The contribution of theory to practice in monetary policy: recent developments

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> ...monetary policy, just like other fields of human activity, always involves (in part) a mismatch between accumulated learning and the need to take specific policy actions. (Issing 2001)

1 Introduction

Monetary theory and the practice of monetary policy have long informed one another – this two way interaction is in perhaps its healthiest state in the last forty years. It is an interaction that has greatly interested Otmar Issing (e.g., Issing 2001) and one to which he has been an insightful contributor. My focus is on recent additions to accumulated learning, in Issing's words, that have provided insights to those who are faced with the need to take specific policy actions. Today's productive exchanges between academic and policy economists derive in large part from the use of a common class of models. New insights from these models are shaping policy discussions and practices. In contrast to the models used

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by academic economists in the 1970s and 1980s, with their underlying skepticism about the ability of systematic policy to have beneficial real economic effects, a major task in monetary theory today is that of contributing to the design and analysis of systematic rules to reduce the costs of inflation and business cycle fluctuations.

The work on policy rules and systematic policy behavior represents a sweeping change from the vision for monetary economics set out by Lucas and Sargent in 1978. They correctly pointed out that "...[equilibrium methods] will focus attention on the need to think of policy as the choice of stable rules of the game, well understood by economic agents. Only in such a setting will economic theory help predict the actions agents will choose to take. (Lucas and Sargent 1978 (1981, p. 317)). But they then drew the conclusion that

> .. the government countercyclical policy must itself be unforeseeable by private agents...while at the same time be systematically related to the state of the economy. Effectiveness, then, rests on the inability of private agents to recognize systematic patterns in monetary and fiscal policy. (Lucas and Sargent 1978)

If policy effectiveness rests on the "inability of private agents to recognize systematic patterns," there is little reason for economists to investigate optimal systematic policies.

Contrast this with the recent view expressed by Woodford:

> ...the central bank's stabilization goals can be most effectively achieved only to the extent that the central bank not only acts appropriately, but is also *understood* by the private sector to predictably act in a certain way. The ability to successfully steer private-sector expectations is favored by a decision procedure that is based on a rule, since in this case the systematic character of the central bank's actions can be most easily made apparent to the public. (Woodford 2003)

While Woodford also emphasized rules, he stresses that it is the ability of private agents to discern systematic policy actions that contributes to the effectiveness of monetary policy.

This recognition has breathed new life into the study of optimal policy design and explains why the research interests of academic and central bank economists have converged. Monetary theory has again become relevant for monetary policy.[1] The evolution of theory from the perspective offered by Lucas and Sargent to the one provided by Woodford is central to understanding why theory has, over the past fifteen years, had a much greater impact on practice than previously.

I will focus on four areas in which recent advances in monetary theory have relevance for the practice of monetary policy: understanding the monetary transmission mechanism, designing policy rules, dealing with uncertainty, and assessing the welfare gains from optimal policy. I begin, however, with brief comments on the use of dynamic stochastic general equilibrium (DSGE) models that integrate optimizing behavior with nominal rigidities.

2 The DSGE approach

Twenty years ago, the canonical academic paper in monetary economics employed a simple, linear rational expectations model to analyze monetary policy issues. Key components of the model were likely to be a Lucas supply function relating deviations of output from potential to surprise inflation and some variant of an IS-LM model to link the money supply, treated as the instrument of policy, to aggregate demand. Exogenous stochastic shocks were typically appended to both the supply and the demand relationships. These models made no pretense at empirical veracity, and they were far removed from the models used in central

[1] Of course, earlier models employed by central banks also implied that systematic policy mattered. These models, though, "started from curves" and the equilibrium conditions of the models were not derived from the underlying decision rules of households and firms. Thus, the models were open to the Lucas critique, reducing their attractiveness as frameworks for conducting policy experiments. In contrast, the modern approach leads to models in which equilibrium conditions are based on well-specified decision problems faced by the households, firms, and even policy makers. The form these decision problems take depends on the environment the model builder specifies, but the objective is to develop models immune to the Lucas critique, able to match importance characteristics of macro data, and within which one can conduct policy experiments.

banks for providing actual policy advice. Policy makers viewed these models as unhelpful and academics viewed central bank models as crippled by the Lucas critique.

The contrast with today's canonical paper in monetary economics is striking. A modern paper would be based on a dynamic, stochastic general equilibrium (DSGE) model in which optimizing agents – households and firms – interact in an environment characterized by nominal rigidities. These models provide laboratories in which one can address normative issues of optimal policy design. As a consequence, an explosion in policy-relevant research has taken place, one in which both academic economists and central bank research economists are active participants. To take just two recent examples of this interplay, the Reserve Bank of New Zealand sponsored a workshop on "Dynamic Stochastic General Equilibrium (DSGE) models" in August 2005 and the Federal Reserve held a Conference on "DSGE Modeling at Policy making Institutions: Progress and Prospects" in December 2005. Both these events involved academics and central bank economists, reflecting the prevalence of DSGE modeling approaches inside and outside of central banks.[2] Clarida, Galí, and Gertler (1999) pointed to the development of DSGE models with nominal rigidities as one of the two factors leading to the revival of interest in the study of monetary policy design. The other factor they cited was new empirical evidence suggesting the importance of monetary factors in accounting for cyclical fluctuations. I would add a third; the treatment of the interest rate rather than the quantity of money as the instrument of policy, a shift that made monetary theory much more relevant from the perspective of policy makers.

The current generation of DSGE models have contributed to policy in several important ways (see Galí 2001). First, they offer new insights into the transmission process of monetary policy. Second, they force model builders to think more carefully about the underlying sources of economic disturbances, and this has led to a better appreciation that the simple

[2]The common approaches taken by academic economists and central bank economists is a point emphasized by McCallum (1999).

dichotomy between demand shocks and supply shocks is not helpful for policy analysis. Instead, one must understand the nature of the disturbances and whether they lead to inefficient fluctuations. Third, these models provide model-consistent measures of the output gap relevant for policy. Fourth, these models provide grounds for welfare-based policy, giving new insights into the costs of inflation and the appropriate objectives of stabilization policy.

The DSGE modeling approach is now wide spread among central bank researchers, and several central bank's have adopted DSGE models for use in policy analysis, affecting directly the practice of monetary policy. Parameters in these models are not arbitrary but characterize the economic environment faced by private sector decision makers. Economic theory can often, though not always, provide guidance as to the values of these parameters. This allows the models to be calibrated, a feature that can be particularly important in situations in which major structural changes have occurred that limit the informativeness of macro time series for estimating policy models.[3] However, these models are reaching the stage where they are being taken to the data and are able to match quarterly business cycle data in ways that increase our confidence that they can serve to generate the type of short-run projections that are central to the monetary policy decision process. Central bank economists have been among the leaders in developing and estimating DSGE models (e.g., Smets and Wouter 2003).

[3]For example, some aspects of the Forecasting and Policy System (FPS) model of the Reserve Bank of New Zealand are calibrated rather than estimated.

3 Forward-looking expectations and the monetary transmission mechanism

Some of the most important insights from recent research have been into the role forward-looking expectations play in affecting the monetary transmission process and the implications this has for both policy design and central bank communications.

At least since the 1950s and the work of Friedman and Modigliani and Brumberg, economists have recognized the importance of forward-looking behavior. What is new in the models currently employed for policy analysis is the role played by forward-looking expectations in the adjustment of prices and wages. Standard models in which firms set prices that may remain unchanged for some time naturally imply that firms must be forward looking, assessing not just the current economic environment but the outlook for the future as well.

It is because forward-looking expectations matter that the systematic behavior of the central bank plays a critical role in determining the real effects of monetary policy, as only the systematic part of policy will affect future expectations. This lesson is one that has clearly influenced how central banker's think about monetary policy. To quote just one, Mervyn King (2005) has stated that "Because inflation expectations matter to the behaviour of households and firms, the critical aspect of monetary policy is how decisions of the central bank influence those expectations." He even goes so far as to quote Michael Woodford that "very little else matters."

There are many ways in which a consideration of forward-looking expectations is vital for understanding key elements of policy design, but let me highlight two: the gains from commitment and the role of transparency.

3.1 Commitment

As Lucas and Sargent emphasized, one must think of policy in terms of stable rules, but central banks must not only follow rules, they must be seen to be doing so. That is, the ability of a central bank to commit to a rule is critical. Recent developments in monetary theory have provided new insights into the gains from credibility and policy commitment.[4]

Earlier analysis of time inconsistency and the gains from commitment focused on understanding the average inflation bias that might arise under discretion. In that framework, the underlying source of the inflation bias was an unrealistically ambitious policy goal for economic activity. If the central bank would only focus correctly on stabilizing the output gap, the inflation bias would disappear and so would the distinction between discretion and commitment.

Today, we understand better that even in the absence of an average inflation bias, there are gains from commitment. By anchoring future inflation expectations through a commitment to a low inflation target, central banks can improve the trade off they face between inflation and output gap volatility.

The gain from commitment arises because the central bank potentially has two instruments at its disposal – the current short-term interest rate and private sector expectations of future inflation. In a discretionary environment, only the first instrument can be used. If both instruments can be employed, the central bank can achieve better outcomes. Specifically, less output gap volatility is associated with any given level of inflation variability.

Of course, a central bank can only affect future expectations systematically if it is credible. And, just as recent theory has provided new insights into the gains from commitment, it has also illustrated the form that commitment policies take in practice. For example, when policy actions affect the economy with a lag, policy must be forward-looking; policy

[4]See Bernanke (2004) for a discussion of what economists have learned about credibility since the Volcker disinflation.

in such an environment is characterized as inflation-forecast targeting. But forward-looking behavior by the private sector leads optimal monetary policy to be backward looking. This introduces an inertia into policy that would be absent in a discretionary environment. Conditioning current policy on the past is a means of honoring past commitments. Private agents will believe the central bank's promises about future policies only if it has delivered on past promises.

There is a great deal of empirical evidence that central banks actually do display inertial behavior, but debate exists over how to interpret this behavior. Does it simply reflect attempts by central banks to honor past commitments? Or does it reflect simply sluggish behavior by central banks? Regressions of policy interest rates that included the lagged interest rate always find large and statistically significant coefficients on the lagged rate. This is often interpreted to mean that central banks engage in partial adjustment, moving the policy rate only gradually towards the desired rate. However, inertial behavior under optimal commitment is not equivalent to partial adjustment – it is the desired rate itself that depends on past policies. Rudebusch (2005) argues that the Fed does not engage in partial adjustment behavior. Instead, the apparent inertia in the federal funds rate results from, as Rudebusch puts it, "slow accretion of information relevant to the setting of the policy interest rate by policymakers."

Regardless of the eventual explanation for policy inertial in practice, recent theory has given us new insights into both the gains from commitment and the form commitment polices take.

3.2 Transparency

If forward-looking expectations are important for the monetary transmission process, transparency about future policy is crucial in ensuring consistency between the central bank's intentions and private sector expectations. Yet despite this, few central banks are com-

pletely transparent about future policy. The Federal Reserve, while cutting rates in 2000 and raising them in 2005 and 2006, provided signals to the market about the future direction of rate changes. And the inflation reports of the Norges Bank now provide future interest rate projections along with inflation and output gap projections. But most central banks do not provide explicit interest rate projections and, until recently, several based output and inflation projections on constant interest rate paths that were clearly not meant as forecasts of future interest rates.

Modern theory gives insights, however, into how transparency can help achieve what are the central bank's primary objectives. Central banks increasingly recognize the importance of communication so that the public understands the systematic nature of policy. This recognition has played a large part in motivating the greater transparency with which policy is now conducted (Issing 2005a). Eijffinger and Geraats (2005) provide an index of transparency for a set of developed economies that includes some inflation targeters (Australia, Canada, New Zealand, Sweden, and the UK) as well as non-targeters (Japan, Switzerland, and the US). They find that between 1998 and 2002, transparency increased for virtually all the central banks they studied. Even the Federal Reserve, which has so far resisted calls to establish a formal inflation target, has moved to make its policy practices more transparent.

But, as Otmar Issing has noted that "Transparency is not an end in itself: a central bank is not established with the primary objective of communicating with the public" (Issing 2005a). Transparency can improve the ability of monetary policy to achieve its goals by ensuring that private market expectations are consistent with the aims of central bank policy. In the forward-looking new Keynesian model that has seen wide-spread use for monetary policy analysis, the effectiveness of monetary policy depends on the ability of policy to affect expectations about the future path of interest rates (Woodford 2003). A transparent policy, one that reduces uncertainty about future policy actions, can improve

the trade off between output and inflation objectives and increase the effectiveness of policy. This contrasts strongly with the analysis of transparency in models from the 1970s through 1990s in which policy could only be effective if it were opaque and able to surprise private agents.

Transparency is not unambiguously desirable, however. Recent research has dropped the assumption of common information that characterizes most models and investigated the role of central bank announcements when private agents and the central bank have diverse and imperfect information.[5] Because the central bank announcements are public information, information shared by all, private agents may overreact to it. If central bank announce forecasts that are subject to error, these forecast errors may introduce undesirable volatility into the economy as private agents overreact to the public nature of central bank announcements. This does capture a concern of policy makers. For example, in discussing the release of FOMC minutes, Janet Yellen expressed the view that "Financial markets could misinterpret and overreact to the minutes." (Yellen 2005). So, while conclusions from this literature are not yet firmly established, it provides a further example of how work in monetary theory is tackling directly issues that are of relevance to monetary policy makers.

4 Policy rules

John Taylor desires the credit for reviving academic interest in policy rules. In 1993, he demonstrated that a simple reaction function expressing the Fed's policy instrument as a function of an inflation gap and an output gap could track the actual path of the federal funds rate surprisingly well (Taylor 1993). This finding opened up new avenues of research in both theory and practice. Economists began exploring the extent to which the behavior of other central banks could be captured by simple rules, the characteristics of optimal

[5]The basic theory is due to Morris and Shin (2003). For an application in a standard new Keynesian model of monetary policy, see Walsh (2005c).

simple rules in both theoretical, calibrated, and estimated models, and the comparative performance of simple rules and optimal rules.

Monetary theory has offered a number in insights concerning policy rules that have proven relevant for practice.

4.1 The Taylor Principle

The use of forward-looking models of inflation determination renewed interest in assessing the restrictions on policy that were necessary to guarantee a determinant equilibrium. In general, determinacy is ensured under interest rates rules that follow the Taylor Principle, responding more than one-for-one to deviations of inflation from target. The Taylor Principle is the means through which modern central banks provide a nominal anchor and ensure low and stable inflation.

Optimal policy is often described in terms of a description of "how a central bank would respond to any conceivable shock in the future..." (King 2005). This sounds like a daunting task, but in fact, policy can be expressed, not in terms of reactions to hard to shocks, but as reactions to a small number of macro variables. In fact, the analysis of policy rules that ensure determinacy has lead to a recognition that policy *must* respond to endogenous variables, not solely to exogenous shocks. This represents an important shift from earlier research. This earlier literature emphasized the role of policy in responding to exogenous shocks. Monetary theory today has shown how such policies are not consistent with determinacy. Policy must react to endogenous variables. Since shocks are generally unidentified, research on optimal responses to endogenous variables such as inflation and output has lead to findings that are much more relevant for policy makers.

4.2 Learning and Learnability

While the Taylor Principle was initially viewed as a necessary requirement for determinacy, it has also been shown to play a role in determining whether a rule is learnable (Bullard and Mitra 2002). A policy rule is learnable if private agents can learn the fundamental, rational expectations equilibrium of the model under simply learning dynamics. Learnability is important; with the ability of policy makers to achieve their stabilization goals contingent on the public's understanding of the systematic aspects of policy, it is necessary that the private sector be able to learn correctly about the central bank's rule.

Of course, the central bank must also take into account the fact the private sector is learning. Gaspar, Smets, and Vestin (2005) have shown that if the private sector learns adaptively, simple policy rules can lead to explosive behavior. As they put it, central bankers must engage in 'sophisticated' policy that acknowledges the learning behavior of the private sector.

It is not just the private sector that is learning; policy makers too are learning about the economy. Optimal learning models generally imply some experimentation, a recommendation unlikely to win support among policy makers. However, Cogley, Colacito, and Sargent (2005) have shown that the gains from policy experimentation are small, and they conclude that central bankers should learn but not experiment.

4.3 Instrument rules versus targeting rules

Another area in which theory has demonstrated its relevance to practice has been in the analysis of policy rules. There are many ways policy rules can be expressed. For example, a Taylor rule is an instrument rule; it describes the setting of the policy instrument as a function of a small set of macro variables. In contrast, a targeting rule represents "a condition to be fulfilled by the central bank's target variables (or forecasts thereof)" (Svensson

2004). A targeting rule does not involve exogenous shocks; the condition to be maintained involves only the central bank's target variables.

Targeting rules are common among inflation-targeting central banks.[6] For example, a statement to the effect that policy will aim to ensure the x-period ahead inflation forecast equals the inflation target is an implicit statement of a targeting rule. Such a rule may or may not reflect an optimal policy.

Optimal targeting rules are first-order conditions. Thinking of policy in terms of such first order condition is natural. From the perspective of understanding how central banks behave, starting from the presumption that they have well defined objectives and set policy optimally to achieve those objectives is consistent with the approach economists take to studying private sector behavior.

There is at least one example of a central bank that employs a targeting rule – the Norges Bank. In their January 2005 *Inflation Report*, the Norges Bank list several criteria a future interest rate path should meet. The first is basically the Taylor Principle. Let me quote from the second: "..the inflation gap and the output gap should be in reasonable proportion to each other until they close. ... If both gaps are positive, for example, a path with a higher interest rate would be preferable, as it would bring inflation closer to the target and contribute to more stable output developments." This provides a description of a targeting rule. Under discretion, it corresponds to the optimal targeting rule in a simple model with a quadratic loss function in inflation and the output gap. As is well known, the first-order condition under discretion in this case implies that the output gap and the inflation gap should move in proportion to one another, and they should be of opposite sign.

There are two problems with the targeting rule criterion described by the Norges Bank.

[6]Svensson (2004) noted that a Google search on "'targeting rules' monetary" produced 1700 results in April 2003 and 2100 in August 2004. A similar search in January 2005 resulted in 16,800 hits.

First, this rule is model specific. Alternative models of the monetary transmission mechanism or alternative formulations of policy objectives will not lead to such a simple targeting rule.

Second, this rule ignores the gains from commitment – it fails to exploit the expectational channel of policy. The optimal targeting rule under commitment relates inflation to the change in the output gap so that a positive inflation gap should not be accompanied by a rising output gap. Both inflation and the output gap could be positive, a long as the output gap is falling towards zero. The optimal targeting rule under commitment also displays inertia (Woodford 2003). The policy called for under the rule depends on past outcomes in a way that reflects the desirability of delivering on past promises.

Because targeting rules are model specific, they have not seen wide adoption. Central banks prefer simple rules, and, as the next section discusses, this preference may arise from a desire for robustness in the face of the uncertainty. However, the use of simple rules has been criticized, particularly by Svensson (2003, 2004), who highlights four problems with simple instrument rules: 1) they exclude important state variables; 2) commitment to a simple rule does not allow for any subsequent improvement in the rule as "new information about the transmission mechanism, the variability of shocks, or the source of shocks arrives"; 3) "commitment to a simple instrument rule does not provide any rules for when discretionary departures from the simple instrument rule are warranted" – as such, they are not sufficient descriptions of good monetary policy; and 4) no central bank has announced an explicit commitment to a simple rule.

All of these are serious criticisms, though simple rules also have their defenders (McCallum and Nelson 2004). As an alternative to such rules, Svensson makes two proposals. The first, which he labels commitment to a general targeting rule, requires the central bank to announce, and commit to, a specific objective function. His second proposal is that central banks commit to a specific targeting rule, essentially an expression for the policy instrument

derived from the first order condition for the central bank's optimal policy.

Unfortunately, each of these proposals is subject to the many of the same criticisms levied at simple rules. Committing to an objective function would require the central bank to state, explicitly, how willing it is to trade-off inflation for output gap fluctuations. But one of the key insights provided by Woodford (2003) is that how policy objectives should be balanced depends on the structure of the economy. As information about the transmission process changes, as structural change in the economy takes place, commitment to a general targeting rule would not allow the central bank to alter its preferences. In the face of structural change that affects the costs of inflation, it is likely to be easier for the central bank to alter its instrument rule than to alter its publicly announced objectives. Even when an objective function is announced, as Svensson notes "In practice, the loss function is not specified in this detail, and the central bank has some discretion over the translation of the stated objectives into a loss function." But how much discretion? And what are the rules for governing the departures? These questions are left unanswered. Finally, no central bank has announced an explicit loss function.

At this point, it seems both instrument rules and targeting rules have useful roles to play in policy analysis. But the debate over instrument and targeting rules serves to illustrate the real contribution modern monetary economics has made to issues of direct relevance for the practice of monetary policy.

5 Uncertainty

> ....while the academic profession has made tremendous progress in analyzing risk in well-defined stochastic economies, the "Knightian" uncertainty that confronts central bankers and sometimes markets is of an all together different dimension. (Issing 2002)

> I put forward an approach to monetary policy making under uncertainty that involves two main components: first, a firm reliance on the fundamental and robust results of monetary economics; second, a pragmatic attitude to policy implementation, which takes in due consideration lessons from central banking experience. (Issing 2005b)

Recently, economists have taken new looks at optimal monetary policy under uncertainty. Work by Levin and Williams (2003), Hansen and Sargent (2003), Giannoni and Woodford (2003), Svensson and Williams (2005) and many other have produce new insights and new perspectives on optimal policy in the face of uncertainty.

Giannoni and Woodford (2003) have emphasized that optimal targeting rules, because they involve only target variables, are independence of the specific stochastic behavior of economic disturbances. Optimal policy responses to inflation and output gap movements are the same regardless of whether shocks tend to be transitory or highly persistent.[7] The Giannoni and Woodford approach, however, involves only additive uncertainty in settings in which certainty equivalence holds. This is clearly only a small subset of the forms of uncertainty policy makers face, and economist have developed methods for dealing with more general forms of uncertainty. Two of the most important sources of uncertainty are observational uncertainty and model uncertainty.

5.1 Observational uncertainty

Observational uncertainty is the uncertainty faced by policy makers due to their limited ability to observe accurately the contemporaneous state of the economy. Observational uncertainty arises from data uncertainty and from the fact that quantities our theory implies

[7] Their result, however, is model specific. If lagged inflation appears in the inflation adjustment equation, for example, the optimal targeting rule will involve expectations of future inflation. To form forecasts of future inflation, the central bank must know the process followed by the distrubances.

should play a critical role in policy decisions are not directly measurable. The output gap illustrates both sources of this problem.

Policy decisions must be made using real-time data. The importance of real-time date for understanding, and reconstructing, the environment in which actual decisions are made is critical. Orphanides (2003) has shown, for example, how the failure to correctly assess changes in trend growth during the 1970s contributed to serious policy mistakes in the U.S. Researchers have investigated how outcomes under simple rules are affected by observational uncertainty. Simple rules that respond to output gap changes, so-called difference rules, appear to be more robust to data uncertainties than standard Taylor rules (Orphanides and Williams 2002, Walsh 2003), and the Norges Bank employes such a difference rule as one of its alternative simple rules used to construct projections.

Data uncertainty is not the only source of observational uncertainty. Equally important is the role of unobservable theoretical quantities in optimal policy design. For example, new Keynesian models imply central banks should focus on inflation and the gap between output and the flexible-price equilibrium output level, or between actual output and the welfare-maximizing output level. Neither the flexible-price nor the welfare-maximizing output levels are observable. Recently, a new generation of estimated DSGE models offer the possibility of measuring these theoretical quantities. Doing so forces model builders, and policy makers, to think carefully about the nature of economics disturbances and their implications for economic welfare.[8]

5.2 Model uncertainty

Several insightful new approaches to model uncertainty have been pursued by monetary economists. These approaches have emphasized the need to find policy rules that are robust

[8] See Walsh (2005b).

to various aspects of model mis-specification.[9]

The notion that policy may be more robust if based on a systematically distorted model of the economy is a key implication of the approach to robust control explored by Hansen and Sargent (2003). The robust control approach proceeds from the assumption that the central bank has a model of the economy that is believed to be a reasonable approximation to the true model, but the policy makers also knows that this approximating model may be subject to mis-specification. Rather than viewing the set of possible mis-specifications as purely random, the policy maker assumes "nature" is an evil agent who will choose the mis-specification that makes the policy maker look as bad as possible. In such an environment, optimal policy aims to minimize the worst-case outcome that could arise. In a number of cases that have been analyzed, the worst-case model is characterized by increased persistence; the dangers of underestimating the degree of persistence appear to be greater than those of overestimating persistence.

From the perspective of policy strategies, the use of a distorted model has several problems. Basing forecasts on a model that the policy maker knows is distorted would make it more difficult to communicate the rationale behind policy actions. Robust control has been criticized on the grounds that worst-case outcomes are likely to be low probability events. As a consequence, a robust policy is, from a Bayesian perspective, too heavily influenced by such events.

An alternative approach is to seek policy rules that perform well across a range of possible models, even if the rule is not optimal for any one model. In exploring this approach, for example, Levin and Williams (2003) have shown that policy rules designed to be optimal in backward-looking models are much more robust than rules optimized for forward-looking models. Thus, somewhat paradoxically, the expectations channel is important for understanding the monetary transmission channel, but it should not be relied on by a central

[9]McCallum (1988) has long argued for assessing the robustness of rules across different models.

bank that desires its policies to be robust.

Seeking a rule that does well across a range of models is often done heuristically, without grounding the analysis in an explicit Bayesian assessment of the probabilities associated with the alternative models. When Bayesian approaches have been adopted, there has been a tendency to focused on specific sources of uncertainty while ignoring others. Recently, Svensson and Williams (2005) have proposed a general approach to optimal policy design under uncertainty, an approach that can simultaneously handle forms of data, coefficient, and model uncertainty. In fact, Svensson and Williams (2005, p. 11) claim that "Generally, aside from dimensional and computational limitations, it is difficult to conceive of a situation for a policymaker that cannot be approximated in this framework." However, their approach does require exact knowledge of the probability distribution over different models at each date t and the transition matrix that describes how these probabilities evolve over time. While these probabilities can be estimated, current theory is still far from addressing "the 'Knightian' uncertainty that confronts central bankers", to quote Issing again.

5.3 Communicating uncertainty

In practice, central banks have always recognized the uncertainties they face. However, what has changed markedly in recent years are the ways this uncertainty is communicated to the public. Several central banks have followed the lead of the Bank of England in producing fan charts as a method for communicating the range of inflation outcomes that could occur. In practice, these fan charts reflect only the uncertainty arising from the additive and exogenous disturbance terms that appear in the forecasting model. A much more important source of uncertainty is undoubtedly model uncertainty, and theory is beginning to develop new methods that will allow central banks to incorporate forms of model uncertainty into the construction of fan charts. For example, the work of Svensson and Williams (2005) provides techniques for deriving optimal policy and forecast fan charts

that can incorporate many forms of uncertainty. These fan charts both communicate the extend of uncertainty to the public and focus policy makers on distribution forecast inflation targeting in which policy is chosen so that the distribution of future inflation and output gap projections look good.

6 Welfare and policy objectives

Recent developments in monetary theory have obtained important new insights into the costs of economic fluctuations, the benefits of stabilization policies, the conditions under which price stability is optimal, and the objectives of optimal policy. These developments are a natural consequence of the DSGE modeling approach. By specifying clearly the preferences of the economic agents in the model and the environment in which they operate, DSGE modeling has made it feasible to investigate the implications of policy for the welfare of the agents in the economy.

Lucas (2003) has argued that the welfare gain from improved macroeconomic stabilization policies is small. As he puts it, "The potential gains from improved stabilization policies are on the order of hundredths of a percent of consumption, perhaps two orders of magnitude smaller than the potential benefits of available 'supply-side' fiscal reforms." The implication is that the energy directed towards fine-tuning stabilization policy is misdirected. Recent work in monetary theory, however, work closely associated with Mike Woodford, has demonstrated that focusing solely on consumption volatility misses important welfare costs associated with inflation. These costs are distinct from the traditional shoe-leather costs common to monetized economies with positive nominal interest rates. The recent literature has focused on the way non-zero inflation distorts the signals provided by the price system when non-synchronized price adjustment across firms leads to an inefficient dispersion of relative prices. One attractive aspect of this result is that it captures an

older but not formally modeled view that inflation reduces the ability of the price system to allocate resources efficiently. Similarly, staggered wage adjustment causes inefficient relative wage dispersion when wage inflation is non-zero.

When the distortions due to relative price and wage distortions are accounted for, the potential gains from stabilization policy appear to be much larger than Lucas obtained. For example, employing an estimate DSGE model of the US with wage and price rigidities, Levin, Onatski, Williams, and Williams (2005) find that the welfare costs of business cycles are equivalent to a 2.6 percent reduction in steady-state consumption under the historical policy rule. Even under the optimal Ramsey policy, these costs are still a sizable 2 percent of steady-state consumption. Thus, theory is providing new understanding of the importance of well-designed monetary policies. Interestingly, most of these costs are the result of nominal wage rigidities, and a robust policy rule in their model is one that stabilizes nominal wages.

These new perspectives on the costs of inflation provide support from theory for the practice followed by many central banks of focusing on core inflation. Core inflation typically removes sectors with volatile prices such as food and energy from the overall price index. This leaves core inflation as a better measure of inflation in the sticky-price sectors of the economy, and these are the sectors that generate the largest welfare costs due to inflation.

The linkages between economic structure and policy objectives in modern theory has one important implication for policy makers who employ a range of models in evaluating alternative polices. Different models will imply different consequences for welfare of inflation and real economic fluctuations. The importance of price stability relative to reducing real volatility will depend on the model's assumptions about the form of and rationale for nominal rigidities. In general, the common practice of employing a constant measure of welfare and evaluate it using several different economic models is internally inconsistent. Objectives will depend on the central bank's model (or models).

Central banks have been less transparency about objectives than about other aspects of policy. None have publicly revealed their loss function. This shows good judgment on the part of central bankers. We do not know enough, and our models are too simple, to take the welfare implications too literally. Despite the importance of the labor market and wage behavior for the costs of fluctuations, standard models are only now incorporating unemployment in new work integrating the modern theory of unemployment with DSGE models with nominal and real rigidities.[10] Other work has began to investigate the extent to which the appropriate response to the distributional costs of business cycles is a social insurance program rather than macro stabilization (e.g., Costain and Reiter 2005). Current policy models also do not incorporate micro-founded financial markets that reflect the informational imperfections that help shape these markets. As theory moves away from simplistic financial structures, we will probably gain new insights into the role of money in the design of monetary policy.

By offering new understandings of the costs of fluctuations, the appropriate objectives of policy, and the potential benefits of well-conceived and designed monetary policies, hopefully, theory will continue to be relevant for the practice of monetary policy.

7 Conclusions

> The critical requirement....is an ongoing fruitful dialogue between monetary theory and monetary policy. (Issing 2001)

Today, the dialogue Issing called for is active and fruitful. Central banks employ DSGE models for policy analysis. Policy makers think in terms of rules. They recognize the value of credibility and commitment. They try to reduce uncertainty in markets by providing information about the likely future path of interest rates. All these characteristics of the

[10] For example, see Trigari (2004), Walsh (2005a), Gertler and Trigari (2006).

modern practice of policy have been grounded in recent developments in monetary theory. And academic economists are focusing their analysis on issues that are of interest to and of practical relevance for policy makers.

I have tried to highlight a few of the topics that recent theory has investigated and that are relevant for policy makers. The role of forward-looking expectations, the importance of credibility and transparency, the design of systematic policy rules, new approaches to studying policy under uncertainty, and new insights into the welfare costs of inflation and real fluctuations are areas in which theory is relevant for practice. Some of the lessons from recent theory do qualify as, to quote Issing again, among "the fundamental and robust results of monetary economics" which can provide the foundation on which policy makers can ground their "pragmatic attitude to policy implementation."

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