i_t + i_{t+1} + i_{t+2} + i_{t+3})/4$$

A.II.7 Unemployment Rate

The unemployment rate (u_t) is characterized by a "gap version" of the Okun's law. The equation implies that a one percentage point increase in the unemployment gap (u_t) is associated with

approximately two percentage point decrease in the output gap. The NAIRU ($\bar{u}_t$) is assumed to follow a stochastic process that has both shocks to the level and to the growth rate.

$$u_t = \bar{u}_t + u_t$$

$$u_t = \underset{(0.4)}{\rho^u} u_{t-1} - \underset{(0.4)}{c_1^u} y_t + \varepsilon_t^u$$

$$\bar{u}_t = \bar{u}_{t-1} + \Delta\bar{u}_t + \varepsilon_t^{\bar{u}}$$

$$\Delta\bar{u}_t = \underset{(0.9)}{\rho^{\Delta\bar{u}}} \Delta\bar{u}_{t-1} + \varepsilon_t^{\Delta\bar{u}}$$

A.II.8. Potential Output

The potential growth rate ($\Delta\bar{y}_t$) is assumed to converge to its steady state level ($\Delta\bar{y}^{ss}$) in the longer term. However, it can deviate from the steady-state level for prolonged periods of time.

$$\Delta\bar{y}_t = \underset{(0.97)}{\rho^{\bar{y}}} \Delta\bar{y}_{t-1} + \underset{(2)}{(1-\rho^{\bar{y}})} \Delta\bar{y}^{ss} + \varepsilon_t^{\Delta\bar{y}}$$

A.II.9. The Rest of the World

The Canadian economy is linked to the rest of the world through both the trade linkage and the financial linkage. The rest-of-the-world output gap relevant for the Canadian economy is defined as a weighted average of output gaps in the seven regions (U.S., Euro Area, Japan, China, Emerging Asia, Latin America, and the rest of the world), using export shares as weights.

$$y_t^{World} = \underset{(0.79)}{\varpi^{Exp,US}} y_t^{US} + \underset{(0.04)}{\varpi^{Exp,EU}} y_t^{EU} + \underset{(0.02)}{\varpi^{Exp,JA}} y_t^{JA} + \underset{(0.04)}{\varpi^{Exp,CH}} y_t^{CH} + \underset{(0.04)}{\varpi^{Exp,EA}} y_t^{EA} + \underset{(0.02)}{\varpi^{Exp,LA}} y_t^{LA} + \underset{(0.05)}{\varpi^{Exp,RC}} y_t^{RC}$$

The equilibrium real interest rate in Canada is closely linked to that in the U.S.

$$\bar{r}_t = \underset{(0.6)}{\rho^{\bar{r}}} \bar{r}_{t-1} + (1-\rho^{\bar{r}}) \bar{r}_t^{US} + \varepsilon_t^{\bar{r}}$$

A.II.10. Commodity Terms of Trade

The real price of oil (rp_t^{Oil}) is defined as the global oil price (p_t^{Oil}) in U.S. dollars relative to the U.S. CPI (p_t^{US}). In the equilibrium, the real price of oil is assumed to grow at a rate of zero,

although the actual growth rate can deviate from zero for long periods of time. The real price of oil gap (rp_t^{Oil}), defined as the difference between the real price of oil and its equilibrium value, is modeled as an autoregressive process with a shock.

$$rp_t^{Oil} = p_t^{Oil} - p_t^{US}$$

$$rp_t^{Oil} = \overline{rp}_t^{Oil} + rp_t^{Oil}$$

$$\Delta \overline{rp}_t^{Oil} = \underset{(0.95)}{\rho^{\Delta \overline{rp}^{Oil}}} \Delta \overline{rp}_{t-1}^{Oil} + \varepsilon_t^{\Delta \overline{rp}^{Oil}}$$

$$rp_t^{Oil} = \underset{(0.7)}{\rho^{rp^{Oil}}} rp_{t-1}^{Oil} + \varepsilon_t^{rp^{Oil}}$$

We follow similar modeling strategy for the real price of food.

$$rp_t^{Food} = p_t^{Food} - p_t^{US}$$

$$rp_t^{Food} = \overline{rp}_t^{Food} + rp_t^{Food}$$

$$\Delta \overline{rp}_t^{Food} = \underset{(0.95)}{\rho^{\Delta \overline{rp}^{Food}}} \Delta \overline{rp}_{t-1}^{Food} + \varepsilon_t^{\Delta \overline{rp}^{Food}}$$

$$rp_t^{Food} = \underset{(0.7)}{\rho^{rp^{Food}}} rp_{t-1}^{Food} + \varepsilon_t^{rp^{Food}}$$

The terms-of-trade gap (tot_t) for Canada is determined by the real price of oil gap (rp_t^{Oil}) and the real price of food gap (rp_t^{Food}). The coefficients of the two terms represent the shares of these two commodities in Canada's GDP.

$$tot_t = \underset{(0.03)}{c_1^{tot}} rp_t^{Oil} + \underset{(0.002)}{c_2^{tot}} rp_t^{Food}$$

The real exchange rate depreciation consistent with changes in the terms-of-trade (Δz_t^{tot}) is related to movements in the real price of oil (Δrp_t^{Oil}) and food (Δrp_t^{Food}), adjusted for their relative size in the total export. The same condition holds for those variables at their respective equilibrium values.

$$\Delta z_t^{tot} = -c_0^{\Delta \bar{z}^{tot}} (c_1^{\Delta \bar{z}^{tot}} \Delta rp_t^{Oil} + c_2^{\Delta \bar{z}^{tot}} \Delta rp_t^{Food}) / (c_1^{\Delta \bar{z}^{tot}} + c_2^{\Delta \bar{z}^{tot}})$$

(0.25) (0.03) (0.002)

$$\Delta \bar{z}_t^{tot} = -c_0^{\Delta \bar{z}^{tot}} (c_1^{\Delta \bar{z}^{tot}} \Delta \overline{rp}_t^{Oil} + c_2^{\Delta \bar{z}^{tot}} \Delta \overline{rp}_t^{Food}) / (c_1^{\Delta \bar{z}^{tot}} + c_2^{\Delta \bar{z}^{tot}})$$

(0.25) (0.03) (0.002)

The terms-of-trade premium that goes into the UIP condition (σ_t^{tot}) is modeled as the "surprise" component in the real exchange rate movement consistent with the terms of trade.

$$\sigma_t^{tot} = 4(z_t^{tot} - E_{t-1} z_t^{tot})$$