# The Monetary Transmission Mechanism and the Evaluation of Monetary Policy Rules

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This paper explores the connection between the monetary transmission mechanism—the channel through which a change in monetary policy affects the economy—and the choice of monetary policy rules to guide central bank decisions. Different views of the monetary transmission mechanism are readily apparent in the many different models that monetary economists use to evaluate monetary policy. For example, a symposium on "The Monetary Transmission Mechanism" in the *Journal of Economic Perspectives* in the fall of 1995 contains five papers representing alternative views. The question is: Do these different views lead to substantial differences in the optimal rules for monetary policy? To answer this question, I draw on evidence obtained in recent and ongoing research on the quantitative evaluation of monetary policy rules. In fact, there has been an explosion of this type of normative macroeconomic research in recent years, reflecting both an increase in supply by researchers and an increase in demand by policymakers. Most of the *new normative macroeconomics* takes as given that the central bank has an explicit or implicit inflation target, and this assumption immediately makes the research useful to many central bankers. The purpose of this research is then to find policy rules to guide policymakers in setting the policy instruments so as to bring the inflation rate close to the target and keep it there, while taking account of the short-run trade-offs that impinge on output, employment, and exchange rate variability.

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By an inflation target I simply mean a numerical value (usually near zero) for the inflation rate in the objective function used for policy evaluation; the "target rate of inflation is therefore given" (Taylor, 1979, p. 1276). Having an inflation target, however, does not necessarily mean a particular *operating procedure* for the central bank, such as setting the instruments of policy so as to bring a forecast of inflation into equality with the target, or so that the instruments react in a certain way to real output or the exchange rate. The choice of an operating procedure (a policy rule) is an outcome of the normative macroeconomic research, not an input into it. Although having an inflation target does not necessarily mean that the central bank is explicit rather than implicit in announcing the target, there is wide agreement about the benefits of a more transparent policy.

This new normative macroeconomics is ideally suited for answering questions about the connection between the monetary transmission mechanism and the policy rule. First, the recommendations for policy rules that emerge from this research are highly specific and usually expressible in the form of precise algebraic equations. Second, the recommendations are derived from explicit structural models of the economy in which the researchers have taken clear positions on the monetary transmission mechanism. Hence it is possible to trace the connection between views of the monetary transmission mechanism and policy choices in a way that was not possible before. The results are therefore new and in some cases quite surprising. One possible disadvantage of this approach should be mentioned at the start. By focusing on quantitative research, the approach does not deal with less formal or "verbal" descriptions of the monetary transmission mechanism, or with more basic theoretical models that have not yet been specified quantitatively for empirical work.

The paper proceeds as follows. I first briefly summarize different views of the monetary transmission mechanism. Because understanding the results of this paper requires an appreciation of the novel nature of the new normative macroeconomics, I next describe the methodology of the policy research in some detail. I then endeavor to classify eighteen policy models according to the approach they take to the monetary transmission mechanism, distinguishing between aggregate demand and price adjustment effects. In the remainder of the paper, I examine how these different views affect the estimated performance of different policy rules.

I look at a simple benchmark rule, at policy rules with inertia, and at policy rules designed for small, open economies. In cases where the results seem surprising or paradoxical, I examine and compare the different monetary transmission mechanisms in more detail. One byproduct of this approach might therefore be a better understanding of how the different views compare. I summarize and discuss the results in the last section of the paper.

## 1. Terminology and a Summary of the Different Views

Some terminology is needed to distinguish among the different views of the monetary transmission mechanism. One view, very common in new normative macroeconomic research, is the *financial market price* view (see Taylor, 1995, for details). This view stresses the impact of monetary policy on the prices of and rates of return on financial assets—including bond prices, interest rates, and exchange rates—and thereby on the spending decisions of firms and households. There are different versions of the financial market view. For example, different degrees of emphasis are placed on the exchange rate versus other asset prices; these differences are partly a matter of the degree of openness of the economy being studied. In smaller, more open economies the exchange rate is, of course, quantitatively more important than in larger economies. How does a greater influence of the exchange rate affect the optimal policy rule?

Another view of the monetary transmission mechanism, frequently put forth as an alternative to the financial market price view, is the *credit* view (see Bernanke and Gertler, 1995, for details). The credit view emphasizes changes in lending by banks and other financial intermediaries as an alternative to internal finance. Quantitative measures of credit and corporate cash flows are therefore an important input to this view. Does it matter for the choice of a monetary policy rule whether one thinks the financial market price view or the credit view dominates?

There are also different views about what *rigidities* are needed to explain why a change in a nominal quantity like the money supply affects real variables. Most of the research evaluating policy rules uses some variant of a *staggered price* or *wage setting* theory to generate the impact of policy. A distinguishing feature of these models is that expectations of future inflation affect price setting. They differ in the degree of backward looking that is mixed in with the forward looking, and whether or not it is the expected inflation rate or the expected price level that affects decisions.

Another, completely different type of rigidity that has been used in normative macroeconomic research is that of the *limited participation* model (see Christiano, Eichenbaum, and Evans, 1997, for a review). In these models investors are limited in the amount of funds they can transfer from one financial account to another each period. How much difference do these different models make for the choice of an optimal policy rule?

Finally, despite broad agreement that expectations are very important in financial markets, and therefore in the monetary transmission mechanism, there is disagreement about the best way to model expectations. How different is the performance of policy rules in models that assume rational expectations from that of policy rules in models that do not?

## 2. The Nature of the Models and the Policy Research

The approach of this paper is to first classify different models used for policy evaluation into structural types based on the approach they take to the monetary transmission mechanism, and then to see whether these different structures affect the evaluation of policy rules in systematic ways. All the quantitative models of the monetary transmission mechanism examined in this paper are stochastic, dynamic, and economy-wide. The models are also used in the same way for analysis and policy evaluation. Hence the differences are not in the methodology, but rather in the economic structure. It is helpful to discuss these methodological similarities and review their rationale before examining the structural differences.

The models must be stochastic if one is to predict how effective policy rules are at cushioning the economy from unanticipated shocks. The stochastic shocks are added to equations of the model, and their stochastic properties (variances and covariances) are matched with historical experience just as other parameters of the models are.

The models must be dynamic for two reasons: first, because there are lags in the monetary transmission mechanism, and second, because expectations of the future are important in financial markets. The most common—although not universal—expectations assumption used in these models is the rational expectations assumption, in which people's expectations of the future are equal to the model's mathematical conditional expectations.

The models are economy-wide or general-equilibrium models because monetary policy has impacts on the whole economy. Moreover, the rational expectations assumption requires a complete model of the economy in order to explain how expectations are formed. Some researchers prefer to use the term "model consistent" rather than "rational expectations," to emphasize that expectations depend on a complete model of the economy (see Brayton and others, 1997a and b, for example).

Stochastic, dynamic, economy-wide macroeconomic models with rational expectations give rise to mathematical structures that involve systems of difference equations in which both past and expected future values of variables appear. A typical model of the transmission mechanism used for policy evaluation can be written in the form

$$f_i\left( y_t, y_{t-1},..., y_{t-p}, E_t\, y_{t+1},..., E_t\, y_{t+q}, a_i, x_t \right) = u_{it} \;, \tag{1}$$

for $i = 1, ..., n$, where $y_t$ is an $n$-dimensional vector of endogenous variables at time $t$, $x_t$ is a vector of exogenous variables at time $t$, $u_{it}$ is a vector of stochastic shocks at time $t$, and $a_i$ is a parameter vector.

The simplest rational expectations model of the monetary transmission mechanism is the case where the model in equation (1) is a single linear equation ($i = 1$) with one lead ($q = 1$) and no lags ($p = 0$). This is the well-known rational expectations version of the Cagan model (see Sargent, 1987, for example) in which the endogenous variable ($y_t$) is the current price level, the expected future variable ($E_t y_{t+1}$) is the one-period-ahead price level, and the exogenous variable ($x_t$) is the money supply (the instrument of policy). Of course, models used to evaluate policy in realistic situations (other than hyperinflations) need to be more complex than the Cagan model, and indeed all the models examined in this paper have more than one equation and values of $p$ or $q$ greater than one. In many applications the system of equation (1) is linear, although nonlinear versions of equation (1) are not uncommon.

A solution to equation (1) is a stochastic process for $y_t$.[1] Obtaining such a solution in a rational expectations difference equation system is much more difficult than doing so in a simple backward-looking difference equation with no expectations variables. This difficulty makes the new normative macroeconomics difficult to teach and requires more expertise than is needed for conventional policy evaluation methods. This complexity is one reason why the methods are not explained in detail in textbooks in macroeconomics.

How do researchers use the model in equation (1) for policy evaluation? Alternative monetary policies are characterized by rules that stipulate how the instruments of policy (usually the short-term interest rate) react to observed variables in the economy. The rules may be simple or complex, but in general they contain some feature that one is interested in investigating, such as how reactive policy should be to the exchange rate or to real output. In particular, one might want to know the optimal response of the policy instrument to these variables.

The method used to answer the question can be described in the following series of steps:

- Place the candidate policy rule into model $f_i$ (.).
- Solve the model using one of the solution algorithms.
- Look at the properties of the stochastic steady-state (stationary) distribution of the variables (inflation, real output, and unemployment).

1. Many papers have been written on algorithms for obtaining solutions to systems like equation (1). In the case where $f_i$(.) is linear, Blanchard and Kahn (1980) showed how to get the solution to the deterministic part of equation (1) by finding the eigenvalues and eigenvectors of the system. Under certain conditions the model has a unique solution. Many macroeconomists have proposed algorithms to solve equation (1) in the nonlinear case (see Taylor and Uhlig, 1990, for a review). The simple iterative method of Fair and Taylor (1983) has the advantage of being very easy to use even in the linear case but is less efficient than other methods. Brian Madigan at the Federal Reserve Board has developed a very fast algorithm to solve such models. I have found that the iterative methods work very well in teaching advanced undergraduates and beginning graduate students. The algorithms are easy to program within existing user-friendly computer programs such as Eviews. I use such iterative methods to solve my multicountry rational expectations model (Taylor, 1993b). I think more emphasis on solving and applying expectational difference equations should be placed in the economics curriculum, especially at the graduate level but also at the undergraduate level. Many graduate students come to economics knowing how to solve difference and differential equations, but *expectational* difference equations such as equation (1) are not yet standard and require time and effort to learn well. It is difficult to understand, let alone do, modern macroeconomic policy research without a basic knowledge of how these expectational stochastic difference equations work.

• Choose the rule that gives the most satisfactory performance (a loss function may by useful here to help compare points on the tradeoff between the variance of one target variable and another).
• Check the results for robustness using other models.

The use of policy rules in this way is the most noticeable characteristic of policy evaluation research in macroeconomics today, especially when compared with the days before the rational expectations revolution.[2] The introduction of the rational expectations assumption into macroeconomics significantly increased the advantages of using policy rules in this way to evaluate policy. With rational expectations, people's expectations of policy matter greatly for the impact of changes in the instruments of policy, as demonstrated forcefully by Lucas (1976). Hence, in order to evaluate the impact of a policy, one must state what that future policy will be under different contingencies. Such a contingency plan is nothing more than a policy rule.

Woodford (1999b) emphasizes the importance of the "timelessness" aspect of the above approach to policy evaluation. By focusing on a stationary policy rule and the stationary distribution, one is ensuring that the policy rule is no different than the one that the policymaker would follow under the same conditions at any other time. This timelessness, or stationarity, feature makes the evaluation of the policy rule much more accurate and less subject to serious errors. In effect, it assumes away any credibility problems that plague the evaluation of policy rules when people are forward-looking, as discussed in McCallum (1999).

## 3. Different Views of the Monetary Transmission Mechanism as Seen From the Policy Models

Several of the quantitative models that I examine in this study consist of only two structural equations. The first is an *aggregate demand* or *IS equation* showing how real GDP (aggregate demand) depends on the interest rate and the exchange rate, and the second is

2. Of course, there are examples of policy rules research that predate the rational expectations assumption (see Phillips, 1954, for example). Policy rules have always had considerable appeal for researchers interested in applying engineering control methods to macroeconomics; rules have also had the advantage of less uncertainty and greater accountability, as stressed by Milton Friedman.

a *price adjustment equation* showing how inflation evolves over time in response to changes in capacity utilization or in exchange rates. When combined with a policy rule, these simple models make up a three-equation system. These systems include such models as the Fuhrer and Moore (1995) rational expectations model, the Rudebusch and Svensson (1999) time-series model, the Ball (1997, 1999) models of closed or open economies, and the Woodford (1999b) or Clarida, Gali, and Gertler (1999) simplified "new Keynesian" models.[3] Other models used for policy evaluation (for example, Taylor, 1993a, or the Federal Reserve's FRB/US model) involve many more than three equations. These models have either a more detailed description of aggregate demand (with consumption, investment, net exports, and government purchases modeled separately, for example) or a more detailed description of price adjustment (with both wages and prices being modeled separately, for example). However, even these larger models can be described conceptually as "three relationship" systems (one relationship being the policy rule). Equations relating consumption, investment, and net exports to interest rates and the exchange rate combine to form an IS block of equations; wage and price setting equations with exchange rate pass-through combine to form a price adjustment block of equations. Hence, for both small models and large models, it is possible to classify differences in the monetary transmission mechanism according to whether they pertain to aggregate demand or price adjustment, and such a distinction is useful for the purposes of this paper.

Tables 1 and 2 use this framework to classify eighteen different models that have been used for policy evaluation in the last few years. The tables show several ways in which the models differ in their treatment of the monetary transmission mechanism as defined above. Table 1 focuses on differences relating to aggregate demand, and table 2 focuses on differences relating to price adjustment.

3. The use of the term "new Keynesian" is not universal and may be confusing because it has been associated with particular microeconomic foundations of price and wage adjustment such as menu costs. These types of models are also called "dynamic new Keynesian" models by Bernanke, Gertler, and Gilchrist (1999) and "new neoclassical synthesis" models by Goodfriend and King (1997). In my view the key characteristic of the models is that they are dynamic, stochastic, economy-wide models with forward-looking behavior and some rigidities that make them useful for policy evaluation along the lines defined in this paper.

## Table 1. Classification of Selected Models according to the Approach Taken to the Aggregate Demand Component of the Monetary Transmission Mechanism

| *Model* | *Size* | *Price or credit view*[a] | *Interest rate*[b] | *Partial adjustment*[c] | *Exchange rate*[d] |
|---|---|---|---|---|---|
| Ball (1997) | Small | Price | Short-term | Yes | No |
| Ball (1999) | Small | Price | Short-term | Yes | Yes |
| Bernanke, Gertler, and Gilchrist (1999) | Medium | Credit | Long-term | No | No |
| Batini and Haldane (1999) | Medium | Price | Short-term | Yes | Yes |
| FRB/US: Brayton and others (1997a and b) | Large | Price[e] | Long-term | Yes | Yes |
| Chari, Kehoe, and McGrattan (2000) | Medium | Price | Long-term | No | No |
| Christiano and Gust (1999) | Medium | Price | Long-term | Yes | No |
| Clarida, Gali, and Gertler (1999) | Small | Price | Long-term | No | No |
| Fuhrer and Moore (1995) | Small | Price | Long-term | Yes | No |
| King and Wolman (1999) | Small | Price | Long-term | No | No |
| McCallum and Nelson (1999a) | Small | Price | Long-term | No | No |
| McCallum and Nelson (1999b) | Small | Price | Long-term | No | Yes |
| MSR: Levin, Wieland, and Williams (1999) | Medium | Price | Long-term | No | No |
| Rotemberg and Woodford (1999) | Medium | Price | Long-term | No | No |
| Rudebusch and Svensson (1999) | Small | Price | Short-term | Yes | No |
| Svensson (1999a) | Medium | Price | Long-term | Yes | Yes |
| TaylorMCM: Taylor (1993b) | Large | Price | Long-term | Yes | Yes |
| Woodford (1999a) | Small | Price | Long-term | No | No |

a. "Price" indicates that the model incorporates a financial market price view, and "credit" a credit view, of the transmission mechanism.
b. The measure of the interest rate that, through a rational expectations model of the term structure, influences demand.
c. "Yes" indicates that there is some type of delayed or partial adjustment in response to changes in interest rates.
d. "Yes" indicates that the exchange rate affects aggregate demand.
e. The presence of corporate cash flow in the investment equations of this model may suggest that a "credit" view coexists with a "financial market price" view, but the latter is a much more powerful channel of monetary policy in this model.

## Table 2. Classification of Models according to the Staggered Price Adjustment Component of the Monetary Transmission Mechanism

| *Model* | *Backward- or forward-looking*[a] | *Type of staggering*[b] | *Exchange rate a factor in price determination* |
|---|---|---|---|
| Ball (1997) | Backward | | No |
| Ball (1999) | Backward | | Yes |
| Bernanke, Gertler, and Gilchrist (1999b) | Forward | Price level | No |
| Batini and Haldane (1999) | Forward | Inflation rate | Yes |
| FRB/US: Brayton and others (1997a and b) | Forward | Price level | Yes |
| Chari, Kehoe, and McGrattan (2000) | Forward | Price level | No |
| Christiano and Gust (1999) | Neither[c] | Price level | No |
| Clarida, Gali, and Gertler (1999) | Forward | Price level | No |
| Fuhrer and Moore (1995) | Forward | Inflation rate | No |
| King and Wolman (1999) | Forward | Price level | No |
| McCallum and Nelson (1999a) | Forward | Price level | No |
| McCallum and Nelson (1999b) | Forward | Price level | Yes |
| MSR: Levin, Wieland, and Williams (1999) | Forward | Price level | No |
| Rotemberg and Woodford (1999) | Forward | Price level | No |
| Rudebusch and Svensson (1999) | Backward | | No |
| Svensson (1999a) | Forward | Price level | Yes |
| TaylorMCM: Taylor (1993b) | Forward | Price level | Yes |
| Woodford (1999a) | Forward | Price level | No |

a. "Backward" indicates that the staggered price adjustment mechanism is purely backward-looking, and "forward" that it is at least partly forward-looking.
b. "Price level" indicates that price setting and forward-lookingness are in terms of levels of prices, as in the staggered contract model in Taylor (1979) or the random geometric version of Calvo (1983); "inflation rate" indicates that it is in terms of the inflation rate, as in Fuhrer and Moore (1995).
c. The model is a limited participation model.

It is not possible to consider all the models that have been developed to date, but I think the eighteen models in tables 1 and 2 are representative. Because research at central banks is ongoing at this time, only two models actually in use at central banks (the Federal Reserve Board models FRB/US and MSR) are included in tables 1 and 2. It would be useful to consider models used at the Bank of Canada (Black, Macklem, and Rose, 1998), the Reserve Bank of New Zealand (Drew and Hunt, 1998), the Swedish Riksbank (Dillen and Nilsson, 1998), the Bank of England (King, 1999), and other central banks where research is under way.

I realize that it is difficult to evaluate my classification method without a direct knowledge of all these models. For each model I give a reference to a paper that describes the model and/or uses it for the purpose of evaluating monetary policy rules. It is through the model listings and descriptions in these references—descriptions in the form of equation (1)—that I have classified each model according to several characteristics, such as whether the credit view is used or whether the exchange rate is a channel for monetary policy. (The exact characteristics are defined in the notes to each table and are repeated in the text.) Of course, tables 1 and 2 do not include all the differences among the models. For example, some models use more explicit optimization methods to derive their equations than do other models, some models fit the data better than others, and some models describe exchange rate behavior differently from others (for example, Ball, 1999, and Svensson, 1999, differ in this regard). However, I think the two tables capture the key differences in the monetary transmission mechanism that might affect the evaluation of monetary policy rules. In any case, it seems clear from tables 1 and 2 that a variety of approaches have been taken to modeling the monetary transmissions mechanism. Now the question is whether the differences identified in tables 1 and 2 make a difference for the evaluation of policy rules.

## 4. A Class of Policy Rules

To answer the question just posed, I consider policy rules of the form

$$i_t = g_\pi \pi_t + g_y y_t + g_{e0} e_t + g_{e1} e_{t-1} + \rho i_{t-1} , \tag{2}$$

where $i_t$ is the interest rate, $\pi_t$ is the inflation rate (usually smoothed over four quarters for quarterly models), $y_t$ is the deviation of output from potential, and $e_t$ is the exchange rate (defined such that an increase represents an appreciation of the local currency).

The g parameters and ρ are policy choices. The interest rate is the instrument of monetary policy for all values of the policy parameters in this equation.[4] The form of this simple policy rule allows for several of the major differences of opinion about policy rules. For example, the question of whether there should be interest rate smoothing (or inertia) in interest rate setting is captured by whether ρ is zero or not. I have suggested (Taylor, 1993a) that ρ should be zero, but others (Woodford, 1999a, for example) have recently argued that it should be greater than zero and even close to one. How much of this difference of opinion about policy is explained by differences of opinion about the monetary transmission mechanism? Similarly, the question about whether monetary policy—especially in a small, open economy—should react to the exchange rate is captured by whether $g_{e0}$ or $g_{e1}$ should be zero or not.

Of course, focusing on the functional form in equation (2) does not capture all differences in policy. In fact, fully optimal policy rules will be much more complex than equation (2). However, policy rule research has suggested that the simpler rules are close approximations to fully optimal policy rules in many cases. One might also wonder whether the *forecast* of inflation should be in the policy rule, rather than the four-quarter smoothed inflation rate. In my view (supported by simulations reported in Taylor, 1999b) there does not appear to be much difference between the impacts of policy rules that use forecasts of inflation in equation (2) rather than smoothed values of inflation over a few quarters. At least if the forecast is not too far out in the future, such forecast-based rules are in the spirit of equation (2). Moreover, it is difficult to compare different monetary transmission mechanisms for forecast-based rules because the forecasts themselves depend on the monetary transmission mechanism.

4. I could also have considered the impact of the monetary transmission mechanism on the choice of the policy instrument in the policy rule, for example, whether the instrument should be the monetary base or the overnight interest rate. That the interest rate is, in fact, the instrument in most of the policy evaluation research is an obvious indication that the monetary transmission mechanism in these models does not focus on the money supply, largely because of uncertainty about velocity. Hence one of the biggest differences in monetary transmission mechanisms (money versus interest rates) has already had a big impact on policy rules.

## 5. Effects of the Monetary Transmission Mechanism on a Benchmark Rule

Consider a version of the simple rule in equation (2) for which there is no reaction to the lagged interest rate and no reaction to the exchange rate. This is the type of rule I suggested in Taylor (1993a) as a guideline for the Federal Reserve, and I refer to it here as a benchmark rule, because many researchers have examined this rule in comparison with other possible rules or with actual policy performance. A natural question to ask is whether the performance of the benchmark rule is affected by the different views of the monetary transmission mechanism.

### 5.1 Effects of Different Views on Financial Market Prices

Simulations of the benchmark rule with a coefficient on inflation of 1.5 and a coefficient on output of 0.5 (Taylor, 1993a) show reasonably good performance—or at least no great depression or great inflation—across the range of models that use a financial market price and a sticky or staggered price adjustment view of the monetary transmission mechanism. Evidence for this comes from simulations of nine of the models in tables 1 and 2 (see Taylor, 1999a). These simulations indicate that when this simple rule is used, the variance of inflation and the variance of real output are small for the models that incorporate a financial market price view of the monetary transmission mechanism. To be sure, there is some preference for a weight on output above 0.5 in the policy rule if the objective function places more weight on output. However, there is no dominance—in terms of both output and price stability—of a rule with a weight on output of 1.0 rather than 0.5. In fact, a rule with a coefficient on output of 1.0 is just as reasonable as a rule with 0.5; the results say more about the use of rules of this general type than about specific coefficients.

The result—that the form of the monetary transmission mechanism does not have much effect on the performance of the benchmark rule—does not mean that no other policy rules will work better in some of the models. Indeed, as I discuss below, a policy rule with a reaction to the exchange rate may work better in models of small, open economies. Rather, the result is more like a robustness property that says the benchmark rule works pretty well; it does not lead to poor performance across a range of models that incorporate a financial market price view of the monetary transmission mechanism. Evidently, the range of different approaches to the financial market price view—a short-term rate focus, a long-term rate focus, complete forward-looking behavior, complete backward-looking behavior, more or less disaggregation—generate a similar policy-relevant relationship among interest rates, inflation, and output. Hence the same benchmark rule works well for this range of models. But does this robustness result carry over to other models of the monetary transmission mechanism?

## 5.2 Effect of the Limited Participation View versus the Staggered Price Setting View

Consider the radically different theory of the transmission mechanism based on limited participation. Surprisingly, a stability analysis of the limited participation model of Christiano and Gust (1999) indicates that replacing sticky prices with limited participation does not lead to deterioration in the performance of the benchmark rule. As long as the weight on output is not too high, this simple rule also performs well in keeping the inflation rate and real output stable. (A weight on output of 0.5 works very well, but for some model parameters a weight of 1.0 is too large.)

Again, this is a robustness result. The benchmark rule is robust to a very different view of the monetary transmission mechanism. The result appears paradoxical simply because the limited participation view is so different structurally from the sticky-prices view. The explanation for the paradox comes from looking at how a change in monetary policy affects the economy. Most important is that a change in monetary policy can temporarily affect the real rate of interest—just as in the sticky-prices models. This change in the real interest rate then affects spending and employment for the same reasons it does so in other models of monetary transmission. As described by Christiano and Gust (1999), "The household's date $t$ decision about $Q_t$ [the amount spent on goods] must be made before the date $t$ realization of the shocks, while all other decisions are made afterwards. This assumption is what guarantees that… the equilibrium rate of interest falls, and output and employment rise." Thus the paradox is explained by the fact that a monetary policy-induced decline in the real interest rate affects aggregate demand, much as in the sticky-prices models.

## 5.3 Effects of the Credit (Financial Accelerator) View versus the Traditional Market Price View

Now consider the model of Bernanke, Gertler, and Gilchrist (1999), which is the one model in table 1 incorporating an explicit credit view. This credit view is embodied in what the authors call a *financial accelerator*: "The idea that fluctuations in borrowers' net worth lead to fluctuations in real activity is what we mean by the financial accelerator" (Bernanke, Gertler, and Gilchrist, 1996, p. 3). The key assumption—the one that gives the financial accelerator its credit view flavor—is that internal borrowing is cheaper than external borrowing. Hence an increase in net worth, which would accompany a reduction in the interest rate, increases firms' ability to finance investment internally, and thus stimulates investment much as with the typical interest rate channel. As stated by Bernanke, Gertler, and Gilchrist (1999, p. 1369), "The unanticipated increase in asset prices raises net worth, forcing down the external finance premium, which in turn further stimulates investment." The financial accelerator amplifies the impact of the interest rate. "With the financial accelerator mechanism present ...smaller counter-cyclical movements in interest rates are required to dampen output fluctuations" (Bernanke, Gertler, and Gilchrist, 1999, p. 1364).

Bernanke and Gertler (1999) report simulations of a policy rule like that in equation (2) in an estimated model with a financial accelerator. The rule they simulate is not exactly the one obtained by setting the coefficients on the exchange rate terms and the coefficient on the lagged dependent variable to zero, because they also set the coefficient on output to zero and use a forecast of the inflation rate rather than a smoothed value of the exchange rate. They find that this rule, which is similar to the benchmark rule, works reasonably well in their model. The variances of both inflation and output are small. Hence it appears that if one held a credit view of the monetary transmission mechanism—at least as embodied in the financial accelerator—it would have little effect on one's assessment of the usefulness of a simple benchmark rule for policy.

As in the case of the limited participation model, this robustness may appear paradoxical.[5] However, the explanation for the

5. Because Bernanke and Gertler (1999) report simulations of a rule without a weight on output and with a forecast of inflation, the results are not strictly comparable with the other simulation results reported here. In my view the rule is close enough to warrant the conclusions stated here, but until additional simulations are done, one cannot know for sure.

paradox is already contained in the above explanation of the financial accelerator. The change in the interest rate and its effect on spending is still the main story of how monetary policy works. The one change that could make a difference—that the financial accelerator increases the sensitivity to the interest rate—either is not large enough to damage the performance of the benchmark rule, or in the process of estimation the parameters are chosen so that the net effect of an interest rate change on spending is similar to other models of the monetary transmission mechanism.

## 5.4 Robustness to the Exchange Rate Channel in a Small, Open Economy

An important question about the benchmark rule is how the exchange rate channel affects its performance. Svensson's (1999) simulations of a small, open economy model are directly relevant to this question. He reports that the benchmark rule (without the exchange rate terms) performs well in reducing the variability of inflation around the inflation target and the variability of output around its potential. In assessing these results with the benchmark rule, Svensson (1999) concludes that the rule "appears somewhat robust; perhaps surprisingly robust." Again, this robustness finding does not mean that no better rule exists for Svensson's model; in fact, the benchmark rule leaves the variability of the real exchange rate higher than do other rules.[6] The main point is that even a small, open economy view of the monetary transmission mechanism does not change the assessment that the simple benchmark rule—responding systematically only to inflation and output—works well and is robust.

As with the other views of the monetary transmission mechanism, the explanation of this finding is that the exchange rate channel effectively makes a connection from the interest rate to aggregate spending. Rather than simply changing the real interest rate, a change in monetary policy changes the real exchange rate as well. The exchange rate change magnifies the real interest rate effect but does not affect its direction. Hence a reaction of the policy rule only to inflation and output works just fine in stabilizing output and inflation.

6. In a small, open economy the exchange rate has direct effects on the inflation rate, so that choosing the correct measure of the target inflation rate is important.

## 5.5 Toward Improved Monetary Policy Rules

Thus far I have focused on the benchmark policy rule in equation (2) for which there is no inertia ($\rho = 0$) and no response to the exchange rate ($g_{e0} = g_{e1} = 0$). The conclusion is that this rule is robust across the range of views of the monetary transmission mechanism that are represented in current policy evaluation models. Stated differently, none of the current alternative views of the monetary transmission mechanism have a significant negative effect on the performance of this rule.

As I have emphasized, however, one cannot conclude from these findings that there are no better monetary policy rules. Moreover, from a very practical perspective, although there were successes in monetary policy in the 1990s, various kinds of monetary crises did occur, suggesting that there is a lot of room for improvement. Many suggestions for improving on the benchmark rule have been made. For example, several researchers (Woodford, 1999a; Williams, 1999) have suggested introducing inertia. Others have considered incorporating a response to the exchange rate (Ball, 1999; Svensson, 1999) in order to improve on the benchmark rule. In the next two sections I consider these two suggestions for improvement from the perspective of different views of the monetary transmission mechanism.

# 6. How the Monetary Transmission Mechanism Affects Policy Rules with Inertia

Simulation results for policy rules with inertia for nine of the models in tables 1 and 2 (Taylor, 1999a) indicate that the monetary transmission mechanism has a big effect on the performance of such rules. For example, consider the case where $\rho = 1$, $g_\pi = 1.2$, and $g_y = 1.0$. The simulation results show that whether this inertial rule improves performance (in terms of the variability of inflation and output) over the benchmark rule ($\rho = 0$, $g_\pi = 1.5$, and $g_y = 0.5$) depends on the monetary transmission mechanism used in the model. The inertial rule leads to improved performance in five of the nine models in tables 1 and 2 for which results are available: McCallum and Nelson (1999a), Rotemberg and Woodford (1999), the MSR model (Levin, Wieland, and Williams, 1999), the FRB/US model (Brayton and others, 1997a and b), and the TaylorMCM model (Taylor, 1993b).

The same rule leads to poorer performance in two of the models (Ball, 1999, and Rudebusch and Svensson, 1999), with the inertial rule becoming completely unstable for the latter. The two rules cannot be ranked for the other two of the nine models (Batini and Haldane, 1999, and Fuhrer and Moore, 1995).

There is a systematic difference between the monetary transmission mechanism in models for which inertia enhances performance and that in models for which it detracts from performance. A glance at table 1 shows that the difference is not whether the model assumes an open versus a closed economy. Inertia makes things better for both some closed- and some open-economy models, and it makes things worse for some other closed- and some other open-economy models. Nor is the difference in whether the model takes the financial market price view versus the credit view. The key difference, rather, is in the degree of forward-looking behavior. The two models for which performance deteriorates are *not* rational expectations models, whereas the five models for which performance improves *are* rational expectations models. Moreover, in the rational expectations models the long-term interest rate affects spending (through an expectations theory of the term structure; see table 1); they also assume forward-looking behavior in staggered price setting. One might worry that these rational expectations models are too forward-looking, with insufficient rigidities. However, some of the rational expectations models have many backward-looking terms as well. Indeed, the Taylor multicountry model, for which the inertial rule dominates the benchmark rule, has a considerable number of rigidities in wage setting and in the pass-through of exchange rate changes.

That rational expectations are the essential difference explaining the effects of inertial policy rules is bolstered by the fact that things get worse with inertia for all the non-rational expectations models. To be sure, things do not get better with inertia for all the rational expectations models. Both of the models that do not allow a ranking between the two rules (because inflation and output variances move in opposite directions) are rational expectations models. However, both employ a staggered price setting theory in which the rate of inflation rather than the price level is the effective decision variable (see table 2). Although it would be useful to look into this alternative explanation, the comparative results are at least consistent with rational expectations being a necessary, if not sufficient, condition for an inertial rule to improve performance.

There are good theoretical reasons why an inertial rule requires rational expectations to generate an improvement over the benchmark rule. The lagged interest rate in the rule means that interest rates will rise for many periods in the future if inflation does not come back to target. Expectations of such rising interest rates raise long-term interest rates today in a rational expectations model and have an anti-inflationary spending effect, thereby mitigating the need for a rise in future interest rates. In a non-rational expectations model there is no way for these expectations to have a dampening effect, and it is quite possible for the model to become unstable.

Even though the improvement in performance that can come from inertial rules is not robust to the expectations component of the monetary transmission mechanism, it is worthwhile pursuing ways in which using forward-looking expectations can improve monetary policy. If the gains from such inertial policies are great enough, they might even provide more incentives to institutionalize the rules. Moreover, as hinted at in the next series of results, the payoffs may be even greater when the exchange rate is considered in addition to the interest rate.

## 7. The Transmission Mechanism and the Use of the Exchange Rate in Policy Rules

Open-economy issues have not been ignored in the research on policy evaluation. The exchange rate is part of the transmission mechanism in six of the models listed in tables 1 and 2. The exchange rate enters both in the determination of net exports and in the determination of inflation, as changes in the prices of foreign goods are passed through in part to domestic prices. Moreover, there is a link between the exchange rate and the interest rate through the capital markets. In general, the models used for policy evaluation assume perfect capital mobility, by specifying either an ex ante interest rate parity condition or a reduced-form relationship between the real interest rate and the real exchange rate.

Before discussing the implications of the monetary transmission mechanism for the use of the exchange rate in policy rules, it is important to point out that the policy evaluation research that informed my (1993a) proposal for a policy rule did consider the role of the exchange rate. Simulations of my multicountry model and other models (see Bryant, Hooper, and Mann, 1993) led me to believe that if the Federal Reserve reacted strongly to the exchange rate, inflation-output performance in the United States would deteriorate. It was for that reason that I omitted the exchange rate in the rule I proposed in Taylor (1993a) as a guideline for the United States. However, it is clear that the same conclusion would not necessarily be reached for other countries, especially small, open economies. A country's size, openness, capital mobility, market completeness, and elasticities would matter greatly.

Work by Ball (1999) and Svensson (1999) on small, open economy models is therefore most welcome. Ball (1999) proposed a policy rule of the form of equation (2), without inertia but with the exchange rate included, for small, open economies. For his (1999) open-economy model, Ball found that such a rule would improve on the benchmark rule. For example, for the same standard deviation of output (1.4 percent), the interest rate rule that reacts to the exchange rate (with $g_{e0}$ negative and $g_{e1}$ positive) as well as to output and inflation reduces the standard deviation of the inflation rate around its target from 2.0 percent to 1.9 percent (Ball, 1999, p. 134). However, although this illustrates the effect that an open-economy view of the transmission mechanism has on the policy rule, it is not a very big improvement.

Svensson (1999) considers a rule very similar to that of Ball (1999) in a more forward-looking open-economy model. Although the motivation for this rule is not optimality (the rule is not optimal in his model), Svensson (1999) finds that this rule reduces the standard deviation of CPI inflation from 2.1 to 1.8. However, it increases slightly the variance of output, from 1.7 to 1.8, and therefore does not even dominate the benchmark rule. Again it seems that the open-economy aspect of the monetary transmission mechanism is not finding major improvements in the policy rule.

In another study (Taylor, 1999b) I considered the use of such a rule for the European Central Bank (ECB). I simulated my multicountry model to try it out. The exchange rate (*e*) relevant to the ECB is the dollar-euro exchange rate. I found that, compared with the benchmark rule, the rule with the exchange rate rule led to better performance for France and Italy, but had countervailing effects in Germany. Because the ECB does not have the freedom to set different interest rates in the different member countries, the policy rule cannot, of course, be aimed at different countries. However, the bloc of countries participating in European Monetary Union is similar in size to the United States, and findings for this group of countries might not be relevant for smaller open economies.

For comparison I list the policy parameters in equation (2) for these three studies:

| | $g_{e0}$ | $g_{e1}$ |
|---|---|---|
| Ball (1999) | –0.37 | 0.17 |
| Svensson (1999) | –0.45 | 0.45 |
| Taylor (1999b) | –0.25 | 0.15 |

Each parameter has the same sign in all three studies. An appreciation of the domestic currency leads to a cut in the interest rate, followed in the next period by an offsetting increase in the interest rate. In the Ball (1999) model, the negative response is called for because the appreciation is contractionary, and a cut in interest rates offsets this contraction. The positive offset in the next period occurs because the favorable effects of the appreciation on inflation will be followed by unfavorable effects, which will raise inflation and require an increase in the interest rate.

The implication of these simulations is that although an open-economy emphasis on the monetary transmission mechanism makes a difference for policy rules, in practice it does not seem to have a big effect. At least this is so with respect to the current models and the focus on the variability of inflation and output. Taken at face value, the results imply that simple policy rules that focus on a smoothed inflation measure and real output and do not try to react to the exchange rate might actually work well. However, in my view it is likely that the current models probably understate the exchange rate effects in small, open economies and therefore tend to underestimate the costs of exchange rate fluctuations. This suggests the need for future research to look at the effects of exchange rate variability. The costs of such fluctuations may be very high for countries where there is a mismatch of assets by currency or duration (see Eichengreen and Hausmann, 1999) or where there may be large swings in the current account. Moreover, the forward-looking nature of the exchange rate suggests that there may be significant gains from policies that utilize rational expectations in the same way that inertial rules for the interest rate do in the closed-economy models discussed in the previous section.

## 8. Conclusion

The results of this paper can be summarized with three major conclusions. First, some of the biggest and most widely discussed differences in views of the monetary transmission mechanism seem to have only a small effect on the evaluation of simple policy rules. More specifically, within the range of views now represented in quantitative models used for policy evaluation—and that includes financial market price views, credit views, staggered price setting, limited participation, and exchange rate channels—the monetary transmission mechanism seems to lead to very similar choices about simple monetary policy rules. In particular, a simple benchmark rule seems to be robust to all these views about how monetary policy works.

Second, more-complex policy rules that incorporate inertial factors are more dependent on the particular form of the monetary transmission mechanism; in particular, they depend on a rational expectations assumption to improve economic performance. Although this suggests a lack of robustness, the estimated gains in rational expectations models may be large enough to motivate further research on the performance of such rules. Such rules may be particularly useful in small, open economies.

Third, although monetary transmission mechanisms with strong exchange rate channels do affect the choice of policy rule—and suggest the need for the central bank to adjust the interest rate in response to the exchange rate, as well as to inflation and real output—the gains from such rules over simple rules that react only to smoothed inflation and output seem surprisingly small. This result suggests the need for more research on the effect of exchange rate fluctuations on small, open economies, and for policy rules that take account of the forward-looking feature of exchange rates.

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