Simple Rules for Monetary Policy*

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How effective are "simple" monetary policy rules at stabilizing the economy? This paper explores the characteristics and performance of monetary policy rules designed to minimize fluctuations in inflation, output, and interest rates using the Federal Reserve Board's large-scale FRB/US macroeconometric model. I find that a smoothed measure of inflation, the output gap, and the lagged funds rate are sufficient statistics for the setting of monetary policy. Efficient simple rules that respond to these three variables perform nearly as well as fully optimal policies that respond to the hundreds of variables in the model, and the simple rules are more robust to model misspecification. Efficient policies smooth the interest rate response to shocks and use the feedback from anticipated policy actions to stabilize inflation and output and to moderate movements in short-term interest rates. These results hold in a wide range of macro models but are sensitive to the assumption of rational expectations.

1. Introduction

This paper explores two key questions regarding the design and performance of efficient simple monetary policy rules. First, what are the basic features of efficient simple rules? In particular, to what variables should policy respond and by how much? Second, how well do simple rules perform compared to more complicated rules that respond to a larger information set? Or, in other words, what is the cost, measured in terms of stabilizing the economy, of following a simple rule when the best possible policy incorporates a wide range of information?

My approach to evaluating monetary policy rules follows in the tradition dating to Phillips (1954), where one computes a policy that minimizes the magnitude of fluctuations of a set of target variables based on simulations of a macroeconomic model. By the early 1970s, application of optimal control techniques to traditional macroeconometric models appeared to provide a precise answer to this problem, one that was based on a concrete description of policymakers' preferences and the law of motion of the economy. But, then this methodology came under attack from two sides, causing a fundamental reassessment of the approach to policy evaluations. First, Lucas (1976) decried the fact that the structural parameters of the macroeconomic models used for policy evaluation were assumed to be invariant to policy, contradicting the notion of optimizing agents. Second, Kydland and Prescott (1977) argued that the optimal policies are likely to be time inconsistent in that a policymaker would find it advantageous to deviate from the policy. During the past decade there has been a resurgence in research on the design and performance of monetary policy that has responded, at least partially, to these criticisms. In response to the Lucas critique, much of the recent research has been conducted using macroeconomic models that feature explicit optimization-based microeconomic foundations and rational expectations. In addition, research has tended to focus on "simple" policy rules such as the Taylor (1993a) rule in which the interest rate is determined by a small set of variables. Arguably, the transparency of simple rules may help the policymaker commit to the rule by increasing the visibility of discretionary policy actions and thereby reducing the incentive to deviate from the rule.[1]

Much of the research on monetary policy rules has been conducted using small- to medium-scale models. Because

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1. This argument was put forth by Currie and Levine (1985). Dennis and Söderström (2002) examine the magnitude of the stabilization bias resulting from the time inconsistency problem by comparing performance under optimal discretionary policies and under commitment to a simple rule.

these models contain only a small number of variables they provide little scope for an evaluation of the performance of simple vs. optimal rules. In this paper, I conduct my analysis using the Federal Reserve Board of Governor's large-scale FRB/US model that contains a far richer description of the determinants of output and prices than the small-scale models typically used for monetary policy evaluation. Optimal monetary policy in FRB/US responds to literally hundreds of inputs, including asset prices, foreign variables, and disaggregated spending, price, and labor market variables. In the past, the computational cost associated with solving and simulating such a large-scale rational expectations model was prohibitive, and policy evaluation was limited either to comparing small sets of policies in large-scale models, as in Bryant, et al. (1989, 1993) and Taylor (1993b), or to using small-scale models, as in Fischer (1977), Phelps and Taylor (1977), Taylor (1979), and Fuhrer (1997). Recent increases in computer speed and the development of more efficient model solution algorithms have made the detailed evaluation of monetary policies in large-scale rational expectations models such as FRB/US feasible.

Although the policymaker faces a complicated world in FRB/US, I find that simple policy rules perform nearly as well as more complicated or even fully optimal policies and that simple rules are more robust to model misspecification. A key characteristic of successful policies under rational expectations is a strong degree of persistence in movements in the federal funds rate. Efficient rules smooth the interest rate response to shocks and use the feedback from anticipated policy actions to stabilize inflation and output and to moderate movements in short-term interest rates. These results hold in a wide range of rational expectations macroeconomic models but are sensitive to the assumption of rational expectations.

The remainder of the paper is organized as follows. Section 2 presents a brief description of the FRB/US model. Section 3 analyzes the characteristics of efficient simple monetary policy rules in the model. Section 4 compares the performance of optimized simple policy rules to fully optimal rules. Section 5 then explores the robustness of these results to various assumptions. Section 6 concludes.

2. The FRB/US Model

FRB/US is a large-scale rational expectations two-country macroeconometric model that was developed by the staff of the Federal Reserve Board of Governors in the early 1990s as a replacement for the MPS model. Each period of time in the model corresponds to one-quarter of a year. The U.S. economy is modeled in considerable detail, while a small set of reduced-form equations is used for aggregate measures of foreign GDP, prices, and interest rates. The model's dynamic properties accord reasonably well with those of the data. For example, model impulse responses generally match those of small-scale VAR models, and model second moments are reasonably close to those of the data. For more detailed accounts of the model's design and properties, see Brayton, Mauskopf, et al. (1997), Brayton, Levin, et al. (1997), and Reifschneider, et al. (1999).[2]

In the model, households are assumed to maximize lifetime utility and firms are assumed to maximize the present discounted value of expected profits, subject to adjustment costs that hinder instantaneous adjustment of quantities following a change in fundamentals. The supply side of the economy is described by a three-factor (capital, labor, and energy) production function. GDP is disaggregated into more than a dozen categories of household, business, and government spending as well as trade. Tinsley's (1993) generalized adjustment cost model is used to capture the inertia evident in many categories of spending and labor inputs. This specification differs from the simple quadratic adjustment model in that it allows for the appearance of lagged growth rates in the estimated decision rules.[3]

The model's wage-price block contains separate equations for the prices for domestic output, consumption goods, crude energy, non-oil import goods, oil imports, and labor compensation. Price inflation is determined by the level of the markup of prices over factor (labor and energy) costs, recent past inflation, expected future growth in factor costs, and the expected unemployment gap (the difference between the unemployment rate and the NAIRU), with a positive unemployment gap putting downward pressure on prices. Labor compensation growth is determined by the level of the productivity-adjusted real wage, past compensation growth, expected future growth in prices and productivity, and the expected unemployment gap, with a positive unemployment gap putting downward pressure on compensation growth. The specification of price dynamics in FRB/US yields intrinsic inertia in the inflation rate, similar to that resulting from the staggered price model introduced by Buiter and Jewitt (1981) and empirically implemented by Fuhrer and Moore (1995), and the indexing assumptions used by Galí and Gertler (1999) and Christiano, et al. (2001). It contrasts with that of the staggered price-setting models of Taylor (1980) and Calvo (1983), and the quadratic adjustment cost model of

2. To take advantage of powerful computational methods, I have linearized the model equations; because the model's structure is already nearly linear, the linearization has little effect on the model's properties.

3. The dynamic specification is similar to that used by Fuhrer (2000) for consumption and by Christiano, et al. (2001) for investment.

Rotemberg (1982), each of which generates intrinsic inertia in the price level but not the inflation rate, in the absence of serially correlated shocks.

Overall, the FRB/US model can be characterized as a hybrid model that incorporates more intrinsic persistence in prices and output than "optimizing" rational expectations models such as those developed by Kerr and King (1996), Rotemberg and Woodford (1997), McCallum and Nelson (1999), and Clarida, et al. (1999), but significantly less intrinsic persistence than in traditional backward-looking models developed by Fair and Howrey (1996), Ball (1999), and Rudebusch and Svensson (1999). As such, it occupies the potentially instructive middle ground. Given the controversies regarding the specification of output and price dynamics, I explore the robustness of the results from FRB/US to different model specifications below.

Given the sluggish adjustment of prices, monetary policy influences the real short-term rate through changes in the nominal federal funds rate. Movements in the real federal funds rate affect real long-term rates, the real value of wealth, and the real exchange rate according to standard no-arbitrage conditions. In addition to the interest rate channel of the monetary policy transmission mechanism, spending by households and firms also depends directly on current income and cash flow, respectively, reflecting the effect of credit constraints consistent with the evidence from Carroll (1997) and Gilchrist and Himmelberg (1995).

3. The Characteristics of Optimized Simple Rules

I assume that the monetary policymaker's objective is to minimize a weighted average of the unconditional variances of the output gap (the percent deviation of real GDP from potential output), y, and the deviation of the annualized one-quarter personal consumption expenditure (PCE) price inflation rate, π, from a target level, π^*, subject to an upper bound on the unconditional variance of the nominal federal funds rate, r.[4] Specifically, the minimization problem is given by

$$(1) \qquad \min \quad \lambda\sigma_y^2 + (1-\lambda)\sigma_{\pi-\pi^*}^2$$

$$(2) \qquad \text{s.t.} \quad \sigma_r^2 \leq k^2,$$

where $\lambda \in [0, 1)$, k^2 is the constraint on interest rate variability, and σ_x^2 is the unconditional variance of variable x. The numerical method of solving the model and computing the asymptotic variances of model variables is discussed in the appendix. If $\lambda = 0$, the policymaker places no weight on output gap variability; at the other extreme, when λ is nearly unity, the policymaker places virtually no weight on deviations of inflation from its target.

I adopt the constraint on interest rate variability in the policy objective because in the absence of such a limitation, the optimized monetary policy rules would generate wild swings in the funds rate with an unconditional variance of several hundred percent. The model itself imposes no restrictions on or costs to interest rate variability. However, there are a number of reasons why such highly variable short-term rates are likely to be highly undesirable in practice, and the ad hoc constraint on interest rate variability attempts to capture this. One problematic aspect of highly variable interest rates is the zero lower bound, which constrains how variable interest rates can be in practice (see Rotemberg and Woodford 1999). A second argument is that the term premium paid on bonds may be positively related to the variance in expected short-term rates, implying the existence of a long-run tradeoff between the volatility of short-term interest rates and potential output through the effect of the term premium on the cost of capital that is absent from the model (Tinsley 1998).[5] A third argument has a more political economic nature: Policymakers may wish to avoid reversals in the direction of policy out of the fear that such actions may be misinterpreted as "mistakes," which may eventually have consequences for central bank independence and credibility. Finally, the hypothesized invariance of model parameters to changes in policy rules is likely to be stretched to the breaking point under policies that differ so dramatically in terms of funds rate variability from those seen historically. Note that in this paper interest rate variability is measured by the variance of the *level* of the funds rate, as suggested by Rotemberg and Woodford (1999). The basic results from the FRB/US model reported in this paper are unchanged if interest rate variability instead is measured by the variance of the one-quarter *change* in the funds rate, as in Rudebusch and Svensson (1999), Levin, et al. (1999), and others.

I refer to the set of best obtainable pairs of the unconditional variances of the inflation rate and the output gap corresponding to the range of values of λ between zero and one as a "policy frontier," and refer to the policies that underlie these frontiers as "efficient" or "optimized" policies. By varying k, I can draw the three-dimensional surface that

4. The specification and parameterization of the policy objective in this analysis are admittedly ad hoc but are common to much of the literature on policy rule evaluation. In principle, the explicit treatment of household preferences in FRB/US enables one to evaluate monetary policy rules on the basis of consumer welfare, as in Ireland (1997), Rotemberg and Woodford (1999), Amato and Laubach (2001), and others. I leave the analysis of consumer welfare-maximizing monetary policies in the context of the FRB/US model to future work.

5. Similarly, extremely volatile interest rates may induce or exacerbate fragility in financial markets.

represents the constraints the model places on the policymaker in terms of the policy objectives of stabilizing inflation, output, and short-term interest rates. Note that my approach differs from a common practice found in the literature (for example, Rudebusch and Svensson (1999)) where interest rate variability is included directly in the policy objective. The advantage of my approach is that it allows me to plot frontiers in two-dimensional space.

Throughout the following, I assume that the federal funds rate is always set according to the specified policy rule and that the public knows the full specification of the rule. That is, I study policy under commitment. I also assume that private agents and the monetary policymaker have full knowledge of the model and observe all variables in real time.[6] Note that from time to time such policy rules will prescribe negative nominal interest rates. In this paper, I do not explicitly incorporate the non-negativity constraint on nominal rates in the analysis, but the efficient simple rules computed here lose little of their effectiveness if the non-negativity constraint is imposed even with an inflation target of zero, as shown in Reifschneider and Williams (2000).

The first step in evaluating simple policy rules is to choose the specification of the rule, that is, select the variables that determine the policy instrument, the federal funds rate. As shown by Svensson and Woodford (2003) and Giannoni and Woodford (2002), the fully optimal policy with a quadratic objective and a linear model can be described by a policy rule in which the federal funds rate depends only on leads and lags of the variables in the objective function. I start by limiting the rule to having three free parameters. In this case, a natural specification for a simple policy rule is one in which the nominal interest rate depends on some weighted moving average of the inflation rate, the output gap, and the interest rate. I assume policy responds only to current and lagged values of variables, but below I consider policies that respond to forecasts of future variables. I further restrict the analogues to rules that yield a unique rational expectations equilibrium. In practice, the model yields a unique solution for a wide range of values of θ_r and θ_y as long as θ_π exceeds about 0.04. See Levin, et al. (2003) for a detailed discussion of the determinacy conditions in this model.[7]

Experimentation within this class of three-parameter policy rules leads to the following specification:

(3) $$r_t = \theta_r r_{t-1} + (1-\theta_r)(rr_t^* + \bar{\pi}_t) + \theta_\pi(\tilde{\pi}_t - \pi^*) + \theta_y\, y_t\,,$$

where rr^* is the long-run equilibrium real interest rate, $\bar{\pi}$ is the average inflation rate over the past year and $\tilde{\pi}$ is the average inflation rate over the past three years. The degree of policy inertia is measured by θ_r. Rules in which $\theta_r = 0$ are termed "level" rules because the level of the funds rate responds to the level of the output gap and the inflation rate (the Taylor rule and the Henderson-McKibbin (1993) rules are examples of this class). Rules with $0 < \theta_r < 1$ are said to exhibit "policy inertia." The special case of $\theta = 1$ is often termed a "difference rule" or "derivative control" (Phillips 1954). The case of $\theta_r > 1$ is termed "super-inertial policy" by Rotemberg and Woodford (1999).

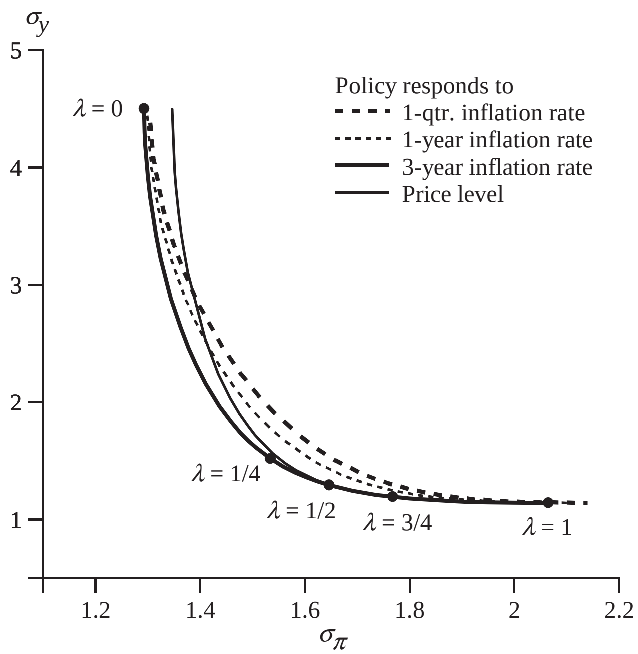
Although the policy objective is written in terms of the variance of the one-quarter inflation rate, the best-performing simple rule responds to the three-year average inflation rate that filters out high frequency noise. By contrast, in the literature, policy is assumed to respond either to the one-quarter inflation rate or the four-quarter inflation rate. I experimented with a range of measures of the inflation rate in the policy rule, including the annualized one-quarter inflation rate and the one-, two-, three-, and four-year average rates of inflation.[8] I also tried a variant of the rule in which the policy responds to the deviation of the price level from a predetermined target path, instead of the inflation rate implying that past deviations from the inflation target must be reversed. Figure 1 shows four representative policy frontiers corresponding to policy rules differing by the measure of inflation used. These frontiers are computed with the standard deviation of the funds rate constrained to be less than or equal to 4 (the constraint is binding in each case), which is about the historical average of the nominal funds rate in the postwar period. Reference values of λ are indicated for the frontier corresponding to frontier rules that respond to the three-year inflation rate.

6. Staiger, et al. (1997), Orphanides and van Norden (2002), Laubach and Williams (2003), and others have documented the difficulties in estimating the NAIRU, the output gap, and the equilibrium real interest rate, respectively. A number of authors, including Smets (1999), Orphanides, et al. (2000), McCallum (2001), and Rudebusch (2001, 2002), have investigated the effects of output gap uncertainty on the coefficients of simple policy rules. The results from this analysis suggest muting the response to the output gap but not eliminating it. Orphanides and Williams (2003) examine the implications of imperfect knowledge on the part of the public on efficient monetary policy rules.

7. Note that the "Taylor Principle," as described by Woodford (2003), which implies that for $\theta_y = 0$, stability is achieved for any $\alpha_\pi > 0$, does not strictly apply here because the specifications of the model and the policy rule differ from that analyzed by Woodford. Nonetheless, the stability condition in FRB/US is nearly the same.

8. I also experimented with different moving averages of the output gap. Policy rules that respond to a two-quarter moving average of the output gap or the lagged output gap performed worse than those that respond to the current gap.

FIGURE 1
POLICY FRONTIERS AND THE MEASURE OF INFLATION IN THE POLICY RULE



As seen in the figure, the frontier resulting from the rule that responds to the three-year inflation rate lies inside the other frontiers, indicating that it offers the best performance. These results are not sensitive to the particular value of the constraint on interest rate variability underlying this chart. Interestingly, the performance of optimized price-level targeting rules is nearly as good as rules that respond to inflation; in fact, in terms of *inflation* and output stabilization, such price-level targeting rules outperform rules that react to the one-year inflation rate for values of $\lambda > 0.1$.[9]

Starting from a frontier policy corresponding to a moderate amount of interest rate variability, further increases in interest rate variability yield modest stabilization benefits. Panel A of Figure 2 shows three policy frontiers, computed for values of $k = 3$, 4, and 6. As the constraint on interest rate variability is relaxed, the frontiers move slightly inward toward the origin. However, the incremental improvement in stabilization performance becomes progressively smaller as k increases.

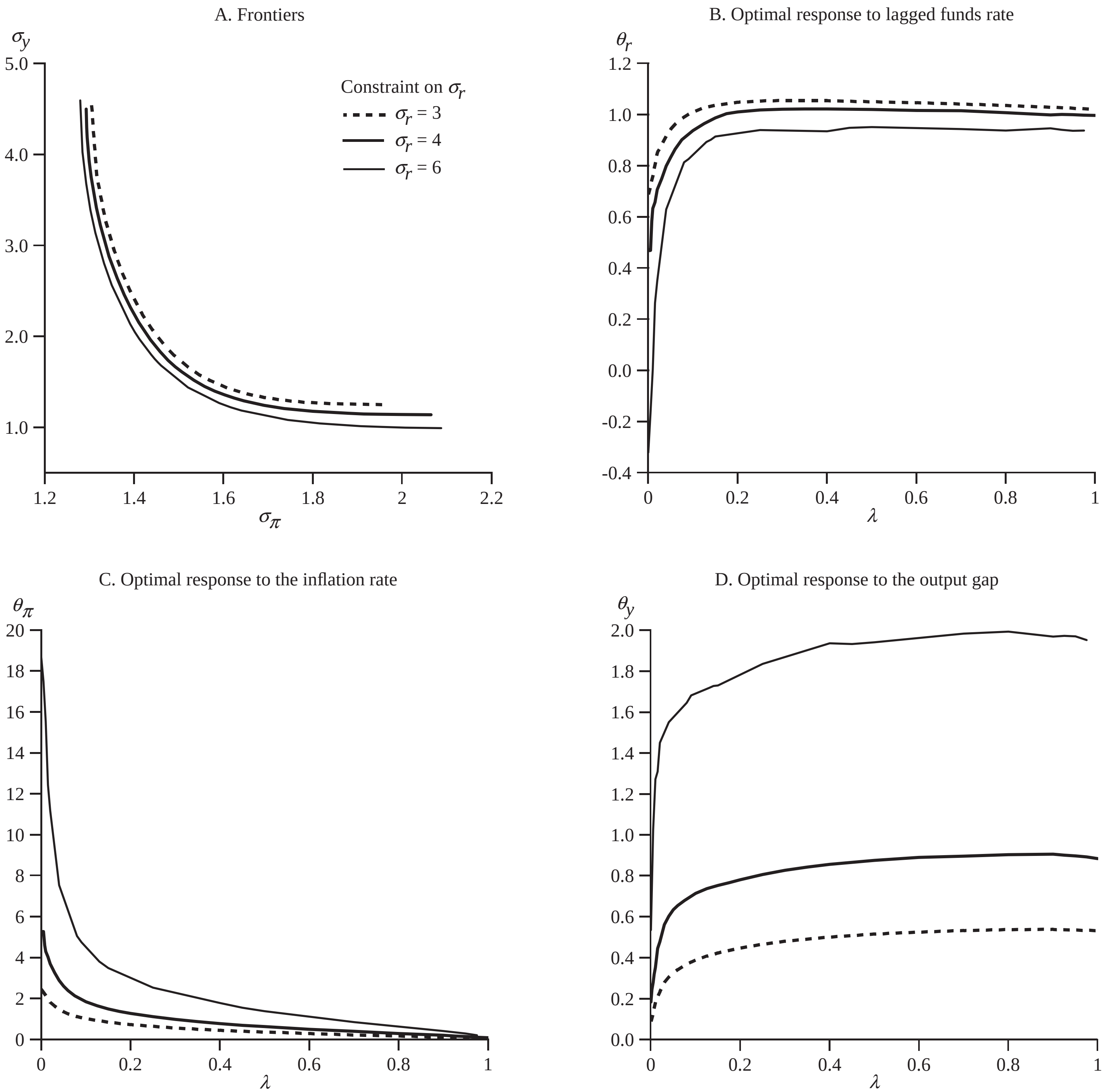
9. See also Svensson (1999), who finds that price-level targeting can be more effective at stabilizing inflation and unemployment than inflation targeting if the monetary authority cannot commit to its actions in advance.

The most striking result regarding efficient policies is the large value of θ_r, the coefficient relating the current funds rate to last period's funds rate, for most values of λ and k. Panel B of Figure 2 shows the optimized values of θ_r for the range of values of λ and the three values of k. When λ is close to zero, the optimal value of θ_r is small or even negative. Evidently, in that case, the optimal response to an unwanted movement in inflation is to act quickly and aggressively with the funds rate. In all other cases, however, θ_r is very close to and in some cases exceeds unity. In such cases, the policy response to movements in the output gap and the inflation rate is initially modest but then grows in magnitude as long as the deviations from the target levels persist.

The result that efficient rules incorporate a great deal of inertia stems from the penalty on the variability of the short-term interest rate. The optimal degree of policy inertia, as measured by θ_r, declines as the constraint on interest rate variability is relaxed. Because the expectations theory of the term structure determines bond rates in FRB/US, a small but sustained rise in the funds rate achieves the same change in the current bond rate as a large but short-lived increase in the funds rate but with far less variability in short-term interest rates. Given the desire to avoid fluctuations in short-term rates, the efficient response to an undesired increase in output or inflation is to hold the funds rate at an elevated level for an extended period of time (Goodfriend 1991). This high level of policy inertia in optimized simple rules holds in a wide variety of rational expectations models in which output is determined by a long-term bond rate (Rotemberg and Woodford 1999, Woodford 1999, Levin, et al. 1999).

The optimized response to the output gap is very small when λ is near zero, that is, when the policymaker cares only about the variability of inflation; the response to deviations of the inflation rate from target, in contrast, is very large. As shown in the last two panels of Figure 2, as the weight on output variability rises, the optimized coefficient on the output gap rises and that on inflation declines. When the policymaker places nearly all weight on output gap variability, the optimized value of θ_π is the minimum value sufficient to assure a unique stable equilibrium. Not surprisingly, both the inflation and output gap coefficients increase as the constraint on interest rate volatility is relaxed. The upper bound constraint on interest rate variability is strictly binding for the values of k considered here (recall that in the absence of the constraint the optimized rule would entail a variance of the interest rate greater than 100), so an increase in k allows more vigorous responses to output and inflation.

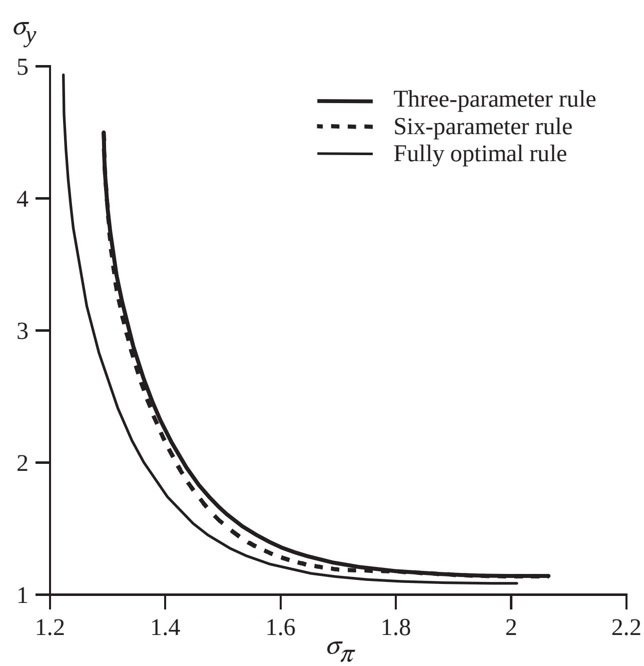
FIGURE 2
POLICY FRONTIERS AND FRONTIER POLICIES



4. The Relative Performance of Simple and Complicated or Fully Optimal Rules

The simple rules studied in the previous section ignore a large amount of information about the economy: FRB/US contains hundreds of variables representing prices and quantities in the goods, labor, financial, and foreign markets. Abstracting from the claimed benefits of parsimony in the specification of the policy rule, the cost to following a simple rule is the inability to take advantage of this information. There has been relatively little study of the magnitude of this cost, mainly because most monetary policy evaluation exercises usually take place using small-scale models for which a simple rule is optimal or nearly so by default. Levin, et al. (1999), Rudebusch and Svensson (1999), Dennis (2002), and Levin and Williams (2003) compare the performance of simple rules to that of more complicated or fully optimal rules in small- to medium-scale macro models. These studies typically find only small improvements in performance moving from simple three-parameter rules to complicated or fully optimal rules. However, these studies may underestimate the costs of following simple rules because they use models that understate the true complexity of the economic environment. Indeed, Finan and Tetlow (1999) compare simple rules to fully optimal policies using FRB/US and find larger losses in performance from following simple rules than in small-scale models.

FIGURE 3
PERFORMANCE OF SIMPLE VERSUS COMPLICATED RULES



I first consider the performance of a more complicated policy rule that responds to six variables: two lags of the funds rate and the output gap, the current one-quarter inflation rate, and the three-year average inflation rate. The frontier resulting from this six-parameter rule, computed with $k = 4$, is shown by the dashed line in Figure 3; for comparison, the frontier resulting from the three-parameter rule is shown by the thick solid line. I repeated this experiment numerous times trying a wide range of variables in the policy rule, including stock prices, spending components, and the unemployment rate, and the result was always the same: moderately more complicated optimized rules yield only trivial stabilization gains over optimized three-parameter rules. Similarly, as shown in Levin, et al. (2003), including forecasts of inflation and output—which embody information on hundreds of variables in the model economy—yields only trivial stabilization gains in FRB/US over simple three-parameter rules based on current and lagged variables. In fact, in FRB/US the optimal forecast horizon for inflation is zero quarters and that for output is only two quarters.

Even if policy responds optimally to *all* the variables in the economy, the improvement in macroeconomic performance over the optimized three-parameter rule is still fairly small, with the reduction in the weighted average of output and inflation variances averaging only about 10 percent. The frontier corresponding to the fully optimal policy is shown by the thin solid line in Figure 3.[10] For a policymaker who cares only about inflation ($\lambda = 0$), moving from the optimized three-parameter simple rule to the fully optimal rule reduces the standard deviation of inflation by less than 0.1 percentage point. The difference in performance is about the same all along the frontier. With balanced preferences ($\lambda = 1/2$), the standard deviations of both output and inflation are less than 0.1 percentage point apart between the frontiers. And, for the policymaker who cares only about stabilizing output, switching to the fully optimal policy reduces the standard deviation of the output gap by less than 0.1 percentage point.

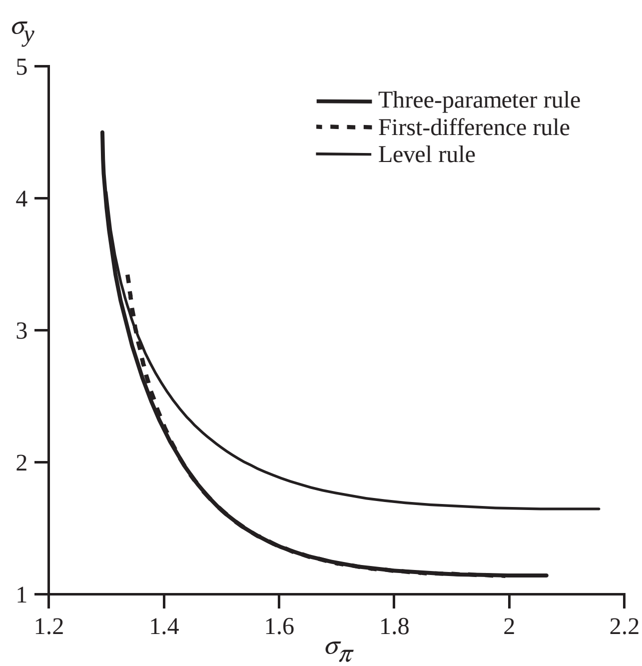
Why are the gains to adding more information to the policy rule so small? According to the FRB/US model, the lagged interest rate, the current output gap, and a smoothed measure of the inflation rate constitute sufficient statistics

10. I use the Finan and Tetlow (2001) procedure to solve for the fully optimal policy under commitment. This algorithm takes a mere four minutes on a personal computer equipped with a 1.2 Mhz Pentium III to solve the optimal policy and compute the associated unconditional moments for one value of policy preferences. Their method assumes a quadratic loss function which differs from my setup where frontiers are computed with a constraint on interest rate variability. To derive the frontiers, for a given value of λ, I computed optimal policies for a range of penalties on interest rate variability. I then interpolated the results to find the best point subject to the constraint on interest rate variability.

for setting monetary policy. Other variables generally are highly correlated with the three variables already in the rule and thus provide little additional information. In addition, the expectations channel assists simple rules in stabilizing the economy. Even if the policymaker does not respond immediately to all available information, the public knows that policy will respond to any deviations of inflation or output from target levels. Expectations of these future actions and their consequences help contain unwanted movements in inflation and output before the policy action takes place. For example, consider a disequilibrium increase in wages. Although the simple rule does not respond directly to this movement in wages, the knowledge that policy will respond to the ensuing increase in inflation causes bond rates to rise immediately, thus dampening output and inflationary pressures. In such instances, the expectations channel substitutes for a more complicated policy response.

The loss from simplifying the policy rule further by constraining the value of θ_r to equal unity is generally trivial, while constraining θ_r to zero can have somewhat more deleterious effects on macroeconomic performance. Figure 4 compares the frontier from first-difference rules where $\theta_r = 1$ to the three-parameter rule frontier. In both cases, the frontiers are computed under the constraint that $\sigma_r \leq 4$. The two frontiers differ by an imperceptible amount except where the policy objective places very little weight on the variability of the output gap. In such cases, the optimal value of θ_r is well below unity and the restriction causes a small deterioration in stabilization performance. The figure also shows the frontier for policies where θ_r is constrained to equal zero. Except for cases where λ is near zero, such "level" rules perform moderately worse than the three-parameter rules. For a policymaker who cares mostly about inflation variability, the level rules perform nearly as well as the three-parameter rules and slightly better than the first-difference rules.

FIGURE 4
PERFORMANCE OF SIMPLE
TWO- AND THREE-PARAMETER RULES



5. Robustness

A frequent criticism of model-based policy evaluation is that it is by its nature model-specific (McCallum 1988). Considerable uncertainty exists regarding parameter estimates and the appropriate specification of model equations. In this section I consider the robustness of the main results of this paper to alternative assumptions regarding the model.

The basic results about the characteristics and performance of simple rules presented above have been found to generalize to a wide range of rational expectations macroeconomic models. Levin, et al. (1999) examine the effects of different features of model design and specification by computing policy frontiers for FRB/US, the Fuhrer and Moore (1995) model, Taylor's (1993b) multicountry model, and the Monetary Studies Research model of Orphanides and Wieland (1998). Each of these models assumes rational expectations on the part of the public. The results from these other models confirm those from FRB/US. Indeed, a striking result is that simple frontier rules from FRB/US are found to be highly efficient in the three other models. Levin, et al. (2003) extend this analysis to include the New Keynesian model and show that the same characteristics and properties of optimal rules carry over to this model, which incorporates no intrinsic inertia in inflation and output. In all of these models, optimized simple rules incorporate a great deal of inertia, with the optimal value of θ_r near or above unity in many rational expectations models where there is a penalty on interest rate variability. Furthermore, Orphanides and Williams (2002) show that difference rules are less susceptible to mismeasurement of the long-run equilibrium real interest rate. Finally, as noted above, the finding that complicated or even fully optimal rules yield relatively small gains over simple policy rules is common to many estimated macro models.[11]

11. For example, as shown in Levin and Williams (2003), the optimized simple rule yields performance within 15 percent of the first-best in each of the three models.

Although simple policy rules have been found to be robust to model uncertainty, complicated policy rules and fully optimal policies tend not to be, as demonstrated in Levin, et al. (1999) and Levin and Williams (2003). Complicated rules and fully optimal rules are fine-tuned to the particular details of a model's specification. These details tend to differ across models, reflecting the uncertainty modelers face in specifying macroeconomic relationships.[12] This fine-tuning can be counterproductive when the details differ substantially across models. A concern for robustness argues against complicated or fully optimal policies, which even in the best circumstances yield small performance benefits over simple rules. The more basic features of how monetary policy affects inflation and output, however, are similar across the models, and as a result, simple rules tend to be more robust.

The finding that optimized policy rules exhibit considerable policy inertia, however, is sensitive to the assumption of rational expectations, that is, that expectations are consistent with the model structure and the policy rule in place. If expectations are backward-looking, as in the models of Fair and Howrey (1996), Ball (1999), and Rudebusch and Svensson (1999), the expectations channel is cut off. As a result, as demonstrated in Rudebusch and Svensson (1999), high values of θ_r are associated with poor performance and can even be destabilizing owing to the instrument instability problem where the gradualism in the policy response causes explosive oscillations in the economy. This outcome was noted first by von zur Muehlen (1995), who used a simple macro model to show that interest rate smoothing policy rules that are stabilizing if expectations are forward-looking can be destabilizing if inflation expectations are backward-looking. As shown in Levin and Williams (2003), policy rules that are robust to the assumption of backward-looking expectations are characterized by moderate policy inertia, with θ_r around 0.5.

6. Conclusion

In this paper, I evaluate monetary policy rules using the Federal Reserve Board's FRB/US model. I find that simple policy rules are very effective at minimizing the fluctuations in inflation, output, and interest rates. Although the policymaker faces a complicated world in FRB/US, rules that respond to large sets of variables yield relatively modest stabilization benefits over efficient simple rules. In addition, simple rules tend to be more robust to model uncertainty than complicated rules that are fine-tuned to a particular model's features. A key characteristic of successful policies under rational expectations is a strong degree of persistence in movements in the federal funds rate. Efficient rules smooth the interest rate response to shocks and use the feedback from anticipated policy actions to stabilize inflation and output and to moderate movements in short-term interest rates. These results are robust across a range of rational expectations models.

12. Currie and Levine (1985) make this argument but do not test it.

Appendix

Computing Unconditional Variances and Optimized Simple Rules

Much of the analysis of this paper involves computing unconditional second moments of aggregate variables. In order to make this computationally feasible, the model is log-linearized around sample means; the relevant dynamic properties of the model are virtually unaffected by this approximation. In its companion form, the linearized system is given by

$$E_t \sum_{j=-1}^{1} H_j x_{t+j} = G e_t ,$$

where x_t is the vector of endogenous variables, and e_t is a mean-zero vector of serially uncorrelated random disturbances with finite second moments, $E(ee') = \Omega$. I estimate Ω using the equation residuals from 1966 to 1995. The information set for expectations formation differs across sectors; expectations in the financial sector incorporate knowledge of the current state of the economy, while expectations in the other sectors are based on information that is lagged one quarter.

One equation in this system corresponds to the monetary policy rule, described by a vector of parameters, θ. For a given specification of the policy rule, I solve for the saddle point rational expectations solution, if it exists, using the AIM algorithm developed by Anderson and Moore (1985). The reduced-form representation of the solution is given by

$$x_t = A_\theta x_{t-1} + B_\theta e_t ,$$

where the elements of the matrices A and B depend on the policy rule parameter vector θ. For notational convenience, I set all constants to zero so that the unconditional expectation of all variables is zero, $E(x) = 0$.

Given the reduced-form solution, I compute an approximation to the unconditional variance-covariance matrix for x, $V_\theta \equiv E(xx')$,

$$V_\theta = \sum_{j=0}^{\infty} A_\theta^j B_\theta \Omega B_\theta' A_\theta'^j ,$$

using the doubling algorithm of Hansen and Sargent (1998). This approach is more efficient at computing highly accurate answers than the standard method of stochastic simulations. Using a personal computer with an Intel Pentium III 1.2 Mhz processor, computation of the saddle path solution and the unconditional covariance matrix for a given policy rule takes about 20 seconds.

To compute optimized simple rules, I use a minimization routine that varies the rule parameters to minimize the weighted variances of the inflation rate and the output gap and 10,000 times the squared difference between the standard deviation of the interest rate and the specified value of k. Inclusion of this final term assures that the interest rate variability constraint is satisfied. The minimization routine takes between 20 minutes and 2 hours to compute a single point on the simple rule frontier. This compares to about four minutes to compute the fully optimal policy using the Finan and Tetlow (2001) procedure.

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