Monetary Policy and Learning: Some Implications for Policy and Research

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Conferences sponsored by Federal Reserve Banks tend to focus on well-defined, policy-oriented topics related to issues faced by policymakers and the economic research staff. Such conferences present an opportunity for academics to pursue research considered policy-relevant by Federal Reserve Banks, not only because the work may influence policy but also because it helps promote ongoing interaction between policymakers and leading researchers.

The Federal Reserve Bank of Atlanta hosted a conference on monetary policy and learning on March 21–22, 2003.[1] The conference papers and discussions are part of an emerging literature that introduces the process of learning into dynamic macroeconomic models.[2] Recent technical advances have enabled the analysis of dynamic models that include a role for learning (about the economy or about the model used by policymakers). In some models, monetary policymakers learn about the workings of the economy while in others private agents learn about the model(s) the central bank uses to formulate monetary policy.

By focusing on this specific area of research, the conference brought together policy advisers and researchers currently investigating closely related topics to promote interaction and synergies that may propel further research on monetary policy and learning. The conference participants and the attendees included leading researchers at universities and central banks as well as policy advisers and monetary policymakers from around the world.

This article outlines the implications of some of the conference papers and summarizes the ensuing discussion, focusing on broad themes that have relevance for monetary policy. As a setup to this discussion, the first section describes the Phillips curve framework, a common simplified model of the macroeconomy, and outlines key issues raised in Sargent (1999) about how to interpret monetary policy behavior and economic performance over the past few decades using this model and different assumptions about learning. Following from that work, the conference papers focusing on understanding the recent economic history of inflation attempt to detect the role of monetary policy behavior in generating the recent, more benign inflation performance. The discussion then reviews the implications from conference papers that model learning behavior in a variety of settings. The article also follows up on some implications from the literature relating to central bank transparency, its relevance for effective communication to the public about monetary policy, and its likely role in future learning models. Finally, the article introduces Lars Svensson's speech at the conference (published in this issue of the *Economic Review*), which describes a monetary policy framework and highlights the role of transparency for effective monetary policy in that framework.

The Monetary Policy Problem

What economists describe as the "monetary policy problem" has a variety of interpretations. For a policymaker using a stylized monetary model, the problem might boil down to determining the choice of an optimal path for the policy variable (say, the federal funds rate of interest) in a given economic model to achieve key objectives, such as chosen target values for output and inflation. In a model, the policymaker has an objective function to maximize and a policy tool with associated (assumed) effects on the target objectives. From a practical policymaking perspective, the problem may be defined more generally as implementing monetary policy consistent with policy goals. Federal Reserve System goals (more or less) include financial stability, desirable output, and inflation outcomes. How to achieve those goals might represent the monetary policymaker's problem.

From a practical policymaking perspective, the monetary policy problem may be defined generally as implementing monetary policy consistent with policy goals.

The monetary policy problem is extraordinarily complex, and modeling that complexity for practical policy implementation has not been successful. Instead, most macroeconomists simplify the policy issue to concentrate on key macroeconomic measures central to the monetary policy process—the average performance of the inflation rate and the unemployment rate (or a real output measure). A popular economic framework used to model monetary policy assumes a loss function for the policymaker in which the central bank aims to generate an average inflation rate consistent with small fluctuations around the natural rate of unemployment (or, comparably, deviations of output away from potential output). The observed outcome should not deviate much from the best achievable combination of the inflation rate, the expected inflation rate, and unemployment.[3] The policymaker believes the expectations-augmented Phillips curve describes the way in which deviations of the inflation rate from the public's expectations of that rate drive the unemployment rate away from the natural rate of unemployment.[4] A simplified expectations-augmented Phillips curve can be expressed as

(1) $U = U^* - \theta(\pi - \pi^e)$,

where U is the unemployment rate, U^* is the natural rate of unemployment, θ is the Phillips curve parameter, π is the inflation rate (set by the policymaker), and π^e is the public's expectation of the inflation rate.

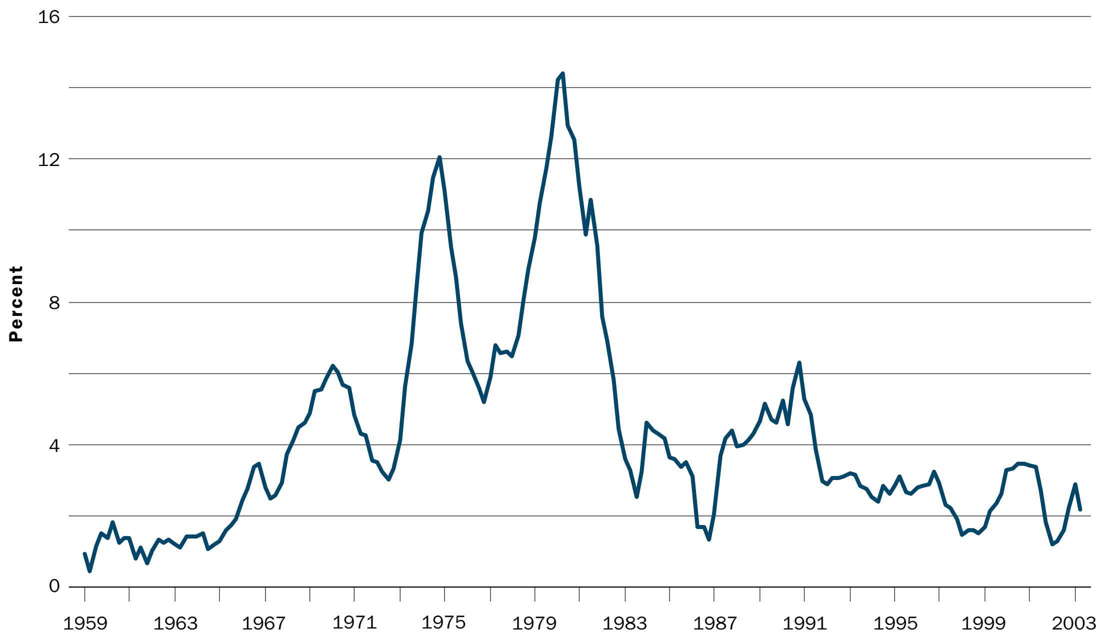
There is economic slack in this framework if the unemployment rate exceeds the natural rate (or actual output is less than potential output). The economic slack implies that firms do not fully utilize existing capacity and thus generate less wear and tear on capacity and productive resources (excess capacity); the slack should thus dampen the rate of increase in labor compensation and in other input costs. During slack periods, firms typically eschew raising prices because price increases in an economy with weak demand will potentially reduce sales and market share. As a result, the approach predicts lower inflation rates in times when the unemployment rate is above the natural rate (or when output is less than potential, that is, a positive output gap exists). Conversely, if unemployment falls below the natural rate (or output exceeds potential), the condition signals serious strain on scarce productive inputs. In that case, scarcity induces suppliers to bid up the prices of inputs (labor, capital, and other inputs) as producers try to increase productive capacity in order to produce desired output. As a result, firms' output prices rise. This train of events contributes to rising inflation. Note that the inflation dynamics of these models are driven by real economic phenomena, in contrast to monetary phenomena as in Friedman (2003), although monetary factors are likely operating in the background.

Varieties of Explanations and Stories

In the mid-1970s the basis for macroeconomic forecasting and policy analysis was macroeconomic models incorporating Keynesian features and hinging on an empirical relationship—the Phillips curve—notably, without augmenting the models for expectations. In these unaugmented models, policies could be perceived as choices of unemployment and inflation from along a curve, as if policymakers could "trade off" lower unemployment by allowing higher inflation. Over time, policymakers were faced with accumulating empirical evidence—the simultaneous observation of high unemployment and rising inflation—that was inconsistent with their model predictions. Partly in response to these empirical

FIGURE

Inflation Measured Using the Consumer Price Index



Sources: Consumer Price Index, U.S. Bureau of Labor Statistics

contradictions, an innovative strand of the macroeconomic literature took as its core element the formulation of expectations by economic agents. Models with rational expectations imply that outcomes on average match the expectations of participants in the economy (Sargent 1999, 136).[5] Concentration on the role of expectations led to a heightened appreciation of the role expectations play in determining economic outcomes and led to adaptations of existing models, like the expectations-augmented Phillips curve.

The interaction between macroeconomic policy and observed macroeconomic performance stimulated research on issues that are now considered central to monetary policy and to the research in the learning literature. The figure above, displaying the inflation rate from 1960 to 2002, highlights a sharp disparity in observed inflation rates: Inflation during the 1960s and 1990s was much lower than the high inflation of the 1970s and early 1980s. Explaining what caused the difference in inflation rates has been the focus of much macroeconomic research and is a common element of several conference papers. The observation is important for monetary policy analysis because some explanations blame inappropriate monetary policy for the high inflation of the 1970s and 1980s.

Sargent (1999) examines the 1970s inflation, the 1980s disinflation, and the low inflation since the 1990s by investigating alternative interpretations of

1. The late Bruce Smith of the University of Texas at Austin offered the conference planners the idea and provided the inspiration for holding a conference on this topic.
2. The conference papers are available on the Atlanta Fed's Web site (www.frbatlanta.org) on the News & Events/Conferences page. Some of these papers will eventually be published in the *Review of Economic Dynamics.*
3. The speech by Svensson (in this issue) describes in more detail how this framework has become the bulwark model among central bankers in industrialized countries and how monetary policy implementation can be improved through its use.
4. The output gap, rather than the expectations-augmented Phillips curve, can be the device that detects the degree of slack in the economy.
5. These models were technically challenging to solve and computationally demanding to estimate. Typically, statistical tests rejected the model predictions. Initial modeling efforts offered limited policy implications, or the policy implications were often not palatable to policymakers. Whereas statistical tests often rejected the model predictions, the introduction of rational expectations produced insights toward more rigorous and productive modeling strategies and has led to offshoots such as learning.

recent economic history. He describes one interpretation as the "triumph" of the natural rate; the combination of the rational expectations assumption with the natural rate theory of unemployment produces a monetary policy implication that recommends policymakers should aim only at low inflation. Policies that attempt to achieve unemployment rates lower than the natural rate will cause rising inflation. In other words, rational expectations–natural rate models indicate that good monetary policies recognize the futility of trying to devise monetary policies that attempt to permanently alter the unemployment rate.

An alternative explanation described by Sargent—the vindication of econometric policy evaluation—blames inappropriate monetary policy for the inflation of the 1970s and credits improved monetary policy for lower inflation outcomes since the 1980s. Consistent with this view, Romer and Romer (2002) argue that Fed policymakers overestimated the growth potential of the U.S. economy (or similarly, they believed that the natural rate of unemployment was lower than it really was). In a standard output gap model for price dynamics, an overestimate of potential output (or an underestimate of the natural rate of unemployment) generates a policy error that leads to rising inflation. According to Sargent (1999), policymakers learn about the parameters of a "true" Phillips curve model that underlies the data. The policymaker uses an adaptive model, one in which the coefficients of the forecasting model are updated in light of new information. In this setting, this model with learning can explain the rise and fall of inflation in the 1970s and 1980s. As Sargent (1999) describes the explanation, Fed policy improved, despite using a misspecified model, because econometric evidence accumulated and indicated that there was no exploitable trade-off between unemployment and inflation. The bad news, though, is that over time the same methodology—accumulating evidence from econometric estimates of a misspecified model—might suggest a more benign and perhaps exploitable trade-off, potentially tempting policymakers into making the mistakes of a prior generation and resulting in higher-than-desired inflation rates.

Models with learning incorporate assumptions about what agents know about the economy and how policymakers choose the economic model as the basis for policy analysis.

The two alternative descriptions above implicitly place central bank policy as the primary cause of the "Great Inflation" in the United States. But the question of Federal Reserve culpability for the behavior of inflation is unsettled and is the topic of substantial empirical research.

Empirical results in Sims (1999) and in Bernanke and Mihov (1998a, 1998b) imply that Federal Reserve monetary policy was not responsible for rising inflation in the 1970s nor for the mild inflation of the 1990s. Rather, causes external to the monetary policy process were the primary source of inflation fluctuations. Namely, the U.S. economy was hit with exogenous shocks that were simply much worse in the 1970s and early 1980s than in the other periods. Sims demonstrates that the volatility of exogenous shocks declined in the 1990s and that the parameters of econometric estimates that involve monetary policy parameters do not change significantly over time. The model with fixed parameters and time-varying volatility of shocks fits the data relatively well. The unchanged parameter estimates suggest that the Fed made policy in the usual manner throughout the sample and that the volatility and severity of the economic shocks over these periods differed dramatically. Hence, unexpected shocks underlie the inflation outcomes; the Fed was lucky in the 1990s and unlucky in the 1970s.[6]

Taylor (1997), De Long (1997), and Romer and Romer (2002) focus on how monetary policy outcomes have improved over time. Taylor suggests that there was a systematic change in how monetary policy was implemented in the late 1980s and 1990s. More forcefully, the Romers, as mentioned above, argue that monetary policy was ill conceived in the 1970s and caused the high inflation, which required Paul Volcker, then chairman of the Federal Reserve Board, to initiate a substantial recession in order to reduce the rate of inflation. With the "improved policy" arguments, the empirical prediction is that the policy parameters drift over time because the changes in parameters are associated with different monetary policy procedures or policy regimes. The underlying assumption is that monetary policies are important for describing and determining the observed inflation outcomes.

Distinguishing between these two explanations for the behavior of inflation over recent economic history has been challenging because it is difficult to detect drift or changes in parameters separately from fluctuations in the volatility of exogenous shocks.

The conference paper by Cogley and Sargent (2003) addresses these empirical challenges and tries to design more powerful empirical tests to distinguish between "the Fed got lucky" and "the Fed policy improved" interpretations. Specifically, the model (made up of unemployment, the federal funds rate, and consumer price index [CPI] inflation) includes both time-varying parameters and time-varying shock volatility and tries to uncover whether parameter drift takes place. Empirical evidence from one test indicates that the parameters drift over time, but other test results are unable to indicate such drift. Although the results contrast with those of Sims (1999), the authors conclude that this is not a compelling contradiction.[7] Still, the finding of parameter drift begs for additional research on the question. Del Negro (2003), in his discussion of the Cogley and Sargent paper, adds commodity prices to their model to test robustness of the results. Del Negro shows that the parameter drift results are robust to this model alteration and notes a strong positive covariance between commodity and consumer prices. The positive covariance may indicate that underlying exogenous shocks (reflected in commodity prices) drove the high inflation outcomes, offering support to the luck hypothesis. Further research may aim toward deriving more powerful tests to distinguish between time-varying elements resulting from volatility versus parameter drift.

In macroeconomic models, it has been difficult to match fully specified statistical models to the high inflation and disinflation in the 1970s and 1980s. Schorfheide (2003) estimates a fully specified model that allows for regime shifts in monetary policy (that is, from a low- to a high-inflation regime and vice versa), and the public learns over time about which regime presides. The statistical tests support the full-information model, but there are some peculiarities that make those tests less compelling. Instead, Schorfheide wants to interpret the disinflation of the 1980s as being more consistent with the delayed response of a learning model than with a full-information model. Harald Uhlig, the discussant, remarked that interesting questions remain regarding why the average inflation rate increased, namely, whether policymakers simply raised the implicit inflation target (or tolerated higher inflation) or the severity of exogenous shocks increased over the period.

Bullard and Eusepi (2003) investigate whether a large portion of 1970–80s inflation was a result of unobserved changes in productivity. In their setting, the central bank faces problems monitoring and learning about productivity growth. In the theoretical model, monetary policy uses a Taylor rule, which sets the short-term interest rate in response to measures of the output gap that could be mismeasured as a result of negative productivity shocks. The paper offers simulation results for the model under a variety of learning specifications. The model specification in which both the private sector and the central bank learn provides results that are most consistent with the 1970s inflation arising from misperceived productivity estimates. The discussant, Mark Gertler, prefers an explanation of the inflation history that focuses on how policymaking has improved. He views recent inflation regimes as reflecting the evolution of monetary policy toward a better equilibrium and is more comfortable with modeling learning specifications like those in Sargent and Williams (2003), in which the central bank learns about the true model from estimating models with more and more data.

Models with learning incorporate assumptions about what agents know about the economy and how policymakers choose the economic model as the basis for policy analysis. Learning models may also examine what policymakers know or believe for a particular class of learning rules given the macro model. Sargent and Williams (2003) characterize the shifts in monetary policy outcomes between suboptimal to nearly optimal inflation in an equilibrium model with learning. The authors investigate whether a monetary policy model can display an inflation rate below the Nash inflation rate (above optimal rate) in the form of "escapes."[8] In their paper, the government has prior beliefs about how much parameter variation is present in their misspecified Phillips curve model. The authors gauge how different values of the parameter that controls "prior belief" affect the simulation results. In this paper, the government does not know the true model of the economy, but the public understands the process

6. Sims (2001) suggests that policy may fluctuate between "regimes" reflecting more or less responsiveness to inflation shocks and that these regimes reflects temporary shifts in policy activism, not systematic improvement. This argument is more subtle than those discussed in the text.

7. Bernanke and Mihov (1998a, 1998b) also find weak evidence for parameter drift and find support for unchanged parameter estimates and time-varying volatility of shocks for their reduced-form VAR (vector autoregression) model.

8. The Nash inflation rate is the suboptimal inflation rate consistent with a self-confirming equilibrium in which the policymaker learns about the underlying expectations-augmented Phillips curve model, as in Sargent (1999).

that governs policymaking. The government learns about the economy from estimating misspecified models; the government's subjective ideas about the model affect the behavior of the data, and the subjective ideas are also a function of the data. For example, the policymaker's prior beliefs affect economic outcomes, so policymaker beliefs are crucial to isolating the outcomes likely to arise in these models. The self-confirming equilibrium result generates higher-than-optimal inflation at the natural rate of unemployment, and this equilibrium persists longer when a strongly held prior belief restricts the time variation in model parameters (that is, in the extreme, the parameters are time invariant).

In most macroeconomic research, transparency implies the clear communication of policy goals as well as the policy tools aimed to achieve these goals.

The Sargent and Williams paper shows that misspecified models may eventually get close enough to the true generating model's equilibrium path to produce the most desirable (Ramsey) outcomes for inflation and output. These "escapes" to lower inflation occur more frequently if the government has less prior belief in a stable, Phillips curve relationship (that is, it allows drifting parameters in the model). One interpretation of Sargent and William's results is that a government that believes strongly in its misspecified model will more likely achieve its less preferred (higher-inflation) outcome, with fewer opportunities to escape to the low inflation equilibrium. The practical implication of this analysis is significant. By holding to a strongly held belief in a stable, Phillips curve relationship and ignoring the signals from data that the model parameters have changed, central bank policy behavior supports the Nash high inflation outcome.

In contrast to Sargent and Williams, Orphanides and Williams (2003) introduce learning on the part of the public about the economy and policymaker decisions. The specification of their model, comparable to the one in Svensson (2003, this issue), raises the sensitivity of the public's inflation expectations to shocks and generally reduces the influence of policy on macroeconomic fluctuations relative to a rational expectations specification. The learning specification also suggests that the central bank will produce better policy outcomes if policies respond to forecasts (expectations) of both the public and the policymaker rather than to data outcomes. This result does not arise in a rational expectations specification. In the learning model, the central banker monitors the inflation expectations of private market participants as well as making its own forecasts of inflation, and it can improve policy by responding to the public's expectations of inflation. The public's expectations provide an additional information source for the central bank since they inform the policymaker about the imperfect model the public uses to forecast inflation. This result is consistent with Svensson's, who refers to the public's expectations as "independent state variables" and describes practical methods for central banks to utilize private-sector expectations.

Leeper and Zha (2003) investigate how a central bank might implement monetary policy by using a (misspecified) model estimated from actual U.S. data. The authors use this estimated model as the laboratory for policy experiments to determine whether the model, though misspecified, can still provide useful policy analysis for a central bank. In the model setting, the public does not really know how the central bank determines monetary policy decisions. As a result, the public tries to learn and understand, by observing data and the Fed actions over time, how the central bank makes decisions and how that behavior affects economic outcomes. The public can use these observations for inferring whether the central bank has changed its policy behavior, but detecting small departures from an established "standard" policy behavior is difficult. As a result, most of the routine adjustments to monetary policy—that is, standard behaviors—are unlikely to affect the public's typical economic behavior in response to those policy adjustments. The empirical experiments indicate that an approximate or misspecified model may still provide reasonable forecasts of implied responses to modest policy interventions. Only large changes in monetary policy poke through the noise to send a clear signal of "policy change" to the public and then disrupt standard responses to policy interventions. In other words, monetary policy can use misspecified models with reasonable effectiveness in many cases.

Sims (2003) explores the effects of costly information flow using the concept of rational inattention—that there is a limit to how much information a human being can process (or chooses to process) about economic data. People have more interest in everyday living than in constantly checking and evaluating new economic statistics. In preliminary analysis, the ideas suggest that the public will not react if there is a low signal-to-noise ratio (the data are noisy and fluctuate for no significant reason). But the public will react if economic signals are strong enough and the effects are large enough. A notable implication of Sims's paper is that greater policy transparency (here, making policy decisions clear to the public) may raise the signal-to-noise ratio and magnify policy effects on inflation and output by more than just reducing uncertainty. The implication, though, raises an issue of just what the transparency of monetary policy should imply and what form it should take.

Transparency and Learning

Transparency of monetary policy may be useful for central bank accountability as well as for improving policy effectiveness. The key issues surround helping the public understand the goals and views of the central bank and establishing groundwork for support if the central bank is faced with difficult policy decisions. Freedman (2002) suggests that central banks generally believe that increasing transparency improves monetary policy outcomes. The problem with this view is that there is no compelling empirical work that predicts unambiguous improvement to policy and to the economy from moving toward further transparency. Cecchetti and Krause (2002) suggest that central bank transparency can reduce economic uncertainty by removing the uncertainty produced by the central bank itself. Measuring the degree of transparency or effective transparency, however, is subject to debate. Additional research measuring the value of transparency for producing good monetary policymaking is warranted.

In most macroeconomic research, transparency implies the clear communication of policy goals as well as the policy tools aimed to achieve these goals. The policymaker informs the public about what policies have been put in place and what those policies are expected to produce—that is, the policymaker lets economic agents know what policymakers are thinking about the economy and how policy may change if outcomes differ from earlier forecasts and the forecasts change. These elements of transparency imply that the policymaker lets the public know the policy model or framework. The goals of transparency are clear, as are procedures to generate it, in these models. In reality, the practical implementation of transparency and the communication efforts to improve it are complicated. As Cukierman (2002) emphasizes, tremendous ambiguity remains about what policy model information should be conveyed to the public mainly because there is so much controversy in the economics profession about the correct model of the economy for policymakers to use. Without an explicit model, it is difficult for the public to detect a simple reaction function for policy, and it is not clear that the objective function of the policymaker, the approximate decision rule, or the effective model underlying the forecasts is as transparent as is implied in academic research.

Kohn and Sack (2003) estimate whether there are measurable effects of public announcement of Federal Reserve System policy-related information (as distinct from policy actions) on the volatility of a selection of financial variables (yields). Notably, this research investigates the effects of information release on second moments—that is, volatility of financial asset yields, which does not imply sizable effects on mean yields. Kohn and Sack's results, using information from 1989 to 2003, suggest that the release of the policy statement has some impact on federal funds rate futures and short-term interest rates, perhaps indicating that the statement reflects some information about future policy moves but not about longer-term Treasury issues. The speeches of the Federal Reserve chairman have little systematic effect on financial volatility. Notably, the congressional testimony of the chairman that includes the FOMC economic outlook has some effect on the volatility of longer-term yields, perhaps an indication that markets glean inferences about longer-term monetary policy as an update of the economic forecasts of private market agents. These initial findings suggest that the release of central bank information may have an effect on the economy separate from the policies themselves. At this point, such information is at least associated with more volatility in the yields of certain debt vehicles. Whether the information is news or noise to trade upon is not yet clear.

Transparency of monetary policy is a theme central to Svensson's policy framework and highlighted

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in his speech, which follows in this issue. Increased transparency with an explicit model may heighten communication between private decision makers and public policymakers. Svensson notes that transparency of monetary policy should be a key element of learning models but that it was somewhat overlooked in the conference papers. The learning literature may help to evaluate the role of transparency in producing good monetary policy, whereby clear communication from the central bank to the public may improve the way private agents learn about the policymaker's model.

Transparency of monetary policy, though difficult to achieve in reality, appears a noble goal; it is still debatable how best to achieve that goal. Further research should aim at making clear distinctions about precisely what information would best communicate monetary policy intentions. Such research would help make requests for greater transparency more compelling and operative.

A Workhorse Model for Central Banks—and a Recommended Approach

Monetary policy in reality is more complicated than macroeconomic models, including the learning models, propose. But policy is implemented on a real-time basis, and policymakers, often faced with unpleasant choices as policy options, make decisions in the presence of great uncertainty, as described above. From the practitioner's viewpoint, the implementation of monetary policy is a tricky business. There is no user's manual for policymakers because the author would have to understand monetary policy and the way it is transmitted to the real economy. Among macroeconomists, the transmission mechanism for monetary policy remains subject to debate.

Amidst the imperfect understanding of monetary policy and its interactions with the real economy, it is surprising to find some agreement among central banks about the way(s) monetary policy should be implemented (see Bernanke 2003). This agreement may reflect the difference between the economics profession and central bank practitioners. The central bank consensus framework centers on a few basic assumptions about the impact of monetary policy on private agents' economic decision making and thereby its effects on the real economy. Using this consensus as its basis, Svensson's speech at the March conference serves as a current version of a suggested user's guide for monetary policymakers to improve policy effectiveness. Needless to say, learning about the evolution of monetary policymaking will continue.

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