CHAPTER 15

Simple and Robust Rules for Monetary Policy[☆]

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Contents

Abstract

This paper focuses on simple normative rules for monetary policy that central banks can use to guide their interest rate decisions. Such rules were first derived from research on empirical monetary models with rational expectations and sticky prices built in the 1970s and 1980s. During the past two decades substantial progress has been made in establishing that such rules are robust. They perform well with a variety of newer and more rigorous models and policy evaluation methods. Simple rules are also frequently more robust than fully optimal rules. Important progress has also been made in understanding how to adjust simple rules to deal with measurement error and expectations. Moreover, historical experience has shown that simple rules can work well in the real world in that macroeconomic performance has been better when central bank decisions were described by such rules. The recent financial crisis has not changed these conclusions, but it has stimulated important research on how policy rules should deal with asset bubbles and the zero bound on interest rates. Going

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forward, the crisis has drawn attention to the importance of research on international monetary issues and on the implications of discretionary deviations from policy rules.
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1. INTRODUCTION

Economists have been interested in monetary policy rules since the advent of economics. In this chapter we concentrate on more recent developments, but first we begin with a brief historical summary to motivate its theme and purpose. We describe the development of the modern approach to policy rules and evaluate this approach using experiences before, during, and after the Great Moderation. We contrast in detail this policy rule approach with optimal control methods and discretion. We also consider several key policy issues, including the zero bound on interest rates and the issue of output gap measurement, using the lens of policy rules.

2. HISTORICAL BACKGROUND

Adam Smith first delved into the subject of monetary policy rules in the *Wealth of Nations* arguing that "a well-regulated paper-money" could have significant advantages in improving economic growth and stability compared to a pure commodity standard. By the start of the nineteenth century Henry Thornton and then David Ricardo were stressing the importance of rule-guided monetary policy after they saw the monetary-induced financial crises related to the Napoleonic Wars. Early in the twentieth century Irving Fisher and Knut Wicksell were again proposing monetary policy rules to avoid monetary excesses of the kinds that led to hyperinflation following World War I or seemed to be causing the Great Depression. Later, after studying the severe monetary mistakes of the Great Depression, Milton Friedman proposed his constant growth rate rule with the aim of avoiding a repeat of those mistakes. Finally, modern-day policy rules, such as the Taylor rule (1993a), were created to end the severe price and output instability during the Great Inflation of the late 1960s and 1970s (see also Asso, Kahn, & Leeson, 2007, for a detailed review).

As the history of economic thought makes clear, a common purpose of these reform proposals was a simple, stable monetary policy that would both avoid creating monetary shocks and cushion the economy from other disturbances, reducing the chances of recession, depression, crisis, deflation, inflation, and hyperinflation. There was a presumption in this work that such a simple rule could improve policy by avoiding monetary excesses, whether related to money finance of deficits, commodity discoveries, gold outflows, or mistakes by central bankers with too many objectives. In this context, the choice between a monetary standard where the money supply jumped around randomly versus a simple policy rule with smoothly growing money and credit seemed obvious. The choice was both broader and simpler than "rules versus discretion." It was "rules versus chaotic monetary policy," whether the chaos was caused by discretion or unpredictable exogenous events like gold discoveries or shortages.

A significant change in economists' search for simple monetary policy rules occurred in the 1970s, however, as a new type of macroeconomic model appeared on the scene. The new models were dynamic, stochastic, and empirically estimated. But more important, these empirical models incorporated both rational expectations and sticky prices making them sophisticated enough to serve as a laboratory to examine how monetary policy rules would work in practice. These models were used to find new policy rules, such as the Taylor rule, to compare the new rules with earlier constant growth rate rules or with actual policy, and to check the rules for robustness. Examples of empirical modes with rational expectations and sticky prices include the simple three equation econometric model of the United States in Taylor (1979), the multi-equation international models in the comparative studies by Bryant, Hooper, and Mann (1993), and the econometric models in robustness analyses of Levin, Wieland, and Williams (1999). Nearly simultaneously, practical experience was confirming the model simulation results as the instability of the Great Inflation of the 1970s gave way to the Great Moderation close to the same time that actual monetary policy began to resemble the proposed simple policy rules.

While the new rational expectations models with sticky prices further supported the use of policy rules — in keeping with the Lucas (1976) critique and time inconsistency (Kydland & Prescott, 1977) — there was no fundamental reason why the same models could not be used to study more complex monetary policy actions that went well beyond simple rules and used optimal control theory. Indeed, before long optimal control theory was being applied to the new models and refined with specific microfoundations as in Rotemberg and Woodford (1997), Woodford (2003), and others. The result was complex paths for the instruments of policy which had the appearances of "fine tuning" as distinct from simple policy rules.

The idea that optimal policy conducted in real time without the constraint of simple rules could do better than simple rules thus emerged within the context of the modern modeling approach. The papers by Mishkin (2007) and Walsh (2009) at recent Jackson Hole Conferences were illustrative. Mishkin (2007) used optimal control to compute paths for the federal funds rate and contrasted the results with simple policy rules, which stated that in the optimal discretionary policy "the federal funds rate is lowered more aggressively and substantially faster than with the Taylor-rule . . ..This difference is exactly what we would expect because the monetary authority would not wait to react until output had already fallen." The implicit recommendation of this statement is that simple policy rules are inadequate for real-world policy situations and that policymakers should therefore deviate from them as needed.

The differences in these approaches are profound and have important policy implications. At the same Jackson Hole Conference that Mishkin (2007) emphasized the advantages of the optimal control approach compared to simple policy rules, Taylor (2007) found that deviations from the historical policy rule added fuel to the housing boom and helped bring on the severe financial crisis, the deep recession, and perhaps the end of the Great Moderation. For these reasons we focus on the differences between these two approaches in this paper. Like all previous studies of monetary policy rules by economists, our goal is to find ways to avoid such economic maladies.

In the next section we review the development of optimal simple monetary policy rules using quantitative models. We then consider the robustness of policy rules using comparative model simulations and show that simple rules are more robust than fully optimal rules. The most recent chapter in the *Handbook in Economics* series on monetary policy rules is the comprehensive and widely cited survey published by Ben McCallum (1999) in the *Handbook of Macroeconomics* (Taylor & Woodford, 1999). Our paper and McCallum's are similar in scope in that they focus on policy rules that have been designed for normative purposes rather than on policy reaction functions that have been estimated for positive or descriptive purposes. In other words, the rules we study have been derived from economic theory or models and are designed to deliver good economic performance rather than to statistically fit the decisions of central banks. Of course, such normative policy rules can also be descriptive if central bank decisions follow the recommendations of the rules, which they have done in many cases. Research of an explicitly descriptive nature, which focuses more on estimating reaction functions for central banks, goes back to Dewald and Johnson (1963), Fair (1978), and McNees (1986), and includes, more recently, work by Meyer (2009) on estimating policy rules for the Federal Reserve.

McCallum's chapter in *Handbook of Macroeconomics* stressed the importance of robustness of policy rules and explored the distinction between rules and discretion using the time inconsistency principles. His survey also clarified important theoretical issues such as uniqueness and determinacy, and he reviewed research on alternative targets and instruments including both money supply and interest rate instruments. Like McCallum we focus on the robustness of policy rules. We focus on policy rules where the interest rate rather than the money supply is the policy instrument, and we place more emphasis on the historical performance of policy rules reflecting the experience of the dozen years since McCallum wrote his findings. We also examine issues that have been major topics of research in academic and policy circles since then, including policy inertia, learning, and measurement errors. We also delve into the issues that arose in the recent financial crisis including the zero lower bound (ZLB) on interest rates and dealing with asset price bubbles. Because of this, our chapter is complementary to McCallum's useful *Handbook of Macroeconomics* chapter on monetary policy rules.

3. USING MODELS TO EVALUATE SIMPLE POLICY RULES

The starting point for our review of monetary policy rules is the research that began in the mid-1970s, took off in the 1980s and 1990s, and is still expanding. As mentioned earlier, this research is conceptually different from previous work by economists because it is based on quantitative macroeconomic models with rational expectations and frictions/rigidities, usually in wage and price-setting.

We focus on the research based on such models because it seems to have led to an explosion of practical as well as academic interest in policy rules. As evidence consider Don Patinkin's (1956) *Money, Interest, and Prices,* which was the textbook in monetary theory in a number of graduate schools in the early 1970s. It has very few references to monetary policy rules. In contrast, the modern day equivalent, Michael Woodford's (2003) book, *Interest and Prices*, is packed with discussions about monetary policy rules. In the meantime, thousands of papers have been written on monetary policy rules since the mid-1970s. The staff of central banks around the world regularly use policy rules in their research and policy evaluation (Orphanides, 2008) as do practitioners in the financial markets.

Such models were originally designed to answer questions about policy rules. The rational expectations assumption brought attention to the importance of consistency over time and to predictability, whether about inflation or policy rule responses, and to a host of policy issues including how to affect long-term interest rates and what to do about asset bubbles. The price and wage rigidity assumption gave a role for monetary policy that was not evident in pure rational expectations models without price or wage rigidities; the monetary policy rule mattered in these models even if everyone knew what it was.

The list of such models is now way too long to even tabulate, let alone discuss, in this chapter, but they include the rational expectations models in the volumes by Bryant et al. (1993), Taylor (1999a), Woodford (2003), and many more models now in the growing model database maintained by Volker Wieland (Taylor & Wieland, 2009). Many of these models go under the name "new Keynesian" or "new neoclassical synthesis" or sometimes "dynamic stochastic general equilibrium." Some are estimated and others are calibrated. Some are based on explicit utility maximization foundations, others more ad hoc. Some are illustrative three-equation models, which consist of an IS or Euler equation, a staggered price-setting equation, and a monetary policy rule. Others consist of more than 100 equations and include term structure equations, exchange rates, and other asset prices.

3.1 Dynamic stochastic simulations of simple policy rules

The general way that policy rule research originally began in these models was to experiment with different policy rules, trying them out in the model economies, and seeing how economic performance was affected The criteria for performance was usually the size of the deviations of inflation or real GDP or unemployment from some target or natural values. At a basic level a monetary policy rule is a contingency plan that lays out how monetary policy decisions should be made. For research with models, the rules have to be written down mathematically. Policy researchers would try out policy rules with different functional forms, different instruments, and different variables for the instrument to respond to. They would then search for the ones that worked well when simulating the model stochastically with a series of realistic shocks. To find better rules, researchers searched over a range of possible functional forms or parameters looking for policy rules that improved economic performance. In simple models, such as Taylor (1979), optimization methods could be used to assist in the search.

A concrete example of this approach to simulating alternative policy rules was the model comparison project started in the 1980s at the Brookings Institution organized by Ralph Bryant and others. After the model comparison project had gone on for several years, some participants decided it would be useful to try out monetary policy rules in these models. The important book by Bryant et al. (1993) was one output of the resulting policy rules part of the model comparison project. It brought together many rational expectations models, including the multi-country model later published in Taylor (1993b).

No one clear "best" policy rule emerged from this work and, indeed, the contributions to the Bryant et al. (1993) volume did not recommend any single policy rule. See Henderson and McKibbin (1993) for analysis of the types of rules in this volume. Indeed, as is so often the case in economic research, critics complained about apparent disagreement about what was the best monetary policy rule. Nevertheless, if one looked carefully through the simulation results from the different models, it could be seen that the better policy rules had three general characteristics: (1) an interest rate instrument performed better than a money supply instrument, (2) interest rate rules that reacted to both inflation and real output worked better than rules that focused on either one, and (3) interest rate rules that reacted to the exchange rate were inferior to those that did not.

One specific rule derived from this type of simulation research with monetary models is the Taylor rule. It says that the short-term interest rate, i_t, should be set according to the formula:

$$i_t = r^* + \pi_t + 0.5\,(\pi_t - \pi^*) + 0.5\,y_t, \tag{1}$$

where r^* denotes the equilibrium real interest rate; π_t denotes the inflation rate in period t; π^* is the desired long-run, or "target," inflation rate; and y denotes the output gap (the percent deviation of real GDP from its potential level). Taylor (1993a) set the equilibrium interest rate r^* equal to 2 and the target inflation rate π^* equal to 2. Thus, rearranging terms, the Taylor rule says that the short-term interest rate should equal one-and-a-half times the inflation rate plus one-half times the output gap plus one. Taylor focused on quarterly observations and suggested measuring the inflation rate as a moving average of inflation over four quarters. Simulations suggested that response coefficients on inflation and the output gap in the neighborhood of one half would work well. Note that when the economy is in steady state with the inflation rate equaling its target and the output gap equaling zero, the real interest rate (the nominal rate minus the expected inflation rate) equals the equilibrium real interest rate.

This rule embodies two important characteristics of monetary policy rules that are effective at stabilizing inflation and the output gap in model simulations. First, it dictates that the nominal interest rate reacts by more than one-for-one to movements in the inflation rate. This characteristic has been termed the Taylor principle (Woodford, 2001). In most existing macroeconomic models, this condition (or some close variant of it) must be met for a unique stable rational expectations to exist (see Woodford, 2003, for a complete discussion). The basic logic behind this principle is clear: when inflation rises, monetary policy needs to raise the real interest rate to slow the economy and reduce inflationary pressures. The second important characteristic is that monetary policy "leans against the wind"; that is, it reacts by increasing the interest rate by a particular amount when real GDP rises above potential GDP and by decreasing the interest rate by the same amount when real GDP falls below potential GDP. In this way, monetary policy speeds the economy's progress back to the target rate of inflation and the potential level of output.

3.2 Optimal simple rules

Much of the more recent research on monetary policy rules has tended to follow a similar approach, except that the models have been formalized to include more explicit microfoundations and the quantitative evaluation methodology has focused on specific issues related to the optimal specification and parameterization of simple policy rules like the Taylor rule. To review this research, it is useful to consider the following quadratic central bank loss function:

$$L = E\left\{(\pi - \pi^*)^2 + \lambda y^2 + \upsilon(i - i^*)^2\right\} \tag{2}$$

where E denotes the mathematical unconditional expectation and $\lambda, \upsilon \geq 0$ are parameters describing the central bank's preferences. The first two terms represent the welfare costs associated from nominal and real fluctuations from desired levels. The third term stands in for the welfare costs associated with large swings in interest rates (and presumably other asset prices). The quadratic terms, especially those involving inflation and output, represent the common sense view that business cycle fluctuations and high or variable inflation and interest rates are undesirable, but these can also be derived as approximations of welfare functions of representative agents. In some studies these costs are modeled explicitly.[1]

The central bank's problem is to choose the parameters of a policy rule to minimize the expected central bank loss subject to the constraints imposed by the model and where

[1] See Woodford (2003) for a discussion of the relationship between the central bank loss function and the welfare function of households. See Rudebusch (2006) for analyses of this topic of interest rate variability in the central bank's loss function. In the policy evaluation literature, the loss is frequently specified in terms of the squared first-difference of the interest rate, rather than in terms of the squared difference between the interest rate and the natural rate of interest.

the monetary policy instrument – generally assumed to be the short-term interest rate in recent research — follows the stipulated policy rule. Williams (2003) described numerical methods used to compute the model-generated unconditional moments and optimized parameter values of the policy rule in the context of a linear rational expectations model. Early research (see, e.g.,, the contributions in Taylor, 1999a and Fuhrer, 1997) focused on rules of a form that generalized the original Taylor rule:[2]

$$i_t = E_t\{(1-\rho)(r^* + \pi_{t+j}) + \rho i_{t-1} + \alpha(\pi_{t+j} - \pi^*) + \beta\, y_{t+k}\}. \tag{3}$$

This rule incorporates inertia in the behavior of the interest rate through a positive value of the parameter ρ. It also allows for the possibility that policy responds to expected future (or lagged) values of inflation and the output gap.

A useful way to portray macroeconomic performance under alternative specifications of the policy rule is the policy frontier, which describes the best achievable combinations of variability in the objective variables obtainable in a class of policy rule. In the case of two objectives of inflation and the output gap that was originally studied by Taylor (1979), this can be represented by a two-dimensional curve plotting the unconditional variances (or standard deviations) of these variables. In the case of three objective variables, the frontier is a three-dimensional surface, which can be difficult to see clearly on the printed page. The solid line in Figure 1 plots a cross-section of the policy frontier, corresponding to a fixed variance of the interest rate, for a particular

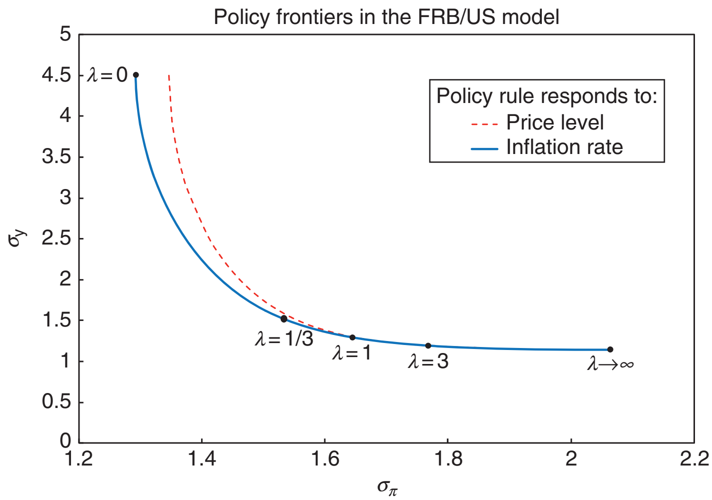

Figure 1 Policy frontiers in the FRB/US model.

[2] An alternative approach is followed by Fair and Howrey (1996), who do not use unconditional moments to evaluate policies, but instead compute the optimal policy setting of based on counterfactual simulations of the U.S. economy during the postwar period.

specification of the policy rule.[3] The optimal parameters of the policy rules that underlie these frontiers depend on the relative weights placed on the stabilization of the variables in the central bank loss. These are constructed using the Federal Reserve Board's FRB/US large-scale rational expectations model (Williams, 2003).

One key issue for simple policy rules is the appropriate measure of inflation to include in the rule. In many models (Levin, Wieland, & Williams, 1999, 2003), simple rules that respond to smoothed inflation rates such as the one-year rate typically perform better than those that respond to the one-quarter inflation rate, even though the objective is to stabilize the one-quarter rate. In the FRB/US model, the rule that responds to the three-year average inflation rate performs the best and it is this specification that is used in the results reported for FRB/US in this chapter. Evidently, rules that respond to a smoothed measure of inflation avoid sharp swings in interest rates in response to transitory swings in the inflation rate.

Indeed, the simple policy rules that respond to the percent difference between the price level and a deterministic trend perform nearly as well as those that respond to the difference between the inflation rate and its target rate (see Svensson, 1999, for further discussion on this topic). In the case of a price level target, the policy rule is specified as:

$$i_t = E_t\left\{(1-\rho)(r^* + \pi_{t+j}) + \rho i_{t-1} + \alpha(p_t - p^*) + \beta\, y_{t+k}\right\}. \tag{4}$$

where p_t is the log of the price level and p^* is the log of the target prices level, which is assumed to increase at a deterministic rate. The policy frontier for this type of price-targeting policy rule is shown in Figure 1. We will return to the topic of rules that respond to price levels versus inflation later.

A second key issue regarding the specification of simple rules is to what extent they should respond to *expectations of future* inflation and output gaps. Batini and Haldane (1999) argued that the presence of lags in the monetary transmission mechanism argues for policy to be forward-looking. However, Rudebusch, and Svensson, (1999), Levin et al. (2003), and Orphanides and Williams (2007a) investigated the optimal choice of lead structure in the policy rule in various models and did not find a significant benefit from responding to expectations out further than one year for inflation or beyond the current quarter for the output gap. Indeed, Levin et al. (2003) showed that rules that respond to inflation forecasts further into the future are prone to generating indeterminacy in rational expectations models.

A third key issue is policy inertia or "interest rate smoothing." A significant degree of inertia can significantly help improve performance in forward-looking models like FRB/US. Figure 2 compares the policy frontier for the optimized three-parameter rules to that

[3] The variance of the short-term interest rate is set to 16 for the FRB/US results reported in this paper. Note that in this model, the optimal simple rule absent any penalty on interest rate variability yields a variance of the interest rate far in excess of 16.

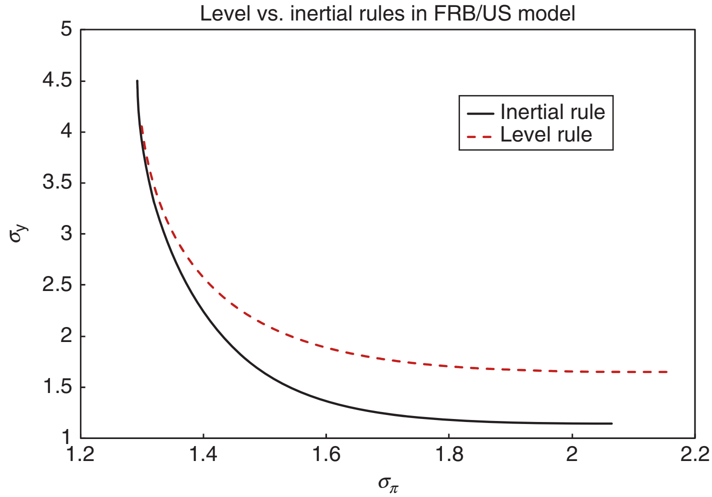

Figure 2 Level versus inertial rules in FRB/US model.

for "level" rules with no inertia ($\rho = 0$). As seen in this figure, except for the case where the loss puts all the weight on inflation stabilization, the inertial rule performs better than the level rule. In fact, in these types of models the optimal value of ρ tends to be close to unity and in some models can be greatly in excess of one, as discussed in Section 4. As discussed in Levin et al. (1999) and Woodford (1999, 2003), inertial rules take advantage of the expectations of future policy and economic developments in influencing outcomes. For example, in many forward-looking models of inflation, a policy rule that generates a sustained small negative output gap has as much effect on current inflation as a policy that generates a short-lived large negative gap. But, the former policy accomplishes this with a small sum of squared output gaps. As discussed in Section 4, in purely backward-looking models, however, this channel is entirely absent and highly inertial policies perform poorly.

The analysis of optimal simple rules described up to this point has abstracted from several important limitations of monetary policy in practice. One issue is the measurement of variables in the policy rule, especially the output gap. The second, which has gained increased attention because of the experiences of Japan since the 1990s and several other major economies starting in 2008, is the presence of the ZLB on nominal interest rates. The third is the potential role of other variables in the policy rule, including asset prices. We address each of these in turn.

3.3 Measurement issues and the output gap

One practical issue that affects the implementation of monetary policy is the measurement of variables of interest such as the inflation rate and the output gap (Orphanides, 2001). Many macroeconomic data series such as GDP and price deflators are subject to measurement errors and revisions. In addition, both the equilibrium real interest rate and the output gap are unobserved variables. Potential errors in measuring the equilibrium real interest rate and the output gap result from estimating latent variables as well as uncertainty regarding the processes determining them (Edge, Laubach, & Williams, 2010; Laubach &Williams 2003; Orphanides & van Norden, 2002). Similar problems plague estimation of related metrics such as the unemployment gap (defined to be the difference between the unemployment rate and the natural rate of unemployment) and the capacity utilization gap. Arguably, the late 1960s and1970s were a period when errors in measuring the output and unemployment gap were particularly severe, but difficulties in measuring gaps extend into the present day (Orphanides, 2002; Orphanides & Williams, 2010).

A number of papers have examined the implications of errors in the measurement of the output (or unemployment) gap for monetary policy rules, starting with Orphanides (1998), Smets (1999), Orphanides et al. (2000), McCallum (2001), and Rudebusch (2001). A general finding in this literature is that the optimal coefficient on the output gap in the policy rule declines in the presence of errors in measuring the output gap. The logic behind this result is straightforward. The response to the mismeasured output gap adds unwanted noise to the setting of policy that can be reduced by lowering the coefficient on the gap in the rule. The optimal response to inflation may rise or fall depending on the model and the weights in the objective function.

In addition to the problem of measurement of the output gap, the equilibrium real interest rate is not a known quantity and may vary over time (Laubach & Williams, 2003). Orphanides and Williams (2002) examined the combined problem of unobservable unemployment gap and equilibrium real interest rate. In their model, the unemployment gap is the measure of economic activity in both the objective function and the policy rule. They consider a more generalized policy rule of the form:

$$i_t = E_t\left\{(1-\rho)(\hat{r}_t^* + \pi_t) + \rho i_{t-1} + \alpha(\pi_t - \pi^*) + \gamma \hat{u}_t \ + \ \delta \Delta u_t\right\}. \tag{5}$$

where $\hat{r}_t^*$ ($\hat{u}_t$) denotes the central bank's real-time estimate of the equilibrium real interest rate (unemployment gap) in period t, and Δu_t denotes the first-difference of the unemployment rate.

The presence of mismeasurement of the natural rate of interest and the natural rate of unemployment tends to move the optimal policy toward greater inertia. Figure 3 shows the optimal coefficients of this policy rule for a particular specification of the central bank loss as the degree of variability in the equilibrium real interest rate and the natural rate of unemployment rises. The case where these variables are constant and known by the central bank is indicated by the value of zero on the horizontal axis. In that case, the optimal policy is characterized by a moderate degree of policy inertia. The case of a moderate degree of variability of these latent variables, consistent with the lower end of the range of estimates of variability, is indicated by the value of 1 on the horizontal axis. Values of 2 and above correspond to cases where these latent variables

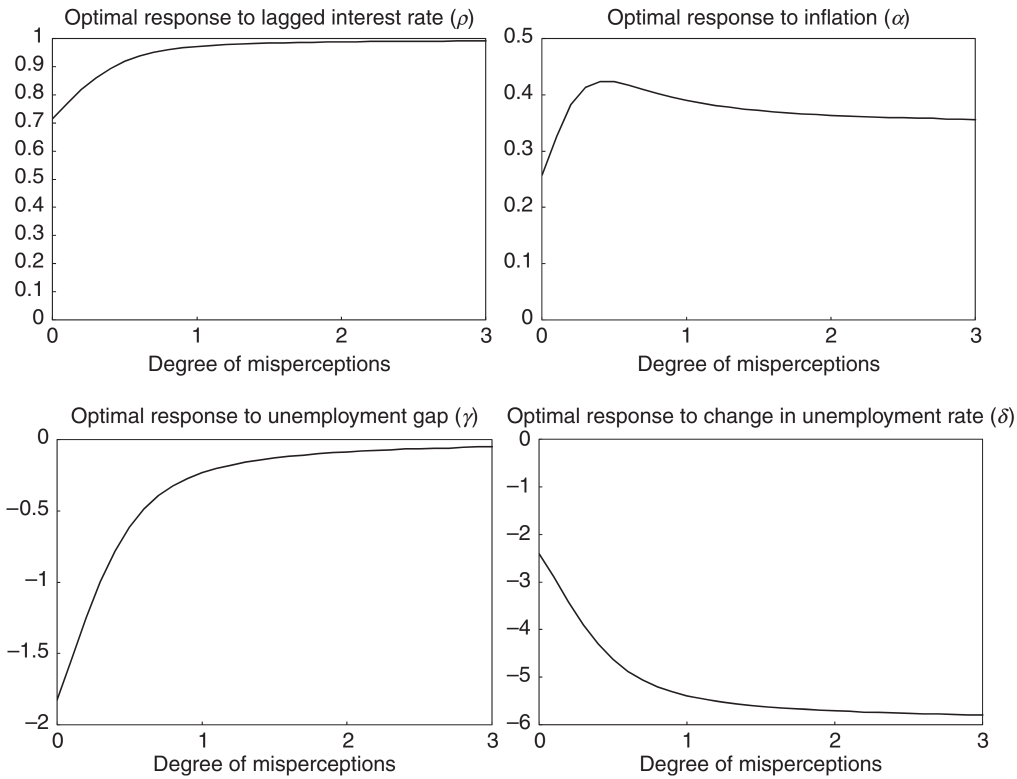

Figure 3 Optimal response to lagged interest rate, optimal response to inflation, optimal response to unemployment gap, and optimal response to change in unemployment rate.

are subject to more sizable fluctuations, consistent with the upper end of estimates of their variability. In these cases, the central bank's estimates of the equilibrium real interest rate and the natural rate of unemployment are imprecise, and the optimal value of ρ rises to near unity. In such cases, the equilibrium real interest rate, which is multiplied by $(1 - \rho)$ in the policy rule, plays virtually no role in the setting of policy.

The combination of these two types of mismeasurement also implies that the optimal policy rule responds only modestly to the perceived unemployment gap, but relatively strongly to the change in the unemployment rate. This is shown in the lower two panels of Figure 3. These policy rules that respond more to the change in the unemployment rate use the fact that that the direction of the change in the unemployment rate is generally less subject to mismeasurement than the absolute level of the gap in the model simulations. If these measurement problems are sufficiently severe, it may be optimal to entirely replace the response to the output gap with a response to the change in the gap. In the case where the value of ρ is unity, such a rule is closely related to a rule that targets the price level, as can be seen by integrating Eq. (5) in terms of levels.

See McCallum (2001), Rudebusch (2002), and Orphanides and Williams (2007b) for analysis of the relative merits of gaps and first differences of gaps in policy rules.

3.4 The zero lower bound on interest rates

The discussion of monetary policy rules so far has abstracted from the ZLB on nominal interest rates. Because an asset, cash, pays a zero interest rate, it is not possible to for short-term nominal interest rates to fall significantly below zero percent.[4] In several instances — including the Great Depression in the United States, Japan during much of the 1990s and 2000–2006, and several countries during the recession that began in late 2007 — the ZLB has constrained the ability of central banks to lower the interest rate in the face of a weak economy and low inflation. A concern is that the inability to reduce interest rates below zero can impair the effectiveness of monetary policy to stabilize output and inflation (see Coenen, Orphanides, & Wieland, 2004; Eggertsson & Woodford, 2003; Fuhrer & Madigan, 1997; Reifschneider & Williams 2000; Williams, 2010; and references therein).

Research has identified four important implications for monetary policy rules owing to the ZLB. First, the monetary policy rule in Eq. (3) must be modified to account for the zero lower bound:

$$i_t = \max\left\{0, E_t\left\{(1-\rho)(r^* + \pi_t) + \rho\widetilde{i}_{t-1} + \alpha(\pi_t - \pi^*) + \beta\, y_t\right\}\right\} \tag{6}$$

where $\widetilde{i}_{t-1}$ denotes the preferred setting of the interest rate in the previous period that would occur absent the ZLB. This distinction between the actual lagged interest rate and the unconstrained rate is crucial for the performance of inertial rules with the ZLB. If the lagged interest rate appears in the rule, deviations from the unconstrained policy are carried into the future, exacerbating the effects of the ZLB (Reifschneider & Williams 2000; Williams 2006).

Second, the ZLB can imply the existence of multiple steady states (Benhabib, Schmitt-Grohe, & Uribe, 2001; Reifschneider & Williams 2000,). For a wide set of macroeconomic models, one steady state is characterized by a rate of inflation equal to the negative of the equilibrium real interest rate, a zero output gap, and a zero nominal interest rate. Assuming the target inflation rate exceeds the negative of the equilibrium real interest rate, a second steady state exists. It is characterized by a rate of inflation equal to the central bank's target inflation rate, a zero output gap, and a nominal interest rate equal to the equilibrium real interest rate plus the target inflation rate. In standard models, the steady state associated with the target inflation rate is locally stable because the economy returns to this steady state following a small disturbance. Due to the existence of the ZLB, if a large contractionary shock hits the economy, monetary policy alone may not be sufficient to bring the inflation rate back to the target rate.

[4] Because cash is not a perfect substitute for bank reserves, the overnight rate can, in principle, be somewhat below zero, but there is a limit to how negative nominal interest rates can go as long as cash pays zero interest.

Instead, depending on the nature of the model economy's dynamics, the inflation rate will either converge to the deflationary steady state or will diverge to an infinitely negative inflation rate. Fiscal policy can be used to eliminate the deflationary steady state and assure that the economy returns to the desired steady-state inflation rate (Evans, Guse, & Honkapohja, 2008).[5]

Third, the ZLB has implications for the specification and parameterization of the monetary policy rule. For example, Reifschneider and Williams (2002) found that increasing the response to the output gap helps reduce the effects of the ZLB. Such an aggressive response to output gaps prescribes greater monetary stimulus before and after episodes when the ZLB constrains policy, which helps lessen the effects when the ZLB constrains policy. However, there are limits to this approach. First, it generally increases the variability of inflation and interest rates, which may be undesirable. In addition, Williams (2010) showed that too large a response to the output gap can be counterproductive. The ZLB creates an asymmetry between the very strong responses to positive output gaps and truncated responses to negative output gaps that increases output gap variability overall.

Given the limitations of the approach of simply responding more strongly to output gaps, Reifschneider and Williams (2000, 2002) argued for modifications to the specification of the policy rule. They considered two alternative specifications of simple policy rules. In one, the policy rule is modified to lower the interest rate more aggressively than otherwise in the vicinity of the ZLB. In particular, they considered a rule where the interest rate is cut to zero if the unconstrained interest rate falls below 1%. This asymmetric rule encapsulates the principle of adding as much monetary stimulus as possible near the ZLB to offset the effects of constraint on monetary stimulus when the ZLB binds. In the second version of the modified rule, the interest rate is kept below the "notional" interest rate following episodes when the ZLB is a binding constraint on policy. Specifically, the interest rate is kept at zero until the absolute value of the cumulative sum of negative deviations of the actual interest rate from the notional values equals that which occurred during the period that ZLB constrained policy. This approach implies that the rule "makes up" afterwards for lost monetary stimulus resulting from the ZLB.

Both of these approaches work well at mitigating the effects of the ZLB in model simulations when the public is assumed to know the features of the modified policy rule. However, these approaches rely on unusual behavior by the central bank in the vicinity of the ZLB, which may confuse private agents entailing unintended and potentially undesirable consequences. An alternative approach advocated by Eggertsson and Woodford (2003) is to adopt an explicit price-level target, rather than an inflation target. Reifschneider and Williams (2000) and Williams (2006, 2010) found that such

[5] See also Eggertsson and Woodford (2006). In addition to fiscal policy, researchers have examined the use of alternative monetary policy instruments, such as the quantity of reserves, the exchange rate, and longer term interest rates. See McCallum (2000), Svensson (2001), and Bernanke and Reinhart (2004) for discussions of these topics.

price-level targeting rules are effective at reducing the costs of the ZLB as long as the public understands the policy rule. Such an approach works well because, like the second modified policy rule discussed earlier, it promises more monetary stimulus and higher inflation in the future than a standard inflation-targeting policy rule. This anticipation of future monetary stimulus boosts economic activity and inflation when the economy is at the ZLB, mitigating its effects. This channel is highly effective in models where expectations of future policy have important effects on current output and inflation. But, as pointed out by Walsh (2009), central bankers have been unwilling to embrace this approach in practice.

Finally, the ZLB provides an argument for a higher target inflation rate than otherwise would be the case. The quantitative importance of the ZLB depends on the frequency and degree to which the ZLB constraint is expected to bind, a key determinant of which is the target inflation rate. If the target inflation rate is sufficiently high, the ZLB rarely impinges on monetary policy and the macroeconomy. As discussed in Williams (2010), the consensus from the literature on the ZLB is that a 2% inflation target is sufficient to avoid significant costs in terms of macroeconomic stabilization, based on the historical pattern of disturbances hitting the economy over the past several decades. This figure is close to the inflation targets followed, either explicitly or implicitly, by many central banks today (Kuttner, 2004).

3.5 Responding to other variables

A frequently heard criticism of simple monetary policy rules is that they ignore valuable information about the economy. In other words, they are too simple for the real world (Mishkin, 2007; Svensson, 2003). However, as shown in Williams (2003), even in large-scale macroeconometric models like FRB/US, adding additional lags or leads of inflation or the output gap to the three-parameter rule of the type discussed previously yields trivial gains in terms of macroeconomic stabilization. The same is true for other empirical macro models (Levin & Williams, 2003; Levin et al., 1999; Rudebusch & Svensson, 1999). Similar results are found using microfounded DSGE models where the central bank aims to maximize household welfare (Levin, Onatski, Williams, & Williams, 2005; Edge et al., 2010).

One specific issue that has attracted a great deal of attention is adding various asset prices, such as the exchange rate or equity prices, to the policy rule (see Bernanke & Gertler, 1999; Clarida, Gali,& Gertler, 2001; and Woodford, 2003, for discussions and references). Research has shown that the magnitude of the benefits from responding to asset prices is generally small in existing estimated models. For example, the FRB/US model includes a wide variety of asset prices that may deviate from fundamentals. Nonetheless, including asset price movements (or, alternatively, nonfundamental movements in asset prices) to simple policy rules yields negligible benefits in terms of macroeconomic stabilization in this model. One reason for this is that asset price movements unrelated to fundamentals lead to movements in output and inflation in the model. The simple policy rule responds to and offsets these movements in inflation and the output gap.[6] Moreover, in practice it is difficult to accurately measure nonfundamental movements in asset prices, arguing for muted responses to these noisy variables.

4. ROBUSTNESS OF POLICY RULES

Much of the early research focused on the performance of simple policy rules under "ideal" circumstances where the central bank has an excellent knowledge of the economy and expectations are rational. But, it had long been recognized that such assumptions are unlikely to hold in real-world policy applications and that policy prescriptions needed to be robust to uncertainty (McCallum, 1988; Taylor, 1993b). Now research focuses on the issue of designing robust policy rules that perform well in a wide set of economic environments (Brock, Durlauf, Nason, & Rondina, 2007; Brock, Durlauf, & West, 2003, 2007; Levin & Williams, 2003; Levin et al., 1999, 2003; Orphanides & Williams, 2002, 2006, 2007b, 2008; Taylor & Wieland, 2009; Tetlow, 2006).

Evaluating policy rules in a variety of models has the advantage of helping to identify characteristics of policy rules that are robust to model misspecification and those that are not. Early efforts at evaluating robustness took the form of taking evaluating candidate policy rules through a set of models and comparing the results with regard to macroeconomic performance. Later, this approach was formalized as a problem of decision making under uncertainty.

One example of robustness evaluation is the joint effort of several researchers to compare the effects of policy rules in different models, reported in Taylor (1999b). In that project, five different candidate policy rules were checked for robustness across a variety of models. These policy rules were of the form of Eq. (3); the parameters are reported in Table 1. Note that the interest rate reacts to the lagged interest rate with a coefficient of one in Rules I and II, with Rule I having higher weight on inflation compared to output and Rule II having a smaller weight on inflation compared to output. Thus these two rules have considerable "inertia" in the terminology used earlier. Rule III is the Taylor rule. Rule IV has a coefficient of 1.0 rather than 0.5 on real output, which had been suggested by Brayton, Levin, Tryon, and Williams (1997). Rule V is the rule proposed by Rotemberg and Woodford (1999); it places very little weight on real output and incorporates a greater than unity coefficient on the lagged interest rate.

[6] If the policy objective included the stabilization of asset prices, then the optimal simple rule would need to contain the asset prices as well as the other objective variables.

Table 1 Policy Rule Coefficients

	α	β	ρ
Rule I	3.0	0.8	1.0
Rule II	1.2	1.0	1.0
Rule III	0.5	0.5	0.0
Rule IV	0.5	1.0	0.0
Rule V	1.5	0.06	1.3

In this exercise, nine models were considered (Taylor, 1999b). For each of the models, the standard deviations of the inflation rate, of real output, and of the interest rate were computed. Taylor (1999b) reported that the sum of the ranks of the three rules shows that Rule I is most robust if inflation fluctuations are the sole measure of performance; it ranks first in terms of inflation variability for all but one model for which there is a clear ordering. For output, Rule II has the best sum of the ranks, which reflects its relatively high response to output. However, regardless of the objective function weights, Rule V has the worst sum of the ranks of these three policy rules, ranking first for only one model (the Rotemberg-Woodford model) in the case of output. Comparing rules I, II, and III with Rules III and IV) shows that the lagged interest rate rules do not dominate rules without a lagged interest rate. Indeed, for a number of models the rules with lagged interest rates are unstable or have extraordinarily large variances.

This type of exercise has been expanded to include other models and to formally search for the "best" simple rule evaluated over a set of models. One issue that this literature has faced is the characterization of the problem of optimal policy under uncertainty. Different approaches have been used, including Bayesian, minimax, and minimax regret (see Brock et al., 2003; and Kuester & Wieland, 2010, for detailed discussions).

The Bayesian approach assumes that the existence of well-defined probabilities, $p_{j,}$ for each model j in a set of n models The choice of the optimal rule under uncertainty then is the choice of the parameters of the rule that minimizes the expected loss over the set of models. In particular, denote the central bank loss generated in model j by $L_{j.}$ The Bayesian central bank's expected loss, L^B, is given by:

$$L^B = \sum_{j=1}^{n} L_j p_j \tag{7}$$

This formulation treats the probabilities as constant; see Brock et al. (2003) for the description of the expected loss in a dynamic context where the probabilities are updated each period.

Levin and Williams (2003) applied this methodology to a set of three models taken from Woodford (2003), Fuhrer (2000), and Rudebusch and Svensson (1999). They place equal probabilities on these three models. They find that the Bayesian optimal simple three-parameter rule is characterized by a moderate degree of policy inertia, with $\boldsymbol{\rho}$ no greater than 0.7. In the two forward-looking models, the optimal response to the lagged interest rate is much higher than 0.7. In contrast, in the backward-looking Rudebusch-Svensson model, the optimal policy is characterized by very little inertia. In fact, in that model, highly inertial policies can lead to explosive behavior.

The robustness of simple rules to alternative parameterizations can be illustrated using the concept of fault tolerance (Levin & Williams, 2003). Figure 4 plots the deviations of the central bank loss relative to the fully optimal policies for the three models studied by Levin and Williams for variations in the three parameters of the policy rule. This figure shows results for the case of $\lambda = 0$. The upper panel shows how the central bank loss changes in the three models as the value of ρ ranges from 0 to 1.5. In constructing these curves, the other two parameters of the policy rule are held constant at their respective optimal values. The middle and bottom panels show the results when the coefficient on inflation and the output gap, respectively, are varied. In cases where the curves are relatively flat, the policy is said to be fault tolerant, meaning that model misspecification does not lead to a large increase in loss relative to what could be achieved. If the curve is steep, the policy is said to be fault intolerant. Robust policies are those that lie in the fault tolerant regions of the set of models under consideration.

As seen in Figure 4, inertial policies lead to very large increases in the central bank loss in the Rudebusch-Svensson model. Highly inertial policies with values of ρ greater than one are damaging in the Fuhrer model as well. The reason for this result from the Rudebusch-Svensson models is that monetary policy effects grow slowly over time and there is no feedback of these future effects of policy back onto the current economy. A highly inertial policy will be behind the curve in shifting the stance of policy, amplifying fluctuations, and potentially leading to explosive oscillations. In forward-looking models, in contrast, expected future policy actions help stabilize the current economy, which reduces the need for large movements in interest rates. Nonetheless, excessive policy inertia with $\rho > 1$ is undesirable in forward-looking models with strong real and nominal frictions such as the Fuhrer model and FRB/US.

The choice of the responses to inflation and the output gap can be quite different when viewed from the perspective of robustness across models rather than optimality in a single model. For example, in the case shown here, macroeconomic performance in the Fuhrer model suffers when the response to inflation is too great. The case of the optimal response to the output illuminates the tension between optimal and robust policies. In two of the models, the optimal response is near zero. However, such a response is highly costly in the third (Rudebusch-Svensson) model. Similarly, the relatively large response to the output gap called for by the Rudebusch-Svensson

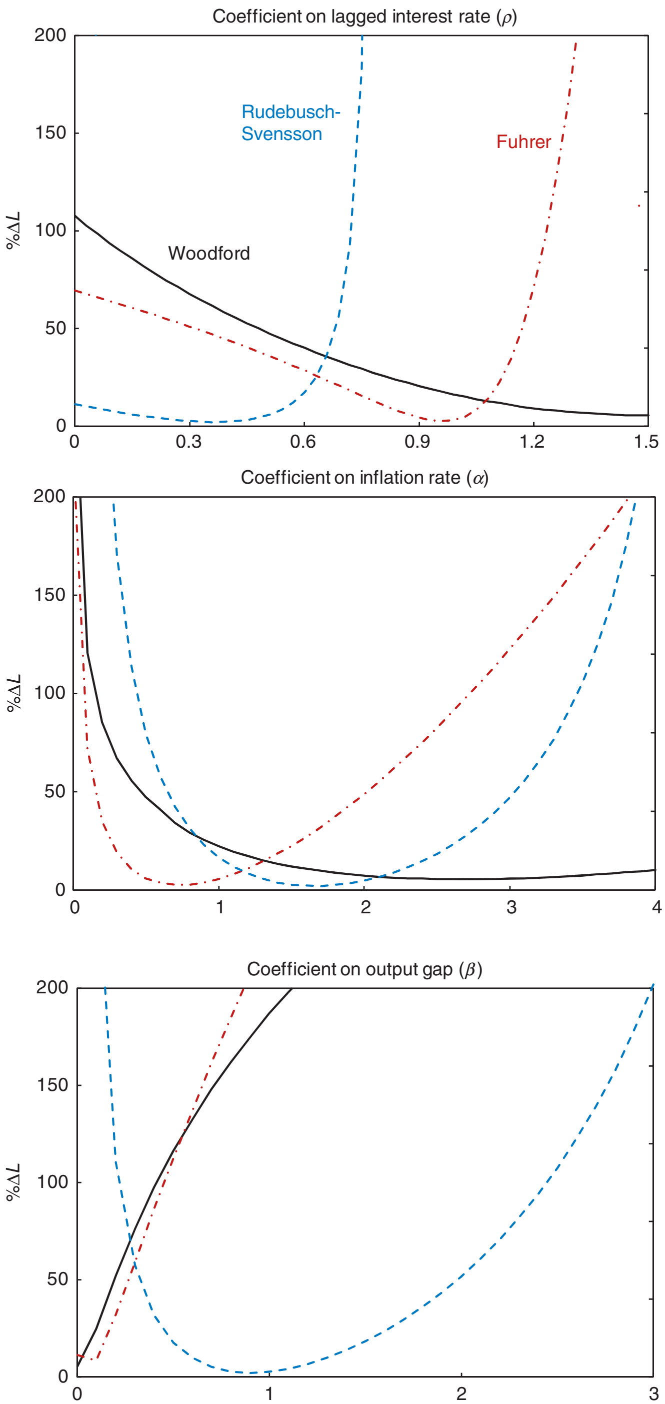

Figure 4 Coefficient on lagged interest rate, coefficient on inflation rate, and coefficient on output gap.

model performs poorly in the other two models. Evidently, the robust policy differs significantly from each optimal policy by having a modest response to the output gap that is suboptimal in each model, but highly costly in none.

Orphanides and Williams (2006) conducted a robustness analysis where the uncertainty is over the way that agents form expectations and the magnitude of fluctuations in the equilibrium real interest rate and the natural rate of unemployment. Figure 5 plots the fault tolerances for three models that they study. For this exercise, the

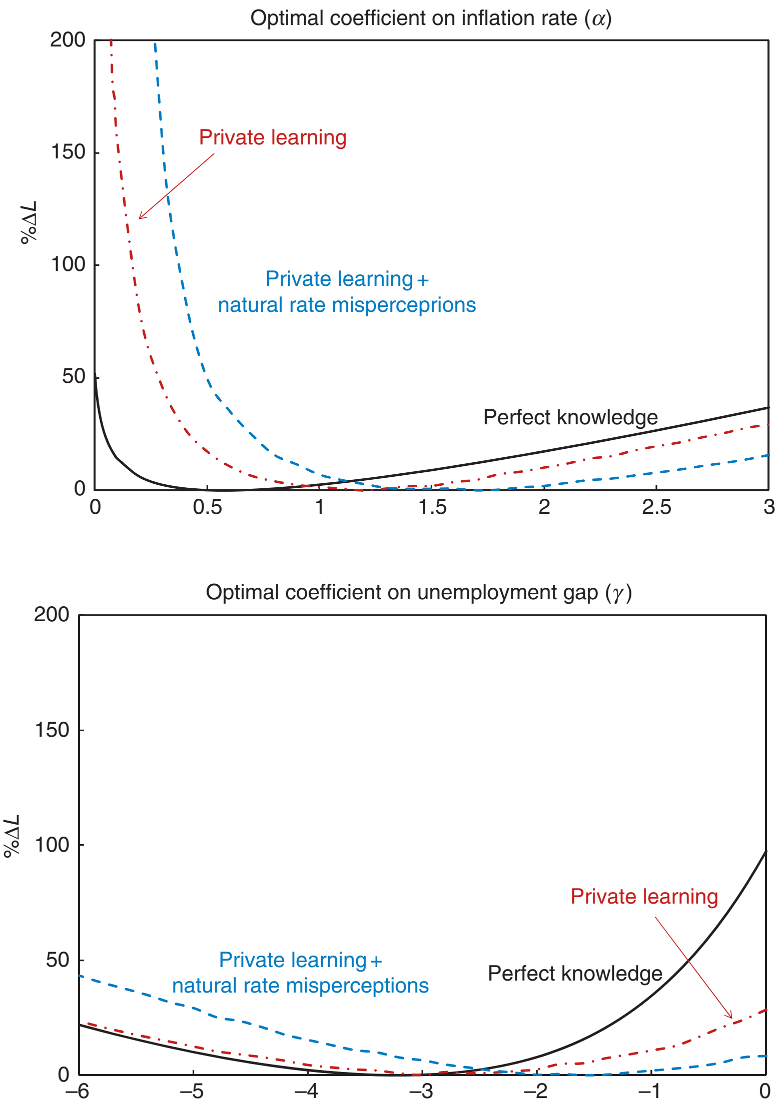

Figure 5 Optimal coefficient on inflation rate and optimal coefficient on unemployment gap.

coefficient on the lagged interest rate was set to zero. In one model, labeled "perfect knowledge," private agents possess rational expectations and the equilibrium real interest rate and the natural rate of unemployment are constant and known. The second model, labeled "private learning," replaces the assumption of rational expectations with the assumption that private agents form expectations using an estimated forecasting model. The third model, labeled "private learning + natural rate misperceptions," adds uncertainty about the equilibrium real interest rate and the natural rate of unemployment to the model with learning.

The optimal policy in the "perfect knowledge" model performs poorly in the models with learning and natural rate misperceptions. In particular, as seen in the upper panel of the figure, the perfect knowledge model prescribes a modest response to inflation in the policy rule. Such a policy is highly problematic in the other models with learning because it allows inflation expectations to drift over time. The optimal policies in the models with learning feature much stronger responses to inflation and tighter control of inflation expectations. Such policies engender relatively small cost in performance in the perfect knowledge model and represent a robust strategy for this set of models.

As mentioned earlier, the Bayesian approach to policy rule evaluation under model uncertainty requires one to specify probabilities on the various models. In practice, this may be difficult or impossible to do. In such cases, alternative approaches are minimax and minimax regret. The minimax criterion, L^M, is given by:

$$L^M = \max\{L_1, L_2, \ldots, L_n\}. \tag{8}$$

Levin and Williams (2003) and Kuester and Wieland (2010) analyzed the properties of minimax simple rules. One problem with this approach is that it can be very sensitive to outlier models. Hybrid approaches such as that of Kuester and Wieland (2010) and ambiguity aversion described by Brock et al. (2003) allow one to combine the Bayesian approach with robustness to "worst-case" models. This is done less formally by examining the performance of the candidate policy not only in terms of the average performance across the models, but also in each individual model.

A recurring result in the literature is that optimal Bayesian policy rules entail relatively small stabilization costs, relative to the optimal policy, in nearly all the models in the set (see Levin & Williams, 2003; Levin et al., 1999, 2003; Orphanides & Williams, 2002, 2008, and references therein). That is, the cost of robustness to model uncertainty tends to be relatively small, while the benefits can be very large. The existing analysis, however, has tended to examine uncertainty within a relatively small group of models. Indeed, some robustness exercises yield conclusions that are contradicted by an otherwise similar exercise using a different set of models. Given the great deal of uncertainty about model specification and parameters, as well as other issues discussed here, a fruitful area of research is to incorporate a much wider set of models in these robustness exercises. The model database should facilitate such research (see Taylor and Wieland 2009).

5. OPTIMAL POLICY VERSUS SIMPLE RULES

An alternative approach to that of simple monetary policy rules is that of optimal policy (Giannoni & Woodford, 2005; Svensson, 2010; Woodford, 2010). The optimal policy approach treats the monetary policy problem as a standard intertemporal optimization problem, which yields optimalilty conditions in terms of first-order conditions and Lagrange multipliers. As discussed in Giannoni and Woodford (2005), the optimal policy can be formulated as a single equation in terms of leads and lags of the objective variables (inflation rate, output gap, etc.). A key theoretical advantage of the optimal policy approach is that it, unlike simple monetary policy rules, takes into account all relevant information for monetary policy.

The value of this informational advantage has been found to be surprisingly small in model simulations, even when the central bank is assumed to have perfect knowledge of the model. Of course, in small enough models, the optimal policy may be equivalent to a simple policy rule, as in Ball (1999). But, in larger models, this is no longer the case. Williams (2003), using the large-scale Federal Reserve Board FRB/US model, found that a simple three-parameter monetary policy rule yields outcomes in terms of the weighted sum of variances of the inflation rate and the output gap that are remarkably close to those obtained under the fully optimal policy. This result is illustrated in Figure 6, which shows the policy frontiers from the FRB/US model between the fully optimal policy and the three-parameter rule. For a policymaker who cares equally about inflation and the output gap ($\lambda = 1$), the standard deviations

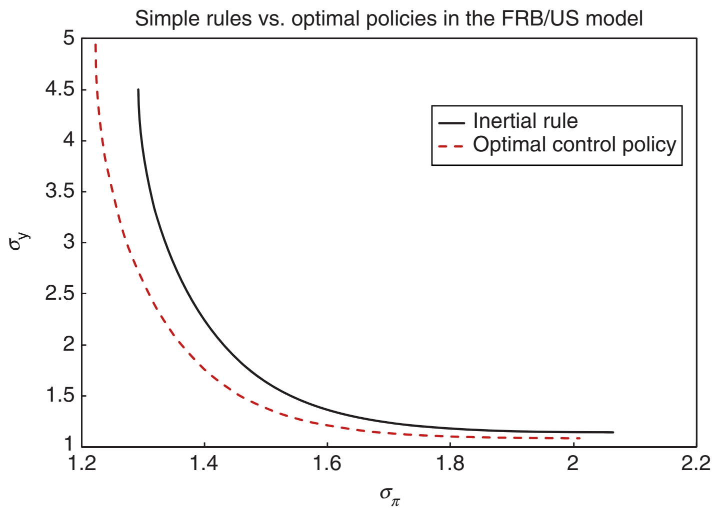

Figure 6 Simple rules versus optimal policies in the FRB/US model.

of both the inflation rate and the output gap are less than 0.1 percentage point apart between the frontiers.

Similar results are obtained for a wide variety of estimated macroeconomic models (Edge et al., 2010; Levin et al., 2005; Levin &Williams, 2003; Rudebusch & Svensson, 1999; Schmitt-Grohe and Uribe, 2007). Giannoni and Woodford (2005) provided the theoretical basis for why simple rules perform so well. They show that the fully optimal policy can be described as a relationship between leads and lags of the variables in the loss function. Evidently, simple rules of the type studied in the literature capture the key aspects of this relationship between the objective variables.

One potential shortcoming of the optimal control approach is that it ignores uncertainty about the specification of the model (see McCallum & Nelson, 2005, for a discussion). Although in principle one can incorporate various types of uncertainty to the analysis of optimal policy, in practice computational feasibility limits what can be done. As a result, existing optimal control policy analysis is typically done using a single reference model, which is assumed to be true.

Levin and Williams (2003) and Orphanides and Williams (2008) found that optimal policies perform very poorly if the central bank's reference model is misspecified, while simple robust rules perform well in a wide variety of models, as previously discussed. This research provides examples where optimal polices can be overly fine-tuned to the particular assumptions of the model. If those assumptions prove to be correct, all is well. But, if the assumptions turn out to be false, the costs can be high. In contrast, simple monetary policy rules are designed to take account of only the most basic principle of monetary policy of leaning against the wind of inflation and output movements. Because they are not fine-tuned to specific assumptions, they are more robust to mistaken assumptions. Figure 7, taken from Orphanides and Williams (2008), illustrates this point. The optimal control policy derived under the assumption of rational expectations performs slightly better than the two simple rules in the model where expectations are in fact rational. But, in the alternative models where agents form expectations using estimated forecasting models, indexed by the learning parameter κ, the performance of the optimal control policy deteriorates sharply while that of the simple rules holds up well.

One potential solution to this lack of robustness is to design optimal control rules that are more robust to model misspecification. One such approach is to use robust control techniques (Hansen & Sargent, 2007). An alternative approach is to bias the objective function so that the optimal control policy is more robust to model uncertainty. The results for such a "modified optimal policy" are shown in Figure 4. In this case, the modification is to reduce the weights placed on stabilizing unemployment and interest rates in the objective function when computing the optimal policy (see Orphanides & Williams, 2008, for a discussion). Interestingly, although this policy is more robust than the standard optimal policy, overall it does not do as well as the optimal simple inertial rule, as seen in Figure 4.

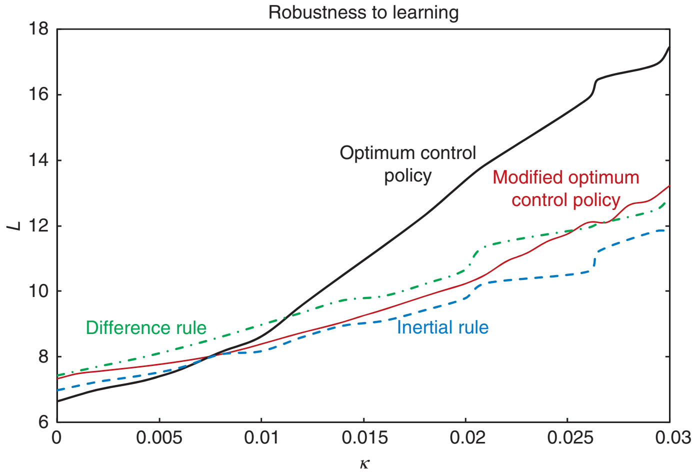

Figure 7 Robustness to learning.

A final issue with optimal policies is that they tend to be very complicated and potentially difficult to communicate to the public, relative to simple rules. In an environment where the public lacks a perfect understanding of the policy strategy, this complexity may make it harder for private agents to learn, creating confusion and expectational errors, as discussed by Orphanides and Williams (2008).

These robustness studies characterize optimal policy in terms of an optimal feedback rule — a function relating policy instruments to lagged policy instruments and other observable variables in such a way that the objective function is maximized for a particular model. This optimal feedback rule is then compared with simple (not fully optimal) rules by simulating the rules in different models. There are a variety of ways other than feedback rules to characterize optimal policy. For example, as mentioned earlier the policy instruments could depend on forecasts of future variables, as discussed by Giannoni and Woodford (2005). In general there are countless ways to represent optimal policy in a given model. When simulating how optimal policy works in a different model, the results could depend on which of these representations of optimal policy one uses. An open question, therefore, is whether one characterization of optimal policy might be more robust than those studied so far.

6. LEARNING FROM EXPERIENCE BEFORE, DURING AND AFTER THE GREAT MODERATION

Another approach to learn about the usefulness of simple policy rules is to look at actual macroeconomic performance when policy operates, or does not operate, close to such rules. The Great Moderation period is good for this purpose because economic performance was unusually favorable during this period, either compared to the period before or, so far at least, the period after.

By all accounts the Great Moderation in the United States began in the early 1980s. In particular, it is reasonable to date the beginning of the Great Moderation with the first month of the expansion following the 1981–1982 recession (November 1982) and to date its end at the beginning of the 2007–2009 recession (December 2007). Not only did inflation and interest rates and their volatilities diminish compared with the experience of the 1970s, but the volatility of real GDP reached lows never seen before. Economic expansions became longer and stronger while recessions became shorter and shallower. No matter what metric you use — the variance of real GDP growth, the variance of the real GDP gap, the average length of expansions, the frequency of recessions, or the duration of recessions — there was a huge improvement in economic performance. There was also an improvement in price stability with the inflation rate much lower and less volatile than the period from the late 1960s to the early 1980s. This same type of improved macroeconomic performance also occurred in other developed countries and most developing countries (Cecchetti, Flores-Lagunes, & Krause, 2006).

Is there evidence that policy adhered more to simple policy rules during the Great Moderation? Yes. Indeed the evidence shows that not only the Federal Reserve, but also many other central banks became markedly more responsive and systematic in adjusting to developments in the economy when changing their policy interest rate. This is a policy regime change in the econometric sense: one can observe it by estimating, during different time periods, the coefficients of the central bank's policy rule, which describes how the central bank sets its interest rate in response to inflation and real GDP.

A number of researchers used this technique to detect a regime shift, including Judd and Rudebusch (1998), Clarida, Gali, and Gertler (2000), Woodford (2003), and Stock and Watson (2002). Such studies have shown that the Federal Reserve's interest rate moves were less responsive to changes in inflation and to real GDP in the period before the 1980s. After the mid-1980s, the reaction coefficients increased significantly. The reaction coefficient to inflation nearly doubled. The estimated reaction of the interest rate to a one percentage point increase in inflation rose from about three-quarters to about one-and-a-half. The reaction to real output also rose. In general the coefficients are much closer to the parameters of a policy rule like the Taylor rule in the post mid-1980s period than they were before. Similar results are found over longer sample periods for the United States. The implied reaction coefficients were also low in the highly volatile pre-World War II period (Romer & Romer, 2002).

Cecchetti et al. (2007) and others have shown that this same type of shift occurred in other countries. They pinpoint the regime shift as having occurred for a number of countries in the early 1980s by showing that deviations from a Taylor rule began to diminish around that time. While this research establishes that the Great Moderation and the change in policy rules began about the same time, it does not prove they are connected. Formal statistical techniques or macroeconomic model simulation can help assess causality. Stock and Watson (2002) used a statistical time-series decomposition technique to assess the causality. They found that the change in monetary policy had an effect on performance; they also found that other factors, mainly a reduction in other sources of shocks to the economy (inventories, supply factors), were responsible for a larger part of the reduction in volatility. They showed that the shift in the monetary policy rule led to a more efficient point on the output-inflation variance trade-off. Similarly, Cecchetti et al. (2006) used a more structural model and empirically studied many different countries. For 20 of the 21countries that had experienced a moderation in the variance of inflation and output, they found that better monetary policy accounted for over 80% of the moderation.

Some additional evidence comes from establishing a connection between the research on policy rules and the decisions of policymakers. Asso et al. (2007) documented a large number of references to policy rules and related developments in the transcripts of the Federal Open Market Committee (FOMC) in the 1990s. Meyer (2004) made it clear that there was a framework underlying the policy based on such considerations. If you compare Meyer's (2004) account with Maisel's account (1973), you see a very clear difference in the policy framework.

So far we have considered evidence in favor of a shift in the policy rule and improved economic performance during the Great Moderation. Is it possible that the end of the Great Moderations was due to another monetary policy shift? In thinking about this question, it is important to recall that the Great Moderation was already nearly 15 years old before economists started noticing it, documenting it, determining the date of its beginning, and trying to determine whether or not it was due to monetary policy. It will probably take as long to draw definitive conclusions about the end of the Great Moderation. After all, we hope that Great Moderation II will start soon. Nevertheless, Taylor (2007) provided evidence that from 2003 to 2005, policy deviated from the policy rule that worked well during the Great Moderation.

6.1 Rules as measures of accountability

This review of historical performance distinguishes periods when policy is close to a policy rule and when it is not. In other words, it focuses on whether or not there is a deviation from a policy rule. In a sense, such deviations from policy rules — at least large persistent deviations — can serve as measures of accountability for monetary policymakers. Congressional or parliamentary committees sometimes use such measures when questioning central bankers, and public debates over monetary policy decisions are frequently about whether policy is deviating from a policy rule or not.[7]

[7] In the past, the Federal Open Market Committee reported its projections for growth in monetary aggregates and credit as part of its biannual Humphrey-Hawkins report, and these could then be compared to policy rule prescriptions.

It is important to point out that using policy rules in this way, while quite natural, was not emphasized in the many original proposals for interest rate rules, such as the one in Taylor (1993a). Rather the policy recommendation was that the rule should be used as an aid for making decisions in a more predictable, rule-like manner. Accordingly, the Federal Reserve staff would show the paths of the federal funds rate under the Taylor rule and other A policy rule to the FOMC, and the FOMC would then use the information when deciding whether or not to change the interest rate. Policy rules would thus inform policy decisions; it would serve as a rough benchmark for making decisions, not a mechanical formula. As Kohn (2007) described in his analysis of the 2002–2004 economic period and the response to Taylor (2007), this is how policy rules came to be used at the FOMC.

The rationale for using deviations from policy rules as measures of accountability came later and is based on historical and international experience over the past two decades. Historical work has shown that there were big deviations from policy rules at the times that performance was less than satisfactory. One question is whether in the future policy rules will be used more often in this more specific way as a measure of accountability rather than as simply a guide or aid for policy decisions. If rules become more commonly used for accountability, then policymakers will have to explain the reasons for the deviations from the rules and be held accountable for them (Levin and Taylor, 2009).

7. CONCLUSION

Research on rules for monetary policy over the past two decades has made important progress in understanding the properties of simple policy rules and their robustness to model misspecification. Simple normative rules to guide central bank decisions for the interest rate first emerged from research on simulations of empirical monetary models with rational expectations and sticky prices in the 1970s and 1980s; this research is built on work going back to Smith, Ricardo, Fisher, Wicksell, and Friedman whose research objective was to find a monetary policy that both cushioned the economy to shocks and did not cause its own shocks.

Over the past two decades, research on policy rules has shown that simple rules have important robustness advantages over fully optimal or more complex rules in that they work well in a variety of models. Experience has shown that simple rules also have worked well in the real world. Progress has also been made in understanding how to adjust simple rules to deal with measurement error, expectations, learning, and the lower bound on interest rates. That said, the search for better and more robust policy rules is never done and further research is needed that incorporates a wider set of models and economic environments, especially models that take into account international linkages of monetary policy and economies. In addition, many of the studies of robustness have looked at only a handful of models in isolation from all the other potential models. A desirable goal is to include large numbers of alternative models in one study. Another goal of future research should be a better understanding of the implications of deviations from policy rules due to discretionary policy actions.

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