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Special Issue

Research on
Inflation Targeting

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Gold Coins of James I of England (1603–1625)

David Bergeron, Curator, Currency Museum

The reign of James I of England was an active period for the minting of gold coins. Gold coins had existed in England before the Roman era but came into common use only with the 1364 introduction of the Noble (valued at 6 shillings, 8 pence) under the reign of Edward III. For the next 200 years, the circulation of gold coins remained fairly stable: In 1464, the Angel, also valued at 6 shillings, 8 pence, replaced the Noble; then the Sovereign (20 shillings)—first issued under Henry VII in 1489—became the standard gold coinage of the realm for over a century. James I continued minting Sovereigns following his accession to the throne in 1603, but their production was short-lived. During his reign, English gold coinage underwent several changes, largely for political, economic, and aesthetic reasons.

King James VI of Scotland had become James I of England when he inherited the throne of England from his distant cousin, Queen Elizabeth I. In 1604, he replaced the Sovereign with the Unite (weighing 10.04 grams), so named because the coin's legends reflected the union of Scotland and England under one crown (a union not made legal, however, until the Acts of Union in 1707). The legend on the Unite, taken from Ezekiel 33:22, read FACIAM EOS IN GENTEM UNAM (*I will make them one nation*). The Unite, along with its fractions the Double-Crown and the Crown with respective values of 20, 10, and 5 shillings, were very popular and aesthetically pleasing. The value of these coins, however, was maintained for only a short period as a sharp rise in the value of gold forced the revaluation of the Unite.

In 1611, the nominal value of all gold coins was raised by 2 shillings for every pound; therefore the Unite was now worth 22 shillings. This change in valuation of gold coins was, however, very awkward, and a new gold coin—the Laurel—was issued by proclamation in 1619. The Laurel, which got its name from the laureate portrait of the king on the obverse, was of a lower quality and weighed less (9.07 grams) than its predecessors in order to reduce its value to 20 shillings. And to avoid any confusion, the denomination "XX" was indicated behind the king's head. Half-Laurels (10 shillings) and Quarter-Laurels (5 shillings) were also minted, but all three coins were discontinued following the accession of Charles I in 1625. The Unite was then re-introduced, containing less gold than James I's Unite, to reduce its value to 20 shillings.

The coins' popularity reflected the stark contrast between the Unite and the Laurel. The Unite featured a beautifully engraved portrait of the king holding an orb and sceptre. The Laurel, on the other hand, was ugly: The king's head was too large and the engraving was crude. Perhaps it is not by coincidence that Charles got rid of the unattractive Laurel and re-introduced the visually appealing Unite.

The coins pictured on the cover are part of the National Currency Collection of the Bank of Canada.

Photography by Gord Carter

Research on Inflation Targeting

John Murray, Guest Editor

This special edition of the *Bank of Canada Review* examines some of the recent research, at the Bank and elsewhere, on alternative monetary policy frameworks. When the inflation control agreement between the Bank of Canada and the government was renewed in 2006, a multi-year research initiative was launched by the Bank in anticipation of the next renewal. The purpose of the research initiative was two-fold: first, to study the prospective benefits and costs of moving to a lower target rate of inflation; and second, to weigh the possible advantages of moving to a price-level target. While the existing inflation-targeting framework has served Canada well, the Bank has a responsibility to see if it can be improved and thereby advance the economic well-being of Canadians. As part of this effort, the Bank committed to reporting regularly on the progress that has been made and the issues that remain outstanding. The four articles in this *Review*, together with those published in a similar special edition of the *Review* last year, 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 in the *Review*, "Next Steps for Canadian Monetary Policy," was written by Robert Amano, Tom Carter, and Don Coletti, and is divided into two parts. The first provides an overview of the recent work on the optimal rate of inflation and some of the important questions that need to be answered in this area. The second part focuses on price-level targeting and critically assesses the insights that have been gained as well as the key challenges that remain. With regard to the optimal rate of inflation, a number of research papers that are reviewed suggest the optimal rate is lower than the Bank's current two per cent target. The amount varies from study to study. Further work will try to extend these results and test their sensitivity by examining the implications of lower inflation for financial intermediation and the functioning of labour markets. In addition, the transition costs associated with moving to a lower target inflation rate as well as the problems that might be posed by the zero lower bound on nominal interest rates will be explored more fully. Price-level targeting has also shown some promise in this research, as a stabilizing tool and possible source of improved economic welfare. One of the main potential benefits is reduced uncertainty about the future level of prices. More research is needed, however, to test the performance of price-level targeting in more realistic and relevant model environments, particularly those faced by small open economies such as Canada. The effects of price-level targeting on the zero lower bound and the endogenous response of agents to such a new monetary regime are particularly important in the present context.

The second article, by Steve Ambler, builds on the overview piece by Amano, Carter, and Coletti and explores the issue of "Price-Level Targeting and Stabilization Policy" in greater detail. It reviews the four principal benefits that price-level targeting might be expected to provide in terms of improved macroeconomic performance, and the conditions under which these benefits are most likely to be realized. Ambler describes how forward-looking expectations, costly information, endogenous wage-price setting behaviour, and structural flexibility can improve the output-inflation trade-off under price-level targeting. In contrast, backward-looking expectations and rule-of-thumb price-setters pose a potential problem and may favour inflation targeting or price-level targeting with drift. Ambler also examines hybrid forms of monetary regimes, such as average-inflation targeting.

Allan Crawford, Césaire Meh, and Yaz Terajima co-authored the third article, on "Price-Level Uncertainty, Price-Level Targeting, and Nominal Debt Contracts." While Ambler reviewed various aspects of price-level targeting from a more traditional, macroeconomic stabilization perspective, Crawford, Meh, and Terajima focus on the channels through which price-level targeting might affect behaviour through long-term

financial contracts. Although inflation targeting has already reduced long-run price-level uncertainty to historically low levels in Canada, the authors show how further improvements might be realized under price-level targeting. This, in turn, could lead to lower risk premiums on long-term interest rates and higher levels of investment and output. Additional benefits, in the form of reduced unintended wealth redistributions, are also highlighted by the authors, although the results are sensitive to how fiscal policy responds to changes in the government's financial position.

The final article, by Césaire Meh and Yaz Terajima, extends the work of Crawford, Meh, and Terajima with a more detailed empirical examination of "Unexpected Inflation and Redistribution of Wealth in Canada." Estimates of the redistributive effects associated with unexpected changes in the price level are generated, using data from Statistics Canada to construct representative balance sheets for households, non-financial businesses, the government, and foreign investors. The extensive use of unindexed long-term debt in the Canadian economy leads to significant shifts in net worth every time there is an unexpected jump (or decline) in inflation. The authors show that young, middle-income households and governments are the main beneficiaries of positive inflation surprises, since they are the largest net issuers of nominal fixed rate debt. Moreover, the size of these redistributions is larger than many observers might have expected, raising serious questions about the macroeconomic and welfare implications of these transfers. Price-level targeting is identified as an obvious means of addressing them, although other, potentially less positive aspects of this regime would clearly need to be weighed before racing to quickly adopt it.

Next Steps for Canadian Monetary Policy

Robert Amano, Tom Carter, and Don Coletti, Canadian Economic Analysis

- *While Canada's experience with the two per cent inflation target has been positive, there may still be room for improvement in the Canadian monetary framework. This article reviews our findings to date, places them in the context of the broader literature, and identifies avenues for future research leading up to 2011.*
- *The earlier literature and recent studies at the Bank of Canada suggest that an inflation target lower than two per cent may be beneficial.*
- *With regard to the inflation target, future research should focus on (i) wage-setting behaviour in Canada, especially when inflation is low; (ii) the role that financial intermediaries play in modulating inflation's macroeconomic effects; and (iii) the transition between inflation targets.*
- *It is not yet clear whether a price-level target would be preferable to our current inflation target. Further research into price-level targeting is thus a priority for the Bank's economists.*
- *With regard to price-level targeting, there are several topics for future research, including the target's influence on contracting behaviour and inflation expectations, and how policy-makers can ensure credibility in their commitment to price-level targeting. Furthermore, some empirical assessment is needed concerning the Canadian economy's vulnerability to shocks that the literature identifies as particularly detrimental to the target's performance.*
- *The choice of an inflation target and/or the implementation of a price-level target could have implications for the problem of the zero lower bound on nominal interest rates.*

Although the Canadian experience with inflation targeting has been very positive, the Bank of Canada remains alert to the potential for improvement in its approach to monetary policy. In 2006, when the inflation-control target was renewed for another five years, the Bank initiated a research program to reassess the current monetary policy framework (Bank of Canada 2006).[1] This reassessment has focused on two questions: (i) What is the optimal rate of inflation? (ii) What are the costs and benefits of a shift to a price-level target?

The Bank's research program aims to answer these questions in collaboration with partners in academia and at other central banks. This article highlights the progress to date and places the Bank's findings in the context of a broader literature. It also identifies avenues for future research and steps that have been taken in these directions. We begin with a discussion of optimal inflation and then move on to price-level targeting (PT). A brief summary of the findings is provided in the conclusion.

Optimal Inflation

A brief review of the literature

Although inflation can influence macroeconomic outcomes in many ways, the literature tends to focus on two avenues through which inflation impacts the economy, namely pricing decisions and incentives to hold money. We frame a brief review of the literature around these two channels.[2]

1 Under this framework, the Bank's monetary policy is aimed at keeping total CPI inflation at two per cent, with a control range of one to three per cent around the target.

2 A third channel, which has been the subject of some Bank of Canada research, is the interaction between inflation and the tax system (see, for example, O'Reilly and Levac 2000; Black, Macklem, and Poloz 1994).

With regard to pricing decisions, the expectation that real prices will erode over time can lead firms operating in inflationary environments to choose prices that differ substantially from those set when inflation is zero. This effect has been studied extensively using New Keynesian models, where monopolistically competitive firms set nominal prices in a staggered fashion using contracts that hold for several periods. In this environment, firms facing trend inflation anticipate that real prices will fall as contracts mature. To compensate, they choose to raise prices by a margin that grows with the expected rate of inflation. This behaviour, sometimes dubbed "front-end loading," tends to connect higher inflation with greater price dispersion and an inefficient allocation of demand across competitors.[3]

With regard to money-holding incentives, the expectation that the currency's purchasing power will fall over time can discourage agents from carrying transaction balances, particularly if they could otherwise invest in interest-bearing assets. Economists have recently studied this effect using so-called "search-theoretic" models. In these models, following seminal work by Kiyotaki and Wright (1989), agents choose to hold money because their preferences are unlikely to coincide with those of trading partners. Inflation then influences the amount of money that agents choose to carry, with direct implications for the extent and pattern of trade. An alternative method for modelling the relationship between inflation and money holding is highlighted in Cooley and Hansen (1989), which incorporates money into a real business cycle model via a cash-in-advance constraint.

Estimates on the optimal rate of inflation are quite sensitive to assumptions about which of these channels is stronger. For example, when inflation's macroeconomic effects accrue only via its impact on pricing decisions, the main goal for policy-makers is normally to minimize price dispersion, and the optimal rate is near zero. On the other hand, if inflation acts only via money-holding incentives, a negative rate can be optimal: As per the famous "Friedman rule" (1969), deflating at a rate that drives the nominal interest rate to zero resolves the money-holding problem by making agents indifferent between transaction balances and interest-bearing investments.

Prescriptions for deflation can hold in search-theoretic settings (see, for example, Lagos and Wright 2005 and Rocheteau and Wright 2005). They also hold in Cooley and Hansen (1989) and in a subsequent extension to the case of endogenous growth by Gomme (1993), though Gomme finds that the benefits of optimal inflation are relatively small and that the optimal rate is only modestly negative. Several models combining some role for money with New Keynesian price rigidities also find that deflation is optimal, though choosing a target in this setting would now involve balancing the costs associated with price dispersion against those associated with suboptimal money holdings. See Khan, King, and Wolman (2003) for an example. Levin, López-Salido, and Yun (2007) show that strategic complementarities (e.g., quasi-kinked demand and firm-specific capital) tend to enhance the effects of price dispersion, reducing the extent to which money-holding incentives figure in the optimal-inflation decision.

Several related studies aim to estimate the costs of suboptimal inflation from data on money demand. The approach is initially due to Bailey (1956). While varying considerably in their estimates, studies generally find that these costs are modest. Howitt (1990), for example, uses M1 demand estimates produced by Boothe and Poloz (1988) to show that a reduction in Canadian inflation from 9 to 0 per cent would permanently increase output by 0.1 per cent. A key finding in this literature is that results are sensitive to the specification of money demand. For example, Lucas (2000) estimates that lowering inflation from 10 to 0 per cent would improve U.S. output by 0.9 per cent, while an alternative assumption on the money-demand function leads Ireland (2007) to place the gain around 0.1 per cent.

A growing empirical literature has focused on detecting the macroeconomic effects of inflation in time series and international cross-sections. A key theme is that some threshold may exist in the relationship between inflation and economic growth. Despite the findings of Kormendi and Meguire (1985) that the long-run relationship is significantly negative across 47 countries for the years 1950 through 1977, more recent studies, beginning with Fischer (1993), have found that, below a certain rate of inflation, a positive or neutral relationship may exist. Current estimates on this threshold vary dramatically, ranging from 1 per cent for a group of industrial countries in Khan and Senhadji (2000) to 10 per cent for a wider sample in Judson and Orphanides (1996).

Recent work at the Bank of Canada

The Bank's most recent contributions to the optimal-inflation literature can be divided between those

3 See Ambler (2007–2008) for a more comprehensive review of inflation's effects in New Keynesian environments. See also Woodford (2002).

focusing on the New Keynesian environment and those focusing on the search-theoretic perspective.

The New Keynesian approach

Amano et al. (2007) consider an extension of the New Keynesian framework that incorporates exogenous productivity growth and staggered wage and price setting. In addition to the standard "front-end loading" effect, the authors also document an effect that stems from the interaction of inflation, productivity growth, and nominal wage rigidity: Deflation partially compensates for nominal wage rigidity by allowing the real wage to rise as labour productivity improves. Realistic parameterizations imply that the wage effect has stronger welfare implications than price dispersion, leading the authors to conclude that deflation near the rate of productivity growth is optimal. This is consistent with some insights from an earlier literature on the potential benefits of negative trend inflation when productivity improves over time (Selgin 1995).

As explained above, the case for deflation normally depends on some assumption that agents face incentives to hold transaction balances. No such incentives exist in Amano et al. (2007), which features neither a cash-in-advance constraint nor a preference for money holdings and yet finds that deflation is optimal.[4] Amano et al. (2007) also find that deviations from the optimal rate can be quite costly, mainly because of nominal wage rigidities. A shift from two per cent inflation to the optimum improves welfare by 0.8 per cent. This estimate is high relative to those found in previous literature, even in studies featuring staggered price setting.

While Amano et al. (2007) focus on inflation's steady-state effects, Amano, Ambler, and Rebei (2007) consider a more dynamic setting. They relax one of the literature's most common assumptions—that firms failing to reset their prices nonetheless index them to trend inflation—and then estimate the effects of trend inflation in a stochastic environment where firms face various nominal price rigidities.[5] The study extends related work by Bakhshi et al. (2003) and Ascari (2004).

An important finding in Amano, Ambler, and Rebei (2007) is that trend inflation tends to impact the stochastic means of output, consumption, price dispersion, and other key variables more dramatically than their steady states. These results follow naturally from the fact that inflation is more persistent at higher rates of trend inflation. Increases in the volatility and persistence of several macroeconomic variables also follow directly from this relationship, which is invariant to the exact form of nominal rigidity in effect. The authors conclude that estimates based on steady-state calculations are likely to understate the welfare effects of trend inflation. Because the connection between trend inflation and price dispersion is key to their results, they find that inflation near zero is optimal.

The search-theoretic approach

Compared with the New Keynesian approach, which either focuses on cashless economies or introduces money via ad hoc assumptions, monetary search theory explicitly models the frictions that give rise to the need for money. In a key study by Lagos and Wright (2005), for example, agents choose to hold money because, as explained earlier, their preferences are unlikely to coincide when meeting potential trading partners.[6]

At the Bank, Chiu and Molico (2007, 2008) extend the Lagos and Wright (2005) framework to study inflation's effects when money holdings vary across households. Their model is constructed to be consistent with data on aggregate money demand, as well as the distribution of money holdings across households. In this model, inflation can have significant redistributive effects that transfer real balances from cash-rich households to cash-poor households. These redistributive effects partially offset inflation's negative impact as a tax on money holding. As a result, some positive deviation from the Friedman rule can be welfare improving. Furthermore, the costs of suboptimal inflation are found to be smaller than in previous estimates and exhibit non-linearities that invalidate the methodologies applied in Lucas (2000) and Ireland (2007), where costs are calculated from the area under the money demand curve. In contrast to Lucas's estimate of 0.9 per cent, Chiu and Molico (2008) find that reducing inflation from 10 to 0 per cent improves welfare by only 0.59 per cent.

Challenges for the future

The range of estimates on the optimal rate of inflation suggests that findings in the literature are sensitive to assumptions about the economy and the avenues by which inflation can affect real outcomes. Future

4 Wolman (2009) makes a similar case for deflation in a two-sector economy where the relative price of output produced by the sector with greater nominal rigidities is increasing over time.

5 The assumptions that firms index to target inflation or to some weighted average of past inflation are also common and were relaxed in Amano, Ambler, and Rebei (2007).

6 Although agents could conceivably use credit arrangements as an alternative to money holding, an assumption that agents transact anonymously implies that credit contracts cannot be enforced.

research must therefore test how robustly these findings hold as assumptions are relaxed and replaced. Below, we consider four interesting extensions.

Estimates on the optimal rate of inflation are sensitive to assumptions about the economy and the avenues by which inflation can affect real outcomes.

The implications of financial intermediation

A key finding in Chiu and Molico (2007) is that inflation can have non-linear welfare effects, depending on how inflation affects agents' decisions to adjust their money holdings. The ease with which these adjustments can be made likely varies with the structure and sophistication of the banking sector. In this sense, financial intermediaries can play a role in the optimal-inflation narrative.

Another avenue through which intermediaries might modulate the effects of inflation is explored by Chiu and Meh (2008), who recently extended earlier work by Berentsen, Camera, and Waller (2007). Chiu and Meh suppose that entrepreneurs are randomly apprised of investment opportunities and have access to financial intermediation. If a project's costs exceed or fall short of an entrepreneur's money holdings, the entrepreneur can borrow or lend the difference, respectively, although potentially at some fixed cost. In this way, Chiu and Meh capture the role that intermediaries play as providers of liquidity, although they abstract from other roles, such as credit monitoring.

In this environment, interesting non-linearities emerge in the relationships among welfare, intermediation, and inflation. At high levels of inflation, banks are able to improve welfare by offering entrepreneurs a return on their money holdings, motivating them to hold more transactions balances and, thus, to invest in marginal projects. At the Friedman rule, firms cannot justify the fixed cost of intermediation, and liquidity provision by intermediaries cannot improve welfare. At intermediate rates of inflation, it is possible for liquidity provision to have negative welfare effects, since agents fail to take into account a potential externality when borrowing, namely, that an agent's option to borrow reduces his/her demand for money, which can cause the liquidity constraints of other agents to tighten if these agents hold money.[7] As a result, accurate estimates of the welfare effects of a change in the inflation target need to take into account potential shifts in the extent and pattern of liquidity provision by intermediaries. Further inquiry into the role of intermediaries in modulating inflation's welfare effects, particularly during periods of financial instability, would be worthwhile.

Transition between targets

In estimating the welfare effects associated with a shift towards the optimal rate of trend inflation, several of the Bank's recent projects, including Amano et al. (2007) and Chiu and Molico (2007, 2008), compare the long-run implications of trend inflation, ignoring the economy's short-run behaviour during the transition. However, this behaviour may be important: If the differences that emerge in the long-run analysis are modest, then after discounting, they could be offset by losses during transition. Some attention to short-run dynamics is therefore warranted.

The credibility of central bankers can be an important contributor to successful transitions between targets.

Inflation expectations and how agents update them figure prominently in the modern literature on inflation targets. Andolfatto and Gomme (2003), Erceg and Levin (2003), and Moran (2005) all model transitions where agents gradually learn about changes in the central bank's inflation target, rather than assimilating these changes immediately. Moran (2005) demonstrates that the welfare costs during transition vary dramatically with the speed of the learning process, suggesting that the credibility of central bankers can be an important contributor to successful transitions.

New emphasis on labour markets

The finding in Amano et al. (2007) that nominal wage rigidities account for most of inflation's welfare costs suggests that labour markets can play an important role in determining the optimal rate of inflation. Further study into this role should prove worthwhile. In ongoing work, Amano, Murchison, and Shukayev

7 However, as mentioned earlier, this model considers only the brokering, or "liquidity-provision" function of financial intermediaries. A full assessment of intermediation's welfare effects should also consider credit monitoring and other functions.

(2009) relax the allocative wage assumption implicit in Amano et al. (2007): Rather than assuming that workers commit to service whatever demand their nominal wage elicits, as is common in the New Keynesian literature, the authors suppose that workers simultaneously contract on nominal wages and hours worked. The impact of inflation on the labour market is thus substantially weakened. Hours worked remain fixed for most contracts despite inflation-induced shifts in the real wage, and any contracts being renegotiated take these shifts fully into account when setting *both* hours *and* the nominal wage. As a result, it is preferable for the central bank to set policy to minimize distortions elsewhere in the economy. With nominal rigidity in product markets, for example, the optimal rate of inflation is close to zero, rather than being negative, as suggested in Amano et al. (2007). As well, deviations from the optimum prove much less costly than in Amano et al. (2007).

One avenue for future research relevant to the role of labour markets in determining optimal inflation focuses on downward rigidity in nominal wages. Several authors have argued that firms find it difficult to reduce nominal wages and thus have greater freedom to lower real wages when inflation is positive (see, for example, Akerlof, Dickens, and Perry 2000). Statistical evidence of some downward rigidity in Canadian wages is documented in Crawford and Harrison (1998), although Farès and Hogan (2000) fail to find signs that low inflation has hindered the operation of Canadian labour markets. Kim and Ruge-Murcia (2007) recently embedded downward rigidity into a dynamic stochastic environment and placed optimal inflation around 1.2 per cent in the United States.

The zero lower bound on nominal interest rates

As explained in Summers (1991), it may be difficult to implement expansionary monetary policy when rates are at or near zero, since nominal interest rates cannot be negative. Various authors have since noted the example of recent economic weakness in Japan during the years 1995–2005, when short-term rates largely held in this range.

The relevance of the zero lower bound in choosing an inflation target is open to debate. Schmitt-Grohé and Uribe (2007), in their extension of the framework of Altig et al. (2005), show that the bound has no significant implications for their finding that mild deflation is optimal. If the lower bound argument holds, however, it offers an obvious counterbalance to the Friedman rule, which explicitly advocates an inflation target that forces nominal interest rates to zero. It would be optimal for policy-makers instead to target a more positive rate and thus reduce the likelihood of striking the bound. At the Bank, Lavoie and Pioro (2007) show that this likelihood falls as the target rises, so that a two per cent target provides a buffer over the zero bound. In more recent work, Nishiyama (2009) shows that a positive target's usefulness as a buffer grows with the lags attending monetary transmission. Outside the Bank, using a stochastic model where central bankers explicitly trade off the costs of inflation and the likelihood of reaching the bound, Billi (2007) places the optimal inflation rate around 0.7 per cent, which rises to 1.4 per cent when a specific type of model uncertainty is taken into account.

The significance of the zero lower bound has increased in the aftermath of the 2007 subprime-mortgage meltdown.

The significance of the zero lower bound has increased in the aftermath of the 2007 subprime-mortgage meltdown, which prompted dramatic reductions in the policy rates of central banks throughout the developed world. At the Bank of Canada, for example, these developments have motivated recent efforts to better incorporate the zero bound into our projection framework. Further research focusing specifically on the connections between the inflation target and the zero lower bound, as in Lavoie and Pioro (2007) and Nishiyama (2009), should be a priority in the future.

Price-Level Targeting

A brief review of the literature

Despite its recent successes in terms of macro-stabilization, several authors have highlighted some shortcomings in the inflation-targeting (IT) framework. Most notably, uncertainty on the price level grows with the planning horizon, since central banks with inflation targets accommodate shocks to the price level, taking the post-shock level as given and aiming to stabilize inflation from this level. In fact, the price level is unbounded at very distant horizons. Price-level targeting (PT) mitigates this uncertainty by committing central banks to restore the price level to a pre-announced target following shocks. PT is frequently

described as a departure from IT's prescription for letting "bygones be bygones."

A common argument in favour of price-level targeting highlights its effects on inflation expectations.

A common argument in favour of PT highlights its effects on inflation expectations, which may motivate stabilizing behaviour among agents. Thus, under PT, the expectation that policy-makers will target below-average inflation, following positive shocks to the price level, discourages firms from raising prices as dramatically as they would under a regime that accommodated shocks (Svensson 1999). Thus, acting via this expectations channel, PT could theoretically deliver lower volatility in both output and inflation. This finding represents a dramatic departure from the earlier view that PT necessarily involved greater volatility in inflation, since periods of below-average inflation would follow periods of above-average inflation (and vice versa).

While Svensson's analysis focuses on the New Classical Phillips curve, Dittmar and Gavin (2000) and Vestin (2006) show that his findings also hold in a New Keynesian setting. Steinsson (2003) identifies an important exception to the dominance of PT over IT, namely, when a large number of so-called "rule-of-thumb" firms set their prices according to a backward-looking rule. In fact, failure can occur owing to any factor that induces sufficiently backward-looking inflation expectations.

Another argument in favour of PT emphasizes the costs imposed on risk-averse agents facing price-level uncertainty whenever they enter into contracts whose terms are imperfectly indexed to inflation, such as mortgages. To the extent that PT reduces these costs, it may create an incentive for long-term financial contracting, with potential benefits for output and welfare. Views as to whether significant benefits should be expected vary considerably, as shown recently in Ambler (2007–2008) and Côté (2007). Howitt (2001) describes "long-term price-level uncertainty [as] one of the most serious consequences of inflation, because of its ruinous effects on long-term contracting," while Fischer (1994) argues that agents already have sufficient access to insurance against this uncertainty, mainly through indexed bonds.

Recent work at the Bank of Canada

In recent years, PT has attracted greater attention among the Bank's researchers than has optimal inflation. This work can be divided into four areas: (i) PT's general merits from a macrostabilization perspective; (ii) central bank credibility and its implications for PT; (iii) the challenges for PT in a small, open economy; and (iv) avenues through which PT can affect an agent's decision to enter into long-term contracts. We consider each area in turn.

Price-level targeting as a stabilizing tool

As noted in the literature review, the role of expectations as automatic stabilizers opens up the possibility that PT may dominate IT in certain environments. This possibility prompts Cateau (2008) to test PT's performance in Canada using our main projection model, ToTEM.[8] His key finding is that PT indeed outperforms IT. He also finds that, relative to IT, PT proves more robust to model uncertainty in the sense of Hansen and Sargent (2008); that is, if ToTEM is assumed to represent an inaccurate version of the Canadian economy, then PT's performance suffers less dramatically as the model's inaccuracy increases.

Further evidence that PT outperforms IT is offered in Coletti, Lalonde, and Muir (2008), based on work with a Canada–U.S. version of GEM, the IMF's Global Economy Model, calibrated to fit U.S. and Canadian data. The finding that PT performs better than IT is robust to several assumptions, including the specification of U.S. monetary policy. Gains, however, are modest relative to IT. PT tends to trade less-volatile inflation for more-volatile output, rather than reducing volatility in both variables.

Coletti, Lalonde, and Muir (2008) find that PT outperforms IT specifically following shocks that generate positive correlation between inflation and the output gap (such as demand shocks), whereas IT performs better following shocks that induce negative correlation between these variables (such as markup and labour supply shocks). The case for PT thus proves sensitive to the structure and distribution of shocks. In Coletti, Lalonde, and Muir (2008), the finding that PT generally performs better than IT follows from the fact that shocks generating positive correlation between inflation and the output gap account for a greater share of volatility in these variables when the model is taken to Canadian and U.S. data.

8 See Murchison and Rennison (2006) for an overview of ToTEM.

Another key finding in Coletti, Lalonde, and Muir (2008) is that the benefits associated with the shift to PT rise with the weight assigned to forward-looking expectations in the Phillips curve. This point is consistent with the notion that PT operates better when expectations are strongly forward-looking.

While Cateau (2008) and Coletti, Lalonde, and Muir (2008) consider PT in the context of large-scale models, Covas and Zhang (2008) use a more stylized framework based on Bernanke, Gertler, and Gilchrist (1999) to test how robustly the case for PT holds in the presence of financial frictions. More specifically, they consider a sticky-price environment in which entrepreneurs have access only to nominal debt contracts, while capital producers face counter-cyclical, quadratic costs when issuing equity. In this environment, PT continues to dominate IT, although the gain is smaller when financial frictions are taken into account. As in Coletti, Lalonde, and Muir (2008), the results depend on the kind of shocks being modelled. PT's weaker performance in the presence of financial frictions stems directly from a shock to the capital-producing technology; when frictions exist, this shock tends to generate a negative correlation between inflation and the output gap, forcing an undesirable trade-off onto PT.

Credible commitment to price-level targeting

The potential for expectations to serve as automatic stabilizers under PT suggests that performance will depend on the extent to which policy-makers can influence inflation expectations. As a result, the credibility with which policy-makers implement PT likely influences the target's performance, a possibility explored in Kryvtsov, Shukayev, and Ueberfeldt (2008), Cateau et al. (2009), and Masson and Shukayev (2008).

Kryvtsov, Shukayev, and Ueberfeldt (2008) consider the costs of imperfect credibility during the transition from IT to PT. Specifically, they suppose that agents are initially uncertain that the central bank will follow through on its commitment to PT and believe that policy-makers may revert to IT. A key finding is that PT's performance suffers when uncertainty is persistent. Expectations fail to serve as strong stabilizers to the extent that agents forming these expectations assign a positive weight to the shift back to IT. In this case, greater output losses are required to achieve a given price path, relative to the case where policy-makers are perfectly credible. In fact, when persistence exceeds a threshold—specifically, when uncertainty lasts for 10 quarters or more—the authors find that costs arising from imperfect credibility more than offset the benefits accruing from PT's superior performance once credibility has been established. See Cateau et al. (2009) for an extension that uses ToTEM to study PT's performance when agents are initially unconvinced of the central bank's credibility. As in Kryvtsov, Shukayev, and Ueberfeldt (2008), the authors find that imperfect credibility reduces the benefits associated with the shift from IT to PT.

PT's performance suffers when uncertainty about a central bank's commitment to PT is persistent.

In contrast to these two studies, Masson and Shukayev (2008) consider a chronic challenge attending credible commitment to PT. Even after the central bank has shifted from IT to PT, the authors expect that agents may question the bank's willingness to adhere to PT in the face of large shocks that can be reversed only at substantial cost to output. Thus, agents attach some probability to policy-makers' opting to reset the price path.

Masson and Shukayev argue that a precedent for such behaviour can be found in the history of the gold standard in the early 20th century, when the standard was suspended and resumed at new parities. This precedent suggests that PT would likely be implemented with an "escape clause," explicit or otherwise. Masson and Shukayev (2008) develop a model for the escape clause by supposing that a drop in the output gap below some threshold triggers a reset in the price target. In this case, much like Kryvtsov, Shukayev, and Ueberfeldt (2008), agents' assignment of some probability to a reset when forming inflation expectations means that these expectations fail to serve as strong stabilizers. This failure necessitates more aggressive policy, which in turn leads to higher output volatility. This last effect is quite pronounced. For example, when the threshold is set at a level implying that resets will occur with unconditional probability of 0.4 per cent, the output gap is about 30 per cent more volatile than in an economy without an escape clause.

Because the conditional probability of reset evolves endogenously, higher volatility in turn increases the likelihood that the threshold will be breached, potentially giving rise to self-fulfilling crises and multiple equilibria. The authors identify a range of thresholds,

for example, for which their model can support both good and bad equilibria, where bad outcomes are associated with greater volatility and higher probability of reset. These findings suggest that PT's performance hinges critically on the credibility of monetary policy.

Price-level targeting in an open economy

Large, persistent shocks to the terms of trade have been identified as a potential threat to PT in small open economies. The concern here is that central bankers could induce large output fluctuations if they are to unwind all pass-through to the price level.

In their work with a Canada–U.S. version of GEM, Coletti, Lalonde, and Muir (2008) find that PT continues to dominate IT even in the face of shocks accounting for most of the variation in Canada's terms of trade. However, in ongoing work at the Bank, De Resende, Dib, and Kichian (2008) and Amano, Kryvtsov, and Murray (2009) develop open-economy models in which PT's performance can be compromised.

While Coletti, Lalonde, and Muir (2008) abstract from commodity markets and their potential implications for PT's performance in small, open economies, ongoing work by Coletti et al. (2009) considers the transmission of global commodity market shocks using a Canada–U.S. version of GEM that explicitly includes oil and commodity sectors.[9] The authors find that permanent oil supply shocks generate greater macroeconomic volatility under PT, relative to IT. PT's poor performance following these shocks is due to the fact that oil suppliers and demanders face substantial real adjustment costs; as a result, shocks induce highly persistent cost-push pressures, leading to a significant deterioration in the inflation-output trade-off available to central banks, particularly price-level targeters.

Price-level targeting and long-term contracting

The notion that PT may influence long-term financial contracting through a reduction in price-level uncertainty is central to recent work by Meh, Ríos-Rull, and Terajima (2008). The authors develop a framework for estimating the effects of price-level uncertainty on the value of imperfectly indexed assets and liabilities. Using a data-intensive procedure from Doepke and Schneider (2006), they estimate the changes in the distribution of wealth that occur as real payouts vary in response to unexpected shifts in the price level. They then use a heterogeneous-agent framework to understand how redistribution might impact savings and labour decisions for household groups varying in terms of age and socio-economic status.

Long-term instruments are less likely to occasion redistribution under PT.

Since redistribution occurs only if the price level differs at payout from the investor's initial expectation, long-term instruments are less likely to occasion redistribution under PT, which commits the central bank to restore the price path within a certain horizon. Since Meh, Ríos-Rull, and Terajima (2008) find that the average Canadian household holds about 70 per cent of its unindexed assets and liabilities in the form of long-term instruments, PT is able to mitigate the potential for redistribution considerably. Indeed, for a given price shock, the authors report that the extent of redistribution is smaller under PT, relative to IT; effects on labour, savings, and other key macroeconomic variables also tend to be smaller under PT. Since the danger that price shocks will trigger some real redistribution of wealth between borrowers and lenders is a disincentive to long-term nominal contracts, the results suggest that these contracts might be more popular under PT.

The notion that PT is better able to stabilize the real distribution of wealth is also highlighted in Dib, Mendicino, and Zhang (2008), which models business cycles in a multi-sector open economy featuring nominal price rigidities and nominal debt contracts. PT's dominance in this environment stems from the fact that policy-makers are able to rely on automatic stabilizers in achieving their goals, reducing the extent to which they must vary the real interest rate. As a result, there is less potential for redistribution between borrowers and lenders in the market for nominal debt. On the other hand, the real interest rate varies more dramatically under IT. IT is thus forced to trade volatility in the rate of inflation for volatility in the real interest rate, leaving policy-makers ill-equipped to manage *both* price dispersion in the goods market *and* distortion in the nominal debt market. The result proves robust to parameter uncertainty, although the benefits associated with a shift to PT are diminished if IT is implemented with some weight on interest-rate smoothing.

9 See Lalonde and Muir (2007) for a full description of this model.

Challenges for the future

From the foregoing discussion, we can identify several topics for future research. Furthermore, financial intermediaries and labour markets, aside from their implications for optimal inflation, are likely also relevant in the IT-PT debate. In what follows, we focus on four avenues for future research.

Empirical assessment

Although many of our findings to date tend to favour PT over IT, we have shown that PT's performance is sensitive to several factors, including the structure and distribution of shocks and the process underlying the formation of inflation expectations. In particular, PT tends to perform poorly when inflation expectations are highly backward-looking and/or when the economy is vulnerable to large markup shocks, labour supply shocks, and other shocks generating negative correlation between output and inflation. Shocks to the terms of trade and certain commodity shocks may also present challenges. Some empirical assessment is needed to determine whether these problems are quantitatively relevant in the Canadian case.

PT's performance is sensitive to the structure and distribution of shocks and the process underlying the formation of inflation expectations.

With regard to inflation expectations, an accurate assessment could be quite challenging, since the literature is currently divided on the extent to which backward-looking behaviour influences these expectations. Galí, Gertler, and López-Salido (2005), for example, find that the influence is minimal, while Rudd and Whelan (2005) argue that the influence is important, a point with which Dorich (2009) concurs in ongoing work at the Bank. See Dorich (2009) for a thorough review of the literature and a novel approach to the problem.

Endogenous contracting

In studies that apply sticky-price models to the IT-PT debate (e.g., Covas and Zhang 2008), the results can be sensitive to assumptions regarding nominal rigidities. In Covas and Zhang (2008), for example, some assumption must be made about the likelihood that a firm will adjust its nominal price in the current period.[10] Unfortunately, this likelihood may vary across IT and PT regimes, particularly if PT encourages a shift into long-term nominal contracts, as suggested earlier, since PT might then lead firms to adjust prices less frequently. This is an example of the famous "Lucas critique" (1976), which notes that models for policy can be misleading if they fail to take into account all avenues via which policy can affect economic behaviour.

If the Lucas critique is applicable, then future research will require frameworks in which nominal rigidities are at least partially endogenous to monetary policy. Amano, Ambler, and Ireland (2007) have developed a framework that allows households to choose the extent to which their wage contracts are indexed to deviations from trend inflation, conditional on the monetary policy that is in effect. The authors find that households prefer less indexation under PT, mainly because they expect that positive deviations will be unwound as policy-makers aim to restore the target path for the price level.

These points can also apply to financial contracts. In this regard, it is important to note that Meh, Ríos-Rull, and Terajima (2008) take *as given* the portfolios of households, businesses, government, and foreigners when estimating the redistributive effects of inflation under IT and PT. In fact, under a PT regime, agents might opt to hold portfolios with different maturities and/or indexation status. This suggests the need for frameworks that endogenize portfolio choice with respect to monetary policy. Meh, Quadrini, and Terajima (2009) have recently developed a micro-founded model for contracting on indexation status. In ongoing work highlighted in this issue, they have also sought to endogenize choice across maturities.

Endogenous credibility

Aforementioned work by Kryvtsov, Shukayev, and Ueberfeldt (2008), Cateau et al. (2009), and Masson and Shukayev (2008) suggests that imperfect credibility among central bankers can undermine PT's performance. It is natural then to ask what steps policy-makers can take to better ensure their credibility. Research on this front, with special attention to the Bank's communication strategy, would be interesting and rewarding.

10 Covas and Zhang (2008) consider staggered price setting in the sense of Calvo (1983). If we instead considered staggered price setting in the sense of Taylor (1980), as in Amano et al. (2007), the relevant assumption would have to do with the number of periods over which nominal price contracts remain in effect.

The zero lower bound on nominal interest rates (II)

Several authors have recently argued that PT offers a (partial) solution to the problem of the zero lower bound. Svensson (2003) argues that commitment to an upward-sloping price path can help policy-makers to escape a situation where the constraint binds, while Eggertsson and Woodford (2003) and Wolman (2005) suggest that nominal interest rates are less likely to reach their lower bound under PT.

The Bank's researchers and policy-makers are very interested in the zero lower bound, including its implications for PT's performance. Lavoie and Pioro (2007), for example, have used ToTEM to study some of these implications in a Canadian context. In the future, this aspect of the argument in favour of PT will continue to receive attention at the Bank.

Conclusions

The key findings of this review can be summarized briefly. An inflation target below two per cent is likely preferable to the status quo. At this stage, however, it is unclear how much Canadians would benefit from some shift to a lower target. It is also unclear how much lower policy-makers should aim. With regard to a lower inflation target, future research topics include the influence of labour markets and financial intermediaries and the economy's behaviour during transition between targets.

It is also unclear whether a price-level target could improve upon our current inflation target. In particular, the performance of a price-level target may suffer if inflation expectations are highly backward-looking and/or if the economy is vulnerable to shocks generating negative correlation between output and inflation, such as markup shocks, labour supply shocks, and certain commodity shocks. Future research should assess whether these factors are quantitatively relevant for Canadian monetary policy. Other topics for future research include PT's influence on contracting behaviour and strategies for improving central bank credibility under PT.

The choice of an inflation target and/or the implementation of a price-level target could have implications for the problem of the zero lower bound. This possibility needs to be explored more thoroughly, particularly in the current financial climate.

More generally, in this review we aimed at conveying a sense of our findings and the avenues by which they will inform the 2011 decision regarding the Bank's monetary policy framework, while highlighting questions that must be addressed in the time that remains.

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Price-Level Targeting and Stabilization Policy: A Review

*Steve Ambler**

- *The Bank of Canada is leading a research program to address whether and how the monetary policy framework in Canada might be improved.*
- *Part of this research relates to the potential costs and benefits of replacing the Bank's inflation-targeting regime with a price-level targeting regime.*
- *This article reviews arguments for and against price-level targeting put forward by researchers at the Bank of Canada, at other central banks, and in academia.*
- *It summarizes four main arguments in favour of price-level targeting and discusses some issues related to its optimality and implementation.*

In November 2006, the Bank of Canada and the Government of Canada announced the renewal of the Bank's inflation-control target for a period of five years, to the end of 2011. The agreement stipulated that the Bank would continue to aim to keep CPI inflation at two per cent, with a one to three per cent control range around the target. In a background document to the renewal (Bank of Canada 2006), the Bank announced its intention to lead a research program to address whether and how the monetary policy framework in Canada might be improved. The background document raised two broad sets of questions. The first related to the possibility of lowering the inflation target below two per cent. The second related to the potential costs and benefits of replacing the inflation-targeting (henceforth IT) regime with a price-level targeting (henceforth PT) regime. An IT regime is defined as a regime in which the central bank aims to keep some measure of inflation, such as CPI inflation, close to a target rate. By contrast, under a PT regime, the central bank's aim is to stabilize the price level around a known target path, leading it to target a lower (higher) inflation rate after a positive (negative) shock to inflation in order to bring the price level back to its target path.[1]

This article is concerned with the second set of questions. There is a substantial body of research that examines the costs and benefits of PT compared with IT. This article reviews four main arguments from the modern academic literature advanced in favour of PT.[2] In the next section, the traditional arguments for and against PT are summarized. This is followed by an

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1 A PT regime does not necessarily mean that the long-run price level is constant, since the target path may have a positive slope (which determines the long-run rate of inflation). What a PT regime does mean is that the central bank acts to offset deviations of the price level from the target path.

2 An older literature on PT goes back to Keynes, Fisher, Wicksell, and others. See Duguay (1994) for a cogent survey.

assessment of three of the four main arguments for PT arising from recent research. First, committing to PT affects expectations of future inflation and leads to a better trade-off in the short run between inflation and output. Second, assigning a price-level target to a central bank that cannot commit to its future policies can, to some extent, substitute for that commitment and lead to improved economic performance. Third, it can lead to smaller forecast errors for firms that use these forecasts to set their prices. The following section discusses the fourth argument: PT can be beneficial if it reduces the degree to which wage contracts are indexed, since it improves the economy's ability to react to real shocks. Other issues related to PT are then discussed briefly before the article concludes.

Committing to PT affects expectations of future inflation and leads to a better trade-off between inflation and output.

Price-Level Targeting: Arguments For and Against

The Bank of Canada's current target rate of inflation is two per cent. If the annualized rate of inflation is unexpectedly above that rate during the current period, then under the Bank's IT regime, the target remains at two per cent going forward. Under a PT regime, the inflation target would be reduced to below two per cent until the price level itself returned to its original targeted growth path.[3] The positive inflation surprise is offset. Under IT, there is no such offset. A temporary inflation shock leads to a permanent shift in the time path of the price level (this is referred to as "price-level drift"), and shocks to inflation have a cumulative impact on the price level. The future price level is increasingly hard to predict as the forecast horizon increases, and becomes virtually unpredictable at sufficiently long horizons.

The long-run predictability of the price level under PT is precisely the source of the intuitive appeal of this monetary policy regime. It means that the real value of future payments specified contractually in nominal terms is more predictable than it would be under an IT regime.[4] Under a PT regime, current prices convey intertemporal information, since the relative price of future goods in terms of today's goods is predictable, as argued by Coulombe (1998a, 1998b).

This begs the question of why individuals sign long-term contracts that stipulate the value of future payments in nominal terms. There is not a strong consensus among economists as to why this is the case, but the prevalence of contracts with fixed nominal payments is not in doubt. Fischer (1994) argued that the benefits of reduced uncertainty concerning the real value of payments could not be very high, given that individuals in the private sector could easily use other means, such as indexed bonds and contingent contracts, to mitigate the uncertainty without any change in the monetary policy regime. Others infer on the basis of the same evidence that the use of these measures by individuals must be economically costly. For example, Howitt (2001) judged that "long-term price-level uncertainty is one of the most serious consequences of inflation, because of its ruinous effects on long-term contracting."[5]

If reduced price-level uncertainty is the main argument traditionally invoked in favour of PT, the traditional argument against PT is that it must raise the short-run variability of both inflation and output. The logic of this argument seems straightforward. In response to a temporary, unexpected increase (decrease) in inflation in a PT regime, inflation would have to be reduced below (above) its long-run target rate in the short run in order to move the price level back to its target growth path. This increases the variability of inflation, taking the initially lower (higher) price level as a starting point. Since monetary policy operates by affecting aggregate demand, the way to move the price level back down towards the target path would be to raise interest rates in order to reduce aggregate demand. Since no such reduction would be necessary under an IT regime, the variability of output would also be lower under IT.

To summarize, the traditional view sees PT as a trade-off between the longer-run benefits of increased price-level predictability and the short-run costs of increased variability of both prices and output. Formal models from the early 1990s largely confirmed

3 This obviously applies in reverse in response to a negative shock to inflation.

4 The existence of imperfectly indexed long-term nominal contracts has implications for the effects of price-level shocks on the distribution of wealth under PT and IT. This is an active area of research. See, for example, Doepke and Schneider (2006), Meh, Ríos-Rull, and Terajima (2008), and Meh and Terajima (2008).

5 Some recent work analyzes the welfare benefits from reduced uncertainty surrounding the real value of the payoffs of nominal contracts. These studies take the existence of long-term nominal contracts as given. See for example Doepke and Schneider (2006) or Meh and Terajima (2008).

the traditional view concerning increased short-run variability of prices and output under PT. Examples include Lebow, Roberts, and Stockton (1992), and Haldane and Salmon (1995). The contribution of the more recent literature on PT has been to show that, under some circumstances, PT can actually lead to an improved trade-off between inflation and output variability. Much of the focus of recent papers has been to investigate just how wide the range of these circumstances is.

The traditional view sees PT as a trade-off between increased price-level predictability and increased variability of both prices and output.

Optimal Monetary Policy with Forward-Looking Expectations

Much of the modern analysis of PT has been conducted in the context of so-called New Keynesian macroeconomic models.[6] These models have become workhorses for monetary policy analysis by both central banks and academic economists.[7] New Keynesian models have monopolistically competitive firms that set prices optimally but are unable, by assumption, to reset their prices every period. When they do have the opportunity to revise their prices, firms take into account the marginal cost of producing their output and, knowing that they will not be able to adjust their prices for several periods, they forecast the evolution of the overall price level over the period for which their price will remain fixed. The optimal behaviour of firms in such a setting, when aggregated across the different firms in the economy, yields the "New Keynesian Phillips curve." This equation states that current inflation depends directly both on firms' real marginal costs of production and on their current forecast of future inflation. Real marginal cost is in turn related, under certain assumptions (see Clarida, Galí, and Gertler 1999), to the output gap, the difference between aggregate output with sticky prices, and what output would be with complete price flexibility.[8]

The New Keynesian model can be used to derive the optimal monetary policy for a central bank that sets short-term nominal interest rates in order to reduce the variability of both inflation and the output gap.[9] If the central bank can commit to a time path for future interest rates and if the public believes that it will stick to this announced path (so that its commitment is credible), its optimal policy has the feature that the price *level* itself is stable in the long run.[10] In response to a cost-push shock to the inflation rate, inflation initially moves less than the value of the shock itself as the central bank moves the short-term interest rate to affect aggregate demand to partially offset the effect on inflation. Starting with the first period after the shock dissipates, inflation changes sign, and the price level is gradually brought back to its initial pre-shock value. It appears as if the central bank is targeting the price level itself.

The logic of how a commitment to reducing future inflation can be beneficial is simple. By committing to a reduction in future inflation (in response to a positive cost-push shock) even after the shock has passed, current expectations of future inflation are reduced. According to the New Keynesian Phillips curve, current inflation depends directly on expected future inflation as well as on the output gap. This improves the trade-off between inflation and output in the current period, reducing the output loss associated with fighting inflation in the face of a positive cost-push shock. This in turn reduces inflation persistence, thereby reducing inflation variability. The New Keynesian Phillips curve assigns a crucial role to forward-looking expectations of inflation as a determinant of current inflation, and these forward-looking expectations are crucial for the result that is optimal for the central bank to offset shocks to the price level.

6 See Clarida, Galí, and Gertler (1999) for a detailed summary of the standard New Keynesian model and an application to optimal monetary policy.

7 The main model currently in use for internal forecasting purposes at the Bank of Canada, ToTEM, is an elaborate version of a New Keynesian model. See Murchison and Rennison (2006) for a detailed description.

8 The equation can be written as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \psi x_t + \mu_t$$

where π_t is the deviation of inflation from its target or trend at time t, $E_t \pi_{t+1}$ denotes expected future deviation of the inflation rate, x_t is the output gap, μ_t is a "cost-push" error term, and $0 < \beta < 1$ and $\psi > 0$ are parameters.

9 Since the central bank cannot completely eliminate fluctuations in two variables using only one instrument, it minimizes a loss function that depends on a weighted average of squared deviations of inflation from its target rate and of the squared output gap. This form of loss function can be derived under certain assumptions as an approximation to the utility function of a representative household. See Woodford (2003) for details. Inflation has a direct impact on economic welfare because it influences the dispersion of prices across different firms and thereby decreases the efficiency of production.

10 This result was first demonstrated by Woodford (1999) and by Clarida, Galí, and Gertler (1999).

Committing to fighting future inflation improves the trade-off between inflation and output.

Optimal monetary policy under commitment generally has the property that it is *time inconsistent*.[11] That is, it is in the interest of the central bank (and in the interest of society as a whole if the central bank maximizes social welfare) to renege on its announced path for the interest rate. It can achieve a higher level of welfare by choosing a new optimal policy. In turn, if individuals recognize the central bank's incentive to do this, then unless the bank can credibly commit to its announced path for interest rates, its policy will not be believed by the public. An inability to commit to its announced policies reduces the level of economic welfare that the central bank can achieve.

What is the central bank's optimal policy if it is unable to commit to its future policies? (It is standard to refer to optimal policy in this case as "optimal *discretionary* policy.") It can be shown that the optimal policy rule has the property that the rate of inflation—and therefore the short-term interest rate set by the central bank—should vary with the level of the output gap. In this case, the central bank allows a temporary cost-push shock to have a permanent effect on the price level, unlike the case of optimal monetary policy with commitment.

It is also possible to direct the bank to set a goal of reducing fluctuations in output and the price *level*, even if society's true economic welfare depends on reducing fluctuations in output and inflation. Howitt (2001) calls this instructing the central bank to act like a "Zen archer" by aiming at a target that is not society's true target.[12]

In this context, Vestin (2006) demonstrated a remarkable result. In a standard New Keynesian model, as long as cost-push shocks are not persistent, the central bank can attain the same level of economic welfare under discretion as it can under commitment if it uses a loss function that depends on price-level deviations and provided that the relative weight on price-level deviations in the loss function is chosen appropriately. Giving such a loss function to the central bank is a perfect substitute for commitment. It has the effect of affecting expectations of future inflation in the same way as the optimal monetary policy under commitment. In response to a positive cost-push shock to inflation, expectations of future inflation fall, improving the current trade-off between output variability and inflation variability.

Vestin's result holds under quite restrictive assumptions: If the cost-push shock has any persistence, it is no longer possible to attain the same level of welfare as under commitment. However, under a much wider range of circumstances, it is possible to do better than the optimal discretionary monetary policy by assigning a price-level target to the central bank.

Svensson's (1999) seminal paper was the first to construct a model in which an improved short-run trade-off between output and inflation variability is possible under discretion. His model was built around a New Classical Phillips curve, in which current inflation depends on the previous period's expectation of current inflation as well as the output gap. His main result was that, when the output gap is persistent, assigning a price-level target to the central bank improves the trade-off between inflation variability and output variability. Inflation expectations in Svensson's model are indirectly forward-looking. With a persistent endogenous output gap, the central bank can affect the future trade-off between inflation and output variability by affecting the current output gap. As the output gap becomes more persistent, the central bank's ability to affect the future trade-off is enhanced.[13]

Forward-looking inflation expectations, either direct or indirect, are key here. Dittmar and Gavin (2000) showed that replacing the New Classical Phillips curve with the New Keynesian Phillips curve in Svensson's (1999) model leads to an improved trade-off even without endogenous persistence in the output gap. In a recent article, Cover and Pecorino (2005) used the same basic model as Svensson (1999) but changed the assumption of the timing of the central bank's decisions. They supposed that the central bank must choose its optimal policy before knowing the current value of aggregate disturbances. In such a context, the aggregate demand side of the economy plays an active role in the determination of macroeconomic equilibrium, rather than just recursively determining the nominal interest rate necessary to attain the

11 The classic reference on the time inconsistency of optimal government policies is Kydland and Prescott (1979).

12 Assigning an objective different from the true social welfare function to the central bank has a long tradition in macroeconomics. One of the best known examples is Rogoff (1985), who constructed a model in which appointing a "conservative" central banker who is more concerned than society as a whole with fighting inflation could lead to an unambiguously better outcome, with lower inflation and the same average level of output.

13 It can be shown that if the output persistence is purely exogenous (arising from, for example, a persistent error term in the Phillips curve equation), there are no advantages to be had by assigning a price-level target to the central bank.

central bank's chosen rate of inflation. In their model, aggregate demand depends on the real interest rate, equal to the nominal interest rate minus expected inflation based on current information. Their main result is that PT gives an improved trade-off even with no persistence of the output gap. When there is a positive inflation shock under PT, expected future inflation declines, which yields a higher real interest rate for any given level of the nominal interest rate. This reduces aggregate demand, which reduces the equilibrium inflation rate in the current period.

Ball, Mankiw, and Reis (2005) analyzed a model with a Phillips curve derived in a setting where price-setters pay costs to update their information concerning macroeconomic conditions. Like the New Classical Phillips curve, it depends on past expectations of current inflation as well as the output gap. Like Cover and Pecorino (2005), they suppose that the central bank sets its policy before observing current shocks. They show that optimal policy under commitment gives a stationary price level, a result similar to that of Clarida, Galí, and Gertler (1999) and Woodford (1999) for New Keynesian models.[14] Ball, Mankiw, and Reis (2005) stress that the beneficial effects of PT in their model come from reducing the prediction errors of price-setters.

Contracting, Indexation, and Price-Level Targeting

Most of the literature comparing PT and IT takes as given the type and degree of nominal rigidity across the two types of monetary policy regimes. It is important to note that the details of how prices are set in New Keynesian models are imposed by assumption. Any comparison between the two types of regime that holds the type of nominal rigidity constant is potentially vulnerable to the Lucas (1976) critique. Barnett and Engineer (2001, 132) note that:

> The literature has yet to examine how policy endogenously affects contracting and expectations. For example, the Calvo (1983) staggered-price-setting model is used in the New-Keynesian analysis. Yet it is not clear that this model of price setting is optimal in both IT and PT worlds. Similarly, wage and financial contracts may display quite different forms under different policy regimes.

This point was developed in a series of papers by Patrick Minford with various co-authors (Minford 2004; Minford, Nowell, and Webb 2003; Minford and Peel 2003). They build models with households that cannot insure against fluctuations in their real wage and that have a strong interest in smoothing fluctuations in their real wage. The equilibrium degree of indexation of nominal wages to the price level is also endogenous and can depend on the monetary policy regime that is in place. They find that the optimal degree of wage indexation is lower under a PT regime, and that this can lead to substantial welfare benefits. The superiority of PT results from reducing fluctuations in the real wage in response to monetary shocks.

The optimal degree of wage indexation is lower under a PT regime, and this can lead to substantial welfare benefits.

Amano, Ambler, and Ireland (2007) develop a model with nominal wage rigidities and an endogenous degree of indexation to unexpected changes in the price level. They show, as in Minford's work with his co-authors, that the optimal degree of wage indexation is lower under a PT regime. Improved welfare under PT in their model comes from a different mechanism: It helps the economy respond better to real shocks, moving the labour market closer to Walrasian equilibrium.[15]

Other Issues

Price-level targeting and the zero bound

The research program announced by the Bank of Canada in November 2006 proposed looking at both a lower inflation target and the potential advantages of PT. The two sets of questions are actually closely related. A commonly stated objection to a lower inflation target is that it raises the possibility that nominal short-term interest rates will hit the so-called zero bound: The central bank cannot lower its policy rate below zero, given the availability of an alternative asset, namely money balances, that always pays a zero nominal rate of interest. In response to large

14 I conjecture that, as in New Keynesian models, assigning a price-level target to a central bank that is unable to commit to its policies would also be welfare improving in their framework.

15 Walrasian equilibrium refers to a situation where all markets are perfectly competitive and all prices and wages adjust simultaneously to equate supply and demand in all markets.

negative inflation shocks that call for an expansionary monetary policy, the zero lower bound may become a binding constraint on monetary policy.

The possible advantages of PT close to the zero bound are of more than merely theoretical interest. Currently (March 2009), several major central banks have moved their policy rates close to zero and are actively seeking ways to make their monetary policies even more expansionary. One possibility that has received some attention is PT.[16] Under IT, if inflation is expected to remain at or close to zero for an extended period of time, followed by a return to a low targeted inflation rate, the average expected inflation rate over this period would be close to zero. Under a credible commitment to a price-level path, average expected inflation would be equal to the slope of the price-level path (the long-run inflation rate). For the same time path of short-term nominal interest rates, the long-term real interest rate would be lower by the difference in average expected inflation, resulting in stronger aggregate demand.

Monetary policy has more leverage at or near the zero bound under PT than under IT.

Some authors have suggested that, for a given target inflation rate, adopting a PT regime with a price-level path that gives the same rate of inflation in the long run can help to avoid hitting the zero lower bound. The argument for why this would be the case is straightforward. A negative inflation shock under PT is, if the regime is credible, expected to be followed by inflation that is higher than average in order to bring the price level back to its predetermined path. The channel through which monetary policy has real effects operates through the real interest rate. With expected inflation increasing in response to a negative inflation shock, the bank's policy rate has to be reduced by less to achieve the same decrease in the real interest rate compared with a situation in which inflation expectations remain approximately constant. For this reason, monetary policy has more leverage at or near the zero bound under PT than under IT. The effects of PT on the zero bound have been analyzed rigorously by Eggertsson and Woodford (2003) and Wolman (2005). Both papers find that PT is advantageous in helping economies avoid the zero bound problem.

Price-level drift with rule-of-thumb expectations

One shortcoming of the standard New Keynesian Phillips curve, first pointed out by Fuhrer and Moore (1995), is that it is unable to generate persistent inflation. The typical response to this empirical shortcoming has been to add lagged inflation to the New Keynesian Phillips curve equation. The usual justification for the presence of lagged inflation is that a fraction of firms are rule-of-thumb price-setters, setting their price based on past inflation rather than their rational expectation of future inflation (see, for example, Galí and Gertler 1999).

A general result of models with lagged inflation is that some degree of price-level drift is optimal, even if the central bank can commit to its future policies. Steinsson (2003) demonstrates this result in a model in which a fraction of firms follow a particular rule of thumb: They set prices equal to the mean level of prices in the previous period, adjusted for lagged inflation and also adjusted to vary directly with the lagged output gap. He shows that as the fraction of firms that are rule-of-thumb price-setters increases, the amount by which the central bank should optimally offset unexpected changes in inflation becomes smaller.

Why is it not optimal to eliminate price-level drift when expectations are not forward-looking? A change in the price level in New Keynesian models arises because those firms that are able to modify their output price choose to do so. This creates a distortion in relative prices that reduces the efficiency of production.[17] If the central bank tries to bring the price level back to its initial level or path, firms whose relative prices are out of equilibrium may not be able to change their prices, and firms whose prices are on the equilibrium path may be pushed out of equilibrium. Minford (2004) puts it this way:

> The best thing to do strictly depends on the chances of being allowed to change your price. If it is low (the usual assumption),

16 For example, Mankiw (2008) writes, " Suppose the Fed cuts the federal funds rate once again to, say, 25 basis points. More important, at the same time, the Fed announces a target path for the price level as measured by the core CPI. The price path might be, say, an increase of 2 or 3 per cent per year. The Fed promises not to raise the fed funds rate over the next 12 months and, after that, will keep the funds rate at that low level as long as the price level is significantly below its target path. The credibility of the promise is paramount. To get long-term real interest rates down, the Fed needs to convince markets that it will vigorously combat deflation, and that if deflation happens in the short run, the Fed will reverse it by subsequently producing extra inflation. . . . Monetary economists will recognize that this policy is price-level targeting rather than inflation targeting."

17 See Ambler (2007–2008) for a detailed explanation.

then it is best to keep the new price level as there is a low chance of those who already changed their price being allowed to change it back. If it is high (over 50%), then reversal could be worthwhile as there is a good chance that those who already changed could change back. The break-even chance is 50%; below this it is optimal to keep the new price level.

Reversing unexpected price-level changes may merely exacerbate relative price distortions. To the extent that expectations are backward-looking, the benefits in the short run from an improved trade-off between output and inflation are smaller, and it becomes optimal to not completely offset the initial shock to the price level, since fewer additional distortions are created.

Average-inflation targeting

A straightforward way to vary the amount of price-level drift under discretionary monetary policy is by targeting a moving average of current and past inflation rates rather than the current inflation rate. By increasing the size of the window used to calculate the moving average, the amount of price-level drift in the long run in response to an unanticipated change in the price level is reduced. As the size of the window tends towards infinity, price-level drift is eliminated completely, and the price level becomes stationary.

Recent studies show that targeting average inflation can dominate both IT and PT under certain circumstances.

Nessén and Vestin (2005) show that, under discretion, targeting average inflation can yield a superior outcome to IT in a forward-looking model. PT still dominates in a completely forward-looking model. This is not surprising, since Vestin (2006) showed that PT with an appropriately chosen weight on price-level fluctuations can reproduce the optimum under commitment. More interestingly, they show that targeting average inflation can dominate both IT and PT under certain circumstances, as long as the fraction of rule-of-thumb price-setters is positive, but not too large. The size of the window for calculating average inflation that provides the best performance depends directly on the fraction of rule-of-thumb price-setters. In some cases, the performance of average-inflation targeting is very close to the optimal monetary policy under commitment. If the fraction of rule-of-thumb price-setters becomes too large, however, IT is better for economic welfare than PT.

Nessén and Vestin's results on average-inflation targeting are closely related to papers on the practice of hybrid targeting.[18] In these papers, the central bank's loss function is made to depend on a weighted average of price-level deviations and inflation. A positive weight on price-level deviations means no price-level drift in the very long run, but varying the relative weights on price-level deviations and inflation deviations changes the speed at which the price level is brought back to its target path. The behaviour of inflation and prices in the short and medium runs can be made to be very similar to their behaviour under average-inflation targeting. The relative weights that yield the highest welfare depend in a complicated way on the parameters of the model. For some parameter values, hybrid targeting can dominate both IT and PT. As in the case of average-inflation targeting, this tends to occur in cases where price setting is dominated neither by forward-looking nor by rule-of-thumb price-setters.

Prolonged movements in relative prices: Which price level?

Most of the models that have been used to study the costs and benefits of PT have contained either one or a small number of goods sectors. The models feature relative price changes across differentiated goods within a particular sector, which are always inefficient. Prolonged relative price swings across broad classes of goods such as commodities and manufactured goods are absent from these models. Volatile swings in subcomponents of the consumer price index (CPI) have led central banks such as the Bank of Canada to construct measures of "core" inflation that leave out these components. While the official target of the Bank of Canada remains the CPI, core inflation is tracked closely and is used as one of many measures of the pressure on inflation over the short to medium term.

Ortega and Rebei (2006) address this issue in a multi-sector framework. They also analyze the relative advantages of PT and IT and of a weighted average of the two. They construct a small open economy model of the Canadian economy with traded and non-traded sectors, and with nominal price rigidities in both sectors (and differential pricing of traded

18 See Batini and Yates (2003) and Cecchetti and Kim (2005).

goods between domestic and export markets) as well as nominal wage rigidities. No clear advantages of PT over IT emerge, and it is difficult to discern the key assumptions in their model that are responsible for their results. Aoki (2001) builds a somewhat simpler two-sector model. One of the sectors is a competitive, flexible-price sector, and one is a sticky-price sector with monopolistically competitive firms. He finds that the optimal monetary policy in this framework entails the complete stabilization of inflation in the sticky-price sector alone. Insofar as relative prices must fluctuate in order to reduce fluctuations in the output gap, this allows prices in the flexible-price sector to do all of the adjusting.

While Erceg, Henderson, and Levin (2000) do not focus on the choice of the price index, their results are suggestive. They build a forward-looking model with both nominal wage and nominal price rigidities. They show that it is optimal to target a weighted average of wage inflation and price inflation. The relative weight on wage inflation versus price inflation is directly related to the average length of nominal wage rigidity compared with the average length of nominal price rigidity. Their results are compatible with those of Aoki and can be interpreted as a generalization of his results, since the relative degree of rigidity of prices and wages is variable in their model.

Monetary policy should stabilize stickier prices, allowing more flexible prices to adjust on their own.

This suggests that monetary policy should focus primarily (but not exclusively) on reducing fluctuations in prices that are relatively more sticky, allowing more flexible prices to adjust relative to these rigid prices. This solution represents a compromise. It facilitates relative price adjustment across different broad categories of goods while at the same time dampening inefficient relative price fluctuations across different monopolistic producers of the same category of good. Even though the Bank of Canada does not directly target core inflation, looking closely at a less volatile component of the overall price index is in keeping with the spirit of this result.

The result indicating that past inflation surprises should not be offset is related to the discussion of this section. Even though most New Keynesian models have one homogeneous final good, price setting is introduced via differentiated intermediate goods produced by monopolistically competitive firms. These firms have identical production functions, they are all affected in the same way by aggregate technology shocks, and their goods enter the aggregate production function for final output symmetrically. However, since they choose prices at different times (price setting is staggered), they do so based on different information and therefore do not all set the same price.[19] It is not generally optimal to induce firms that are currently setting their prices to lower them in order to compensate for unexpectedly high prices set by firms in previous periods.

Conclusions

Table 1 summarizes the main results from recent research on PT. The principal benefit from PT results from the improved trade-off between output and inflation when expectations are forward-looking, making it less costly for the central bank to reduce current inflation. Expectations can be directly forward-looking, as in the basic New Keynesian Phillips curve, or indirectly forward-looking, as in either Svensson's (1999) model with endogenous output persistence or when forward-looking expectations affect the equilibrium, as happens with both Cover and Pecorino (2005) and Ball, Mankiw, and Reis (2005). In these circumstances, the price level is optimally stationary when the central bank can commit to its future policies, and assigning a price-level target to a central bank can lead to superior outcomes under discretion. When information is costly, as in the Ball, Mankiw, and Reis model (2005), PT can be beneficial by reducing the average size of forecast errors. When price and wage setting depend on the monetary policy regime, PT can reduce the incentive for contingent wage indexation and can improve economic performance in the face of real shocks. Finally, when trend inflation is low, PT can help to alleviate zero bound problems. Only when price setting is based on rule-of-thumb behaviour that does not take into account the model's structure does some drift in the price level become optimal. Even then, pure PT can be superior to pure IT as long as the fraction of rule-of-thumb price-setters is not too high.

19 Price dispersion across firms is one of the main costs of inflation in New Keynesian models. See Ambler (2007–2008) for a discussion.

Table 1: Arguments for and against Price-Level Targeting

Arguments in favour of PT	
Situation	**Advantages of PT**
• Forward-looking price setters	• Prices stable under commitment
• Commitment not possible	• PT can substitute for commitment
• Costly to update information	• Reduced forecast errors under PT
• Endogenous indexation	• Improved response to real shocks
• Low trend inflation	• Zero bound problem less severe
• Flexible prices in some sectors	• Stabilization of index of sticky prices
Arguments against PT	
Situation	**Disadvantages of PT**
• Rule-of-thumb behaviour	• Some price-level drift optimal
• Persistent relative price changes required	• Targeting overall price level not optimal

The rule-of-thumb price-setting rules in current models provide a convenient shortcut that helps to generate the degree of inflation persistence observed in the data; they are also the least theoretically satisfactory feature of New Keynesian models. It is unclear whether policy recommendations should be based on ad hoc modelling assumptions that are as vulnerable to the Lucas critique as previous generations of macroeconomic models. One characteristic of the rule-of-thumb price setting used in New Keynesian macroeconomic models is that it gives no weight whatsoever to monetary policy announcements. It should be possible to come up with price-setting rules that, while not fully compatible with rational expectations, take into account credible announcements of future monetary policy.

Insofar as backward-looking expectations remain an integral part of New Keynesian models (despite the lack of satisfactory microfoundations and despite their vulnerability to the Lucas critique), some amount of price-level drift in response to inflation surprises will be optimal. The section on average-inflation targeting showed that the amount of price-level drift in response to exogenous shocks can be varied by assigning to the central bank an objective function defined in terms of a moving average of past inflation rates as a target rather than the current inflation rate. An important benefit of targeting average inflation is that it could simplify a central bank's communication of its policy to the private sector and minimize the changes in communication strategy in switching from an IT regime to a PT regime.[20] Comparing the level of economic welfare with average-inflation targeting under discretion and that attainable under commitment should be one focus of future research.

The papers reviewed here are normative, having to do with characterizing optimal monetary policy, and depend critically on whether or not the central bank is assumed to be able to commit to its future policies. This begs the question as to which assumption, discretion or commitment, is more appropriate as a positive description of central bank behaviour. This has been a controversial subject in the literature. Price levels in economies with IT regimes appear to have been non-stationary. This could be interpreted as evidence either of discretionary behaviour or of rule-of-thumb price setting in the models used by the central banks to establish their policies.

20 By tracking monthly fluctuations in year-on-year inflation, central banks that target inflation are already targeting a 12-month moving average of monthly inflation rates. Simply changing the number of terms used to calculate the moving average could greatly simplify the adjustment to a new regime.

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Price-Level Uncertainty, Price-Level Targeting, and Nominal Debt Contracts

Allan Crawford, Adviser, Césaire A. Meh, Canadian Economic Analysis, and Yaz Terajima, Financial Stability

- *This article examines several channels through which nominal debt contracts would affect the choice between inflation targeting and price-level targeting.*
- *While uncertainty about the long-run price level has been historically low in recent years, further reductions would be achieved through price-level targeting. Reduced uncertainty would lead to lower risk premiums on longer debt contracts, resulting in higher levels of output and investment.*
- *Given the existence of nominal assets and liabilities, unexpected price-level shocks lead to a redistribution of wealth that affects aggregate output through the asymmetric labour supply responses of young and old households. Since there is less redistribution under price-level targeting than under inflation targeting, the redistributive effects on output are smaller in the former regime. Welfare effects depend crucially, however, on how fiscal policy responds to the change in the government's financial position.*

While a sizable number of central banks around the world, including the Bank of Canada, have successfully embraced inflation targeting (IT), there is ongoing interest in assessing the merits of price-level targeting (PT) as an alternative policy framework (see, for example, Bank of Canada 2006). The differences between these regimes are not trivial. The main difference is that, under IT, unexpected disturbances to the price level are ignored, while under PT, they are reversed. This has important implications for price-level uncertainty: Under IT, uncertainty regarding the future price level increases without bound as the planning horizon grows, while under PT, the price level has a predetermined targeted path and uncertainty about the future price level is bounded.

Since most financial contracts in the real world are not fully indexed to the price level, the difference in paths for the price level under IT and PT is an important consideration. The most important feature of nominal contracts is that changes in the price level lead to changes in the real value of contracts. Specifically, unexpected decreases in the price level increase the real value of nominal debt, while unexpected increases in the price level have the opposite effect. This is often referred to as the "debt-revaluation effect." Thus, uncertainty about the price level imposes a risk premium that increases the cost of capital, which in turn negatively affects economic performance. Because price-level uncertainty is higher under IT than under PT, the associated risk premium is also higher. This risk premium exists for all non-fully indexed financial contracts, regardless of the source of the price-level shock.

This article focuses on the characteristics of PT from a financial perspective—that is, on the role of debt-revaluation risk in assessing the merits of PT relative

to IT. The analysis is approached from several angles (e.g., risk premium, the difference in maturities of nominal debt contracts, and redistribution) but draws a general conclusion: Accounting for the revaluation of nominal debts and assets strengthens the relative merits of PT compared with IT. The article is based on an empirical analysis, as well as on structural models that are designed to capture selected stylized facts for the economy. In addition, although analyzing the source of the shock is another important element for evaluating the overall desirability of PT, the focus here is on the debt-revaluation effect of price-level shocks.[1] The first section assesses the extent of price-level uncertainty under the current IT regime in Canada. The second section quantifies the benefits of PT over IT in a standard structural monetary model with emphasis on nominal debt contracts. In addition, it illustrates the mechanism through which PT reduces uncertainty and encourages economic agents to enter into long-term contracts. The third section examines the potential for wealth redistribution from price-level uncertainty under both IT and PT as nominal claims are revalued in real terms, as well as the implications of these redistributions for aggregate output and welfare. The fourth section presents some explanations for why debt contracts are not indexed to the price level. The final section contains our conclusions.

This article focuses on the role of debt-revaluation risk in assessing the merits of PT relative to IT.

Price-Level Uncertainty in Canada

Many of the benefits of moving to PT would be achieved through its impact on reducing uncertainty about the future price level. Thus, to help quantify the potential effects from a change in policy framework, we begin by reviewing empirical evidence on the amount of price-level uncertainty that remains under Canada's current IT framework. Particular attention is given to uncertainty over the relatively long horizons relevant for many financial contracts.

Before presenting the evidence, it is useful to highlight the relationship between long-run uncertainty about the price level and the conduct of monetary policy. Consider the case of an inflation-targeting central bank that acts systematically to move inflation back to its two per cent target. In this regime, the effects on the price level of deviations of current inflation from the target are not reversed in later periods ("bygones are bygones"), so random shocks will cause the actual price level to deviate from the path implied by extrapolating from the inflation target. The commitment to move inflation back to target means that long-run uncertainty about the price level will be lower than in an alternative regime lacking such an anchor.[2] Nevertheless, the presence of random shocks means that uncertainty will grow without bounds as the horizon increases, even if the current inflation target is fully credible and is perceived to be permanent. If the public believes that the policy objective could change in the future—that the level of the target could be adjusted, for example—there would be an additional source of long-run uncertainty about the price level. For later discussion, this second channel will be referred to as "regime uncertainty."

An important conclusion from the above discussion is that the ideal measure of price-level uncertainty would incorporate the impact of both random shocks and potential future changes in the policy regime. Several approaches to measuring uncertainty are now presented. Since each has its own strengths and limitations, evidence from all of these sources needs to be combined to form a comprehensive assessment of price-level uncertainty arising from the two channels.

Survey evidence

The most direct way to measure price-level uncertainty would be to survey the views of the general public or professional forecasters on the probability that the future price level will lie within various ranges. For Canada, this type of information is quite limited. Since 1999, Consensus Forecasts has asked professional forecasters to report their views on the probability of alternative outcomes for the inflation rate during the current year, but not for longer periods. This source thus provides a measure of price-level uncertainty for the one-year horizon, but not for the longer horizons most relevant for many financial decisions.[3]

1 Ambler (2009, this issue) and Côté (2007) provide comprehensive surveys of the recent literature on PT with emphasis on its stabilization properties. As these surveys suggest, the revaluation of nominal debt has received relatively less attention.

2 See Crawford (2001) for further discussion of how IT increases the predictability of average inflation rates and the price level over long horizons.

3 There is no systematic trend in one-year uncertainty over the period 1999–2009.

Given the limited direct evidence on the uncertainty of individual forecasters, researchers have used survey data on the dispersion of expected inflation rates across different forecasters as an imperfect proxy for inflation uncertainty. One reason for these two variables to move together is that greater clarity about the central bank's policy objective would reduce regime uncertainty, leading to both less dispersion of inflation expectations across different forecasters and less individual uncertainty. Since dispersion is probably correlated with uncertainty, it can be used to supplement other sources of information on how uncertainty has changed over time.[4] Moreover, since a survey provides explicitly forward-looking information, dispersion over long horizons may be particularly useful as an indicator of future regime uncertainty.

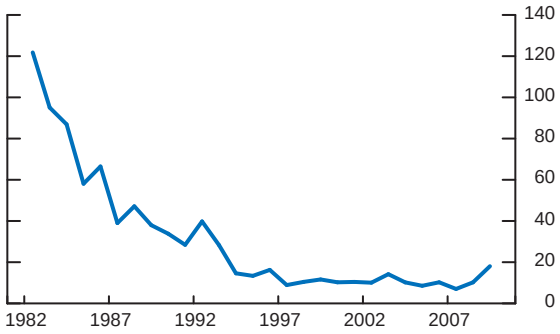
The Watson Wyatt survey of Canadian forecasters reports the dispersion of inflation expectations for the consumer price index (CPI) over horizons up to 15 years. These data can be used to calculate the implied dispersion of price-level expectations (defined as the percentage difference between the expected price level of forecasters at the 75th and 25th percentiles of the distribution). As shown in Chart 1, the dispersion of price-level expectations for 15 years ahead fell significantly over the 1980s as inflation became lower and less volatile. It fell further during the early years of the inflation-targeting period, which began in 1991, and has stabilized at the lower level since the mid-1990s. This profile suggests that IT contributed to a decline in long-run uncertainty about the price level by reducing uncertainty about the future policy objective.

Statistical estimates

An alternative to using survey data is to construct estimates from statistical models of inflation. The regime-switching model is appropriate for this purpose because it allows key features of the inflation process—namely, the mean inflation rate, inflation persistence, and the variance of the error term—to change over time, as would be expected, given a significant change in the monetary policy regime. Parameters from this model can be used to estimate price-level uncertainty over alternative horizons (see Box 1). This model should capture uncertainty related to random shocks. Since it is estimated using historical data, however, it will not fully reflect uncertainty about the *future* policy regime. Accordingly, the forward-looking survey data on dispersion (Chart 1) play a complementary role as indicators of how regime uncertainty changed after inflation targets were implemented.

Chart 1: Dispersion of Price-Level Expectations*

Consumer price index - 15 years ahead



* Measured as a percentage of the price level at the forecast date. For example, the observation for 2008 represents the dispersion of price-level expectations in 15 years' time.

The results show that uncertainty about the level of the CPI at the 15-year horizon peaked during the period of high and volatile inflation in the 1970s and early 1980s, and then moderated significantly by the mid-1980s (Chart 2). This measure fell slightly after the introduction of inflation targets as inflation persistence was eliminated.[5] With the exception of the early part of the sample period, uncertainty is lower for core CPI, which excludes eight of the most volatile components.

Long-run uncertainty has been historically low . . . . Further decreases could be achieved under a PT framework.

The combined evidence from survey and statistical sources suggests that long-run uncertainty has been historically low during the inflation-targeting period. Further decreases could be achieved under a PT framework in which random shocks to the price level are reversed. The credibility of the PT regime would influence the extent to which uncertainty would

4 U.S. evidence shows that dispersion of inflation expectations does tend to be positively correlated with measures of individual uncertainty.

5 There is only a small decline over this period as the effect of lower persistence was largely offset by an increase in the standard deviation of the random error (σ). Uncertainty fell by a greater amount for core CPI as both persistence and σ fell for that price index.

Box 1

Estimating Price-Level Uncertainty

Estimating the parameters

The inflation model $\pi_t = \rho_0 + \rho_1 \pi_{t-1} + \varepsilon_t$ was estimated using annual CPI data from 1953 to 2007, where π_t is the current inflation rate and ε_t is the random error term.[1] The regime-switching approach allows all the parameters of the inflation process, including inflation persistence (ρ_1) and the standard deviation (σ) of the random error, to vary across different regimes. The number of regimes is determined by the data—five regimes were identified over the chosen sample period. The model also provides estimates of the probabilities that a given regime describes the inflation process in the current period. For comparison, another model was estimated for the core CPI, which excludes eight of the most volatile CPI components and the effect of changes in indirect taxes on the remaining components.

Key parameter estimates from the CPI model are shown in Table A. When initial results found no evidence of inflation persistence in a regime, this parameter was eliminated from the final model. Regime 5 covers most of the inflation-targeting period.

Table A: Parameter Estimates for the CPI Model

Regime	1	2	3	4	5
ρ_1	0.29	—	0.64	0.29	—
σ	0.71	0.62	2.19	0.41	0.51
Mean inflation $(\rho_0/(1-\rho_1))$	1.7	3.6	10.9	3.8	1.9
Years*	1954-1967	1968-1973	1974-1983	1984-1992	1993-2007

* Years when the model assigns the highest probability to the regime.

Calculating uncertainty

Price-level uncertainty in regime i (i = 1, ..., 5) is estimated using parameters from that regime (Table A) and the following formula:

$$UNC_i = \frac{\sigma_i}{(1-\rho_{1i})}\sqrt{n + \rho_{1t}^2\frac{(1-\rho_{1i}^{2n})}{(1-\rho_{1i}^2)} - 2\rho_1\frac{(1-\rho_{1i}^{n})}{(1-\rho_{1i})}} \quad (1)$$

where n is the horizon (years).

Uncertainty at period t is a weighted average of uncertainty in each regime, where the weights are the estimated probabilities that the economy is in each regime in period t (PR_{it}):

$$UNC_t = \sum_{i=1}^{5} UNC_i \cdot PR_{it}. \quad (2)$$

This measure is interpreted as the standard deviation of the future price level (measured as a percentage).

Equation 1 illustrates that the model's estimates of uncertainty will include the impact of random shocks through the parameter σ. Although the model produces estimated probabilities that each of the five historical regimes is in effect during the current period, it does not capture uncertainty about a future move to a policy regime that has never been observed during the sample period. Thus, it will not fully reflect uncertainty about the future policy regime.

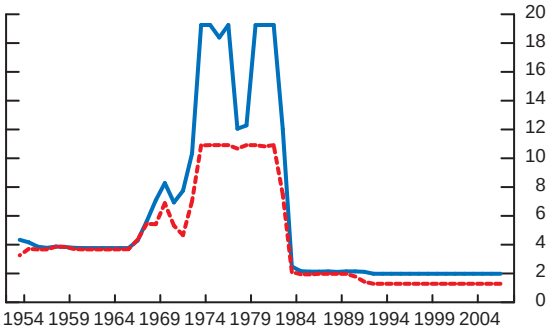
In a regime in which there is no inflation persistence (such as the inflation-targeting period—regime 5), equation 1 simplifies to $\sigma\sqrt{n}$. In this case, price-level uncertainty at a given horizon is lower than if persistence had been positive. Nevertheless, uncertainty under IT still increases as the horizon lengthens (i.e., it is "unbounded" as n increases). In contrast, uncertainty is bounded under PT because random shocks to the price level are reversed.

1 The data used for estimation exclude the effect of changes in indirect taxes, starting in 1984.

decrease and, therefore, the size of the welfare gains described in the remainder of this article.

Chart 2: Statistical Estimates of Price-Level Uncertainty*

15 years ahead



* Standard deviation as a percentage

Price-Level Uncertainty, Risk Premiums, and Economic Performance

A key benefit of PT relative to IT is the reduction in uncertainty about the price level, which will reduce debt-revaluation risks and facilitate long-term financial planning. Howitt (2001) argues that such a reduction in uncertainty is most likely to generate substantial welfare gains through its impact on long-term contracting. Fischer (1994), among others, argues, however, that the benefits for long-term contracting of reducing uncertainty about the price level are likely to be small, since the degree of uncertainty may be small. Yet the mechanism through which price-level uncertainty affects long-term contracting is not well understood, so we first review a quantitative analysis of the relative benefits of PT with one-period nominal debt contracts. This is followed by a qualitative analysis of the channel through which uncertainty about the price level affects the choice between short- and long-term nominal debt contracts.

Quantitative analysis in a medium-scale structural model

Dib, Mendicino, and Zhang (2008) provide a *quantitative* assessment of the benefits of adopting a regime of price-level targeting in a medium-scale New Keynesian model augmented with one-period nominal debt contracts. Although the benefits of PT are generally higher in the presence of long-term nominal debt contracts, the fact that agents are forward looking and that the revaluation effects of nominal debts are present means that PT could still provide benefits in the presence of short-term nominal debts. This is explained in detail below. Dib, Mendicino, and Zhang's dynamic stochastic general-equilibrium (DSGE) model is a small open economy and includes financial market imperfections in both domestic and international markets. The authors take into account several sources of fluctuation in the business cycle, including financial shocks, and estimate the model with Canadian data. Based on social welfare evaluations, they find that PT delivers a welfare gain relative to Canada's current IT regime. Specifically, welfare measured as average annual consumption under PT is 0.36 per cent higher than it is under IT. This number corresponds to $83 per capita per year or, alternatively, to a one-time present-value gain of $2,075 per capita.

In the Dib, Mendicino, and Zhang study, PT outperforms IT because the trade-off between the model's two main sources of distortion—nominal debt contracts and stickiness in price and wage adjustments—is less pronounced. Specifically, the trade-off is as follows: On the one hand, because debt contracts are specified in nominal terms, unanticipated changes in the price level will generate changes in the real cost of debt. This generates risks to entrepreneurs, who are the borrowers in the model, and leads to inefficient allocation of resources. To minimize the volatility in real repayments on nominal debts, the nominal interest rate should be set to stabilize the real interest rate (i.e., the real cost of debt). On the other hand, nominal rigidities in wages and prices generate inefficient wage and price dispersions. To minimize the dispersions, an optimal monetary policy should set the nominal interest rate to stabilize inflation, which would lead to higher volatility in the real interest rate. Under PT, this trade-off is less pronounced because, unlike with IT, forward-looking agents understand that a credible central bank will offset disturbances to the price level, and they will therefore take this into account when setting current prices. It is thus optimal for agents to change prices by less under PT than under IT. This is the so-called "expectations channel."[6] Smaller price changes lead to lower inflation volatility as well as to lower price dispersions.

6 An implication of this is that the trade-off between the reduction in long-run price-level uncertainty and the increase in the short-run inflation volatility in PT relative to IT may not be severe in the model with forward-looking agents. See Ambler (2009, this issue) for a full discussion of the expectations channel under PT. Svensson (1999) pioneered the work highlighting this channel.

With this channel in operation, PT provides more room to optimally set the nominal interest rate to lower the distortion associated with nominal debts. This leads to lower volatility in the real interest rate. Hence, even though the Dib, Mendicino, and Zhang model features one-period nominal contracts, which limit the potential gains from PT, the expectations channel under PT leads to smaller revaluation risks of these contracts. It is worth mentioning that the gain from PT over IT would be even larger if nominal debt contracts are set at greater maturity than the one-period contracts in their model. This suggests that the prevalence of nominal debts in the real world should make PT even more desirable than suggested by their model. We now illustrate this point.

Price-level uncertainty and long-term contracts: A channel

While Dib, Mendicino, and Zhang do not incorporate long-term contracts in their analyses, Meh, Quadrini, and Terajima (2008a) provide a qualitative analysis of the channel through which uncertainty about the price level affects the endogenous choice between short- and long-term nominal debt contracts. Using a small-scale model, they seek to answer the following interrelated questions: Would PT encourage more long-term contracts and, if so, by what channel? Furthermore, what are the implications for aggregate output? To answer these questions, they use a small open economy model featuring two types of persistent shock: a firm-specific productivity shock and an aggregate price-level shock. Information is perfect, so that all agents know the realization of shocks as well as their exogenous processes. Both types of shock are found to play an important role in the choice of the maturity of nominal debts. In the model, firms finance investment by choosing either short- or long-term nominal debts. Long-term debt is an *N*-period contract in which interest payments are constant during the life of the contract. Short-term debt is a one-period contract. An interesting and important feature of the model is that, since firms can choose to default on either type of debt, financial intermediaries charge a risk premium to compensate for default risks. These intermediaries are assumed to be risk neutral and to operate competitively.

The interaction between the two types of shock and default risks makes the choice between short- or long-term nominal debt non-trivial for borrowers. On the one hand, price-level risk makes long-term debt less attractive for firms (i.e., the borrowers) because of the potential for revaluation of nominal debts. The real value of debt increases when the price level is lower than expected and decreases when the price level is higher than expected. The risk premium (or spread) associated with price-level risk is higher for long-term debt than for short-term debt, since it is more difficult to forecast the price level in the distant future. Recent history can help to forecast the price level for the next quarter, but uncertainty increases as the horizon lengthens.

On the other hand, firm-level productivity risks make long-term debt more attractive for firms. With short-term debt, interest payments fluctuate from period to period. With long-term debt, however, they are constant over the life of the debt contract. Hence, long-term debt contracts provide partial insurance to the borrower against fluctuations in interest payments resulting from changes in the level of default risks related to firm-specific productivity shocks.

Reducing long-run price-level uncertainty through PT decreases the risk premium and reduces the cost of capital.

The first finding of the Meh-Quadrini-Terajima study is that reducing long-run price-level uncertainty from the current level (as reported in the first section of the paper) through PT decreases the risk premium and thus reduces the cost of capital. Second, lowering uncertainty about the price level can lead to an increase in the fraction of agents using long-term nominal debt and a rise in aggregate investment and output. These results are consistent with the work of D'Amico, Kim, and Wei (2008) and Hördahl (2008), who argue that the gain from reducing long-run uncertainty about the price level through a lower risk premium could be substantial (they both estimate the premium to be, on average, 50 basis points at the 10-year horizon for a U.S. sample period from 1990 onwards).

Redistributional and Aggregate Effects of Price-Level Shocks

The previous section discusses the risk premium channel, through which lower price-level uncertainty under price-level targeting would affect economic activities, owing in part to the ex ante expectations channel. In this section, we focus on the redistributional effects of realized price-level shocks. An unanticipated rise in the price level redistributes

wealth from lenders to borrowers, since such an increase lowers the real value of nominal assets and liabilities. The size of this redistribution of wealth is different for IT and PT and depends on the maturity structure of nominal assets and liabilities. Under PT, the real value of long-term nominal claims is less sensitive to movements in the price level, since the price level is restored within some horizon after experiencing a shock. Under IT, the real values of long- and short-term nominal claims are equally affected by movements in the price level. As a result, the redistribution of wealth from changes in the price level is higher under IT than it is under PT. Moreover, given that a large part of households' portfolios consists of longer-term assets and liabilities (70 per cent with the term-to-maturity over one year; see Meh and Terajima 2009, this issue), the difference in the size of the redistributions between the two regimes is expected to be large.

Using Canadian data, Meh, Ríos-Rull, and Terajima (2008) consider the effects that arise under IT and PT as nominal holdings are revalued following an unexpected surge in the price level. Specifically, they address two questions. First, through the detailed documentation of nominal portfolios belonging to different agents in the economy (see Meh and Terajima 2009, this issue), they assess the potential wealth redistributions of unexpected shocks to the price level under both IT and PT regimes. Second, they quantify the implications of these redistributions for aggregate output and the welfare implications under both regimes.

Redistribution of wealth

With respect to the first question, the authors find that the size of the redistribution of real wealth is large and consistently greater under IT than it is under PT. Redistributions occur because the level and composition of nominal assets and liabilities varies across agents. In addition, differences between the two monetary policy regimes emerge because of the interaction between the term to maturity of these claims and the post-shock path for the price level under each monetary policy regime. Specifically, under PT, long-term assets and liabilities are more protected from a price-level shock, since the price level would likely be brought back to the pre-shock path by their maturity dates. Given that long-term assets and liabilities are prevalent in the economy, redistributions are expected to be smaller under PT. Based on the portfolios of nominal assets and liabilities in 2005, we analyze a one-time, positive, one per cent price-level shock. Under IT, the price level after the shock stays on a new path at a level that is one per cent higher than it was on the pre-shock path. Under PT, the central bank is assumed to credibly bring the price level back to its original path within a given time horizon. Under IT, the household sector loses wealth equivalent to 0.4 per cent of gross domestic product (GDP) (or $5.5 billion), which is 2.7 times larger than that under PT (with a 6-year target horizon[7]).[8] In addition, on average under both regimes, the young low-income, the young middle-income, and the government—who are all debtors—are the winners, while middle-aged workers, the old, and the high-income are the losers.

Redistribution of real wealth is large and consistently greater under IT than it is under PT.

Aggregate output and welfare effects

Regarding the second question, Meh, Ríos-Rull, and Terajima (2008) use an overlapping-generations model in which agents differ in labour-productivity profiles as well as in their propensities to work and save.[9] Redistributions derived from the first question are assigned to respective agents in the economy, and we observe the changes in their behaviours. A key insight from this work is that analyses of the effect of redistributions on aggregate output and welfare need to consider the role that fiscal policy plays following the government's windfall gains or losses. With a positive price-level shock, for example, the government's nominal debt decreases in real value, which is an improvement in the government's portfolio. The authors do not take a stand on how the government optimally uses its windfall gain. Instead, they illustrate the importance of fiscal policy for the economic effects of redistributions by considering several fiscal policy scenarios that balance the government budget after the initial change in the real value of government debt. The government can transfer the windfall gain through a reduction in the labour tax or as a transfer to retirees.

7 The redistribution of wealth from price-level movements as well as the aggregate output and welfare effects of this redistribution increase with the horizon under PT. See Box 2 for more details.

8 We take a one-time positive one per cent shock as a benchmark. Redistributions regarding other magnitudes and both positive and negative shocks can be found in Meh, Ríos-Rull, and Terajima (2008). IT is generally found to lead to larger redistributions than PT.

9 The model assumes that the central bank credibly commits to its policy. Potential issues with the credibility of the central bank commitment are discussed in Ambler (2009, this issue).

Box 2

Importance of a Horizon for the Target Price Level

The horizon used for price-level targeting (PT) is the time it takes the monetary authority to restore the price level to its initial path following unexpected disturbances. This horizon plays an essential role in determining the economic effects of the redistribution of wealth. Specifically, Meh, Ríos-Rull, and Terajima (2008) show that, as the horizon under PT becomes longer, the magnitude of the redistribution becomes larger and eventually converges to that observed under inflation targeting (IT). The same result holds for the initial reaction of output to the redistributions. This is clearly illustrated in Table A, which shows the initial responses in output to a one-time positive one per cent price-level shock for IT, PT with a 15-year horizon, and PT with a 6-year horizon. The numbers are shown in percentage deviations from the initial steady state. The initial response for IT is more than twice that of PT with a 15-year horizon and more than three times that of PT with 6-year horizon.

Table A: Horizons for Price-Level Targeting and Initial Output Responses from Redistributions

IT	PT: 15-year horizon	PT: 6-year horizon
0.104	0.049	0.031

The key results regarding aggregate output are that the effects of an unexpected change in the price level are larger under IT than under PT (regardless of the fiscal policy scenario). They show that although the redistributions are zero sum across agents in the economy, the aggregate effects on output are non-zero under both regimes. The intuition behind this finding is as follows. In the model, a positive price-level shock, for example, generates redistributions from high-income, old, and middle-aged savers to young, low-income borrowers. This wealth effect causes young households to reduce their labour supply and middle-aged households to increase their labour supply, with no change by the old (who are retired). Independent of fiscal policies, the increase in the labour supply by middle-aged households outweighs the decrease by young households, since the wealth losses of the middle-aged are larger than the wealth gains of the young (see Meh and Terajima 2009, this issue). As a result, there are aggregate effects from the redistribution of wealth, even though the redistribution shock is zero sum across agents in the economy, including the government. Because the initial redistribution is larger under IT, the effect on labour supply is also amplified, and the overall effect on output is larger under IT than under PT. When, for example, the government cuts the labour tax rate to reallocate its windfall gains to households, a one-time, one per cent price-level shock leads to an increase in aggregate output of 0.1 per cent of GDP (or $1.4 billion) under IT, while under PT (with a 6-year horizon), the increase is one-third of that amount.[10] Similarly, the increase in aggregate output is larger under IT than under PT when the government makes transfers to the old.

Welfare effects

The welfare effects of price-level shocks are also larger under IT than under PT. The direction of the change in the weighted welfare of heterogeneous households depends crucially, however, on the fiscal policy scenario used to deal with the government's wealth gains (losses) that arise from changes in the real value of its debt. Specifically, whether aggregate welfare increases or decreases depends on the fiscal policy scenario and the different responses of heterogeneous households to both the redistributions and the fiscal policy. Given the heterogeneous types (e.g., age and income) of households, one way to measure aggregate welfare is to take a weighted average of changes in welfare for each type. The size and the direction of redistributions differ for each type and hence the effects on welfare differ as well. In addition, the change in welfare does not sum to zero because (as explained above) households respond differently to redistributions for aggregate output and because the fiscal policy of reallocating the government gains may be directed to one group over another. If the fiscal policy scenario favours retirees (i.e., an

10 Everything else being equal, cutting the income tax rate for labour increases the labour supply of all workers (e.g., young and middle-aged).

increase in transfers to the old, who were the losers from inflation), following a one per cent price-level shock, welfare increases by 0.20 per cent and 0.09 per cent under IT and PT, respectively. Because the transfers to retirees are distributed equally to each old household regardless of their income class, some of them, e.g., low- and middle-income households, are overcompensated by the transfer, which leads to an improvement in overall welfare. On the other hand, if the fiscal-policy scenario favours workers (i.e., a tax cut on labour income), following a one per cent price-level shock, weighted average welfare falls by 0.06 per cent of consumption under IT and by 0.03 per cent under PT. In this case, weighted welfare falls despite the increase in aggregate output, since tax cuts for younger and middle-aged households bolster the supply of labour, but losses among older households go uncompensated by the fiscal policy.[11] Welfare decreases despite the increase in output because of the heterogeneous responses of households to the negative redistribution of wealth and the fact that the losers from inflation, particularly the retirees, are not compensated by the tax cut on labour income.

Endogenous Indexation of Debt Contracts

While the foregoing sections highlight the challenges that uncertainty about the price level presents for financial contracting, we should recognize that agents can address these challenges by indexing their contracts to the price level. In reality, however, we observe that most financial contracts are not fully indexed. This raises an interesting question: If price-level uncertainty is indeed a source of risk, why do agents choose to bear these risks rather than fully index their contracts to the price level? Answering this question is essential in the IT-PT debate, since indexing behaviour may vary between the two regimes. Several answers have been suggested in the literature; perhaps, for example, the price level cannot be observed in sufficient time (Lucas 1972) or it is costly to incorporate the price level into contracts. Another answer commonly suggested is that different agents may consume different baskets of goods and thus prefer to contract on different prices. Because of this heterogeneity, it may not be optimal to index contracts to a single price index.

In a recent paper, Meh, Quadrini, and Terajima (2008b) provide further insight into the reasons why financial contracts are not fully indexed. They study an equilibrium model featuring repeated moral hazard arising from asymmetric information between firms and financial intermediaries. There are several important findings from their work. First, despite the availability of fully indexed financial contracts, the optimal financial contract is *imperfectly* indexed to the price level because (i) the nominal price level (e.g., the GDP deflator) is observed with delay, and (ii) there is uncertainty with respect to the measurement of prices. This result is consistent with that of Jovanovic and Ueda (1997). Although the delay is considerably shorter in the case of the CPI, it is longer for the GDP deflator, for which revisions occur for extended periods (see Bullard 1994).

The second finding is that the overall degree of nominal indexation increases with price-level uncertainty (arising from nominal shocks). To put it differently, economies with higher uncertainty about the price level experience a higher degree of indexation, while economies with lower uncertainty feature a lower degree of indexation. The last finding is that, in the presence of endogenous indexation, a monetary policy regime that reduces uncertainty about the price level will lead to better macroeconomic stabilization (e.g., output and investment stabilization).[12]

Conclusion

The findings highlighted in this article suggest that accounting for the revaluation of nominal debts and assets is important when comparing IT and PT. Specifically, the work reviewed suggests that the revaluation of nominal debts and assets makes PT a much more desirable monetary policy regime than IT (with respect to nominal shocks). By reducing uncertainty about the price level, PT reduces the risk premium associated with price-level risks on nominal debts and, as a result, encourages more long-term planning and increases both aggregate output and welfare. In addition, the work summarized in this article demonstrates that the extent of long-run uncertainty about the price level (which is at the source of the revaluation effects) is low by historical standards but still remains unbounded under the current IT

11 As Tobin (1965) argues, it is important not to confuse output with welfare. The objective of a benevolent government is to increase the welfare (utility) of its citizens, and not just the output.

12 Interestingly, with a different class of model economy, Amano, Ambler, and Ireland (2007) find similar results, but for the case of endogenous wage indexation. Specifically, they show that the optimal degree of wage indexation is lower under PT (i.e., lower price-level uncertainty) than under IT (i.e., relatively higher long-run uncertainty about the price level) and this leads to an improvement in welfare. Although PT reduces price-level uncertainty, there is still some remaining uncertainty and because of this, agents still optimally choose to index their wage (but to a lesser degree).

regime. Given that a large part of portfolios consists of nominal long-term assets and liabilities, the redistribution of wealth resulting from unanticipated changes in the price level is larger under IT than under PT. The aggregate consequences are also larger under IT than under PT; the welfare consequences of these redistributions depend, however, on the response of fiscal policy.

Because of technical difficulties, the studies summarized in this article have made several simplifying assumptions. A notable assumption when examining the economic effects of PT in the presence of nominal debts is that PT is implemented with perfect credibility. If PT were assumed to be imperfectly credible, there would be additional costs during the transition from IT to PT as well as after the transition in sustaining the PT regime, which would reduce the desirability of moving to PT. Recent research at the Bank of Canada has started making important progress in this direction (see, for example, Kryvtsov, Shukayev, and Ueberfeldt 2008). Another caveat concerns the assumption of the existence of only one-period nominal debts when quantifying the benefits of PT in a medium-scale macroeconomic model. Accounting for long-term nominal debts should increase the benefits of price-level targeting.

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Unexpected Inflation and Redistribution of Wealth in Canada

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- *One of the most important arguments in favour of price stability is that unexpected inflation generates changes in the distribution of income and wealth among different economic agents. These redistributions occur because many loans in the economy are specified in fixed-dollar terms. Unexpected inflation redistributes wealth from creditors to debtors by reducing the real value of nominal assets and liabilities.*
- *This article quantifies the redistributional effects of unexpected inflation in Canada. To this end, we first provide comprehensive evidence of the nominal assets and liabilities of various economic sectors and household groups.*
- *We find that the redistributional effects of unexpected inflation are large even for episodes of low inflation. The main winners are young, middle-income households, who are major holders of fixed-rate mortgage debt, and the government, since inflation reduces the real burden of their debt for both groups. The losers are high-income households and middle-aged, middle-income households that hold long-term bonds and non-indexed pension wealth.*

There is ongoing research on potential refinements to monetary policy regimes in countries with low and stable inflation. In Canada, for example, a systematic review of the current inflation-targeting framework is underway (see the other articles in this issue). An issue that has received relatively less attention is the redistributional effects of unexpected inflation.[1] Redistributional effects occur because many savings, investments, and loans in the economy are specified in money terms (i.e., not adjusted for inflation); unexpected inflation therefore redistributes wealth from lenders to borrowers by lowering the real value of nominal assets and liabilities.[2] The analysis of these effects may be important since the welfare costs of inflation depend not only on aggregate effects but also on potential redistributional consequences. Our calculations show that, even with an episode of low inflation, the redistribution can be sizable. While this is a wealth transfer from one agent in the economy to another, a sense of who wins and who loses is essential in order to assess transitional costs and potential public support for reform.

The goal of this article is to provide insight into the redistributional effects of inflation in Canada. The article is a summary of the recent research of Meh and Terajima (2008).[3] The article proceeds as follows. The first section documents nominal assets and liabilities (i.e., financial assets and liabilities that are denominated in Canadian dollars and not fully indexed to inflation) held by different economic sectors and

1 In this article, we focus on inflation that is either unexpected or partially unexpected. If inflation were completely expected, the change in the real value of the nominal claim would be incorporated in the contract. Hence, there would not be any redistribution.

2 On the other hand, lower-than-expected inflation redistributes wealth from borrowers to lenders.

3 Meh and Terajima (2008) build on Doepke and Schneider (2006) who document nominal assets and liabilities in the United States and develop a methodology to compute the redistribution of wealth caused by inflation.

household groups, while the second part describes the methodology used to compute the redistribution of wealth induced by unexpected inflation. Using this methodology and the documented nominal positions, the third section quantitatively assesses the redistribution of wealth under episodes of low and moderate inflation. The final part of the article concludes.

Nominal Assets and Liabilities

Unexpected inflation generates redistributions because most financial assets and liabilities are specified in money terms. For example, payments on fixed-rate mortgage contracts, bank deposits, non-indexed defined-benefit pension plans,[4] government and corporate bonds, and other types of loans are generally not adjusted for unexpected inflation. Hence, when inflation is high, the value of these assets and liabilities falls in terms of purchasing power, since the prices of other goods and services go up with inflation, but payments on these financial claims are fixed. The extent of the changes in the purchasing power of financial assets and liabilities also depends on the term to maturity, as we will show later on. In this section, we document Canadian holdings by type and maturity in various categories of assets and liabilities. Specifically, we look at asset and liability positions for three sectors: household, government, and non-residents.[5] We also consider different groups of households. The objective is to show that, among these different groups of agents, holdings of nominal assets and liabilities differ in both qualitatively and quantitatively important ways. Given that these differences exist, there is potential for redistribution among them following inflation shocks.

Unexpected inflation generates redistributions because most financial assets and liabilities are specified in money terms.

Data

We use two main data sets, both provided by Statistics Canada: the National Balance Sheet Accounts (NBSA) and the Survey of Financial Security (SFS). The NBSA documents the ownership of financial and non-financial assets and liabilities by sector. We use the NBSA to compute the net asset and liability positions of the household, government, and foreign sectors. The SFS is a household survey data set on income and wealth. We use the 2005 wave (the latest available), involving about 5,000 households, with weights to produce Canadian aggregates. It provides a comprehensive picture of assets and liabilities. For the sake of consistency, we use the 2005 NBSA and focus our analyses on the year 2005.

Categories of nominal assets and liabilities

Following Doepke and Schneider (2006), nominal assets and liabilities are defined as all financial claims that are denominated in Canadian dollars and not fully indexed to inflation. We report net nominal positions (i.e., assets minus liabilities) in four categories, defined as follows:[6]

- *Short-term* – financial assets and liabilities with a term to maturity less than or equal to one year (e.g., domestic currency, bank deposits, consumer credit, and short-term paper)
- *Mortgages* – all mortgage claims
- *Bonds* – non-mortgage and non-pension nominal claims with maturity greater than one year, including government and corporate bonds and bank loans
- *Pensions* – employer pension plans without provisions for indexing benefits to the cost of living, including both defined-contribution plans and non-indexed defined-benefit plans[7]

We distinguish among these categories because they differ in maturity structure. Differences in maturity will emerge as a key factor in assessing the extent of potential redistribution.

Sectoral positions

Table 1 shows net positions in each category, as well as the overall net nominal position (NNP) for each sector. Positions are expressed relative to gross domestic product (GDP) in 2005. Positive numbers indicate net lending; negative numbers, net borrowing.

4 Non-indexed defined-benefit pension plans are those where retirees receive fixed payments not adjusted for inflation.

5 Since all businesses are owned by their shareholders, we allocate business sector portfolios across the three sectors, based on each sector's equity holdings.

6 For more details, see Meh and Terajima (2008).

7 Another type of plan is the indexed defined-benefit plan. These plans are treated as real assets, since inflation will not affect them.

We observe that households are the main net nominal lenders overall, with NNP at 40.14 per cent of GDP. The government sector, at about 43 per cent of GDP, is the main counterparty borrowing from households. The foreign sector has a positive but small NNP of 2.85 per cent of GDP. Households tend to lend through short-term claims, bonds, and pensions, and borrow through mortgages. The government sector borrows mainly through bonds; it also borrows through short-term claims and pensions.[8] The non-resident sector lends in mortgages and bonds and owes in pensions.[9] These observations suggest that households are the likely losers of unexpected inflation, since it lowers the purchasing power of their lending (i.e., savings).

Table 1: Net Nominal Positions as a Percentage of GDP

Sectors	Households	Government	Non-residents
Short-term claims	12.25	-7.60	-4.65
Mortgages	-11.94	3.19	8.75
Bonds	22.14	-29.67	7.53
Pensions	17.69	-8.91	-8.79
NNP	40.14	-42.99	2.85

Household groups

We now look at the household sector in more detail, using the SFS data set. We examine three classes (low-income, middle-income, and high-income) and six age groups (under 36, 36–45, 46–55, 56–65, 66–75, and over 75) to observe differences within the sector.[10] Table 2 presents the overall positions for each age group as a percentage of the group's net worth. We observe that the NNP increases with age, implying that households shift from being net borrowers to net lenders as they get older. Most of the borrowing of the young is from mortgages. With age, more lending (i.e., saving) is observed in pensions and in liquid short-term claims. This implies that young households will gain from unexpected inflation while older households will lose.

Table 2: Nominal Positions as a Percentage of Net Worth by Age

	Age Cohort					
	Under 36	36–45	46–55	56–65	66–75	Over 75
Short-term claims	4.83	-1.01	1.48	2.40	9.00	12.27
Mortgages	-37.95	-13.57	0.07	4.48	3.55	3.29
Bonds	-2.63	4.70	6.50	7.90	6.70	7.68
Pensions	-0.05	-1.31	5.01	7.36	8.68	8.65
NNP	-35.80	-11.19	13.06	22.14	27.93	31.89

Qualitatively, these patterns generally hold across different income classes, although with different magnitudes. Table 3 shows the positions of the three income classes, with the long-term category combining mortgages, bonds, and pensions.[11] The general pattern of "borrowing more when young and lending more with age" holds across different income classes. We observe, however, that levels of borrowing relative to their net worth among young middle-income and low-income households are relatively larger than they are for high-income households, mainly because the portfolios of low-income and middle-income households are concentrated in residential real estate (mortgages). This implies that while the young generally benefit from inflation, benefits are likely concentrated among low-income and middle-income households.

Table 3: Nominal Positions as a Percentage of Net Worth by Age and Income Class

	Age Cohort					
	Under 36	36–45	46–55	56–65	66–75	Over 75
High-income						
Short-term claims	3.86	-3.73	-1.97	-2.36	8.48	8.56
Long-term claims	-6.52	5.89	18.40	19.89	19.03	21.26
Medium-income						
Short-term claims	5.83	2.24	4.39	5.49	9.07	14.91
Long-term claims	-95.27	-28.71	7.01	20.55	20.29	18.97
Low-income						
Short-term claims	18.90	-0.06	5.04	13.84	12.58	10.96
Long-term claims	-71.01	-27.07	-8.30	6.89	1.57	12.79

8 The government sector is a borrower in pensions as it holds liabilities from employer pension plans to its employees.

9 The borrowing in pensions by the non-resident sector indirectly reflects the pension liabilities of the business sector. As previously mentioned, we allocate business sector portfolios across the three sectors, based on each sector's equity holdings.

10 The classes are defined based on a mix of income and wealth. For simplicity, we use the terms low-income, middle-income, and high-income to refer to each class. See Meh and Terajima (2008) for the details.

11 The distribution of households as well as that of net worth by age group and income class is shown in Meh and Terajima (2008).

How Inflation Causes Redistribution

Given the observed differences in nominal positions among households, government, and non-residents, unexpected inflation should induce redistributions of real wealth. But how do we begin to identify the pattern and quantify the extent of the redistributions? The size of wealth redistribution depends on how economic agents adjust their expectations to inflation surprises. We follow Doepke and Schneider (2006) by considering two scenarios that provide upper and lower bounds on the redistribution of wealth. The upper bound is captured by a "full-surprise" scenario (hereafter FS). In this scenario, during several years of experiencing inflation shocks, agents do not anticipate that shocks will continue in subsequent periods; nominal interest rates remain unchanged and the inflation shock lowers the real value of nominal positions each period, regardless of the duration of these positions.

The size of wealth redistribution depends on how economic agents adjust their expectations to inflation surprises.

The lower bound is given by an "indexing ASAP" scenario (hereafter IA), where agents adjust their expectations after the initial shock to take into account the full duration of the shock. This scenario is also known as a gradual inflation episode, since inflation is partially anticipated. Under the IA scenario, the nominal yield curve is adjusted upwards to incorporate the inflation shock. As a result, under the IA scenario, inflation-induced gains or losses depend on the maturity of the nominal position. The position is "locked-in" at the pre-shock nominal interest rate until its maturity date but must be discounted using the new nominal rate, resulting in a lower present value. Intuitively, present-value gains or losses for a claim are larger under the FS scenario because all the positions are affected equally by the inflation episode. Under the IA scenario, however, long-term positions are affected more drastically than shorter positions. Agents are able to mitigate their losses on instruments that mature before the inflation episode ends. Our calculations are based on a present-value analysis, described in Box 1. Box 2 discusses how we assign terms to maturity for each category of claims.

Wealth redistribution from inflation

The goal of this section is to use the nominal positions documented above, combined with the methodology just described, to estimate the redistribution of wealth for an inflation episode. Historically, inflation episodes with different magnitudes lasting for extended periods have occurred. For example, between 2000 and 2004, the average inflation rate in Canada was generally higher than the inflation target rate of two per cent. To illustrate the inflation-induced redistribution of wealth, we will consider a hypothetical inflation episode that lasts five years with an inflation shock of one per cent, starting in the benchmark year 2005.[12]

Redistribution across sectors

Table 4 summarizes the sectoral present-value gains and losses induced by an inflation episode with one per cent shocks that continue for five years, beginning in 2005, under the FS and IA inflation scenarios.

Table 4: Redistribution of Wealth across Sectors as a Percentage of GDP, with a One Per Cent Inflation Shock Lasting Five Years

Sectors	Households			Government	Non-residents
	Net	Gains	Losses		
Full-surprise scenario	-1.95	12.53	-14.48	2.09	-0.14
Indexing ASAP scenario	-1.26	7.61	-8.86	1.49	-0.23

It is apparent from the table that, under the two scenarios, the household sector loses, while the government sector wins. The household sector loss and the government gain are both large. Under FS, the household losses amount to 1.95 per cent of GDP (or $26.8 billion), while the government gain is 2.09 per cent (roughly 5 per cent of NNP). The non-resident sector loses, but the loss is small, just 0.14 per cent of GDP. To understand these findings, recall that, under FS, gains and losses are directly proportional to the initial nominal positions. Since the household sector is the economy's main lender and the government sector is the main borrower, it is not surprising that these sectors are the most dramatically affected by the shock under the FS scenario.

12 Under the current inflation-targeting framework, inflation has not exceeded expectations by one per cent for five consecutive years. However, as a hypothetical scenario, we suppose price-level shocks that push inflation to the upper bound of the range specified in the current framework. The current annual inflation target is two per cent with the target range extending from one to three per cent.

Box 1

Present-Value Analysis of Redistributions[1]

Full-surprise (FS) Scenario

We start with an explanation of how unexpected inflation changes the purchasing power of a nominal claim. Consider an n-year, zero-coupon bond with a total nominal yield at time t of $i_{t,n}$. In the absence of unexpected inflation, the present value of one dollar earned in n periods through investment in this financial claim is given by

$$V_t(n) = exp(-i_{t,n}),$$

where exp indicates the exponential function to base e. Suppose that at time t, there is a one-time *surprise* increase in inflation of θ per cent per year that lasts for T periods. Under the FS scenario, since the inflation shock in each subsequent period is unanticipated, market expectations do not adjust and the nominal term structure is unchanged. As a result, only a proportion, $exp(-\theta T)$, of a position's present value remains, and this proportion falls as the size and duration of the shock increase. The present value of this nominal claim under FS, $V^{FS}{}_t(n)$, is thus given by

$$V^{FS}{}_t(n) = exp(-i_{t,n}) \cdot exp(-\theta T).$$

This equation shows that the present value of a one-dollar claim at time t is independent of the term to maturity of that claim. The present-value gain or loss, $G^{FS}{}_t(n)$, is given by

$$G^{FS}{}_t(n) = V^{FS}{}_t(n) - V_t(n) = V_t(n) \cdot [exp(-\theta T)-1].$$

The net present value of gain or loss depends only on the size and duration of the shock and the initial nominal position. The gain is, indeed, proportional to the pre-shock position, with a coefficient of $[exp(-\theta T)-1]$. If $G^{FS}{}_t(n)>0$, then there is a gain from the inflation episode; otherwise, there is a loss. In order to derive the total gain or loss of an economic agent (e.g., a sector or a household), $G^{FS}{}_t(n)$ is calculated for each claim with a term to maturity n. The gains or losses are then summed over all claims to derive the net redistribution.

Indexing ASAP Scenario

The indexing ASAP scenario corresponds to a one-time announcement at period t that, starting from the current period t, inflation will be θ percent higher than expected during each period for the next T periods. Assuming that the announcement is credible, bond markets will immediately revise their inflation expectations and incorporate these updates into the nominal yield curve. Assuming that the real curve does not change after the shock and that the Fisher equation holds, the new nominal interest rate used to discount a claim is $\hat{i}_{t,n} = i_{t,n} + \theta\ min\{n,T\}$. Therefore, the present value, $V^{IA}{}_t(n)$, of a claim under IA is

$$V^{IA}{}_t(n) = exp(-\hat{i}_{t,n}) = exp(-i_{t,n}) \cdot exp(-\theta\ min\{n,T\}) = V_t(n) \cdot exp(-\theta\ min\{n,T\}).$$

As can be seen from this equation, in contrast to the FS scenario, under IA, a financial position of maturity $n<T$ will be affected only for the n periods of its duration, before which the agent is assumed to reinvest at the pre-shock real yield. This is analogous to the agent's reinvesting in a claim that offers a nominal rate of return that has been indexed to take the inflation announcement into account. The present-value gain or loss of a claim of maturity n under IA is given by:

$$G^{IA}{}_t(n) = V^{IA}{}_t(n) - V_t(n) = V_t(n) \cdot [exp(-\theta\ min\{n,T\})-1].$$

Hence, under IA, the present-value gain or loss depends on (i) the size of the shock (θ), (ii) the duration of the shock (T), (iii) the initial nominal position ($V_t(n)$), and (iv) the maturity of the claim (n). On the other hand, as mentioned above, the gain or loss under the FS scenario for any position is independent of its maturity. The IA scenario provides a lower bound for gain or loss on a claim, since it assumes full adjustment of expectations to the path of inflation following the initial announcement. The total gain or loss of an economic agent is derived in the same way as in the FS scenario, based on the sum of the gains and losses from each claim.

1 This methodology to calculate redistribution can be applied to compare the size of redistribution under different monetary policy regimes such as inflation targeting and price-level targeting. This point is summarized in Crawford, Meh, and Terajima (this issue) and analyzed in detail in Meh, Ríos-Rull, and Terajima (2008).

Box 2

Term-to-Maturity Structure

In this box, we describe how terms to maturity are determined for each claim. For financial short-term claims, we assume that they all have one-year terms to maturity, such that we set $n = 1$. For mortgages, we apply the distribution of fixed-rate mortgages by term in 2005.[1] The distribution is obtained using the *Canadian Financial Monitor* data set from Ipsos Reid Canada, which is compiled from a household survey containing detailed mortgage information. Chart A presents the distribution of mortgages across terms of mortgages, weighted by outstanding balances. It shows that the most common term of Canadian fixed-rate mortgages is five years.

Based on the fractions we obtain from Chart A, we assign a weight for each n. For example, we assign a 60 per cent weight to $n=5$.

We take a similar approach for bonds. We derive a maturity distribution from quarterly data on the maturity and face value of federal government debt.[2] Chart B shows the distribution from the fourth quarter of 2005. We assume that the distribution of terms to maturity for federal government bonds approximates that for all instruments in this category.

For pensions, we focus on two types of pension plans: defined-contribution and non-indexed defined-benefit plans. For defined-contribution plans, we assume that the average investment portfolio is approximated by the holdings of Trusteed Pension Plans.[3] The assets of Trusteed Pension Plans are given in the NBSA. We compute the distributions of these assets over terms to maturity and use them to assign weights to each n value. For non-indexed defined-benefit plans, we assume a fixed stream of annual post-retirement payments. When calculating the present-value gains and losses of pension assets, we apply the formulas in Box 1 to each payment, then sum all the gains or losses. In assigning the term to maturity of each payment, we set n based on the difference between the current age of the household and the age at the time of the payment.

Chart A: Distribution of Fixed-Rate Mortgages by Term

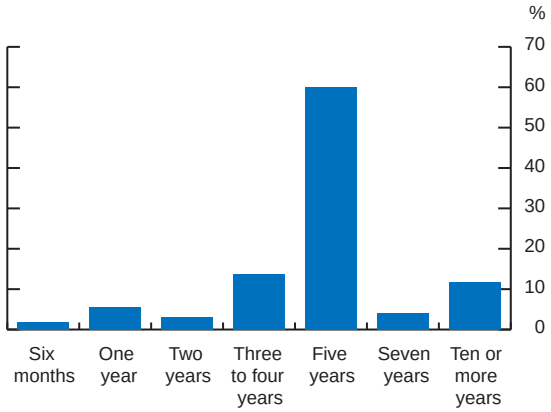
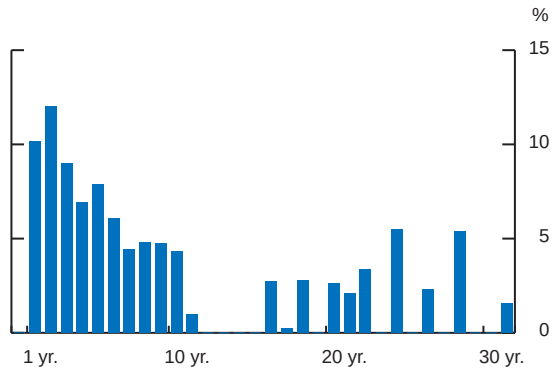


Chart B: Distribution of Government Bonds by Term to Maturity



1 The term of mortgage is the length of the current mortgage agreement. A mortgage can have a long amortization period, such as 30 years, with a shorter term, such as 5 years. When the term expires, a new term agreement can begin at the prevailing interest rate. The term of mortgage, rather than the amortization period, is relevant for our analysis.

2 These data were obtained from the Bank of Canada's Communication, Auction and Reporting System database. See Meh and Terajima (2008) for more details.

3 Trusteed Pension Plans hold approximately 70–75 per cent of employer pension plan assets. See Meh and Terajima (2008) for more details.

It is also clear that gains and losses are generally smaller under IA. The household sector loss under IA is 1.26 per cent of GDP (or $17.3 billion), compared with 1.95 per cent under FS. This change is driven by a reduction in the losses associated with the sector's net savings in long-term bonds and pensions relative to the FS case. The change is offset somewhat, since instruments with a shorter maturity are less sensitive to gradual inflation, and the gains associated with the sector's net debt in mortgage markets shrink relative to the FS case. The government gain drops from about 2.1 per cent of GDP under the FS scenario to about 1.5 per cent under the IA scenario—i.e., it shrinks by almost one-third. This occurs because the government borrows through some bonds that have maturities of less than five years. The non-resident sector's losses, although small, increase from 0.14 per cent of GDP under FS to 0.23 per cent of GDP under IA.

Finally, Table 4 shows gross redistributions for the household sector—i.e., it distinguishes between losses associated with lending and gains associated with borrowing. It should be clear from these results that net calculations substantially understate how much wealth is shifted around. Under FS, the household sector gains 12.53 per cent of GDP and loses 14.48 per cent, implying a total gross redistribution of 27.01 per cent of GDP. In other words, household wealth worth 27 per cent of GDP is reshuffled. Under IA, the total gross redistribution is 16.47 per cent of GDP.

Redistribution between household types

Even though the household sector as a whole loses from surprise inflation, the loss (or gain) is not uniform across different types of households. For different groups of households, we calculate the redistribution of wealth induced by the inflation episode described above. Table 5 reports the present-value gains and losses as a percentage of the average net worth of each group for FS and IA.

Overall, with respect to age categories, young households benefit from inflation and older households lose. On the income dimension, the right column of the table indicates that high-income households lose the most and the loss declines as income becomes lower. Specifically, the main winners are young, middle-income households with large, fixed-rate mortgage debts. Their gain as a proportion of mean net worth is large: 4.34 per cent under FS and 3.91 per cent under IA. The second group of winners is the young, low-income group, who enjoy, on average, gains between 2.53 per cent and 2.66 per cent of their average net worth. The gains of the young low-income group come largely from their holdings of student loans and mortgage debt. Note that this group actually experiences greater gains under IA. As in the case for the non-resident sector, this occurs when there is a maturity mismatch. More specifically, while the gains associated with their net borrowing positions in bonds and mortgages do not vary much between inflation scenarios, the losses associated with their savings in short-term instruments are mitigated under IA, since these claims mature before the shock has ended.

Table 5: Redistribution of Wealth across Households as a Percentage of Net Worth by Age and Income Class, with a One Per Cent Inflation Shock Lasting Five Years

	Age group						
	Under 36	36–45	46–55	56–65	66–75	Over 75	All
Full-surprise scenario							
All	1.74	0.54	-0.63	-1.07	-1.36	-1.55	-0.53
High-income	0.13	-0.10	-0.80	-0.85	-1.34	-1.45	-0.68
Middle-income	4.34	1.28	-0.55	-1.26	-1.42	-1.64	-0.42
Low-income	2.53	1.32	0.16	-1.01	-0.69	-1.15	-0.16
Indexing ASAP scenario							
All	1.66	0.44	-0.54	-0.84	-0.83	-0.82	-0.34
High-income	0.26	-0.18	-0.74	-0.76	-0.82	-0.86	-0.55
Middle-income	3.91	1.15	-0.43	-0.94	-0.89	-0.81	-0.19
Low-income	2.66	1.15	0.28	-0.42	-0.17	-0.56	0.14

The main winners are young, middle-income households with large, fixed-rate mortgage debts.

More age groups among low-income housholds benefit from the inflation episode than those among the middle class or the high-income under FS. This is because low-income households remain net borrowers through to age 56, and therefore the youngest three groups among the low-income are winners. In general, older middle- and high-income households bear most of the losses under the two inflation scenarios. More specifically, under the FS scenario, high- and middle-income households over age 75 are the sector's greatest losers, with losses accounting for 1.45 per cent and 1.64 per cent, respectively, of their respective average net worth. These losses are

mainly owing to their large positions in bonds and non-indexed defined-benefit pensions. Table 5 also shows that most high-income households lose from the inflation episode.

Older middle- and high-income households bear most of the losses . . . owing to their large positions in bonds and non-indexed defined-benefit pensions.

Conclusion

In this article, we quantify the redistributional effects of unexpected inflation in Canada. To this end, we first provide comprehensive evidence of the nominal assets and liabilities of various economic sectors and household groups. We then conduct experiments examining the redistributional consequences of various inflation episodes. The key finding is that the redistributional effects of unexpected inflation are large even for episodes of low inflation. For example, during an episode of low inflation, where inflation is one per cent above expectations for five consecutive years, the loss of wealth among the household sector as a whole could amount to the equivalent of two per cent of GDP, or $27 billion. Among the main winners are young, middle-income households, who are major holders of fixed-rate mortgage debt, and the government, since inflation reduces the real burden of their debts. The losers are a combination of high-income households; middle-aged, middle-income households; and old households, who hold long-term bonds and non-indexed pension wealth. Non-indexed pension assets play an important role in the losses of old households.

A natural question arising from these results is whether these redistributions have implications for the aggregate economy and welfare. These issues are analyzed in recent research by Meh, Ríos-Rull, and Terajima (2008), whose findings are also summarized in Crawford, Meh, and Terajima (this issue).

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