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Special Issue

Lessons Learned from
Research on Inflation Targeting

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Cover

Spanish Vellón, Seventeenth Century

Paul Berry, Chief Curator, Currency Museum

During the sixteenth and seventeenth centuries, Spain was one of the wealthiest and most powerful nations in Europe. It regularly imported huge quantities of gold and silver from its territories in Central and South America. It also controlled large parts of continental Europe, from Portugal to Italy and through central Europe as far north as the Spanish Netherlands. As a bastion of Catholicism during the counter-reformation, it was engaged in almost continual warfare from 1568 to 1660. The stress on Spain's finances was considerable, and in 1597, the government adopted a series of monetary reforms designed to save money.

Such initiatives, which involved reducing the amount of precious metal in coinage, were not new. The ancient Athenians issued silver-plated tetradrachms at the end of the Peloponnesian War, and successive Roman emperors gradually debased their silver coins. But Spanish leaders were reluctant to follow historical precedent, since their precious-metal issues were exported throughout Europe and were an important source of revenue. Instead, they took the unusual step of turning to their base-metal coins for financial relief. Called vellón, because they were made of billon, a low-grade copper/silver alloy, the coins ranged in value from 2 to 4 (and later, 6, 8, and 12) maravedis and were widely used by Spanish citizens in daily transactions.

The government first reduced the coin's silver content in 1597, and two years later removed silver entirely. While this netted some proceeds, what followed proved much more profitable. From 1602 to 1658, Spain frequently recalled, reminted, and revalued the vellón coinage (now a mixture of billon and pure copper coins). Each time money was recoined, the government profited from both seignorage (the difference between the production costs and the face value of the coins) and brassage (the fee for minting). In certain years, the government earned many times the face value of the reminted coins. For example, in 1603, 1636, 1651, and 1658 the government raised the face value of the vellón by 2, 3, 4, and 2 times, respectively. People bringing coins to be restamped were given new coins that had the same value as those they had brought in plus a small premium; the government pocketed the remainder. To offset the inflation that would follow each revaluation, if left unaddressed, the government would subsequently reduce the value of circulating vellón by an amount equal to the previous increase. Thus, in 1628, 1642, 1652, and 1659 the face value of the coins was lowered.

Over time, this process netted the government large profits. Spaniards were reluctant to use the coins, however, since rising prices made paying even small debts difficult because of the large number of coins needed. Artistically, the coins were little more than a hodge-podge of lines. Successive reminting, which involved counterstamping the coins with the date of reissue and with Roman or Arabic numerals indicating the new value, largely obscured the coin's original design. In 1660, all of the old vellón issues were withdrawn and replaced with a new issue of billon coins called vellón rico, containing 6.9 per cent silver.

Although produced in Spain, some of these coins have been found at archaeological sites in Newfoundland, where Spanish sailors were engaged in the fishery. Comparable in size to a twenty-five-cent piece, the coins on the cover form part of the National Currency Collection.

Photography by Gord Carter, Ottawa.

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Special Issue
Lessons Learned from Research on Inflation Targeting

Lessons Learned from Research on Inflation Targeting

Agathe Côté, Guest Editor

This special edition of the *Bank of Canada Review* examines some of the recent research on the monetary policy framework. While the existing inflation-targeting framework has served Canada well, exploring whether it can be further improved is a matter of responsible public policy. To this end, when the inflation-control agreement between the Bank of Canada and the government was renewed in 2006, the Bank launched a multi-year research initiative in anticipation of the next renewal. The Bank identified two broad questions to be addressed: whether economic welfare might be significantly improved by targeting a rate of inflation lower than our current 2 per cent target, and whether economic welfare might be significantly improved by moving from an inflation-targeting framework to some form of price-level targeting. Since then, the global financial crisis and the ensuing "great recession" have revived the question of whether monetary policy should do more to try to counter a buildup of financial imbalances. As a result, the focus of the Bank's research in advance of the 2011 renewal has been expanded to reconsider the question of whether the monetary policy framework needs to be adjusted to give more attention to financial-stability concerns.

As part of the research initiative, the Bank committed to reporting regularly on the progress made and the outstanding issues. The four articles in this *Review*, together with those published in similar special editions of the *Review* in 2008 and 2009, are part of this commitment. They supplement other material that the Bank makes available on this topic via speeches, working papers, and a dedicated website—<www.inflationtargeting.ca>.

The first article, "Monetary Policy and the Zero Bound on Nominal Interest Rates," by Robert Amano and Malik Shukayev, examines how alternative monetary policy frameworks might help to lower the risk and cost of hitting the zero lower bound (ZLB) on nominal interest rates. The recent global experience has demonstrated the critical importance of this issue. The authors present an analytical framework for examining monetary policy at the ZLB, particularly the role of inflation expectations in lowering the real interest rate. The influence of inflation targeting on inflation expectations and how forward guidance or a conditional commitment to future monetary policy may augment traditional monetary policy actions are also examined. The authors then review recent research on the efficacy of price-level targeting (PLT) at the zero lower bound. The research demonstrates that a credible PLT framework can better exploit inflation expectations via history dependence, thereby reducing the likelihood of hitting the ZLB and lessening the economic costs of operating there. PLT is also found to offer stabilization advantages in "normal" times, although these hinge critically on the degree of credibility of the regime.

In the second article, "Price-Level Targeting and Relative-Price Shocks," Stephen Murchison reviews the findings of recent Bank of Canada research on the relative merits of inflation targeting and PLT for a small open economy, such as Canada's, that is susceptible to large and persistent terms-of-trade shocks. These shocks have been identified as a potential threat to PLT, since central bankers may have to induce large fluctuations in output if they are to unwind all pass-through to the price level. The balance of evidence suggests that PLT and inflation targeting, implemented through simple policy rules, are fairly similar in their ability to stabilize inflation, the output gap, and interest rates. The author shows that this conclusion is robust to the inclusion of several types of relative-price shocks, including shocks to the terms of trade. Research on the optimal price index under PLT is also discussed, and Murchison concludes that, conditional on adopting PLT, the overall CPI would represent close to an ideal index to target.

Jean Boivin, Timothy Lane, and Césaire Meh address the question "Should Monetary Policy Be Used to Counteract Financial Imbalances?" The authors examine whether monetary policy should and could do more to lean against financial imbalances (such as those associated with asset-price bubbles or unsustainable credit expansion) as they are building up, or whether its role should be limited to cleaning up the economic consequences as the imbalances unwind. Effective supervision and regulation are the first line of defence against financial imbalances. An important question is whether they should be the only one. The authors argue that the case for monetary policy to lean against financial imbalances depends on the sources of the shock or market failure and on the nature of the other regulatory instruments available. To the extent that financial imbalances are specific to a sector or market and that a well-targeted prudential tool is available, monetary policy may play a minor role in leaning against the imbalances. However, if the imbalances in a specific market can spill over to the entire economy and/or if the prudential tool is broad based, monetary policy is more likely to have a role to play. In such a case, there may be a need to coordinate the use of the two policy instruments.

The final article, by Robert Amano, Kevin Devereux, and Rhys Mendes, provides a summary of the annual conference hosted by the Bank of Canada in November 2009, "New Frontiers in Monetary Policy Design." The conference brought together distinguished scholars from academic institutions and monetary authorities around the world. Reflecting the questions posed in the research initiative launched by the Bank in 2006, the conference agenda included work on the potential costs and benefits of price-level targeting and on the optimal rate of inflation. Other work explored the causes of zero-bound episodes and the efficacy of potential policies to deal with them. Keynote addresses by Lawrence Christiano and Mark Gertler focused on financial frictions and macroeconomic modelling.

Monetary Policy and the Zero Bound on Nominal Interest Rates

Robert Amano and Malik Shukayev, Canadian Economic Analysis

- *The recent financial crisis and the ensuing recession brought renewed focus to the issue of monetary policy options when the interest rate is at or near zero.*
- *The objective of this article is to better understand how different types of monetary policy frameworks might help to lower the risk and cost of hitting the zero bound on nominal interest rates.*
- *When the policy interest rate is at or near its zero bound, an important tool for a central bank's stabilization policy is its influence over inflation expectations, and thereby real interest rates.*
- *Inflation targeting is a monetary framework that allows a central bank to influence inflation expectations, but in extreme circumstances, its influence may not be enough to avoid an economic slowdown. Inflation targeting augmented by a conditional commitment to a future course of policy may strengthen the influence of central bank actions on the economy.*
- *Alternatively, a credible price-level-targeting regime can better exploit inflation expectations, reduce the likelihood of hitting the zero bound, and lessen the economic costs of operating at the lower bound, while keeping long-term inflation expectations fixed on a target rate. Moreover, price-level targeting may offer better stabilization properties than an inflation-targeting framework.*

While the zero lower bound (ZLB) on nominal interest rates has always been an issue of underlying importance for monetary policy, its prominence has ebbed and flowed. During the 1990s, when Japan experienced a long period with a policy interest rate near zero, deflation, and weak economic performance, the issue received considerable attention. Based on this work and other experiences with the zero bound, the general view at the Bank of Canada in 2006, when the inflation-control agreement was renewed, was that episodes of operating at the zero bound were probably rare and manageable.[1] The Bank was not alone in this view. In a paper presented at the 2009 Jackson Hole Symposium on Financial Stability and Macroeconomic Policy, Carl Walsh summarized the general view before the crisis as follows, "In fact, most work suggests that the costs of the ZLB are quite small if the central bank enjoys a high level of credibility" (Walsh 2009, 10). The financial crisis of 2008 and its aftermath have brought these tentative conclusions into question.

Indeed, in the aftermath of the financial crisis, the outlook for global economic growth deteriorated significantly, and central banks in many advanced countries lowered their policy interest rates to historic lows. For example, by December 2009, the U.S. federal funds rate sat at 0.12 per cent, while in England, Switzerland, and Japan nominal interest rates were at 0.45, 0.25, and 0.10 per cent, respectively. At the same time, a number of central banks engaged in unconventional monetary policy, such as "credit easing," aimed at reducing risk premiums and improving liquidity and trading activity in financial markets that were temporarily impaired, and "quantitative easing," aimed at lowering longer-term rates on government or private assets and improving the availability of credit

1 This view was supported by several model-based simulation studies, such as Black, Coletti, and Monnier (1998). Other studies can be found in Amirault and O'Reilly (2001).

more generally in the economy.[2] In Canada, the Bank of Canada substantially expanded its short-term lending facilities in order to increase liquidity in the financial system and to support credit flows, and then moved aggressively to lower its overnight target rate, bringing it to 0.25 per cent in April 2009. At that time, the Bank also made a commitment, conditional on the outlook for inflation, to keep the overnight rate at that level until the end of the second quarter of 2010. To buttress its commitment, the Bank expanded the terms of its short-term lending facilities to correspond to the length of its conditional commitment. These events, as well as similar experiences around the world, have renewed the focus on the issue of monetary policy when the interest rate is at or near zero.

The purpose of this article is not to review these recent experiences, but rather to explore how different types of monetary policy frameworks might help central banks to lower the risk of hitting the ZLB on nominal interest rates and to reduce the economic costs of being at the ZLB. The first section presents an analytical framework for thinking about monetary policy and the zero bound on nominal interest rates, as well as the key role of inflation expectations in lowering the real interest rate. The next section discusses the role that different monetary policy frameworks might play in influencing inflation expectations, and in avoiding or minimizing time spent at the zero bound.

Monetary Policy Transmission: From Policy Rates to Real Economic Activity

Discussions regarding the Bank of Canada's monetary policy often centre on the target overnight rate, but it is important to bear in mind that the real interest rate is the key variable influencing the behaviour of households and firms, and thus aggregate demand. The real interest rate is defined as the nominal interest rate less expected inflation. That is,

$$r = R - \pi^e. \tag{1}$$

As an example, if we assume that inflation expectations (π^e) are anchored on a 2 per cent inflation target, and the nominal interest rate is 4 per cent, then the real interest rate is 2 per cent. So, in periods of economic weakness, the central bank could lower its policy interest rate (R) to, say, 2 per cent to induce the real interest rate (r) to fall to zero and thereby encourage economic activity. In extreme circumstances, such as the recent financial crisis, a negative real interest rate might be required to avert an economic slump. The central bank cannot reduce its policy interest rate below zero, however. So, in this example, it is impossible for the central bank to achieve a real interest rate lower than -2 per cent, even though the economic situation may call for a lower real interest rate.[3] In such a situation, the real interest rate is too high, and monetary policy is said to be facing a binding zero constraint on nominal interest rates.

In extreme circumstances, such as the recent financial crisis, a negative real interest rate might be required to avert an economic slump.

The savings and investment decisions of households and firms are not based on the real policy interest rate but on broader market interest rates. Examples of these broader rates include those on variable rate mortgages and commercial paper, etc. With some simplification, a representative real market interest rate (i) can be written as:

$$i = (R - \pi^e) + \sigma, \tag{2}$$

where the term σ captures various risk and liquidity premiums that lead to a credit spread between market and policy interest rates. Moreover, households and firms often use multi-period financial instruments, such as fixed-rate mortgages or long-term bonds, to conduct their business. A k-period real market interest rate may be loosely written as:

$$i_t^k = \sum_{j=0}^{k} i_{t+j}^e + \tau, \tag{3}$$

2 There are no universally accepted definitions of credit easing or quantitative easing. The definitions used here are taken from the Bank of Canada's framework for monetary policy at low interest rates (Annex to the April 2009 Bank of Canada *Monetary Policy Report*).

3 In theory, nominal interest rates cannot fall below zero, since rational agents would not purchase an asset yielding a negative nominal return when they could hold currency at a zero rate of return. In practice, however, most central banks have stopped short of lowering policy interest rates to zero in order to preserve the efficient functioning of short-term financial markets. For instance, the Bank of Canada considers that 25 basis points is the effective lower bound for the overnight target rate.

where i_t^k is a k-period real interest rate, i_{t+j}^e is an expected one-period real interest rate j periods in the future, and τ captures the term premium. This equation says that the k-period real interest rate comprises a series of expected one-period interest rates and a term premium, and by using different values of k, the equation traces the term structure of real interest rates. During the financial crisis, the credit spread and term premiums were unusually large, owing to illiquidity in credit markets and a perceived increase in risk.

According to equations (2) and (3), there are three ways to lower real market interest rates when the policy rate is at its lower bound. First, central banks can try to reduce the credit spread. Indeed, in the aftermath of the financial crisis, central banks implemented measures to improve the functioning of financial markets, with the goal of reducing spreads and thereby helping to lower market interest rates. Second, central banks can attempt to lower the term premium. In fact, several central banks undertook "quantitative easing" in an effort to lower the yields on multi-period financial instruments and thus stimulate economic activity. The third channel—and the focus of this *Review* article—is for central banks to attempt to influence the expected path of future interest rates and inflation expectations.

The efficacy of the attempts to reduce credit spreads and lower yields on multi-period financial instruments is currently being debated. Indeed, some academics and central bank economists, such as Eggertsson and Woodford (2003) and Carlstrom and Pescatori (2009), have questioned the relevance of these monetary policy measures when standard monetary policy is able to influence inflation expectations. As with many economic debates, it will take time to fully assess the effectiveness of these unconventional measures, and many open questions remain regarding the costs of exiting from these unconventional policies.

There is, however, little debate that when the policy interest rate is at or near its zero bound, the central bank's influence over inflation expectations is an important tool. How this influence should be used is a critical question for monetary policy, since it may require raising inflation expectations above an inflation objective for a period of time in order to achieve a sufficiently lower real interest rate. In other words, a central bank may need to convince households and firms that it will temporarily exceed its inflation objective but, at the same time, maintain its credibility and commitment to low and stable inflation. In principle, it is possible to raise inflation expectations above the inflation target by clearly communicating future monetary policy actions or "forward guidance" (see Eggertsson and Woodford 2003 and Walsh 2009). In particular, a central bank could commit to maintain a "low" interest rate policy even after rates rise from the zero bound. The commitment to hold the policy rate low for a longer period than under normal economic conditions, would lead to strong economic growth and higher anticipated inflation.[4] In the real world, a number of central banks implemented the idea of forward guidance or conditional commitment but in a different manner. Instead of attempting to raise inflation expectations, central banks sought to lower interest rates further along the yield curve by providing more certainty about policy rates over an extended period, while maintaining inflation expectations firmly anchored at the inflation target. A number of central banks enhanced their communications regarding the future path of the policy interest rate and made conditional commitments to hold the policy interest rates at or near zero over a specified period. For instance, the Bank of Canada, in the statement accompanying its April 2009 fixed announcement date wrote, "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." Similarly, the Sveriges Riksbank in their July 2009 *Monetary Policy Report* wrote, "The repo rate is expected to remain at this low level over the coming year."

Central banks sought to lower interest rates further along the yield curve by providing more certainty about policy rates over an extended period, while maintaining inflation expectations firmly anchored at the inflation target.

The preliminary evidence, at least in Canada, has been quite positive, as market participants embodied the conditional commitment on policy interest rates in market interest rates. Indeed, according to empirical work conducted by He (forthcoming), the Bank of

4 The efficacy of these types of forward-guidance measures is still in question. Levin et al. (2009), for example, use results based on a small macroeconomic model to argue that forward guidance alone may not be sufficient in the presence of a large and persistent shock. In contrast, Giannoni (2009) argues that forward guidance is, indeed, effective in his model. In fact, the best possible outcome in the Levin et al. paper can be achieved only with forward guidance.

Canada's conditional commitment appears to have resulted in a persistent lowering of Canadian interest rates since April 2009, relative to what would have been expected without it.

In the remainder of this article, we discuss approaches that may help a monetary authority temporarily raise inflation expectations while maintaining its credibility as an advocate of low inflation.

Monetary Policy at the Zero Bound

Inflation targeting

One way to lower the real interest rate, when one is at or close to the ZLB, might be to raise the target rate of inflation on a *permanent* basis. This may raise inflation expectations and work its way through financial markets via equations (1) to (3). For instance, John Williams (2009) has argued that the U. S. Federal Reserve should increase its implicit inflation objective from the 2 per cent currently viewed by market participants, to something between 2 and 4 per cent to minimize the chances of hitting the ZLB and reducing the economic costs associated with those occasions when it is hit. An IMF staff position paper by Blanchard, Dell'Aricca, and Mauro (2010) seems to support this conclusion, urging more research on the benefits of raising the inflation target from 2 to 4 per cent. In reply, opponents such as Deputy Governor Charles Bean of the Bank of England have written, "This is misguided. Aside from the dubious morality of redistributing wealth from savers to borrowers, we have seen from past experience that a bit of inflation has a nasty habit of turning into a lot of inflation."[5] Bean's warning echoes that of former Bank of Canada Governor John Crow (2009, 12): "I did not think that 4 per cent was a credible goal because I did not think that economic agents would believe that the authorities would stick to a number that promised, essentially, "inflation." That is to say, if 4 was okay, why not 5, why not 6, and so on?"

Rogoff (2008) has suggested that central banks should *temporarily* raise inflation targets in an effort to lower real interest rates and ameliorate debt problems. While an increase in inflation could certainly help to deleverage an economy, it would also entail the cost of undermining public trust by inducing an ad hoc redistribution of wealth from savers to borrowers. Moreover, the credibility of such a policy would always be in question, owing to uncertainty about its temporary status, and this implies that a central bank's ability to influence short-run inflation expectations could be compromised, resulting in less influence over real interest rates.

An inflation anchor is essential, especially when providing extraordinary guidance to markets.

The preceding paragraphs should not be interpreted as an argument against inflation targeting. In fact, a credible inflation target, at a low positive rate, helps to ensure that inflation expectations remain well anchored, allowing for negative real interest rates. As Carney (2009) notes, an inflation anchor is essential, especially when providing extraordinary guidance to markets.[6]

The one disadvantage of inflation targeting at the ZLB is that a period of below-target inflation will be followed by inflation returning to and staying at its target value. That is, the central bank does not attempt to compensate for a period of inflation below the target with a period of above-target inflation. Rational households and firms would, therefore, expect inflation to be below the target in the short run and to be equal to the inflation target in the longer run. The implication of this behaviour is that average inflation expectations would be lower than the inflation target, making it difficult for an inflation-targeting central bank to raise inflation expectations.

Despite this difficulty, some research has found that optimal forms of inflation targeting may be sufficient to avoid the zero bound. Schmitt-Grohé and Uribe (2007) study the zero-bound problem in a medium-scale dynamic stochastic general-equilibrium (DSGE) model with distortionary taxes and three shocks: one to aggregate productivity, one to investment-specific productivity, and one to government spending. Their model is calibrated to U.S. data and shows that under the optimal policy, the probability of the nominal interest rate approaching the zero bound is practically nil. Similarly, Christiano (2004) shows that, in a small macroeconomic model, an implausibly large economic shock is required to bring interest rates close

5 See Bean (2010). Empirical magnitudes of this redistribution effect for Canada can be found in Meh, Ríos-Rull, and Terajima (2010).

6 In cross-country empirical work, de Carvalho Filho (2010) finds that inflation-targeting central banks seem to generate better-anchored inflation expectations, even in the immediate aftermath of a financial crisis.

to zero. All of these studies, however, predate the latest financial crisis.

Recent experience would appear to contradict these predictions: inflation targeting has not been sufficient to avoid the zero bound. One reason may be that the shock was much larger than is considered within the bounds of normal. Amano and Shukayev (2009) propose an alternative explanation. They argue that the addition of a historically measured risk-premium shock to a medium-scale DSGE model specified along similar lines to that in Schmitt-Grohé and Uribe (2007) is sufficient to make the ZLB a binding constraint on monetary policy. In the model, the risk premium is defined as the returns on private assets (which have a time-varying risk component) less those on risk-free government bonds. Intuition for the "special" role of risk-premium shocks can be garnered from the observation that these shocks change the spread between the expected rate of return on capital and the risk-free rate. To accommodate the higher risk premium, this implies that either the expected rate of return on capital must increase, or the risk-free rate must fall, or both. For a wide range of plausible parameter configurations and inflation-targeting rules, Amano and Shukayev find that much of the increase in the risk premium is accommodated by a drop in the risk-free rate, thus increasing the probability of reaching the zero bound.

Price-level targeting

A credible price-level-targeting regime has an important advantage over inflation targeting when the policy interest rate is at or near zero. Unlike inflation targeting, price-level targeting is "history dependent," which means that periods of below-target inflation will be followed by periods of above-target inflation (to return the price level to its target). So, under price-level targeting, long-run inflation expectations will be stable, but short-term inflation expectations will rise or fall, depending on the current position of the price level relative to its target. If prices are currently below their target level, then short-term expectations of inflation will rise above the long-run average inflation rate. Thus, price-level targeting has a built-in mechanism to raise and lower expectations of inflation.

Many researchers, including Coulombe (1998), Duguay (1994), Svensson (2001), Wolman (2005), Amano and Ambler (2010), and Murchison (forthcoming), have noted the benefits of price-level targeting when the policy interest rate is at or near zero. In particular, these authors demonstrate that the ability of price-level targeting to influence inflation expectations via history dependence lowers the risk of reaching the ZLB on nominal interest rates, or at least reduces the economic costs associated with being there. Moreover, as Carney (2009) notes, price-level targeting may offer an additional benefit: since price-level targeting provides clear guidance on the expected price level, it may serve as a better anchor for inflation expectations than an inflation target during a financial crisis. This feature of price-level targeting gives the central bank more latitude to pursue other immediate concerns, such as financial stability, without compromising its monetary policy objective of maintaining price stability.[7] Price-level targeting resolves the inherent uncertainty about how temporary higher inflation would be.

Since price-level targeting provides clear guidance on the expected price level, it may serve as a better anchor for inflation expectations than an inflation target during a financial crisis. It also resolves the inherent uncertainty about how temporary higher inflation would be.

Amano and Ambler (2010) compare inflation targeting and price-level targeting under low trend inflation in a small, calibrated, DSGE model that explicitly takes into account the ZLB. Their conclusions, based on a solution method that allows for the effects of time-varying price dispersion and valid welfare comparisons, are fourfold: (i) Price-level targeting is more effective than inflation targeting in keeping an economy away from the zero bound on nominal interest rates; (ii) An economy under inflation targeting can remain stuck at the lower bound for prolonged periods; (iii) Price-level targeting allows an economy to reap the benefits of lower inflation while avoiding the risks of being stuck at the zero bound; and (iv) Price-level targeting yields a higher level of economic welfare than inflation targeting. While these conclusions are informative, the results do not allow us to draw any quantitative conclusions.

Murchison (forthcoming) examines the ability of inflation targeting and price-level targeting to mitigate the effects of the zero bound on nominal interest rates in ToTEM, a large-scale model of a small open economy

7 This idea is explored in forthcoming work by Christensen, Meh, and Moran.

calibrated to replicate important features of the Canadian economy. As such, this work can offer quantitative insights into the stabilization properties of the two targeting regimes when faced with the zero bound. The simulation results indicate that, relative to a version of the model without the zero bound, economic loss increases by about 2 per cent under an optimized inflation-targeting rule, whereas under an optimized price-level-targeting rule, the increase in loss is less than 1 per cent.[8]

In a recent paper, Coibion, Gorodnichenko, and Wieland (2010) compare inflation and price-level targeting in a New Keynesian model where the effects of trend inflation on the steady-state dynamics and loss function of the model are explicitly modelled. Since the model is micro-founded, it admits a welfare function that allows the authors to engage in normative analysis. The authors report many results, but the most striking is that price-level targeting raises welfare by a non-trivial amount for any steady-state rate of inflation. Moreover, by reducing the variance of inflation and output, price-level targeting lowers the frequency of zero-bound episodes.[9]

An important caveat to the results stated above regarding the apparent efficacy of price-level targeting is the assumption that it is fully credible. If households and firms do not understand the new framework or believe that the central bank will always follow a price-level-targeting rule, then its powerful effect on expectations of inflation will be dampened. To explore the implications of this key assumption, Cateau and Dorich (forthcoming) study a situation where the monetary authority shifts from inflation targeting to price-level targeting when the zero bound is hit. As expected, they find that price-level targeting works well under perfect credibility, but when imperfect credibility is introduced the effectiveness of price-level targeting is reduced. According to their qualitative results, greater degrees of imperfect credibility will increasingly reduce the ability of price-level targeting to help an economy avoid the zero bound on nominal interest rates.

Williams (2006) uses a macroeconomic model where economic agents have imperfect knowledge of their economy (including monetary policy) to study the impact of learning on the effectiveness of price-level targeting at the ZLB. Owing to the absence of complete information, households and firms must continuously re-estimate their forecasting model to form expectations. Williams finds that imperfect knowledge, especially about monetary policy, can undermine the effectiveness of price-level targeting in dealing with the effects of the lower bound. Interestingly, effective communication about monetary policy can reduce the costs associated with being at the zero bound, suggesting that forward guidance may, indeed, be a useful tool for dealing with the lower bound, even if a central bank practices price-level targeting.

Concluding Remarks

The zero bound on nominal interest rates is undeniably a concern for monetary policy-makers, but the problems that it raises are not insurmountable. When the ZLB is a binding constraint, it implies that the real interest rate is "too high." Therefore, creating expectations of higher inflation could be a powerful mechanism for mitigating the effects of the zero bound on an economy. Under inflation targeting, communicating future monetary policy actions, or forward guidance, may be an effective way to raise inflation expectations. Alternatively, research has shown that a credible price-level-targeting framework can reduce the likelihood of reaching the ZLB and lessen the costs of operating at the lower bound on an economy. Moreover, price-level targeting may help a central bank to address a financial-stability concern while keeping expectations of inflation anchored on its long-run objective. For price-level targeting to admit these benefits, the assumption of credibility is crucial: with diminished credibility, the effectiveness of price-level targeting in offsetting the effects of the zero bound falls. Clear central bank communication about monetary policy, however, may help to overcome the reduced effectiveness of price-level targeting arising from imperfect credibility or imperfect knowledge of the economy.

8 Economic loss is calculated as the sum of the variance of inflation and the variance of the output gap, multiplied by half the variance of the change in the policy interest rate.

9 In addition, Coibion, Gorodnichenko, and Wieland find that price-level targeting also leads to a lower level of optimal inflation relative to inflation targeting.

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Price-Level Targeting and Relative-Price Shocks

Stephen Murchison, Canadian Economic Analysis

- *Since 2006, the Bank of Canada has spearheaded a research program to examine the merits of switching to a regime that targets the price level rather than the rate of inflation.*
- *This article reviews model-based research focused on examining the relative merits of the two regimes in a small open economy, such as Canada's, that is susceptible to large and persistent shocks to its terms of trade. Research on the optimal price index under price-level targeting is also discussed.*
- *The balance of evidence suggests that the two regimes, implemented through simple policy rules, are quite similar in their ability to stabilize inflation, the output gap, and interest rates.*
- *Conditional on adopting price-level targeting, the overall CPI would represent close to an ideal index to target.*

In the autumn of 2006, researchers at the Bank of Canada embarked on an ambitious program to explore the potential welfare gains of switching from the Bank's current framework of targeting the *rate of change* in prices (i.e., inflation) to targeting the *price level*.[1] While research to date had suggested possible gains, several questions pertinent to Canada were identified as requiring further research. Among these was, *What are the relative merits of inflation targeting versus price-level targeting in an open economy susceptible to large and persistent terms-of-trade shocks?* (Bank of Canada 2006).

At issue is whether a central bank that targets an aggregate price index, such as the consumer price index (CPI), would be required to generate large fluctuations in output to offset the price-level effects from shocks to specific sectors. For instance, commodity-price movements tend to be both large and persistent, and influence the CPI directly through the price of gasoline and other forms of energy. Whereas a credible inflation-targeting central bank can generally look through these types of fluctuations, since their impact on inflation is highly transitory, a price-level-targeting central bank must respond by generating offsetting price-level movements in other sectors. As a result, price-level targeting could lead to greater aggregate volatility in an economy that is subject to large relative-price shocks.

This article reviews recent Bank of Canada research on the relative merits of price-level targeting (PLT) and inflation targeting (IT) for a small open economy that is subject to large and persistent terms-of-trade shocks.[2] The first section describes the basic mechanics of so-called history-dependent monetary policy, of which PLT is one special case, and discusses the

1 The potential benefits to the Canadian economy of reducing the inflation target from its current level of 2 per cent per year are also being explored.

2 A more general review of research on price-level targeting is provided in Ambler (2009).

conditions required for such policies to be beneficial in terms of economic stabilization. This is followed by an examination of recent model-based research comparing PLT with IT in a small open economy that is subject to relative-price shocks. The robustness of these results to, among other things, alternative assumptions about expectations formation is then discussed. Finally, research on the optimal price index to target under PLT is summarized before conclusions are drawn.

PLT as a Special Case of History-Dependent Monetary Policy

Targeting the price level, as opposed to the rate of inflation, can be thought of as a particular example of what is referred to as history-dependent monetary policy (Woodford 2003). History dependence simply means that monetary policy responds to past economic conditions, in addition to current and expected future conditions. This typically implies that policy will continue to respond to shocks, even after their impact on inflation and/or the output gap has fully dissipated. As a result, inflation will often exhibit a *secondary cycle*, meaning that the price-level effects generated by the shock will be partially, or fully, reversed.[3] For example, if a shock initially causes inflation to rise above some target rate, policy will continue to maintain interest rates above neutral until inflation moves below the target. This would imply that monetary policy causes inflation to undershoot the target when inflation is initially above target, and vice versa.

Based on this description, it is easy to see how price-level targeting represents a special case of history-dependent policy. Consider a central bank that chooses to target a constant price level through time. Following an economic shock that initially raises the price level (and creates inflation), the bank will subsequently engineer a period of deflation until the overall price level returns to the desired level. This type of response pattern is equivalent to responding to the sum of the current, and all previous, rates of inflation.[4] The appeal of PLT within the class of history-dependent policies is its transparency and relative ease of communication.

Having established the mechanics of history dependence, we next turn to the fundamental question of how a central bank might benefit from adopting such an approach to setting monetary policy. It is not immediately obvious why a central bank seeking to stabilize inflation would want to cause secondary cycles in inflation, since this is clearly destabilizing to the economy, *other things being equal*. The key insight from the literature on history dependence is that such a policy will not leave other things equal. Specifically, if expectations of future inflation, which influence current inflation, correctly take account of the secondary cycle in inflation, they will exert a stabilizing effect on current inflation. Indeed, any policy that causes inflation to be lower (higher) in the future will also cause current inflation to be lower (higher) when expectations are forward looking. Intuitively, a firm that is considering a price change in the current period, knowing that this change will have to be reversed in the next period, will have less incentive to institute the change.

The appeal of PLT within the class of history-dependent policies is its transparency and relative ease of communication.

To better understand the mechanics of the expectations channel, consider the simplest form of the so-called New Keynesian Phillips curve (NKPC):

$$\pi_t = \beta \pi_{t+1|t} + \lambda y_t + \varepsilon_t, \qquad (1)$$

where π_t is the rate of price inflation,[5] $\pi_{t+1|t}$ is the rate of inflation expected to prevail in the next period (conditional on period-t information), y_t is the per cent difference between real GDP and potential GDP (i.e., the output gap), β and λ are constant parameters that are set to one for simplicity, and ε_t is a random shock, sometimes interpreted as a change to firms' desired markup of price over marginal cost. The New Keynesian model is based on two crucial assumptions: (i) firms change prices only periodically, meaning that prices generally remain fixed for more than one period, and (ii) firms form their expectations about the future in a rational way. Since it is known that the chosen price will likely remain in effect for

3 The term secondary does not mean that the cycle is of secondary importance, but that it comes after a first cycle.

4 In fact, the price level in any period is proportional to the product of all past gross inflation rates, and approximately equal to the sum of all past net inflation rates, where the gross inflation rate from period t to period $t+n$ is $\frac{P_{t+n}}{P_t}$ and the net inflation rate is $\frac{P_{t+n}}{P_t} - 1$.

5 The inflation target is assumed to be zero.

multiple periods, account is taken of both current and expected future demand conditions, which implies that aggregate inflation is a forward-looking variable.

For the purpose of this discussion, we assume that inflation is determined according to equation (1) and that the instrument of monetary policy is the output gap. Thus, equation (1) also describes how policy influences inflation. Finally, for simplicity, we assume that the central bank cares equally about stabilizing inflation around its target and output around its potential. We can therefore describe the preferences of the central bank in terms of the following simple loss function:

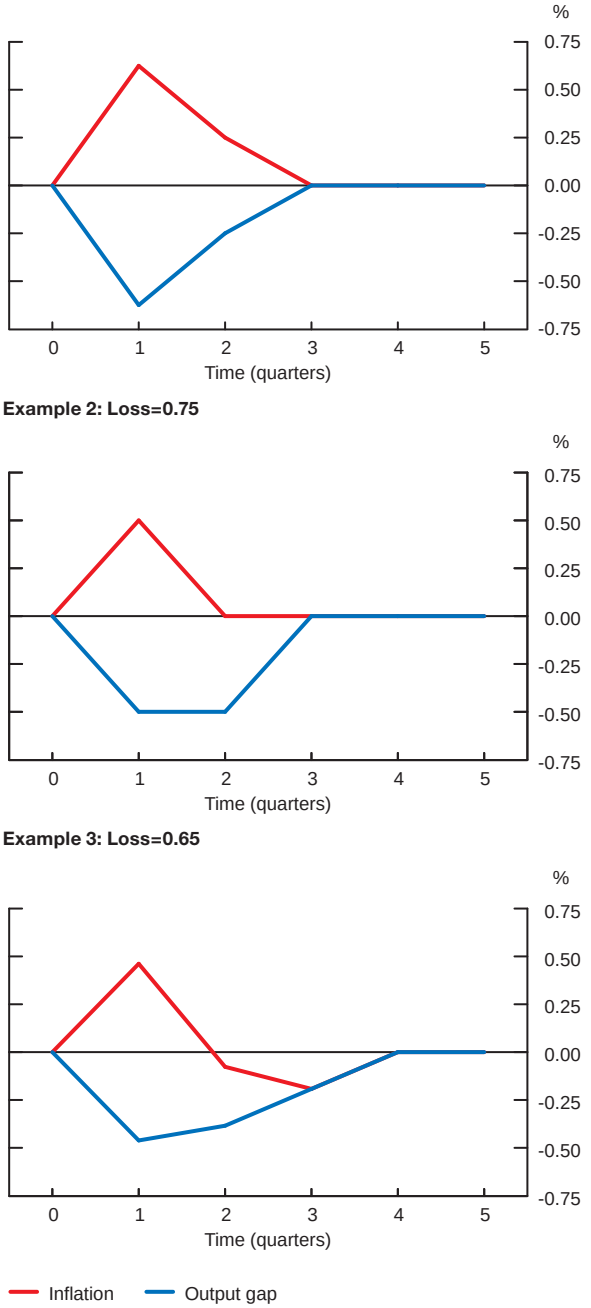
$$L = \sigma_{\pi}^2 + \sigma_{y}^2, \qquad (2)$$

where σ_{π}^2 and σ_{y}^2 are, respectively, the variance of inflation (relative to the target) and output (relative to potential output).

First, suppose that the central bank seeks to minimize equation (2) by responding only to current inflation. We can therefore write the central bank's reaction function as $y_t = \theta\pi_t$. Since we are assuming that $\lambda = 1$ and that ε_t is the only type of shock in the economy, we will obtain the result that $\theta = -1$. Now suppose that the economy is faced with a two-period shock in which $\varepsilon_1 = 1, \varepsilon_2 = 0.5$, and is zero thereafter. The optimal response of the output gap and inflation in each period is plotted in **Chart 1** (example 1), and, as our optimal rule implies, one is just the mirror image of the other, and total loss equals 0.91.

But suppose we relax the assumption that the central bank can respond only to current inflation and, instead, assume that it sets the same value of the output gap in each of the first two periods. In this scenario, the response is consistent with a reaction function of the form $y_t = \theta(\pi_t + \pi_{t-1})$. The optimal level for the output gap is -0.5 in both periods, which results in a total loss of 0.75 (example 2 in **Chart 1**). The reason behind this interesting result is quite simple: the output gap set in period 2 affects inflation in periods 1 and 2 when inflation expectations are forward looking, whereas the output gap set in period 1 affects inflation only in period 1. In this sense, the central bank obtains a better inflation/output trade-off by committing to generating a larger output gap in period 2 and a smaller output gap in period 1, relative to the first example. Of course, such a desirable outcome is possible only if inflation expectations explicitly take account of future demand conditions.

Chart 1: Benefits of history dependence



Source: Bank of Canada calculations

In this particular example, history dependence does not imply any undershooting of inflation, meaning that there are benefits to responding to past economic conditions even if no secondary cycle in inflation is generated. Nevertheless, an even better outcome can be obtained if a secondary cycle is permitted. For instance, suppose we now allow the central bank to

choose the output gap as it wishes in each of the first 3 periods and that the output gap is zero thereafter (as shown in example 3, **Chart 1**). Given this option, the central bank generates a better inflation/output trade-off by maintaining the economy in excess supply in period 3, since this has a stabilizing effect on inflation in periods 1 and 2. The cost of this, as measured by deflation in period 3, is smaller than the benefit, since the overall loss declines from 0.75 in example 2, to 0.65 in example 3.

Woodford (2003) illustrates this basic point using the NKPC given by equation (1) and the loss function given by equation (2).[6] He shows that the optimal response to a positive markup shock, which initially causes inflation to rise, is to subsequently generate deflation until the price level returns to its pre-shock level. In other words, optimal monetary policy under commitment is consistent with targeting the price level, even though it is inflation that appears in the loss function. The particular policy rule consistent with achieving this outcome is given as[7]

$$y_t = y_{t-1} - \phi\pi_t, \tag{3}$$

which is history dependent in the sense that the central bank chooses the current period's output gap partly as a function of the previous period's output gap.[8]

That equation (3) implements PLT while setting the policy instrument as a function of inflation demonstrates the need to distinguish between policy regimes, such as IT and PLT, and the variables appearing in a history-dependent policy rule. In many instances, a history-dependent policy rule may implement aspects of both IT and PLT regimes in the short run. For instance, if we reduce the weight on the lagged output gap, y_{t-1} in equation (3) to a positive number less than one, then a positive markup shock may still eventually lead to a period of deflation, but it will be insufficient to fully return the price level to its control level. In this example, a deliberate undershooting of the inflation target may be inconsistent with the spirit of an IT regime, whereas not fully restoring the price level to its control level would be inconsistent with PLT.

As discussed in the next section, the grey area that exists between pure IT and pure PLT is quite important when researchers compare the two, using policy rules that feature interest rate smoothing.

Recent Research on Relative-Price Shocks and PLT

Comparisons of the efficacy of PLT relative to IT typically involve the use of optimized simple monetary policy rules that implement each regime in a quantitative macroeconomic model. This article surveys recent research using ToTEM, BoC-GEM, and a third small-open-economy model, all of which feature multiple production sectors and significant heterogeneity across sectors.[9]

The simple policy rules considered in each paper can be written as

$$R_t = \rho R_{t-1} + (1-\rho)R^* + \varphi_\pi(E_t\pi_{t+k} - \pi^T) + \varphi_y y_t, \tag{4}$$

(Inflation-forecast rule)

for an IT regime, and

$$R_t = \rho R_{t-1} + (1-\rho)R^* + \varphi_p\left(E_t p_{t+k} - p^T_{t+k}\right) + \varphi_y y_t, \tag{5}$$

(Price-level-forecast rule)

for a PLT regime, where R_t is the policy interest rate in period t; R^* is the long-run steady-state level of interest rates; $E_t\pi_{t+k}(E_t p_{t+k})$ is the period t expectation of inflation (log price level) in period $t+k$; y_t is the output gap; ρ, $\varphi_\pi(\varphi_p)$, and φ_y are fixed parameters that determine the degree of interest rate smoothing and the sensitivity of the policy rate to deviations of inflation (price level) from target and the output gap, respectively.[10] Note that the feedback horizon, k, determines the horizon of the response to inflation relative to its target, π^T, or the (log) price level relative to its target, p^T_{t+k}.

The first rule is referred to as an inflation-forecast (IF) rule, since the policy rate responds to a forecast of inflation, whereas the second rule is referred to as a price-level-forecast (PLF) rule. Since the IF rule ensures

6 Except that the weight on the variance of the output gap is less than one.

7 For simplicity, we ignore the initial-period problem in which policy does not respond to the lagged output gap. The issue of the time-inconsistency of this type of policy, as well as a suggested solution, is discussed in Woodford (2003).

8 If we solve equation (3) "backwards" to eliminate the lag of the output gap, we obtain a (negative) relationship between the current period's output gap and the sum of the current and all past inflation rates. This is equivalent to responding to the price level.

9 For a description of the Terms of Trade Economic Model, ToTEM, see Murchison and Rennison (2006). The Bank of Canada's version of the IMF's Global Economic Model, BoC-GEM, is described in Lalonde and Muir (2007), and a description of the third model can be found in de Resende, Dib, and Kichian (2010).

10 Inflation and interest rates are expressed as quarterly rates of change.

that the rate of inflation equals the target rate in the long run but, in general, makes no explicit provision to return the price level to a pre-specified level, this rule is loosely interpreted as implementing inflation targeting. The PLF rule, in contrast, does set policy explicitly to achieve a particular outcome for prices, $p_t = p_t^T$, and is therefore more consistent with price-level targeting in the long run. Having said that, just as the policy rule given by equation (3) implements aspects of both IT and PLT when the weight on the lagged instrument is less than one, the introduction of a lag of the instrument in equation (4) means that the IF rule will display history dependence and will therefore, to some degree, mimic the behaviour of a PLF rule with no lagged instrument. Similarly, equation (5) will, to some degree, mimic a rule that responds to the *sum* of past price-level gaps. As a result, some caution is warranted in mapping policy regimes, such as IT and PLT, to simple feedback rules such as the IF and PLF rules considered in these studies.

The version of ToTEM used in Murchison (forthcoming) explicitly models the CPI as a function of the Bank of Canada's measure of core CPI and the Canadian-dollar price of energy.[11] A permanent shock to the world oil price has both a demand component, driven by changes in wealth, and a relative-price channel, since commodities are both a factor of production of finished goods and final goods themselves (e.g., gasoline and home heating fuel). As a result, energy-price shocks involve a tension between stabilizing CPI inflation and stabilizing the output gap. Explicitly accounting for energy-price movements is crucial to the question addressed in Murchison since they explain much of the short-term volatility in the CPI, and their effect on the level of the CPI tends to be long lasting or permanent.

Murchison assumes that the policy-maker's preferences are well described by the following simple loss function:

$$L = \sigma_\pi^2 + \sigma_y^2 + 0.5\sigma_{\Delta R}^2, \qquad (6)$$

which penalizes the (unconditional) variance of CPI inflation and the output gap equally, and also puts a weight of 0.5 on the variance of the quarterly change in the policy interest rate, ΔR_t.[12] It is worth noting that this loss function accords no cost to price-level volatility per se, other than via its link to overall inflation volatility. Therefore, it does not capture any explicit benefits associated with reduced price-level uncertainty under PLT.

Using a distribution of shocks estimated by ToTEM over the period 1995Q1 to 2008Q4,[13] together with this loss function, the author simulates losses for different values of the policy-rule parameters ρ, $\varphi_\pi(\varphi_p)$, and φ_y for the IF and PLF rules described by equations (4) and (5). Those parameter values that produce the lowest value of L for each rule are retained and used to compare the IT and PLT regimes.

Coletti, Lalonde, and Muir (2008) use a very similar set-up but with a two-country (Canada and the United States), two-sector (tradables and non-tradables) version of the IMF's Global Economic Model (GEM), calibrated to Canadian and U.S. data from 1983 to 2004.[14] They also consider policy rules of the form given by equations (4) and (5) and a loss function similar to equation (6).

De Resende, Dib, and Kichian (2010) compare IT and PLT in an estimated small-open-economy model with multiple production sectors, sector-specific capital, and imperfect labour mobility between sectors. These model features are motivated by the idea that sector-specific shocks will generally mean that monetary policy will face a trade-off between stabilizing certain sectors and, consequently, destabilizing others. The importance of this trade-off will depend on the degree of factor mobility across sectors. While the authors also consider simple IF and PLF policy rules, their loss function is derived explicitly from the structure of the model.[15] As a result, the parameters of the policy rules are chosen to maximize the expected welfare of the representative household in the model, rather than an ad hoc loss function such as equation (6).

All three studies carefully consider the implications of relative-price shocks, including shocks that affect Canada's terms of trade, and broadly conclude that

11 The author uses the Bank of Canada's energy-commodity price index, which is converted to Canadian dollars using the current nominal exchange rate. This set-up assumes that movements in the world price of energy and the exchange rate are immediately and fully passed through to the consumer prices for energy products, such as gasoline, at a quarterly frequency.

12 Including ΔR_t in the loss function reduces the volatility of interest rate changes quite significantly but has little impact on the variance of inflation or the output gap. Excess instrument volatility may be disruptive to financial markets for reasons not captured by the models used.

13 The various types of structural shocks modelled in ToTEM are described in Murchison and Rennison (2006).

14 They estimate their shocks using a longer sample and use a smaller weight on the variance of the first difference of interest rates (0.1) than Murchison (0.5). They also use core CPI inflation in the loss function.

15 Welfare analysis is conducted based on a second-order approximation of the model (and the utility function) around its deterministic steady state.

Table 1: Inflation- and price-level-forecast rules

$$R_t = \rho R_{t-1} + \varphi_\pi E_t \pi_{t+k} + \varphi_p E_t p_{t+k} + \varphi_y \tilde{y}_t$$

	Coefficients of rule					Loss(PLF-IF)	Var. (PLF-IF)[a]		
Paper/Rule	ρ	φ_π	φ_p	φ_y	k	$\left(\frac{loss(PLF)}{loss\ (IF)} - 1\right)$	σ_π^2	σ_y^2	$\sigma_{\Delta R}^2$
Coletti, Lalonde, and Muir (2008)									
Unconstrained IF	0.97	2.4	-	0.7	2	**-**	-	-	-
PLF	0.85	-	3.7	0.9	3	**-1 %**	-2%	2%	0
de Resende, Dib, and Kichian (2010)[b]									
Unconstrained IF	0.68	2.5	-	0.0	0	**-**	-	-	-
PLF	0.0	-	1.1	0.0	0	**0%**	-	-	-
Constrained IF	0.0	6.0	-	0.0	0	**-**	-	-	-
PLF	0.0	-	1.1	0.0	0	**-5%**	-	-	-
Murchison (forthcoming)									
Unconstrained IF	1.1	0.6	-	0.1	0	**-**	-	-	-
PLF	0.98	-	0.09	0.2	4	**-5%**	-4%	-1%	0
Constrained IF	0.0	3.75	-	0.3	1	**-**	-	-	-
PLF	0.0	-	0.34	0.3	4	**-15%**	-7%	-1%	-7%
IF	0.8	1.6	-	0.2	1	**-**	-	-	-
PLF	0.8	-	0.1	0.2	4	**-9%**	-5%	-3%	-1%

a. Differences in variances across IF and PLF rules are expressed as a fraction of the total loss associated with the IF rule and weighted by their weight in equation (6). Thus, the differences for the three individual variables sum to the difference in loss (subject to rounding error).
b. Variances are not shown, since the differences in welfare-based loss cannot be expressed solely in terms of these variables.

PLF and IF rules yield very similar overall stabilization properties ("Unconstrained" rules, **Table 1**). When all types of shocks are considered, the PLF rule dominates the IF rule by a small margin in ToTEM and in BoC-GEM, whereas de Resende, Dib, and Kichian find no difference. In addition, the results for ToTEM and BoC-GEM suggest that when inflation expectations are calibrated to be highly forward looking, the PLF rule also dominates the IF rule in the presence of relative-price shocks.[16] In other words, the gain realized via the expectations channel outweighs the loss associated with having to stabilize the overall price level in response to sector-specific shocks.

The impact of a permanent 20 per cent increase in the world price of energy, simulated using ToTEM, is illustrated in **Chart 2**. Three policy rules are used: the optimized IF rule, the optimized PLF rule, and fully optimal policy under commitment (labelled Optimal). Fully optimal policy is a natural benchmark: it represents the absolute best outcome that policy can achieve for a given model and loss function.[17] Regardless of the rule considered, an unanticipated rise in energy prices causes an immediate increase in the Canadian-dollar price of energy and, hence, in the overall CPI **(Chart 3)**.

The transmission of commodity-price shocks in ToTEM is discussed extensively in Murchison and Rennison (2006). For the purposes of this article, it is sufficient to highlight that slightly more than 25 per cent of the increase in the world energy price is offset (with the IF rule), in terms of the Canadian-dollar price, by an immediate and permanent appreciation of the Canadian dollar. As a result, the overall increase in the CPI is more muted than would be the case with a fixed exchange rate. As the exchange rate appreciation is gradually passed through to import and export prices, net exports weaken, and upward pressures on core CPI inflation decline.

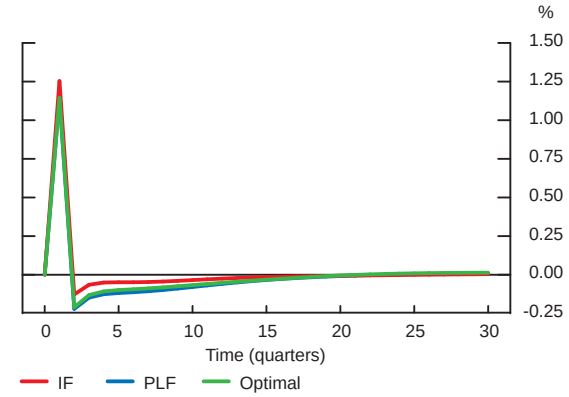
The responses of the IF and PLF rules to the shock are broadly similar: policy gradually tightens (years 1 and 2) and then loosens, in both cases by a modest

16 Coletti, Lalonde, and Muir (2008) also consider a more recent sample (1995 to 2006), nearly identical to that used by Murchison, in which the persistence of inflation is lower than over their full sample. As a result, the weight on lagged inflation in their NKPC is set to zero, and PLT dominates IT for all shocks, including relative-price shocks.

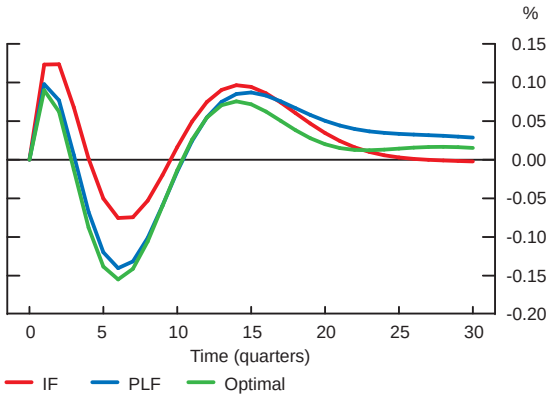
17 Optimal policy is computed in ToTEM following Dennis (2007). It is optimal under the assumption of no uncertainty other than that associated with imperfect knowledge of future shocks and the loss function given by equation (6). It would not generally be optimal in the presence of non-additive uncertainty, such as parameter, model, and real-time data uncertainty (Cateau and Murchison 2010).

Chart 2: Results of a permanent 20 per cent increase to the world price of energy in ToTEM

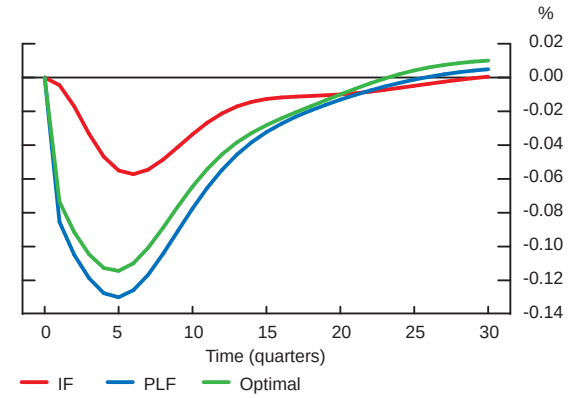
a. Total inflation



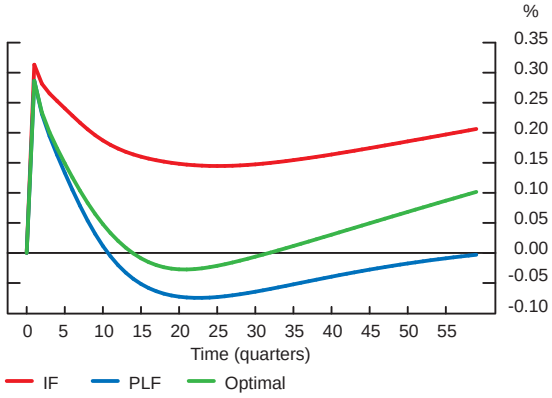
b. Output gap



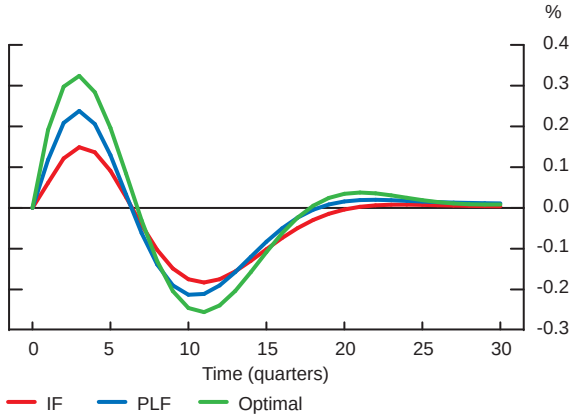
c. Core CPI inflation



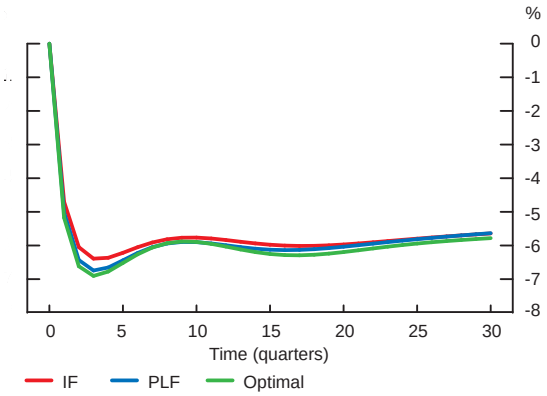
d. Log CPI level



e. Policy rate



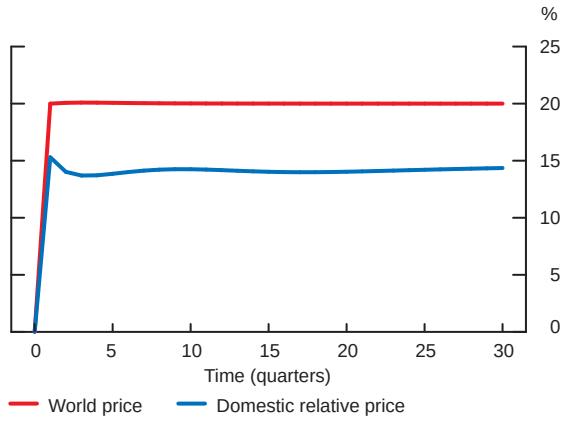
f. Real exchange rate



Note: A decrease represents an appreciation in the real exchange rate.

Source: Bank of Canada calculations

Chart 3: Energy prices



Source: Bank of Canada calculations

amount.[18] However, under the PLF rule, it tightens by roughly 50 per cent more at the peak, implying a smaller initial increase in the output gap and a sharper decline in core CPI inflation.[19] Higher real interest rates also cause a more pronounced appreciation of the exchange rate with the PLF rule, meaning that a smaller proportion of the increase in world energy prices gets passed on to Canadian consumers, and that net exports are weaker in year 2, relative to the IF rule.

Based on these simulation results, the intuition that PLT requires greater volatility in output to stabilize the price level in response to a terms-of-trade shock is validated by ToTEM. To restore the CPI to the target, the PLF rule creates roughly twice as much excess supply (at the trough) as the IF rule. In terms of overall loss, however, which also factors in CPI inflation and instrument volatility, the PLF rule (PLT) still outperforms the IF rule (IT) by 4 per cent, because the initial rise in inflation is smaller under PLT.[20]

To summarize, simulations with ToTEM find that PLT is well suited to handling energy-price shocks and relative-price shocks more generally[21] and that it comes very close to replicating fully optimal policy under commitment. In fact, **Chart 2** illustrates that while optimal policy represents a hybrid between the IF and PLF rules, in the short run, it follows the PLF rule much more closely. It is not until year 3 that optimal policy takes a more expansionary stance, thereby allowing the overall price level to rise permanently above control. Under the PLF rule, the CPI returns to the target near the end of year 3 but then remains below the target for several years. This undershooting of the price level is due to the high weight $(\rho = 0.98)$ on the lagged interest rate in the PLF rule and represents another example of the effect of introducing history dependence.

Simulations with ToTEM find that PLT is well suited to handling energy-price shocks and relative-price shocks more generally and that it comes very close to replicating fully optimal policy under commitment.

When all types of shocks are considered, Murchison shows that the median time required for the price level to return to target is substantially longer than the target horizon for inflation under IT, when optimized simple policy rules are considered. Specifically, it is shown that in a stochastic environment, with representative shocks drawn from the 1995–2008 sample hitting the economy each quarter, the median time required to return the price level to within ±0.5 per cent of the target is about 2.5 years,[22] about double that required to return year-over-year inflation to within ±0.1 percentage points of the target with an optimized IF rule.

As discussed in the previous section, responding to past economic conditions implies history dependence, which can have an important stabilizing effect on the economy when expectations explicitly take into account this feature of monetary policy. History dependence can be introduced directly, via the inclusion of lagged inflation in the policy rule (see example 2, **Chart 1**), or by responding to lags of the policy instrument itself (as in equations 3, 4, and 5). In all three studies cited here, the optimized IF rules respond positively to the level of the policy interest rate in the previous quarter, and the weights (captured by the parameter ρ) range from 0.68 to 1.1. In other words,

18 The shock pushes the Canadian economy into modest excess demand for about one year after the shock. As a result, even the IF rule initially tightens policy, despite the decline in pressures on core CPI inflation.

19 For simplicity, the price-level target in the PLF rule and the inflation target in the IF rule are both zero.

20 While the difference in the initial rise in inflation between the IF and PLF rules is small, loss is calculated using the squared deviation of inflation for each rule. Therefore, the larger the overall inflation response, the greater will be the loss difference, for a given difference in responses across rules. In this shock, the CPI inflation responses peak at between 1.0 and 1.25 percentage points above control, expressed at annual rates.

21 See Murchison (forthcoming) for additional examples.

22 Under the assumption of no future shocks. The choice of 0.5 per cent as the threshold is arbitrary but seems reasonable considering the unconditional variance of the price level under PLT, using the optimized PLF rule.

the similarity between the performance of the IF and PLF rules found in these studies may be partly due to the fact that an IF rule with a high value of ρ can closely mimic the behaviour of a PLF rule.

To explore the sensitivity of the results to the degree of interest rate smoothing, Murchison (forthcoming) and de Resende, Dib, and Kichian (2010) also compare optimized IF and PLF rules that restrict ρ to zero, while Murchison also explores rules with ρ equal to 0.8, which corresponds to the average of the historical estimates for Canada ("Constrained" in **Table 1**). In all cases, eliminating history dependence via interest rate smoothing penalizes the IF rules somewhat more than the PLF rules. Put a different way, rules that are already history dependent, owing to the inclusion of the price level, benefit relatively less from the additional history dependence introduced through the lagged interest rate term.

De Resende, Dib, and Kichian report that their preferred PLF rule generates a 5 per cent reduction in loss relative to the IF rule when $\rho = 0$, compared with no difference when $\rho > 0$. The corresponding numbers for Murchison are somewhat larger—15 per cent ($\rho = 0$) and 9 per cent ($\rho = 0.8$)—since interest rate volatility is explicitly penalized in equation (6) but does not generally appear in welfare-based loss functions.[23]

To summarize: When monetary policy commits to setting the current policy rate partly as a function of the past rate, in addition to the output gap and to a forecast of either inflation or the price level, then IF and PLF rules are fairly similar in terms of their economic-stabilization properties. When policy is restricted to responding only to the output gap and a forecast of either inflation or the price level, then PLF rules are found to dominate IF rules. This suggests that there may be modest economic gains, measured in terms of greater stability, associated with the adoption of a target for the price level rather than for the rate of inflation.

Other Considerations

Robustness

The discussion so far has emphasized the crucial link between the performance of history-dependent monetary policy, including PLT, and the presence of forward-looking price-setting behaviour in the economy. Steinsson (2003) shows that as the relative importance of forward-looking expectations declines in the economy, so do the benefits of fully returning the price level to control following a markup shock. Coletti, Lalonde, and Muir (2008) confirm the same basic result, using a more realistic quantitative model: the relative performance of an optimized PLF rule depends importantly on the weight on lagged inflation. This result is quite intuitive: when pricing decisions depend on past, as opposed to future, economic conditions, future monetary policy actions become less influential for current price-setting behaviour.

In a follow-up paper, using a version of BoC-GEM that explicitly models emerging Asia and the block of commodity-exporting countries, Coletti et al. (forthcoming) show that when inflation is partially backward looking and the short-run supply and demand curves for energy are highly inelastic, IT dominates PLT in response to energy-price shocks, albeit by a modest amount. They also explore the idea that the source of the shock driving the terms of trade may matter for comparisons of PLT and IT. For example, the authors also consider the impact of a permanent increase in global productivity on commodity-importing regions. This shock has important implications for both the price of Canada's exports (through higher energy prices) and for the price of imported goods (through a stronger exchange rate). In this instance, IT outperforms PLT by a significant margin, close to 25 per cent, which is substantially larger than in the case of an oil-supply shock. This is explained by two factors. First, in this version of BoC-GEM, a permanent shock to the demand for oil induces a more persistent response in the price of oil and in marginal cost than a permanent shock to the supply of oil. Second, as opposed to a supply shock, a demand shock increases both the price of oil and the price of non-energy commodities, which reinforces the effect of the shock on the marginal cost. As a result, the impact on marginal cost is larger and more persistent for a demand shock than a shock to the supply of oil. Given the very different results across the different types of shocks to the terms of trade, it would be very useful to have a better idea of the relative importance of these types of shocks for the Canadian economy.

Murchison (forthcoming) generalizes these results somewhat, showing that as past economic conditions become relatively more important than future conditions to current private sector decisions, the relative performance of PLT tends to diminish, since the expectations channel becomes relatively less influential.[24]

23 Responding to the lagged interest rate introduces additional inertia in interest rates, which reduces the variance of interest rate changes.

24 Short-run adjustment costs, rule-of-thumb behaviour, and habit persistence in consumption all tend to increase the relative importance of past economic conditions.

For instance, when households place a high weight on smoothing the growth rate of consumption, the level of previous consumption becomes a more important determinant of current consumption, and the future path of real interest rates becomes relatively less important. Similarly, as short-run adjustment costs associated with changing the relative intensities of factor inputs, such as installed capital, increase, the level of the capital stock in the previous period becomes a more important determinant of the current capital stock.

The overall robustness of PLT will depend on all of the structural parameters that govern the dynamics of the model in question, as well as the overall degree of uncertainty regarding their true values. In a related paper, Cateau, Desgagnés, and Murchison (forthcoming) derive optimized inflation- and price-level-forecast rules for ToTEM and compare their performance across 5000 different parameterizations of the model.[25] They conclude that, overall, optimized PLF rules are more robust to this form of uncertainty than optimized IF rules.

What is the appropriate price index to target?

In a simple one-good model with no relative prices, the choice of the price index is trivial. However, in more realistic multi-good models, such as those reviewed here, the question of what constitutes an ideal price index to target in a PLT regime can be considered from the perspective of minimizing either an ad hoc loss function, such as equation (6), or a welfare-based loss function. De Resende, Dib, and Kichian (2010) compare the performance of simple rules across five distinct sectoral price indexes—the consumption sector (CPI), non-tradables, tradables, manufacturing, and import prices—and find that targeting the CPI maximizes household welfare. Indeed, CPI targeting comes quite close to replicating the level of welfare that would obtain in the absence of nominal-price rigidity. The authors attribute this result to the inclusion of capital-adjustment costs in their model. Specifically, they show that when the cost of adjusting the capital stock in the non-tradable goods sector is low, it is optimal to target the price level in this sector. This result is consistent with previous work in the literature (Erceg, Henderson, and Levin 2000), which shows that monetary policy should aim to stabilize the price level in the sector with the stickiest prices, since it is precisely this stickiness that leads to suboptimal resource allocation and, hence, reduced welfare.[26] De Resende, Dib, and Kichian show that this result need not hold when other sources of rigidity are included in the model.

Shukayev and Ueberfeldt (2010) go a step further and compute the index weights for the eight major sub-components of the CPI that maximize the expected utility of the representative household in their model. In theory, these weights could differ substantially from the expenditure-based weights used by Statistics Canada if there are significant differences in price stickiness across the various components of the CPI. Using a model that includes sector-specific shocks to productivity and price markups, they find the welfare gain from using a PLF rule that responds to the ideal index, relative to the expenditure-based index, to be small.

Conclusion

This article reviews recent Bank of Canada research on the relative merits of price-level targeting and inflation targeting for a small open economy that is subject to large and persistent terms-of-trade shocks. While the quantitative results are mixed and somewhat dependent on the specific features of the model employed and the calibration of expectations, the balance of evidence suggests that PLT and IT, implemented through simple PLF and IF rules, are fairly similar in their ability to stabilize inflation, the output gap, and interest rates, although PLF rules generally perform better. Furthermore, this conclusion is robust to the inclusion of several types of relative-price shocks, including shocks to the terms of trade, although the results in Coletti et al. (forthcoming) indicate that the underlying source of terms-of-trade movements may matter for this assessment. Finally, the research suggests that, conditional on adopting PLT, the overall CPI would represent close to an ideal index to target.

25 These parameters are drawn from the Bayesian posterior distribution of the estimated parameters.

26 The basic intuition for this stylized result is straightforward: if monetary policy can fully stabilize the price level in that sector, the welfare consequences of nominal rigidity become zero, because firms have no incentive to change prices.

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Should Monetary Policy Be Used to Counteract Financial Imbalances?

Jean Boivin, Deputy Governor; Timothy Lane, Deputy Governor; and Césaire Meh, Canadian Economic Analysis

- *The recent financial crisis has revived the question of whether monetary policy should and could do more to restrain a buildup of financial imbalances.*
- *Effective supervision and regulation are the first line of defence against financial imbalances. An important question is whether they should be the only one. Moreover, the interaction between such prudential policies and monetary policy could have important implications for the appropriate use of both kinds of policy.*
- *This article argues that the case for monetary policy to lean against financial imbalances depends on the sources of the shock or market failure and on the nature of the other regulatory instruments available.*
- *To the extent that financial imbalances are specific to a sector or market and that a well-targeted prudential tool is available, monetary policy may play a minor role in leaning against the imbalances. However, if the imbalances in a specific market can spill over to the entire economy and/or if the prudential tool is broad based, it is more likely that monetary policy will have a role to play. In such a case, there may be a need to coordinate the use of the two policy instruments.*

The global financial crisis of 2007–09 serves as a powerful reminder that even the most sophisticated financial systems may be subject to virulent crises that can have a huge impact on the real economy. In the recent crisis, the monetary policy response was forceful: interest rates were moved quickly to historic lows, and unconventional policies were implemented in a number of countries. Together with fiscal stimulus and direct support for financial systems in numerous countries, this response was effective in "cleaning up" after the crisis had broken—contributing to the start of an economic recovery and creating conditions for rebuilding damaged financial systems. Nonetheless, the economic costs of the recession were very large, and many of the policy measures themselves had significant costs.

This experience has renewed attention on crisis prevention. While the main focus has been on strengthening financial supervision and regulation, preventing future crises can also be relevant for monetary policy. Considering that the vulnerabilities underlying the financial crisis developed against the background of a long period of macroeconomic stability raises the question of whether a different set of macroeconomic policies could have helped to prevent the crisis. The experience also gives fresh significance to an old question: should monetary policy, through movements in the policy interest rate, seek to counteract financial imbalances such as those associated with asset-price bubbles or unsustainable credit expansion? In other words, as William White (2009) put it, "Should monetary policy lean or clean?" Should it lean against financial imbalances as they are building up, or should its role be limited to cleaning up the fallout by mitigating the macroeconomic consequences after the imbalances unwind?

As the recent crisis has demonstrated, some element of cleaning up in the wake of a crisis is unavoidable: the central bank's responsibility for price stability dictates that policy is eased in the wake of a crisis that may have powerful contractionary effects on economic activity and inflation. However, systematically easing monetary policy after crises creates a policy asymmetry that, by influencing expectations, may contribute to the buildup of financial imbalances. If investors expect monetary authorities to ease policy in the event of any crash, that expectation may, in effect, establish a floor for asset prices, which creates incentives for excessive risk taking.[1] Since the central bank cannot credibly commit not to clean, it has been argued that, to avoid such a policy asymmetry, monetary policy should act pre-emptively to lean against the buildup of financial imbalances (see White 2009 for a survey of the literature). It is therefore the *desirability* of such leaning that has been at the centre of the debate and that is the primary focus of this article.

The conventional theoretical framework used to study monetary policy—in which social welfare is maximized by achieving stable output and low inflation—provides a direct answer to the question of whether monetary policy should respond pre-emptively to financial sector developments to the extent that these developments are expected to affect output and inflation. In principle, this means that, in responding to financial imbalances, the central bank should take into account not only their direct effect on output and inflation, but also any macroeconomic effects that could materialize later on, when these imbalances unwind. There is thus no inherent inconsistency between inflation targeting and the use of monetary policy to counteract financial imbalances, provided the time horizon is long and flexible enough. From this perspective, the lesson from the recent crisis is not that we need a different policy framework, but that we need better analysis of the macroeconomic effects of financial imbalances (Svensson 2002, 2009).

In practice, however, taking account of financial imbalances in the context of inflation targeting could require changes in how we think about monetary policy. While monetary policy does include an assessment of the risks around the baseline, the primary focus is on the balance of the risks. An emphasis on financial stability, in contrast, focuses on what can be done to mitigate the various risks, including those associated with low-probability "tail events." This revised way of thinking about monetary policy requires different tools. The linear, or linearized, models with symmetric shocks that are generally used to inform monetary policy decisions in most cases explicitly rule out the possibility of crises that may occur at an uncertain date.[2] Conversely, conducting inflation targeting in the context of a highly non-linear model that does capture the possibility of bubbles, credit booms, and other imbalances that lead to crises would be associated with a different focus for monetary policy discussions and might require another practical decision-making framework.

In practice, however, taking account of financial imbalances in the context of inflation targeting could require changes in how we think about monetary policy.

The central question is whether it would be desirable to undertake this task. A general concern is that giving monetary policy explicit responsibility for financial stability would result in a lack of clarity regarding the objectives of monetary policy, and would possibly undermine the credibility of the inflation objective. Arguably, establishing a single, clear objective is critical for monetary policy, because of the importance of expectations in determining actual inflation. Policy credibility cannot be taken for granted, in view of the dynamic inconsistency of optimal monetary policy (Kydland and Prescott 1977; Barro and Gordon 1983). It could prove very challenging for a central bank with multiple objectives, but only a single instrument, to communicate credibly about how it is delivering on its responsibility for price stability.[3]

Another potentially important cost of leaning against financial imbalances stems from the difficulty of identifying them and of calibrating an appropriate response. If financial imbalances are falsely identified, responding to them through monetary policy could induce undesirable economic fluctuations (Greenspan 2002; Bernanke and Gertler 1999). Moreover, to the extent that financial imbalances are sector-specific, monetary policy may be too blunt an instrument for addressing them. The interest rate has economy-wide consequences for inflation and output; tightening monetary policy in response to the building up of persistent financial imbalances in one sector could

1 This type of policy asymmetry is sometimes characterized as "the Greenspan put."

2 For instance, the dynamic stochastic general-equilibrium models prevalent in macroeconomic analysis incorporate transversality conditions that rule out unsustainable movements in prices and other variables, such as asset-price bubbles and debt crises.

3 See Bank of England Discussion Paper (November 2009) for a recent summary of this case.

force inflation to persistently undershoot its target (Kohn 2008; Bean 2009; Dale 2009; and Carney 2009).

As well, any possible role for monetary policy in restraining the buildup of financial imbalances needs to be considered in relation to other available policy instruments—in particular, to prudential policies, that is, the supervision and regulation of the financial system. While such policies have traditionally focused on ensuring the soundness of individual financial institutions and market infrastructure and on the integrity of markets, there has recently been greater emphasis on a system-wide approach that would focus on the stability of the whole financial system. Under this approach, supervision and regulation would aim to make the financial system more robust and would lean against the financial cycle. In the aftermath of the recent crisis, promising initiatives have been launched to develop a framework for system-wide supervision and regulation and to upgrade this toolkit. If these initiatives are successful, they could obviate, or substantially reduce, the need for monetary policy to counteract financial imbalances.

It has thus been argued that system-wide supervision should be the first line of defence against financial instability (Carney 2009; Bernanke 2010; and Kohn 2010). But designing and implementing this new toolkit is a formidable challenge, and there is considerable uncertainty about what will realistically be feasible. While there are many promising proposals on the table (Basel Committee on Banking Supervision 2009)—indeed, this is at the core of the G-20's agenda—much remains to be done.

Granted that appropriate supervision and regulation are the *first* line of defence against financial imbalances, the key question is whether they should be the *only* one. In this context, developing a view on whether monetary policy should lean against financial imbalances requires that we first examine the interaction between the effects of prudential tools and those of monetary policy on financial imbalances that stem from various sources.

In this article, we present two illustrations of these interactions. To do so, we explore the role of monetary policy in two models in which financial imbalances stem from different sources, for which different prudential tools are available. It is important to note that these two examples should be seen merely as useful illustrations and by no means as the final word on the relationship between monetary policy and financial imbalances. In particular, the models used examine financial shocks in the context of linear models and do not explicitly incorporate the possibility of bubbles driven by self-fulfilling expectations, which are often alluded to in the "lean or clean" debate. Nonetheless, these models serve to illustrate a few initial principles that are of broader relevance.

Appropriate supervision and regulation are the first *line of defence against financial imbalances, the key question is whether they should be the* only *one.*

Both examples illustrate that the effectiveness of monetary policy in countering financial imbalances depends on the nature of the shocks, the influence of monetary policy and prudential tools on these imbalances, and the interactions between them. In particular, where financial imbalances reflect specific market failures and regulatory policies can be targeted directly to such failures, monetary policy is less likely to play a useful role. Monetary policy will more likely have a role to play when financial imbalances stem from economy-wide factors.

Of course, in practice, financial imbalances in the economy may well be associated with a combination of factors, and exuberance that is initially contained within specific sectors could spread more broadly through the economy. That was almost certainly the case in the run-up to the 2007–09 crisis, which reflected the complex interplay of imbalances among mortgage markets in the United States and other countries, securitized lending markets, credit default swaps and other derivatives markets, and the banking systems of the United States and some other countries. Thus, the examples presented here, while relevant, should be seen as individual building blocks for analyzing the interaction between monetary and prudential policies.

The rest of this article is organized as follows. First, the two examples are discussed in detail. Then, more general lessons are drawn by comparing these examples and highlighting the likely implications of two features that are absent from them, i.e., the risk-taking channel and the fact that financial imbalances are not easily detectable. The final section ends with some conclusions.

Exuberance in the Housing Sector

A credit-fuelled housing bubble is a particularly relevant example of a financial imbalance. This section considers the case of over-exuberance in the housing sector, represented as a temporary increase in the perceived value of housing that results in a short-term surge in mortgage credit.[4] This example is calibrated to produce housing-market dynamics that are roughly similar to those of the housing market in the United States in the run-up to the recent crisis. Specifically, the size of the shock is set at 5 per cent of the value of housing collateral; this leads to an average increase in mortgage debt in the first year of about 16 per cent, comparable with the average annual growth rate of mortgage debt over the 2003–06 period.

We evaluate the relative merits of using monetary policy to contain this imbalance and compare it with a well-targeted prudential instrument—namely, an adjustment in the mortgage loan-to-value (LTV) ratio. In the policy discussion of counter-cyclical system-wide prudential tools, several indicators of financial imbalances have been suggested, such as debt growth, the debt gap (debt relative to trend), the ratio of debt to GDP, and asset prices. In this example, the LTV ratio can be varied counter-cyclically as a function of the aggregate size of debt relative to trend.

The economic environment used, from Christensen and Meh (2010) and based on Iacoviello (2005), is a standard New Keynesian model with heterogeneous agents, where housing equity influences the borrowing capacity of households. This class of models is widely used in the academic literature and in many policy institutions. See, for example, the *World Economic Outlook* for October (International Monetary Fund 2009). This model implies that house prices have macroeconomic effects through the influence of the borrowing constraints on consumption.

Intuitively, the financial sector in this model works as follows. The amount that households can borrow is constrained by the collateral they can pledge, which is tied to housing values. A rise in house prices increases the value of the collateral held by households and improves the state of household balance sheets. This improvement increases the amount that households can borrow for current consumption and for housing investment.

The model captures an important feedback loop that amplifies the mechanism just described: as house prices rise and balance sheets improve, the increased demand for housing raises house prices even higher. The rise in house prices causes additional improvements in balance sheets, which fuel further increases in consumption and housing investment. Any shock hitting the economy is thus amplified through this mechanism.

A similar model, estimated using post-1980 Canadian aggregate data, captures the relative standard deviations of macroeconomic variables relative to GDP (Christensen et al. 2009). An important feature of this model is that it captures the correlations between consumption and GDP and between consumption and house prices that are produced by a reduced-form vector autoregression. The steady-state level of the LTV ratio is set to 0.8.

The model is used to examine the effect of a financial imbalance—characterized as a significant and sustained deviation of asset prices or financial indicators from longer-run trends—and the appropriate policy response.

Two policy tools are available in this model: monetary policy and prudential policy. Monetary policy is conducted mainly by following a *Taylor rule* with interest rate smoothing. Such a rule stipulates that the monetary authority adjusts the policy rate in response to deviations of the inflation rate from a target and output from potential (the output gap). When conducting policy experiments, an *augmented Taylor rule* is also considered, where the Taylor rule responds to indicators of financial imbalances (such as a divergence of actual household debt from its trend value) in addition to inflation and the output gap.

The model also allows for the possibility of using the prudential instrument, the LTV ratio, in a counter-cyclical manner. The maximum LTV ratio can be lowered when credit rises above its trend value, and raised when credit falls below its trend.

4 A similar strategy is followed by Gertler and Karadi (2010) and Gertler and Kiyotaki (2010).

Financial regulation can be more effective than monetary policy in addressing financial imbalances

The model is used to highlight the relative merits of prudential policy and monetary policy in dealing with financial imbalances. Three main points emerge from this policy experiment and are illustrated in **Chart 1** and **Chart 2**.

The first point is that if exuberance in the housing market is not addressed directly through either policy instrument, it does not have a significant impact on inflation and output, but does have a large impact on household debt. For example, **Chart 1** illustrates that after a 5 per cent shock to collateral, inflation and output barely change, even though mortgage debt increases substantially—at a rate in the first year that is comparable with the trend rate in the United States during the mid-2000s. The effects of this shock on output and inflation are small because the shock affects only a small set of the population (credit-constrained borrower households).

The second point is that if, in addition to inflation and the output gap, the monetary authority reacts explicitly to credit conditions, a sharp increase in interest rates is required to stem the buildup of credit, and this increase will result in a significant drop in inflation and output. The high levels of indebtedness and interest rates generate a stronger drop in consumption because of the higher cost of servicing the debt. Since debt contracts are nominal, this effect is also compounded by the debt-deflation effect,

Chart 1: Effects of a positive 5 per cent shock to housing collateral with no counter-cyclical LTV ratio

Percentage deviation from steady state

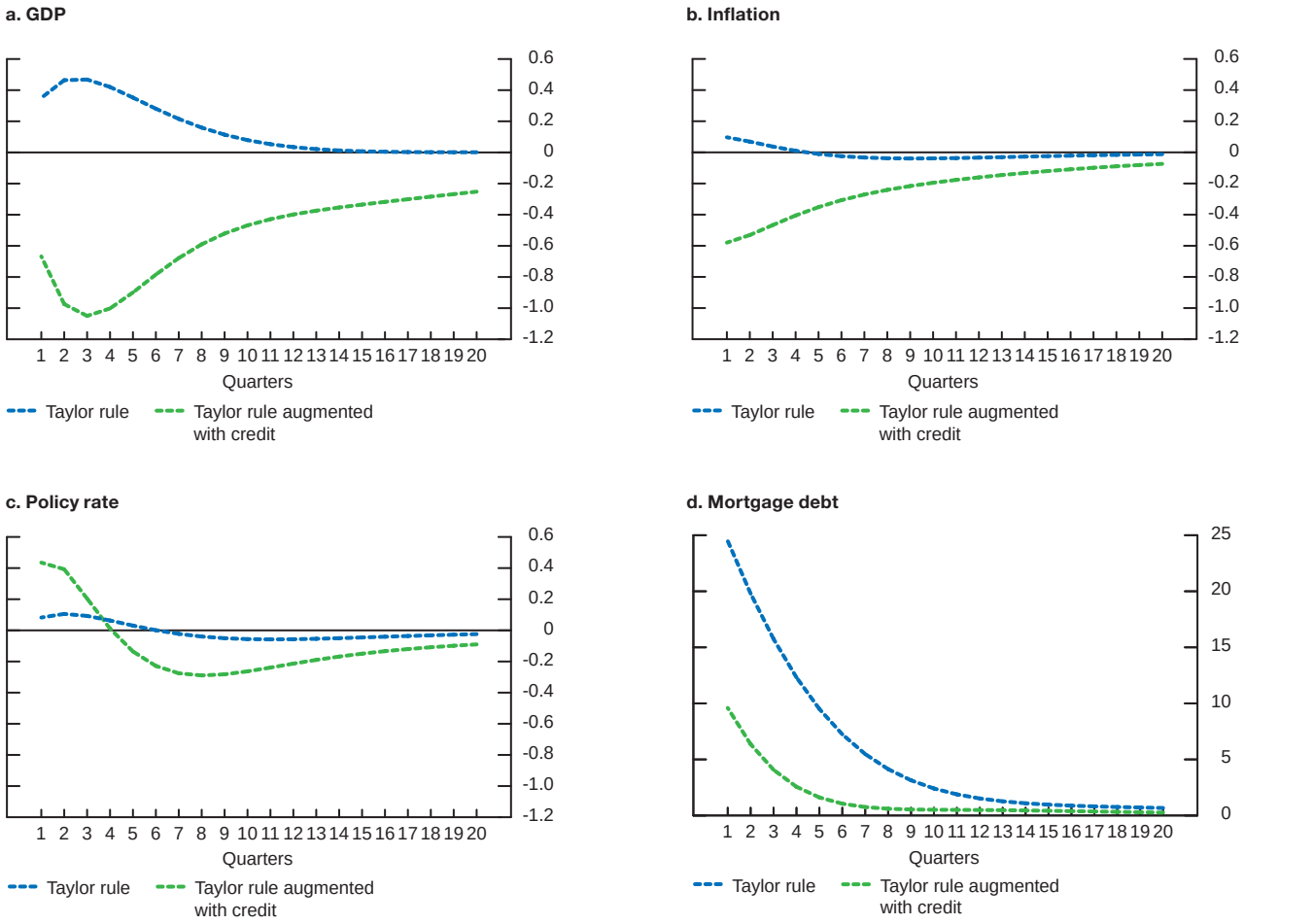
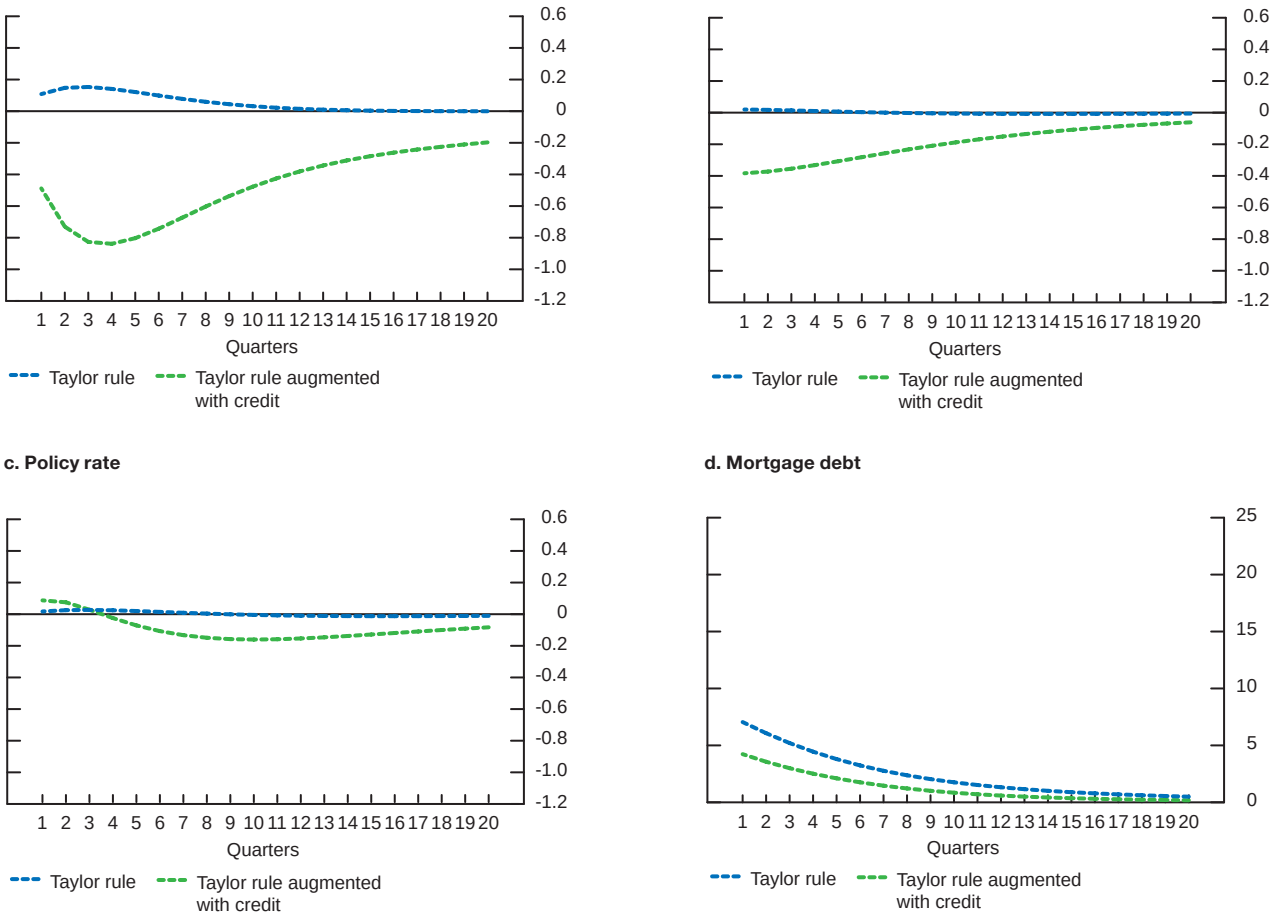


Chart 2: Effects of a positive 5 per cent shock to housing collateral with a counter-cyclical LTV ratio present

Percentage deviation from steady state



because inflation unexpectedly falls below target. This can be seen in **Chart 1**, where the LTV ratio is assumed to be fixed, whereas monetary policy reacts explicitly to deviations of credit from its trend value. In this illustration, dampening the expansion of mortgage debt to 10 per cent above trend comes at the cost of a decrease in output and inflation of up to 1.3 per cent and 0.5 per cent, respectively. This illustrates the idea that monetary policy might be too blunt a tool to stem financial imbalances emerging in a specific sector (as stressed, for instance, in Bank of England 2009).

The third point is that a prudential policy in the form of a counter-cyclical LTV ratio is effective in addressing financial imbalances in the housing market without resulting in larger, and persistent, undershooting of the inflation target, and with less impact on economic activity. This can be seen in **Chart 2**, where there is a counter-cyclical regulatory policy, and monetary policy follows the simple Taylor rule. As the chart illustrates, compared with a monetary policy targeted to achieve a specific financial-stability objective, a counter-cyclical LTV ratio on its own achieves the same dampening of mortgage debt, with fewer adverse effects on inflation and output. The decrease in the LTV ratio in this scenario is up to 2 per cent, suggesting that the greater the adjustment to the LTV, the less monetary policy needs to raise the interest rate and the less inflation will undershoot the target.

This example suggests that when financial imbalances come from a specific sector (e.g., housing), regulation targeted to that sector can be effective, while leaning with monetary policy would generate

unnecessary economic fluctuations. Specifically, responding to exuberance in the housing market, or in any sector, may come at the cost of the stability of economic activity and inflation. An important limitation of this analysis is that while it models a buildup of mortgage debt, it does not capture the possibility that such a buildup could later unwind in ways that cause damage to the financial system and the economy—i.e., a "boom-bust cycle." It therefore understates the benefits of restraining this type of buildup.

When financial imbalances come from a specific sector (e.g., housing), regulation targeted to that sector can be effective, while leaning with monetary policy would generate unnecessary economic fluctuations.

Exuberance in the Banking Sector

This section presents a contrasting illustration where, at least in principle, monetary policy could play a useful role in dealing with financial imbalances, even when a prudential instrument is also available. In the example presented, financial imbalances emanate from the banking sector, and the available prudential tool is a *broad-based,* counter-cyclical capital requirement that reacts to deviations of actual aggregate bank credit from its trend value. The example is also relevant to analyzing one element of the recent crisis, the importance of excessive banking system leverage in transmitting financial stress during the crisis.

In the model used, from Meh and Moran (2010), the condition of bank balance sheets is determined endogenously and has important economic implications. The key innovation of this model is in capturing the role of bank capital in the amplification and propagation of shocks. The model incorporates several nominal and real frictions, in the spirit of state-of-the-art New Keynesian models.

At the heart of the model is an optimal configuration of financial contracts under asymmetric information, building on the seminal work of Holmström and Tirole (1997). Banks intermediate funds between dispersed investors, who are the ultimate lenders, and firms, who are the ultimate borrowers and producers of capital goods. A key function of banks is to monitor firms on behalf of dispersed investors. The intermediation process is complicated by two sources of moral hazard. The first affects the relationship between banks and firms and arises because firms may not exert an optimal level of effort, since effort is costly and not publicly observable. To mitigate this problem, banks can monitor the behaviour of firms and require that they invest their own funds in projects.

The second source of moral hazard pertains to the relationship between banks and investors and stems from the fact that banks (to which dispersed investors delegate the monitoring of firms) may not monitor with optimal intensity, since monitoring is costly and is not publicly observable. In response, investors will provide loanable funds only to banks that are well capitalized. All things being equal, a higher level of bank capital lessens the moral-hazard problem between banks and investors and increases the ability of banks to attract loanable funds.

In the model, banks hold capital both to mitigate these agency problems and to satisfy a regulatory capital requirement (see Christensen, Meh, and Moran 2010). This capital requirement can be time varying and adjusted counter-cyclically with bank-credit conditions. Raising new bank capital is costly, however, and this implies that, in the short run, bank capital is determined mainly by earnings. In the model, the overall effects of shocks depend on the relative amount of bank capital and on the net worth of firms.

Monetary policy is conducted following a Taylor-type rule, as in the previous example. But the financial variable to which monetary policy could react is related to a persistent deviation from the trend of bank business credit. An exogenous monetary policy, where the nominal interest rate is held constant in the face of the temporary shock to the banking sector, is also considered.

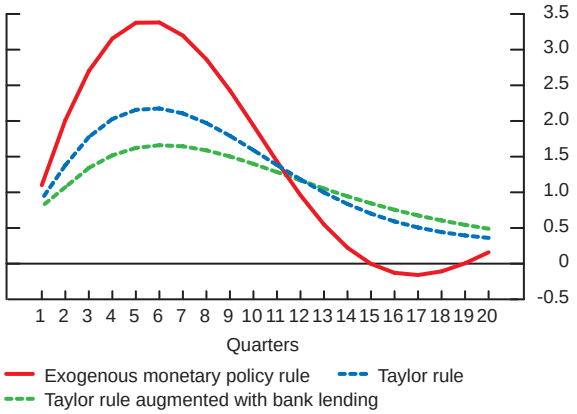
Financial imbalances are represented by an increase in the perceived quality of the assets of financial intermediaries (see Gertler and Kiyotaki 2010). Referred to as bank-capital shocks, these lead to an increase in the capital positions of banks, which, in turn, generate a rise in bank lending and a fall in credit spreads (such as occurred in the mid-2000s). The size of the shock is set at a 5 per cent rise in bank capital to replicate the magnitude of lending and credit spreads during the mid-2000s.

Three findings arise from this example. The first is that exuberance in the banking sector, in the absence of a policy response, can have major effects on output

Chart 3: Effects of a positive 5 per cent shock to bank capital with no counter-cyclical capital requirement

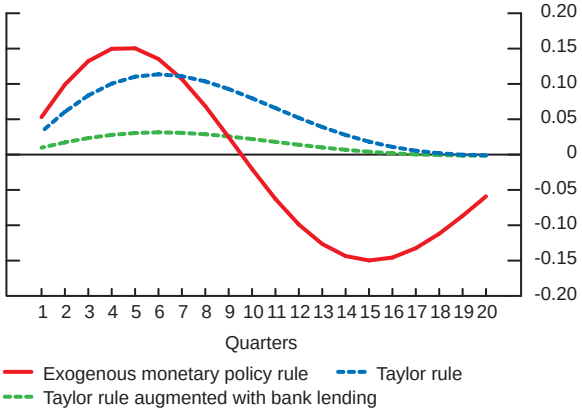
Percentage deviation from steady state

a. GDP



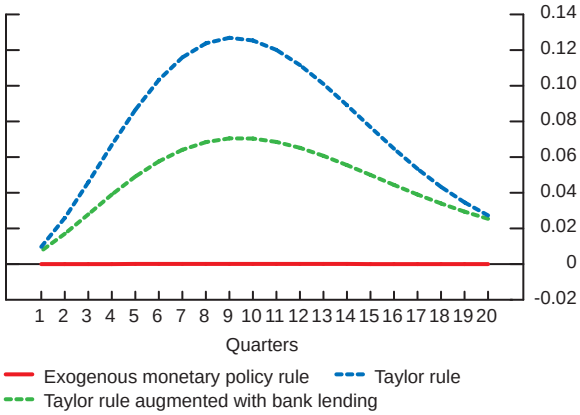
Exogenous monetary policy rule — Taylor rule
Taylor rule augmented with bank lending

b. Inflation



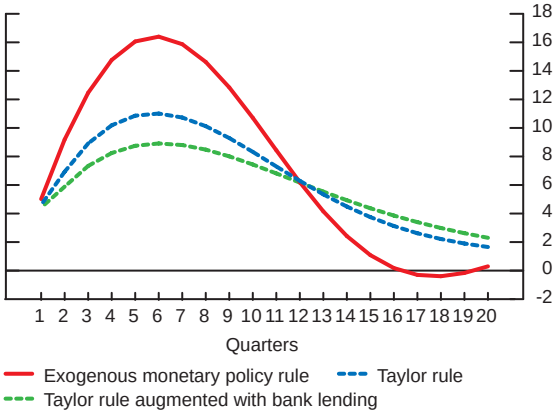
Exogenous monetary policy rule — Taylor rule
Taylor rule augmented with bank lending

c. Policy rate



Exogenous monetary policy rule — Taylor rule
Taylor rule augmented with bank lending

d. Bank lending



Exogenous monetary policy rule — Taylor rule
Taylor rule augmented with bank lending

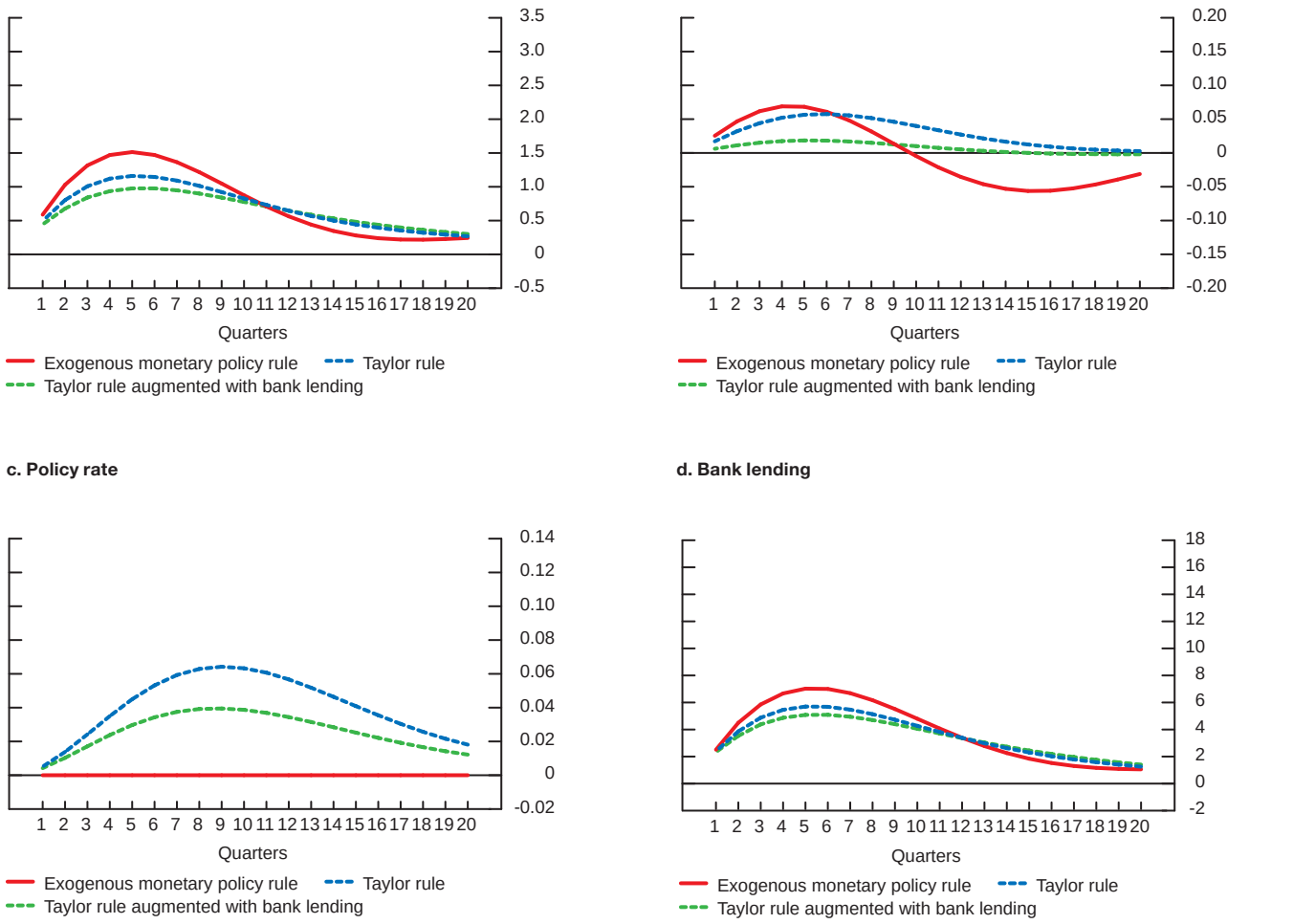
and inflation, as well as on bank lending. In particular, it leads to important fluctuations in inflation and output. This can be seen in the case where monetary policy is exogenous and the capital requirement is constant. As illustrated in **Chart 3**, the exuberance in the banking sector leads to increases of up to 16 per cent in lending, 3 per cent in output, and 0.2 per cent in inflation. Nominal wage rigidities induce inertia in inflation and thus limit the increase in inflation.[5] Developments in the banking sector spill over to the whole economy because of the banking sector's important role in financing the production of the investment good in the model economy. Thus, a rise in the availability of bank credit increases the amount of capital goods, and this has important implications for the entire economy.

The second result is that monetary policy can be used not only to stabilize inflation and output, but also to mitigate the effects of financial imbalances on bank lending. This can be seen in **Chart 3**, when monetary policy is adjusted to counter such imbalances, but regulation is not. When monetary policy reacts to both inflation and the output gap, bank lending is dampened by up to 10 per cent, and monetary policy is able to reduce the fluctuations in inflation and output. When the policy rate also reacts explicitly to credit, the increase in bank lending that results from the exuberance in the banking sector is even smaller, and inflation and output are further stabilized. Thus, in this example, monetary policy can help to dampen the

5 The real side of the model is based on Christiano, Eichenbaum, and Evans (2005).

Chart 4: Effects of a positive 5 per cent shock to bank capital with a counter-cyclical capital requirement present

Percentage deviation from steady state



effects of financial imbalances without diluting the price-stability objective or creating large losses in output. This is consistent with the standard result that monetary policy should respond pre-emptively to developments that affect output and inflation.

The third finding is that regulation in the form of a counter-cyclical capital requirement contributes to further attenuate the fluctuations in inflation and output **(Chart 4)**; alone, it is not as effective as monetary policy. In fact, when dealing with these types of financial imbalances, a counter-cyclical capital requirement and monetary policy complement each other. For instance, in the presence of a counter-cyclical capital regulation, a smaller increase in the interest rate relative to the case with no counter-cyclical capital requirement is needed to stabilize inflation and output, following the development of such financial imbalances. Note also that, in the model economy, forward-looking and rational agents are aware that the central bank will increase the policy rate in the wake of exuberance in the banking sector; as a result, they limit their borrowing and this, in turn, leads to a smaller increase in interest rates (the expectations channel). Moreover, for this example, the steady-state level of the capital requirement is equal to 0.10, and the counter-cyclical capital requirement changes over a range of plus or minus 2 percentage points around this steady state.

In this example, financial imbalances have significant aggregate effects on the economy, and the available prudential policy is relatively *broad based*. In such a case, prudential policy may not be sufficient, and

monetary policy has an important role to play in leaning against these financial imbalances. Prudential policy and monetary policy are therefore complementary tools to stabilize economic activity and reduce the effects of the financial imbalances.

When Should Monetary Policy Lean against Financial Imbalances?

The two examples just discussed, while quite simplified, serve to illustrate the point that the appropriate response of monetary policy to financial imbalances depends on the nature of the imbalances, as well as on the alternative policy instruments available. By comparing the distinguishing features of the two examples, it is possible to go further to identify some factors that influence whether monetary policy should play such a role in practice.

Is the blunt nature of monetary policy a definitive argument against leaning?

As mentioned in the introduction, one argument against using monetary policy to lean against financial imbalances is that it is too blunt an instrument. The logic behind this argument can be seen in the first example, where financial imbalances are contained within a specific sector and do not have a significant short-run impact on the aggregate economy. Responding with monetary policy will generate a material reduction in output and inflation. In that sense, monetary policy is a blunt tool.

But the second case provides a counter-example. It suggests that if the imbalance has a material aggregate economic impact, monetary policy may be effective in countering it. Moreover, if the alternative prudential tool is broad based in nature, it could be equally blunt. In that case, the bluntness argument applies to both monetary policy and prudential policy, and therefore bluntness may not be a strong argument against using monetary policy to lean against financial imbalances.

An interesting case arises when the financial imbalances are such that they have a negligible impact on the aggregate economy in the short run, as in the first example, and when the only available prudential tool is broad based (and, hence, not well targeted to the sources of the imbalances). This is a case in which both monetary policy and the prudential tool are blunt instruments, and their use to counter financial imbalances would cause inflation to deviate from the target for some time and could undermine the credibility of the inflation objective.

This does not necessarily mean that monetary policy should not be used. But a trade-off arises: inflation rises above the target in the short run even if one tool does a better job of hitting the inflation target in the long run. Because of modelling challenges, the simple models considered in this article ignore the crisis dynamics that could result from a persistent buildup of imbalances in one sector. As the recent crisis made clear, however, imbalances in one sector can indeed eventually crash and spill over into the entire economy. Responding to sector-specific imbalances can (and should) be justified by a desire to stabilize the aggregate economy. Whether the resulting reduction in output and inflation is acceptable would depend on the success of such an action in helping to prevent a crisis down the road.

But a trade-off arises: inflation rises above the target in the short run even if one tool does a better job of hitting the inflation target in the long run.

Does a well-targeted prudential tool obviate the need for monetary policy action?

One critical determinant of the appropriate monetary policy response to financial imbalances, evident in the first example, is the availability of alternative prudential policy instruments that can address such market failures at their root. It is thus important to ask how effective targeted prudential policies are likely to be.

Since imbalances can potentially arise in many areas of the financial system, not one, but a whole array of prudential tools may be required to target them. The effectiveness of such tools can change over time: given the ability of financial markets to adapt quickly to a changing environment (including by circumventing existing regulation), the tools would themselves need to adapt. Moreover, the authorities responsible for supervision and regulation would require the scope to adjust the parameters of their policies to target emerging financial imbalances. In practice, such use of prudential policies may be constrained by the need to maintain a stable regulatory environment for financial institutions and markets; the desire to create

a level playing field; and uncertainty with regard to the effectiveness of regulation in achieving system-wide objectives. These are important challenges, and the configuration of prudential tools that are used will necessarily reflect various compromises. In most cases, the goal of keeping things sufficiently straightforward and manageable will likely lead to a set of simple and stable tools. Moreover, because the objective is to smooth the financial cycle as a whole, the prudential instruments would need to be applied broadly to financial intermediaries and markets across the whole financial system. There will also be a range of instruments and policies, some directed at financial institutions (such as capital requirements) and others at markets (such as haircuts). Despite this diversity, it is unlikely that these instruments can be fine-tuned to fully address imbalances emerging in particular financial sectors and markets.

Prudential tools are a very important addition to the policy toolkit, and policy-makers must devote the energy required to developing them. Yet, although prudential tools will be always helpful to prevent and address financial imbalances, they might not be sufficient in every case. The extent to which monetary policy will play a role in mitigating financial imbalances is not clear yet, but it should be an important part of the discussions concerning potential improvements to monetary policy frameworks.

Features Absent from the Models: What Are the Likely Implications?

The two examples discussed here are instructive, but they do not include all the features that might be important to the question under discussion. Some of the missing features, such as the absence of boom-bust dynamics in asset prices and financial variables, were discussed in the previous section. Two additional important elements should be highlighted: (i) the risk-taking channel of monetary policy and (ii) the possibility that financial imbalances may not be detected in time.

The risk-taking channel of monetary policy

It is possible that small changes in the policy rate might have a much larger effect than assumed in the examples considered. This is particularly the case when the risk-taking channel of monetary policy is present. It has been argued that the stance of monetary policy may itself lead to excessive risk taking by economic agents, which, in turn, can lead to financial instability. In particular, some observers (such as White 2006, 2009) have argued that interest rates that were kept too low for too long were an important factor in setting the stage for the 2007–09 crisis.

Specifically, monetary policy could influence the degree of risk that financial institutions decide to bear by influencing their perception and pricing of risk (Adrian and Shin 2009; Borio and Zhu 2008). This can take place through three broad types of mechanisms: (i) the perceived predictability of monetary policy, (ii) the search for yield, and (iii) the insurance effect of monetary policy. The first two mechanisms incite more risk taking in a low-interest-rate environment, while the third provides incentives for financial institutions to take more risks through the moral hazard created by the authorities' perceived reaction function. These three mechanisms can lead financial institutions and economic agents to take on too much leverage and the associated maturity mismatches, which, in turn, can generate financial imbalances. While there is some empirical evidence suggesting that such effects may have been at play prior to the recent crisis, the quantitative importance of the risk-taking channel remains largely unclear. Nevertheless, to the extent that the risk-taking channel is operative, it implies that the stance of monetary policy may contribute to excessive risk-taking behaviour and to the buildup of financial imbalances. This would strengthen the case for leaning against financial imbalances with monetary policy.

Monetary policy could influence the degree of risk that financial institutions decide to bear by influencing their perception and pricing of risk.

What if financial imbalances cannot be detected?

As mentioned in the introduction, one important argument against using monetary policy as a tool in these situations is that financial imbalances cannot be detected with certainty. This uncertainty applies not only to monetary policy, but also to prudential policy, and should play a role in determining how forcefully to react to the prospect of building financial imbalances.

Recent research at the Bank for International Settlements shows that our ability to detect imbalances may have improved. In any case, because we

are confronted with irreducible, or Knightian, uncertainty (Lo and Muller 2010) does not mean that such a prospect should be ignored. If we were interested in conducting monetary policy in a robust fashion—that is, trying to avoid worst-case outcomes rather than achieving the optimum—the probability, even if unquantifiable, of a financial imbalance building would call for some monetary policy response.[6] This response could also be justified in a risk-management framework.

Conclusion

In this article, we have argued that the case for monetary policy to lean against financial imbalances depends on the sources of the shock or market failure and on the nature of the other regulatory instruments available. To the extent that financial imbalances are specific to a sector and that a well-targeted prudential tool is available, monetary policy would play a minor role in leaning against the imbalances. However, if the imbalances in a specific market can spill over to the entire economy and if the prudential tool is broad based, monetary policy will likely have a role to play. In this case, there may be a need to coordinate the use of the two policy instruments.

As stressed in this article, a monetary policy that leans against the buildup of financial imbalances is not inherently inconsistent with a flexible inflation-targeting regime.[7] Such flexibility can be expressed in terms of a longer target horizon (Basant Roi and Mendes 2007; Selody and Wilkins 2007). In practice, however, exercising this flexibility could be challenging (Carney 2008, 2009). The examples presented in this article—and the subsequent discussion of some of the factors that are *not* included in them—highlight the complexities involved in characterizing the appropriate role of monetary policy in a setting where such imbalances may arise.

Much more work will be needed to bring our understanding of these issues to the level required to clarify the implications for the monetary policy framework. This will include further conceptual work on the types of imbalances that may emerge, the crises that may occur when the imbalances unravel, and the influence of monetary and prudential policies on the probability and severity of such crises. It will also include empirical work on the importance of various shocks and on the strength of the relevant macroeconomic linkages. Finally, there will also be a need to work through the operational implications of implementing such a monetary policy.

6 The literature on "robust control" may provide some valuable insights in this regard (Hansen and Sargent 2001, 2008).

7 See Bank of Canada (2006) for the background document on the 2006 renewal of the inflation-control target.

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Conference Summary: New Frontiers in Monetary Policy Design

Robert Amano, Kevin Devereux, and Rhys Mendes, Canadian Economic Analysis Department

The Bank of Canada's annual conference, held in November 2009, was part of a major research program initiated in 2006 in anticipation of the next renewal of the inflation-control agreement in 2011. Although the current inflation-targeting regime has served Canadians well, sound public policy demands the continuous exploration of possible improvements to the monetary policy framework. Research initially focused on two central questions regarding the design of monetary policy: (i) Would an inflation target lower than our current 2 per cent target lead to better economic outcomes? (ii) What are the costs and benefits of price-level targeting relative to inflation targeting? Given the recent experience with policy interest rates near zero, a heavier emphasis has been placed on the implications of the zero bound on nominal interest rates for the design of the monetary policy framework.

Although the current inflation-targeting regime has served Canadians well, sound public policy demands the continuous exploration of possible improvements to the monetary policy framework.

The conference brought together distinguished scholars from academic institutions and monetary authorities around the world to discuss these questions.

Reflecting the original questions asked in 2006, the conference agenda included work that shed new light on the potential costs and benefits of price-level targeting and on the optimal rate of inflation. Other work explored the causes of zero-bound episodes and the efficacy of potential policies. The conference consisted of two special presentations—a luncheon address by Lawrence Christiano and the John Kuszczak Memorial Lecture delivered by Mark Gertler—together with six papers presented over three sessions with two discussants for each paper. The conference concluded with a panel discussion that reviewed the major themes and offered views on select topics.[1]

Session I: The Zero Lower Bound

The events of the financial crisis that began in 2007 have highlighted the importance of the zero lower bound (ZLB) on nominal interest rates. In many advanced economies, central banks lowered their policy rates to what was considered the effective lower bound, constraining their ability to provide additional monetary stimulus. The frequency and severity of such episodes can have important implications for monetary policy design.

Standard dynamic stochastic general-equilibrium (DSGE) models suggest that the ZLB does not significantly constrain optimal policy. However, in their paper "Risk-Premium Shocks and the Zero Bound on Nominal Interest Rates," **Robert Amano** and **Malik Shukayev** (Bank of Canada) argue that standard quantitative DSGE models do not fully capture the importance of the ZLB. They point to the experience of the recent crisis as one example. Amano and Shukayev show that one possible explanation for this disconnect is that the standard models omit shocks to the risk premium. Such shocks drive up the rates of return on private assets relative to the policy rate. Risk-premium shocks were particularly prominent during the recent recession and historically

1 Current versions of the papers presented are listed in the Literature Cited. Some of those still in manuscript form are available on the Bank's website at <http://www.bankofcanada.ca/en/conference_papers/econ_conf09/papers.html>.

are fairly large. Offsetting the effect of these shocks can require a substantial reaction of the policy rate, thus making the ZLB a potentially important constraint. Other, more standard, shocks are not able to push nominal rates close to zero (e.g., shocks to productivity or government spending). Interestingly, Amano and Shukayev note that price-level targeting could help to manage the impact of risk-premium shocks because it leads to less variability in interest rates and, thus, fewer ZLB episodes.

Henry Siu (University of British Columbia) noted that in the real world, risk-premium shocks appear to cause both investment and consumption to fall. In the model, however, only investment falls in response to a positive risk-premium shock, while consumption rises. Siu noted that this discrepancy may be due to the fact that, in reality, movements in the risk premium are correlated with other shocks. He suggested that making the risk premium endogenous might remedy this issue. **Steve Ambler** (Université du Québec à Montréal) agreed that it would be helpful to endogenize the risk premium. He also conjectured that Amano and Shukayev's main result may be an artifact of the way money is introduced in the model. In particular, Ambler noted that hitting the ZLB in the model would require money balances to become very large. Consequently, the elasticity of money demand would tend to infinity. He argued that actual ZLB episodes provided little evidence to corroborate the latter prediction of the model.

During the recent crisis, several central banks provided forward guidance about the path of their policy rate. For example, the Bank of Canada made a conditional statement in April 2009 about the length of time that the policy rate would remain at its effective lower bound.[2] Much of the recent literature on monetary policy at the ZLB has suggested that forward guidance can be a very effective tool in preserving macroeconomic stability in the face of contractionary demand shocks (e.g., Eggertsson and Woodford 2003). Indeed, this strand of the literature goes as far as to suggest that there may be little need for other types of unconventional monetary policy, such as quantitative or credit easing.

In their paper "Limitations on the Effectiveness of Forward Guidance at the Zero Lower Bound," **Andrew Levin**, **David López-Salido**, **Edward Nelson**, and **Tack Yun** (Board of Governors of the Federal Reserve System) use the prototypical New Keynesian model to investigate the extent to which the effectiveness of forward guidance depends on the magnitude and persistence of shocks to the natural interest rate and the interest elasticity of aggregate demand. They find that forward guidance is effective for shocks of moderate size and persistence but much less effective for larger and more persistent shocks. Moreover, the benefits of forward guidance are quite sensitive to assumptions about the interest elasticity of demand. They conclude that for an episode of the magnitude and persistence of the recent crisis in the United States, forward guidance alone is not very effective. They point to this result as a possible rationale for policies such as credit easing and fiscal stimulus.

Sharon Kozicki (Bank of Canada) noted that issues related to credibility and expectations formation could further limit the effectiveness of forward guidance. If the central bank does not have full credibility today that it will follow through on a policy commitment that binds only in the future, a much worse outcome might be obtained. Moreover, she noted that, in the presence of uncertainty, optimal policy includes state-contingent commitments, including state-contingent forward guidance. Kozicki suggested that this, combined with the time inconsistency of optimal policy, could pose significant communications challenges for policymakers. **Marc Giannoni** (Columbia University) was skeptical of the authors' conclusions regarding the limitations of forward guidance. He argued that forward guidance was, in fact, very effective in their model. Giannoni pointed out that although outcomes with forward guidance were not good, they were much better than those without such guidance. Indeed, in the context of the model used by the authors, forward guidance can implement the best possible outcomes. Moreover, he contended that the authors did not make a convincing case for unconventional policy measures.

Luncheon Address

Lawrence J. Christiano (Northwestern University) gave the luncheon address "Implications of 2007–09 for Monetary DSGE Models." He identified two main implications of the crisis for macroeconomic models: (i) the characterization of monetary policy, and (ii) the urgency of modelling financial frictions.

Christiano argued that the crisis should lead the economics profession to change the way it characterizes monetary policy in macroeconomic models. He noted that, before the crisis, policy was modelled as a

2 The statement was explicitly conditional on the outlook for inflation.

procedure for adjusting a particular short-term interest rate. He suggested that, in light of the actual behaviour of central banks during the crisis, an escape clause for "exigent circumstances" should be added to the standard approach. He proposed a definition of exigent circumstances that would require a drop in demand that leads to a ZLB episode and triggers a downward spiral of spending and inflation.

He observed that during the crisis, the Federal Reserve took policy actions that led it to undertake private financial intermediation. He suggested that the rationale for such policies might be some sort of externality that is operative only in unusual circumstances. He identified a pecuniary externality operating through asset prices as one potential candidate.

Christiano also argued that the crisis has made clear that modelling financial frictions must be a priority for macroeconomics. In particular, he noted that developing models with greater financial detail would allow economists to address such issues as whether or not monetary policy should respond directly to financial variables, and the importance of business-cycle disturbances that originate in the financial sector.

Christiano noted that recent work with models that include a financial sector has already made some progress. As an example, he presented research showing that shocks that make borrowers more or less risky may be particularly important for business-cycle fluctuations.

Session II: Optimal Inflation

Standard macroeconomic models suggest that the optimal rate of inflation is zero, or even negative. Yet most central banks aim to maintain small positive rates of inflation. One possible explanation for this observation is that it is difficult to reduce nominal wages even when economic circumstances warrant a reduction. In the presence of downward nominal-wage rigidity (DNWR), a higher rate of inflation will allow easier adjustment of real wages—it will "grease the wheels of the economy" (Tobin 1972). In this situation, a lower rate of inflation will lead to real wages and unemployment that are higher, on average. In their paper "Downward Wage Rigidity and Optimal Steady-State Inflation," **Gabriel Fagan** (European Central Bank) and **Julián Messina** (Universitat de Girona) review the international evidence on DNWR. They conclude that the evidence is consistent with DNWR in the United States, but that the findings for Europe suggest that it is *real* wages that are downwardly rigid. To assess the implications of these findings for optimal inflation, Fagan and Messina present a model with asymmetric menu costs for wage setting that nests DNWR, downward real wage rigidity, standard menu costs, and flexible wages. They estimate the model using a simulated method of moments to match key features of the cross-sectional wage distribution for various countries. Their findings suggest that optimal inflation for European countries is between 0 and 2 per cent, while for the United States it is between 2 and 5 per cent.

David Andolfatto (Federal Reserve Bank of St. Louis) noted several caveats related to the dataset used by Fagan and Messina, including the fact that it includes wage changes only for continuing workers and that it ignores non-wage compensation. He also argued that the labour market might be better modelled as involving enduring relationships rather than as anonymous spot markets. In this case, the relevant concept is the wage profile over the length of the relationship, not at a point in time. **Michael Dotsey** (Federal Reserve Bank of Philadelphia) noted that models in which employers do not observe labour effort also lead to fairly flexible effective wages, even though measured wages are not flexible. Moreover, he cited several other empirical studies that raise doubts about the existence of DNWR. Dotsey concluded that the prevalence of DNWR remains an open question.

In their presentation "Inflation, Nominal Debt, Housing, and Welfare," **Shutao Cao**, **Césaire Meh**, **Yaz Terajima** (Bank of Canada), and **José-Víctor Ríos-Rull** (University of Minnesota and Federal Reserve Bank of Minneapolis) evaluate the welfare effects of lowering the long-run inflation target in a life-cycle, heterogeneous-agent model of housing, nominal debt, and money. They assume that housing and debt transactions are costly, while money holdings are not subject to any transactions costs. This gives money a natural advantage as a vehicle for self-insuring against idiosyncratic earnings risk. They find that reducing the long-run rate of inflation from 2 per cent to 1 per cent reduces the cost of holding money and therefore facilitates the use of money for self-insurance. They conclude that a reduction in the rate of inflation would not only increase aggregate welfare in the long run, but would also improve the welfare of roughly 68 per cent of the population alive at the time of the change.

Peter Howitt (Brown University) noted that the model deals with only a one-time shock to inflation: at all other times inflation is constant and predictable. If the inflation rate were subject to uncertainty, households would allocate their portfolios differently. He also

suggested modifications, including an explanation of the motivation behind the assumption of quadratic costs for bond transactions, the inclusion of other real assets in addition to housing, and the addition of longer-term bonds to the model. Finally, he expressed doubts about households using cash holdings to self-insure and argued that the cash holdings implied by the model were implausibly large.

John Kuszczak Memorial Lecture

Mark Gertler (New York University) delivered the 2009 John Kuszczak Memorial Lecture, "A Model of Unconventional Monetary Policy."[3] He observed that over most of the postwar period, the Federal Reserve has conducted monetary policy by adjusting the federal funds rate in order to affect market interest rates—it has avoided lending directly in private credit markets. Since the onset of the crisis in August 2007, the situation has changed dramatically, and the Fed has injected credit directly into private markets. Gertler cited statistics indicating that private assets held by the Fed had increased from virtually nothing to nearly $1.5 trillion. He noted that the Fed had taken these actions in an attempt to offset a considerable fraction of the decline in private financial intermediation by expanding central bank intermediation.

Gertler pointed out that whenever the short-term interest rate is at the zero lower bound, central banks are unable to stimulate the economy using conventional means. In these situations, they must rely exclusively on unconventional balance-sheet operations. He noted, however, that the baseline versions of standard models assume frictionless financial markets. Accordingly, these models are unable to capture financial-market disruptions that could motivate the type of central bank interventions in loan markets observed during the crisis. To remedy this situation, he presented a quantitative macroeconomic model in which it is possible to analyze the effects of unconventional monetary policy.

Gertler's model incorporated financial intermediaries within an otherwise standard macroeconomic framework. He assumed a simple agency problem between intermediaries and their depositors in order to generate an effect from the balance sheets of intermediaries on the overall flow of credit. The agency problem introduced endogenous constraints on the leverage ratios of the intermediaries, which link overall credit flows to equity capital in the intermediary sector. In the model, a deterioration of the intermediaries' capital disrupts lending and borrowing in a way that mimics what happened during the crisis. To study unconventional monetary policy, Gertler allowed the central bank to act as an intermediary, but assumed that public intermediation would generally be less efficient than private intermediation. He showed that the welfare gains from interventions in credit markets could actually be quite large, as long as efficiency costs are sufficiently modest.

Session III: Price-Level Targeting

Recent research on monetary policy design has produced several results suggesting that price-level targeting (PLT) might yield better results than inflation targeting (IT). The papers in this session evaluated the performance of PLT under alternative assumptions about price setting, and the effectiveness of PLT in managing tail risks.

Studies evaluating the efficacy of monetary policy rules and regimes are often based on a benchmark New Keynesian model in which the parameters are assumed to be policy invariant. It is possible, however, that some key parameters may not be invariant to changes in monetary policy. In "Endogenous Rule-of-Thumb Price-Setters and Monetary Policy," **Robert Amano**, **Rhys Mendes**, and **Stephen Murchison** (Bank of Canada) use a hybrid New Keynesian Phillips curve to examine the question of IT versus PLT when price-setters endogenously choose to behave either in an optimal forward-looking manner or to follow a simple rule of thumb for setting prices. Although other factors may also be endogenous, they focus on the degree of forward-looking behaviour, since it has been identified in the literature as a crucial parameter affecting the performance of PLT versus IT. They allow firms in their model to choose between using a simple backward-looking rule of thumb (RT) and paying a cost to set prices optimally in a forward-looking (FL) manner. They find that the benefits (relative profitability) of being FL versus RT depend on the regime. In their model, the success of PLT in stabilizing the economy makes the simple rule of thumb relatively more attractive, leading to an increase in RT behaviour. They show that this increase in RT behaviour could reduce the benefits of PLT over IT. They conclude that if a central bank fails to account for the impact of policy changes on the proportion of RT price-setters, outcomes can be significantly worse than anticipated.

3 This lecture is funded by the Bank of Canada in memory of our colleague John Kuszczak, who died in 2002.

Ricardo Reis (Columbia University) began by pointing out that the literature on monetary policy design has identified a very substantial set of potential benefits of PLT relative to IT. Yet, PLT is almost never implemented in practice. Reis argued that this puzzle is one of the largest gaps between the theory and practice of monetary policy. He went on to question the generality of the results presented by Amano, Mendes, and Murchison. In particular, he noted that the rule of thumb assumed by the authors may, in fact, change with the policy regime. In addition, he argued that the cost of behaving in a forward-looking manner should be included as a resource cost in the model. **Frank Smets** (European Central Bank) agreed with these points. He also suggested endogenizing some of the parameters of the rule of thumb and considering some alternative policy rules and feedback horizons.

Roberto Billi (Federal Reserve Bank of Kansas City) then presented his evaluation of the "risk-management" properties of PLT in "Price-Level Targeting and Risk Management in a Low-Inflation Economy." He notes that low inflation implies low nominal interest rates and a greater probability of hitting the ZLB. Thus, downside risks to the economy are greater when inflation is low. He demonstrates that PLT mitigates downside tail risks relative to IT, while generating only slightly worse outcomes, on average. He concludes that PLT is a more effective policy framework than IT for the management of downside tail risks in a low-inflation economy.

Kevin Moran (Université Laval) suggested that Billi formalize the idea that reducing downside tail risks should be considered desirable. He also expressed surprise that IT dominated PLT in the model in terms of average welfare. He argued that this result may be due to the use of first-difference interest rate rules in the model. **Gauti Eggertsson** (Federal Reserve Bank of New York) agreed that the first-difference rules were the source of the surprising welfare result. He noted that what really mattered in the model was the degree of history dependence in the policy rule, not the specific source of the history dependence. Eggertsson also argued that the fact that PLT appeared to be more robust against "deflationary black holes" could be a rationale for PLT over IT.

Panel Discussion

The conference concluded with discussion by a panel consisting of **John Murray** (Bank of Canada), **Vincent Reinhart** (American Enterprise Institute), and **Michael Woodford** (Columbia University).

Michael Woodford discussed four related issues: (i) the desirability of a price-level target, (ii) the importance of forward guidance, (iii) reconsideration of optimal inflation targets, and (iv) a role for "unconventional policy." On the desirability of price-level targeting, Woodford noted that recent research implies that PLT is optimal in the presence of cost-push shocks and a good approximation to optimal policy in the presence of cost-push shocks and a zero bound on nominal interest rates. Work presented at the conference did little to sway Woodford from these conclusions.

Woodford argued in favour of forward guidance (and PLT) and questioned the conclusions of Levin et al., who compared the commitment policy with an unattainable first-best policy instead of the more relevant comparison between commitment and purely forward-looking policy. The real issue concerning the application of forward guidance and PLT, according to Woodford, is whether the central bank can assume full credibility or rational expectations, since their absence would impinge on the efficacy of forward guidance and PLT. He noted, however, that not all ways of moving away from full rational expectations weaken the case for PLT.

The zero bound on nominal interest rates is an issue that has led some to argue in favour of higher inflation targets. Woodford pointed out that this is a very inefficient solution to the zero-bound problem if history-dependent policy can be made credible. He noted that a good policy should promise temporary re-inflation (after a deflation) but not permanently higher inflation, and that PLT is a regime that allows for this. PLT, moreover, may be a good way to explain how temporary re-inflation can be consistent with a commitment to low inflation. On the final point, Woodford sees a case for active credit policy when interest rates approach their zero bound, since policy rates can no longer be used to help offset potential distortions in credit markets.

Vincent Reinhart began by discussing the traditional problems with price-level drift. That is, the presence of drift fails to anchor nominal levels; impedes credibility, since bygones are bygones; and limits the effectiveness of stabilization policy. Reinhart argued that, given these problems with base drift, PLT may be a useful monetary policy framework, especially in regard to stabilization.

He noted, however, that communication issues may hinder the usefulness of PLT. In particular, he argued

that policy-makers may be reluctant to adopt PLT because they lack confidence in their ability to convey information to the public about more than a single factor. For example, they may be concerned about their ability to communicate how policy would be conducted in a different economic situation or how it might differ in the future relative to the present.

John Murray first returned to the two original questions mentioned in the Bank of Canada's 2006 background document on the renewal of the inflation targets. That is, (i) should the inflation target be lower than 2 per cent? and (ii) should we move to a price-level target? To put these questions in context, he also discussed things that we thought we knew in 2006: (i) measurement bias and nominal wage rigidities were not major concerns; (ii) the main impediment to a lower inflation target was the ZLB on nominal interest rates, which, based on past experience and work at that time, was probably rare and manageable; and (iii) according to model simulations and the plausibility of the arguments, PLT seemed to be a promising idea with the added benefit that it might help deal with zero-bound episodes.

Murray then turned to the question, What have we learned since then? To answer this, Murray used the recent crisis and associated events, including the application of unconventional monetary policies as an (unexpected) natural experiment. He concluded that there may be inconsistency between some of the tentative conclusions drawn from previous research and recent real-world events. Murray then turned to the conference papers and divided them into two camps. The first camp offered cautionary messages: namely, zero-bound episodes may be more frequent than earlier anticipated, the effectiveness of forward guidance may be limited in the face of a serious shock, downward nominal-wage rigidity may be more significant than we think, and endogenous pricing behaviour may reduce the benefits of PLT. The second camp painted a more positive picture: distributional and equity arguments support a lower rate of inflation, PLT may be helpful insurance against downside tail risks, and unconventional monetary policies can work.

Our success with inflation targeting has raised the bar for a move to another, potentially better, framework for monetary policy.

To conclude, Murray asked a final question: What do we need to know? With regard to optimal inflation, he suggested that more work on the frequency of future zero-bound episodes and the effectiveness of unconventional policies would be useful. He also wondered whether we need to revise our thinking on downward nominal-wage rigidity. With regard to PLT, Murray asked if economic agents would value greater price-level certainty and if there is a way to test whether agents would understand PLT and change their behaviour accordingly. Finally, he talked about the puzzle mentioned by Ricardo Reis in his discussion and the fact that our success with inflation targeting has raised the bar for a move to another, potentially better, framework for monetary policy.

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