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

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- *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.

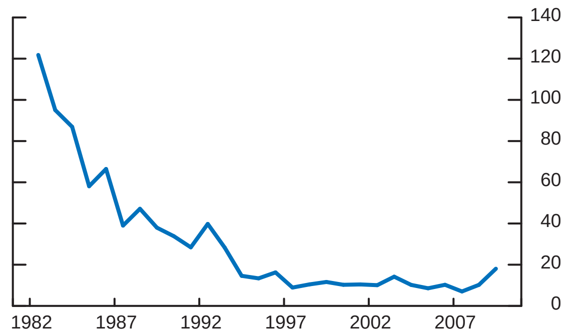
The Watson Wyatt survey of Canadian forecasters reports the dispersion of inflation expectations for the consumer price index (CPI) over horizons up to 15 years. These data can be used to calculate the implied dispersion of price-level expectations (defined as the percentage difference between the expected 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 ($\sigma$). Uncertainty fell by a greater amount for core CPI as both persistence and $\sigma$ 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 $\pi_t$ is the current inflation rate and $\varepsilon_t$ is the random error term.[1] The regime-switching approach allows all the parameters of the inflation process, including inflation persistence $(\rho_1)$ and the standard deviation $(\sigma)$ 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 |
|---|---|---|---|---|---|
| $\rho_1$ | 0.29 | — | 0.64 | 0.29 | — |
| $\sigma$ | 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.

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

## 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).

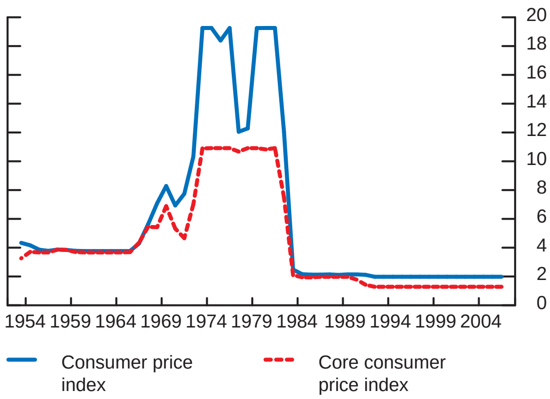
Equation 1 illustrates that the model's estimates of uncertainty will include the impact of random shocks through the parameter $\sigma$. Although the model produces estimated probabilities that each of the five historical regimes is in effect during the current period, it does not capture uncertainty 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.

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.

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.

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

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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