2002 conference

Price Adjustment and Monetary Policy

Proceedings of a conference held by the Bank of Canada, November 2002

Table of Contents

Introduction

The focus of the 2002 Bank of Canada conference was price adjustment and its implications for monetary policy. Rather than pursuing a specific policy question, its aim was to take stock of the current state of knowledge on a critically important issue for monetary policy.

Although voluminous research has developed on the issue of what determines aggregate price adjustment, interest from the academic community has ebbed and flowed. The early rational-expectations literature and real-business-cycle models of the 1970s and 1980s did not include a role for sticky prices and thus downplayed the importance of monetary policy. In the macroeconomics literature of the 1990s and 2000s, in contrast, there has been general acceptance of the existence of price stickiness in goods or labour markets, or both, and of the important role that monetary policy can play in an economy. The timing was therefore appropriate for a conference that would focus on current developments in this area of research, particularly within a Canadian context.

The conference consisted of a memorial lecture, five sessions of one or two presentations each, and a closing panel discussion. Designated discussants commented on each session, and questions were taken from the floor. Pierre Duguay, Deputy Governor of the Bank of Canada, Gregor Smith of Queen's University, and Michael Woodford of Princeton University were the distinguished members of the closing panel. Papers ranging from surveys of recent literature to empirical studies and theoretical treatments explored several important themes: alternative sources of inflation persistence; estimating forward-looking models of inflation; the complex issues surrounding price adjustment in an open economy, including movements in the exchange rate, and their effect on economic behaviour; the interaction between wage adjustment, price inflation, and real economic outcomes; and the macroeconomic effects of technology shocks.

Session 1: Empirical Models of Price Adjustment

The so-called New Keynesian Phillips curve (NKPC) is an approach to understanding price dynamics that incorporates sticky prices into profitmaximizing models of firm behaviour in which firms form expectations rationally. In the benchmark NKPC, current inflation depends solely on future expected inflation and the real marginal cost of production (the ratio of marginal cost to price) or detrended output. It thus provides no explicit link between current and past inflation, which has two related implications. First, since lagged inflation plays no role, the persistence of inflation will be determined solely by the persistence of real marginal cost, a result that is usually insufficient to explain inflation persistence. Second, the absence of lagged inflation means that inflation will respond very quickly to new developments, so that costless, or even beneficial, disinflations are possible. This result is inconsistent with historical disinflation episodes.

Sharon Kozicki and **Peter Tinsley** examine four variants of the benchmark NKPC that are designed to improve the model's ability to account for the observed persistence of inflation in Canada and the United States. The first extension relaxes the assumption of rational expectations. More specifically, some studies (e.g., Roberts 1997, 2001 and Galí and Gertler 1999) have assumed that a fraction of agents use a simple autoregressive structure to forecast inflation. Assuming this alternative form for inflation expectations is one way to rationalize the inclusion of lags of inflation in the benchmark NKPC. A second alternative is to introduce staggered contracting specifications, using an extension of Taylor's (1980) framework to obtain more complicated lag dynamics. A third approach considers costs of adjusting prices, inflation, and potentially, changes in inflation. This extension also admits additional lags of inflation into the Phillips curve. The final extension allows for a non-zero “perceived target” for inflation that could evolve as an additional source of inflation stickiness.

The authors conclude that although shifts in long-run anchors of agent expectations contribute “importantly to observed persistence in U.S. and Canadian inflation,” they are clearly not the only source. Models that admit additional lags and leads of inflation, such as the staggered-contract model, are clearly able to explain inflation better than purely forward-looking specifications, even after accounting for shifts in the perceived target. Discussant **Michel Normandin** cautioned that the econometric tests employed were not very powerful for discriminating among the various specifications and that the results may be sensitive to the selection of measures of inflation and the method used to detrend output.

Alain Guay, **Richard Luger**, and **Zhenhua Zhu** study the sensitivity of previous NKPC estimates to various econometric assumptions. Using Canadian data from 1970 to 2000, they find that previous NKPC estimates are sensitive to different assumptions. They propose an approach to estimation that has three advantages: (i) the asymptotic bias of the coefficient estimates does not increase with the number of instruments; (ii) an analytical method can be adopted for correcting the bias in the estimates of the structural parameters in a non-linear model; and (iii) the estimates are invariant to the normalization of the orthogonality condition. The authors also extend the standard NKPC to the case of an open economy and examine various measures of real marginal cost. The results suggest that none of the NKPC specifications tested in the paper are supported by the data. Discussant Jean Boivin presented some reduced-form Phillips curves that suggest a statistically significant relationship between real marginal costs and inflation. He suggested that richer specifications of the NKPC model than those examined in the paper need to be considered before the NKPC model can be rejected.

Session 2: The Labour Market and Price Adjustment

A well-known fact about labour markets in the United States is that employment is much more variable than real wages. **Michelle Alexopolous** examines the inability of standard limited-participation models to address this issue without relying on unrealistically high elasticities of labour supply with respect to real wages and high price markups over marginal costs. The author embeds an efficiency wage model in a standard limited-participation model with the twist that, instead of firing workers who are shirking, firms simply do not pay them their quarterly bonus. This feature significantly improves the model's ability to explain the relative variability of employment and real wages. In his discussion, **Scott Hendry** proposed numerous extensions, including the addition of labour market search to the efficiency wages in this model. With both frictions in the same model, it would be possible to estimate the relative contributions of search and efficiency wages to the determination of employment and the real wage.

Robert Fay and **Sebastien Lavoie** seek to establish a relationship between the duration of labour contracts and uncertainty (both uncertainty about the real economy and uncertainty about inflation) using data on Canadian wage settlements from 1978 to 2001. The literature suggests that falling inflation uncertainty should be associated with lengthier labour contracts. The results from the estimation of a simultaneous equation probit model confirm previous findings of such a negative relationship between inflation uncertainty and contract duration. The empirical findings, however, do not corroborate theoretical research that suggests that uncertainty about the real economy plays an important role. The discussant, John Knowles, suggested that an explicit accounting for the prevalence of non-indexed contracts is needed before it can be concluded that longer labour contracts in Canada are the result of reduced uncertainty about inflation.

Session 3: Price Adjustment and Monetary Policy

Galí (1999) presents an empirical challenge to the real-business-cycle literature and modelling strategy. Using assumptions similar to those in Blanchard and Quah (1989), he finds that the hours-worked variable initially falls following a positive technology shock and only eventually rises, while the prototypical real-business-cycle model implies that this variable should rise immediately after such a shock. Galí suggests that this decline in hours worked is consistent with the predictions of macroeconomic models that feature nominal rigidities.

Christiano, **Eichenbaum**, and **Vigfusson** argue that Galí's empirical findings are fragile. Their empirical re-examination finds that a permanent positive shock to technology leads to a rise in the number of hours worked as well as rises in output, average productivity, investment, and consumption, and a fall in inflation.

The difference in results can be attributed to the underlying statistical model of per-capita hours worked. The authors assume that hours worked is mean-reverting, whereas the previous literature assumed that only the change in hours worked is mean-reverting. They use statistical tests to argue that the preponderance of evidence supports their conclusion.

The authors also show that although the technology shocks they identify have qualitatively similar effects to those implied by the real-business-cycle model, these shocks explain only a fraction of overall volatility at a business cycle frequency. For example, these shocks are responsible for 10 per cent of the cyclical variation in output, but account for 23 per cent of the cyclical variation in inflation. Technology shocks play a much more important role in determining the low-frequency component of aggregate fluctuations.

Discussant **Kevin Moran** suggested that alternative artificial data sets be used in experiments that test the ability of each of these empirical specifications to recognize the alternative possibility. First, a standard realbusiness-cycle model that generates a positive correlation between hours worked and technology shocks could be used to generate data. Galí's differencestationary specification could then be applied to these data to test whether it recognized the alternative possibility. A similar experiment could be run with a sticky-price model (which generates a negative correlation between technology shocks and hours worked) and subsequently tested with the level specification.

In his discussion, **Martin Gervais** focused on the finding that technology shocks account for very little of the cyclical variation in output. He contrasts this result to earlier work by Prescott (1986) and Aiyagari (1994), which concluded that technology shocks accounted for about 75 per cent of the fluctuations in real output in the post-war period, and concludes that the discrepancy results from differing definitions of a technology shock. Prescott and Aiyagari broadly referred to technology shocks as any shock that directly affects the production frontier, while Galí and the authors limit their discussion to permanent productivity shocks.

Session 4: Small Open-Economy Models

In recent years, considerable research has been devoted to New Keynesian, open-economy models, that is, multi-country dynamic general-equilibrium models with nominal price rigidities, optimizing agents, and stochastic shocks that permit welfare analysis. **David Bowman** and **Brian Doyle** present a survey of this growing area of literature. They review the original Redux model (Obstfeld and Rogoff 1995), its implications, and some of its extensions, specifically those considered qualitatively most important for understanding optimal monetary policy. Static extensions they consider include different preferences for domestic and foreign goods, passthrough from exchange rates to domestic prices, and wage stickiness versus price stickiness. Discussion of dynamic extensions includes stochastic shocks, asset markets, and current-account dynamics. The authors then explore the implications of producer-currency pricing and incomplete passthrough for optimal monetary policy in a single country, as well as the issue of international policy coordination. They conclude that more gains have been made in conceptual insights, such as understanding the transmission of shocks across countries, exchange rate pass-through, and the effects of different pricing rules, as well as how these affect optimal monetary policy rules and international policy coordination, than in providing empirical verification.

Frank Smets, the discussant, noted that this class of model typically has very little new to say about the determination of exchange rates. He pointed to recent developments in the literature that could lead to an improvement in the model's ability to capture and explain movements in exchange rates. In particular, he suggested incorporating transportation and distribution costs that drive a wedge between movements in exchange rates and the fundamentals in the economy (Corsetti and Dedola 2002). He also cited the need for additional research with stochastic models to better understand how risk premiums interact with the macroeconomy (Obstfeld and Rogoff 1998).

Session 5: Price-Setting in a Small Open Economy

Gabriel Srour begins his paper by analyzing monetary policy in a simple, single-period model of a small open economy with nominal-wage rigidities and decreasing returns-to-scale technology. The model's goal is

to examine the efficiency of monetary policy in various environments on the basis of its ability to reproduce the flexible-price equilibrium.

The alternative cases include: (i) a baseline one-sector model with one domestically produced good and one foreign-produced good, where all prices are set in the world market; (ii) a baseline model to which fixed costs of production (a measure of a firm's degree of efficiency) are added, as in Blanchard and Kiyotaki (1987); and (iii) a two-sector model composed of primary goods whose prices are set exogenously in the world market, and traded manufactured goods (which have a higher elasticity of substitution with foreign manufactured goods than with primary goods). In the twosector model, the author examines the two extreme assumptions regarding labour mobility between the sectors, i.e., perfect and none, as well as the two cases where prices of non-primary goods are set in the world market and where they adjust endogenously.

Srour finds that, in one-sector models, monetary policy can reproduce the flexible-price outcome where there are no fixed costs but not always in the model with fixed costs. In the two-sector model, it can reproduce the flexible-price outcome as long as labour is mobile. Monetary policy is unable to replicate the flexible-price equilibrium when labour is immobile across sectors because it cannot achieve potentially conflicting goals in two separate labour markets with only one instrument. The discussant, **Craig Burnside**, suggested extending the model to allow for a less stark analysis of the impact of labour mobility. This adaptation could lead to an empirical assessment of the issues Srour raises.

Michael Devereux and **James Yetman** address the issue of exchange rate pass-through. An extensive literature covering a range of industrialized and developing countries has documented incomplete pass-through of exchange rates to consumer prices, even in the long run. Recently, considerable debate, fuelled in part by the widespread belief that passthrough may have declined in the 1990s, has focused on the causes of this incomplete pass-through. Some explanations include pricing to market by imperfectly competitive firms (Corsetti and Dedola 2002) and domestic content in the distribution of traded goods (Corsetti and Dedola 2002; Burstein, Neves, and Rebelo 2000).[1]

---

1. In a similar vein, Taylor (2000) examines links between monetary policy and passthrough of cost changes to prices.

The authors develop a simple model of a small open economy in which exchange rate pass-through is determined by the frequency with which importing firms change their prices. These firms choose how often to change prices in response to exogenous shocks, comparing the costs of making a price change to the losses associated with not changing their prices (a decline in the relative price). A higher mean inflation rate leads to larger losses from holding prices constant, and is therefore associated with more frequent price changes and a higher degree of exchange rate pass-through. This model implies that there should be a positive, but non-linear, relationship between mean inflation and pass-through, and a positive relationship between exchange rate volatility and pass-through. The authors find evidence of this in their sample of 122 countries. Their results suggest that sticky prices are an important factor in determining the average rate of pass-through and that a low rate of pass-through results at least partly from short-term price rigidities.

Beverly Lapham, in her discussion, focused on the need for a better understanding of price-setting behaviour so that researchers can use measures of exchange rate pass-through that control for other factors affecting prices. She also called for additional studies at higher levels of industry disaggregation and at various stages of production and distribution. The second discussant, **Jeannine Bailliu**, commented on the policy implications for emerging markets. She suggested that this paper could provide some theoretical and empirical support for the largely anecdotal evidence from some emerging markets that a large reduction in the degree of exchange rate pass-through had accompanied the significant reduction in their inflation rates in the 1990s.

Panel Discussion

The panellists provided thought-provoking commentary and interesting suggestions for future research. Gregor Smith focused his comments on econometric issues, noting in particular that single-equation

methods and aggregate macroeconomic data may not provide enough information to answer many of the questions about price adjustment. He cited the Fay and Lavoie study as an excellent example of combining information sources. Smith also suggested that industry-level models or models with a strategic element may be useful in characterizing price adjustment. In particular, he highlighted the importance of paying attention to the cross-sectional dimension of industry-level data.

Michael Woodford focused on the importance to monetary policy of structural models for determining wages and prices. He compared alternative models of the aggregate-supply relationship on the basis of the degree of inflation inertia that they imply, specifically, models of the hybrid NKPC with differing degrees of indexation. He showed that the degree of inflation inertia has important consequences for determining the appropriate stabilization objectives of monetary policy, the optimal long-run inflation target, the degree to which temporary departures from the long-run target should be allowed, and the form of the optimal targeting rule. He concluded by calling for further research on the question of whether inflation inertia should be regarded as truly structural.

Pierre Duguay thanked the participants for their excellent contributions. He agreed with Beverly Lapham's suggestion that more work is required to understand the pricing strategy of firms. He announced that the Bank of Canada would be undertaking a survey of firms, much in the spirit of Blinder et al. (1998), and would be directly asking real-world price-setters how prices are set. This work is currently underway and is expected to be completed in 2003. He expressed reservations about the applicability of the NKPC model of inflation to the Canadian GDP deflator, which is heavily influenced by movements in world commodity prices. He also encouraged researchers to allow for changes in the monetary policy regime in their empirical analysis of the inflation process.

References

Aiyagari, S.R. 1994. “On the Contribution of Technology Shocks to Business Cycles.” Federal Reserve of Minneapolis Quarterly Review 18 (1): 22–34.

Blanchard, O.J. and N. Kiyotaki. 1987. “Monopolistic Competition and the Effects of Aggregate Demand.” American Economic Review 77 (4): 647–66.

Blanchard, O.J. and D. Quah. 1989. “The Dynamic Effects of Aggregate Demand and Supply Disturbances.” American Economic Review 79: 655–73.

Blinder, A., E.R.D. Canetti, D.E. Lobow, and J.B. Rudd. 1998. Asking About Prices: A New Approach to Understanding Price Stickiness. New York: Russell Sage Foundation.

Burstein, A.T., J.C. Neves, and S. Rebelo. 2000. “Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based Stabilizations.” NBER Working Paper No. 7862.

Corsetti, G. and L. Dedola. 2002. “Macroeconomics of International Price Discrimination.” Manuscript.

Galí, J. 1999. “Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?” American Economic Review 89 (1): 249–71.

Galí, J. andM. Gertler. 1999. “Inflation Dynamics: A Structural Econometric Analysis.” Journal of Monetary Economics 44 (2): 195–222.

Obstfeld, M. and K. Rogoff. 1995. “Exchange Rate Dynamics Redux.” Journal of Political Economy 103 (3): 624–60.

———. 1998. “Risk and Exchange Rates.” NBERWorking Paper No. 6694.

Prescott, E.C. 1986. “Theory Ahead of Business Cycle Measurement.” Federal Reserve Bank of Minneapolis Quarterly Review 10 (4): 9–22.

Roberts, J.M. 1997. “Is Inflation Sticky?” Journal of Monetary Economics 39 (2): 173–96.

———. 2001. “How Well Does the New Keynesian Sticky-Price Model Fit the Data?” Federal Reserve Board, Finance and Economics Discussion Series No. 2001–13.

Taylor, J.B. 1980. “Aggregate Dynamics and Staggered Contracts.” Journal of Political Economy 88 (1): 1–23.
———. 2000. “Low Inflation, Pass-Through, and the Pricing Power of Firms.” European Economic Review 44 (7): 1389–1408.