3

Policy Analysis with a Multicountry Model

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I. Introduction

This paper summarizes the results of an empirical study of alternative international monetary arrangements using a multicountry econometric model. The focus of the research is on monetary policy in the Group of Seven countries: Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States. The general econometric approach used is usually referred to as "rational expectations econometric policy evaluation." The hallmark of this approach is fitting a structural model with rational expectations to real world data, with the effect of different monetary policy rules on the performance of the economy determined by stochastic simulations of the estimated model (for simple models the effect can be calculated analytically).[1]

The issues examined using this approach are controversial and continue to be discussed and debated by leading international economists and policymakers.[2] It is perhaps surprising, therefore, that many of the policy implica-

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[1] This approach was used for the evaluation of domestic monetary policy rules for the United States in Taylor (1979) with a small one-country econometric model. The simulation results described in this paper are drawn from unpublished research contained in Taylor (1988d) using a multicountry econometric model. The two-country theoretical model that underlies the empirical multicountry model used for the simulations is described in Carlozzi and Taylor (1985) and Taylor (1985). An early version of the multicountry model is published in Taylor (1988a). The current version is published in Taylor (1988b) or Taylor (1988c)

[2] See, for example, McKinnon (1988), Dornbusch (1988), and Williamson (1988)

tions of the results of the research appear to be unambiguous and robust. The results suggest, for example, that with the current international economic structure it would be a mistake for Germany, Japan, and the United States to attempt to focus their monetary policies on fixing the U.S. dollar/Japanese yen or the dollar/deutsche mark exchange rates. A strongly preferred option *for internal as well as external stability* would be for each of these countries to orient their monetary policies toward domestic price level targets (or perhaps towards domestic nominal gross national product [GNP] targets in which real output also plays a role). One of the reasons for the lack of ambiguity in this study, compared with other studies of exchange rate regimes, may be that I use empirical measures of demand and supply elasticities and empirical estimates of the sizes of the shocks to the demand and supply curves. Thus, the advantage that one international monetary arrangement has for dealing effectively with one type of shock is assessed and measured up against the advantage that another arrangement has for dealing with other types of shocks. This assessment suggests that a more flexible exchange rate arrangement among Germany, Japan, and the United States measures up quite well, as compared with a fixed exchange rate system.

In discussing these econometric results, it is important to clarify their underlying economic rationale. This paper, therefore, attempts to contrast my findings with those of other researchers who have argued the case for a return to a fixed exchange rate system among the United States, Japan, and the European bloc of currencies. I consider, for example, the arguments of McKinnon (1988) and Krugman (1988). I believe many of the arguments made in favor of one international monetary arrangement or another are implicitly considered in empirical multicountry frameworks, such as the one used here. However, the explicit reason why a monetary policy that focuses away from domestic targets toward an exchange rate target seems to lead to a less than optimal performance has either been downplayed or not mentioned in many recent discussions.

The outline of this paper follows the research strategy used for the policy evaluation. In the interest of brevity and clarity, I report results for only three of the seven major industrial countries: Germany, Japan, and the United States. After summarizing the model in Section II, I examine the question of the exchange rate regime in Section III. As already mentioned, I find that policy rules that focus on fixing the exchange rates among Germany, Japan, and the United States perform poorly. I therefore focus the remaining part of the investigation on policies with more flexible exchange rates. Flexible exchange rate policies in which the central banks adjust their interest rate differential in response to movements of the exchange rates away from a long-run purchasing power parity target turn out to work better than a fixed exchange rate. However, for the United States, such policies do not work as well as a domestically oriented policy, and in Germany and Japan, such a policy does not dominate a price or GNP rule. I then go on to consider rules that focus explicitly on domestic price and output stability. In Section IV, I examine whether the choice of parameters of such rules has much effect on economic performance in other countries. Finally, in Section V, I consider the choice between price rules, nominal GNP rules, and mixed rules. Although the monetary policy rules in Sections IV and V do not incorporate exchange rates explicitly, they are evaluated partly in terms of the stability in the behavior of exchange rates. In general, I find that monetary policy rules that focus on domestic price and output stability generate surprisingly stable exchange rate behavior.

II. Key Features of the Multicountry Model

The seven-country model used for the policy experiments consists of 98 stochastic equations and a number of identities. The parameters of the model are estimated using quarterly data for the period from the first quarter of 1971 through the fourth quarter of 1986. On an equations-per-country basis this is not a large model relative to other models used for monetary and exchange rate policy, and the structure of the model should thus be fairly easy to understand. There is no reason to view this type of model as a "black-box" that only the builders of the model and no one else can understand intuitively. For example, the financial programming model that has been used on an operational basis by International Monetary Fund staff in analysis of developing economies' exchange rates and monetary policy is about the same size as each of the country submodels in terms of number of equations.[3] Moreover, most of the assumptions of the model—perfect financial capital mobility, sticky wages and prices, rational expectations, consumption smoothing, and slowly adjusting import prices and import demands—have been discussed widely during the last ten years. However, because of the assumption of rational and of forward-looking expectations in wage setting, consumption, investment, and portfolio decisions, the model is technically difficult to work with and solve, and this may hinder a more practical understanding of its properties.

To explain how the model works, I find it helpful to stress several key assumptions.[4] In my view these assumptions all have sound economic rationales although they continue to be the subject of research and debate.

(1) *Nominal wages and prices (measured in domestic currencies) are sticky.* The specific model of nominal wage determination is the staggered contracts model that I used in Taylor (1979) and elsewhere. Staggered wage-

[3] See Edwards (1988) for a recent discussion of models used by the IMF in policy analysis for developing economies.

[4] It is beyond the scope of this paper to describe all the equations in detail. The equations of the model used in the simulations are published in Taylor (1988b). A two-country analytical model with the same general structure is described in Carlozzi and Taylor (1985) and Taylor (1985). This two-country model is useful for understanding the workings of the multicountry model.

setting equations are estimated for each of the seven countries separately and the properties of these equations differ from country to country. For example, wages adjust most quickly in Japan and most slowly in the United States. A significant fraction of wage setting is synchronized in Japan, but full staggering of wage decisions occurs in the other countries. Prices are set as a markup over wage costs and imported input costs; the markup is not fixed in that prices adjust slowly to changes in costs. Import prices and export prices adjust with a lag to domestic prices and to world prices denominated in domestic currency units. Because of these lags (and because of imperfect competition and imperfect mobility of real goods and services discussed below), purchasing power parity does not hold in the short run in this model. The lags and the short-run elasticities in these equations differ from country to country, but throughout the model, long-run homogeneity conditions are imposed. Hence, all real variables are unaffected in the long run, after prices and wages have fully adjusted by a permanent change in the money supply.

(2) *Aggregate demand determines production in the short run; if the model were not continually shocked, production would eventually return to an exogenously growing level of "potential" output.* With wages and prices sticky in the short run, changes in monetary policy affect real money balances and aggregate demand and thereby affect real output and employment. Aggregate demand is disaggregated into consumption (durables, nondurables, and services), investment (residential and nonresidential), net exports, and government purchases. Both consumption and investment demand are determined according to forward-looking models in which consumers attempt to forecast future income, firms attempt to forecast future sales, and both reduce spending when the real interest rate rises. Export and import demand respond both to relative prices and to income. In all countries, net exports are significantly affected by relative prices and by changes in income. In all components of private demand (consumption, investment, net exports), there are lagged responses to the relevant variables, but these lags are longer for imports and exports than for the other components.

(3) *Government purchases are considered to be exogenous in the policy simulations, as are all components of fiscal policy; the primary operating instrument of monetary policy is the short-run interest rate.* Throughout this research, each country is assumed to have only one effective instrument of macroeconomic policy: the short-term money market rate, which is adjusted according to the behavior of prices, output, or exchange rates. Focusing on monetary policy and treating fiscal policy as exogenous appears to be a reasonable assumption, given current political realities. We seem to have enough trouble getting the level of fiscal policy right without worrying about countercyclical or exchange rate management as a goal of fiscal policy. Focusing on the interest rate rather than on the money supply also appears to be a more realistic characterization of monetary policy and automatically deals

with velocity shocks.[5]

(4) *Financial capital is mobile across countries, and within each country bond markets are efficient; however, time varying "risk premiums" exist both in foreign exchange markets and in domestic bond markets.* It is assumed that interest rate differentials between countries are equal to the expected rate of depreciation between the two currencies plus a random term that may reflect a risk premium or some other factor affecting exchange rates.[6] The risk premiums are estimated during the sample period and in the policy simulations are treated as exogenous random variables (first order autoregressions) with the same properties as in the sample period. Similarly, the long-term interest rate in each country is assumed to be equal to the expected average of future short-term rates plus a term that reflects a risk premium. This risk premium term is treated as an exogenous, serially uncorrelated random variable.

(5) *Expectations are assumed to be rational.* This assumption seems appropriate for examining more long-run issues such as the choice of an international monetary regime, which one would hope would remain in place for a relatively long period of time. Rational expectations does not, however, mean perfect foresight in these policy experiments. As described below, all equations of the model have stochastic shocks that cannot be anticipated. Hence, forecasts of the future are not perfect. Errors can sometimes be quite large. All we assume is that over the long run, the underforecasts and the overforecasts average out to zero.

(6) *The behavioral equations of the model are subject to continual disturbances, and the average size and correlation of these disturbances is similar to that observed during 1971–86.* This stochastic part of the model is essential to the policy evaluation. The policy question is how different types of policies affect the performance of the economy when hit by exogenous disturbances. Such disturbances are a fact of life: velocity shocks, international portfolio preference shocks, supply shocks, investment shocks, and so forth, can occur in all countries and are probably correlated across countries. Is one policy better than another in ironing out shocks, or does the policy tend to amplify (or cause) such shocks? In this research, the equations are "shocked" in two different ways:

- using a random number generator the equations are shocked with disturbances that have a normal probability distribution with a covariance matrix equal to that estimated for the structural residuals during the sample period, and
- the equations are shocked with exactly the same shocks that were estimated to have occurred during the sample period.

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[5] Indeterminacy of the price level is avoided as long as the interest rate responds to prices as it does for all policy rules considered in this research.

[6] It should be clear that "risk premium" is not the only interpretation of this term. Miller and Williamson (1988) refer to a similar term as a "fad."

The properties of the variance-covariance matrix indicate that there is a significant amount of correlation between the shocks to the different equations (particularly the exchange rate equations and the import price equations) and that the size of the disturbances differs from country to country.[7] Hence, using the full variance-covariance matrix seems necessary. One disadvantage with this approach is that it implicitly assumes that future disturbances will be similar to those in the past. This disadvantage, however, exists with any empirical analysis based on actual data and can be dealt with by sensitivity analysis, that is, by changing the disturbances slightly and observing whether the results change. For example, if one suspected that the shocks to the exchange rate equations (the "risk premium terms") might be reduced significantly if exchange rates were fixed, the simulations could be conducted with and without the risk premium shocks. This approach is followed in the results reported below.

Several technical issues relating to the stochastic shocks are important. First, the shocks were estimated during the sample period by solving the model dynamically, using data through each sample point and using these simulations to substitute out for each expectations variable in each equation. Econometrically speaking, these constitute the structural disturbances to each equation. Second, because the sample size (which equals the number of estimated structural residuals to each equation) is less than the dimensions of the covariance matrix, the estimated covariance matrix is actually singular. Although certain algorithms, in particular the Cholesky decomposition (Faddeeva, 1959, pp. 81–84) for decomposing the matrix for the random number generator, cannot therefore be used, it is possible to make such a decomposition and draw the random numbers in the standard way. Nevertheless, it should be noted that the normal distribution generated randomly is singular. Finally, when actually drawing the shocks to each equation, in each time period it is assumed that the expectation of future shocks is zero (their unconditional mean). These shocks, however, prove not to be zero when the future periods of the simulation occur.

III. Choice of an Exchange Rate Regime

In order to evaluate the performance of a fixed exchange rate regime in comparison with a flexible-rate regime, I first specify the particular type of monetary policy rule used in each regime. Under both regimes the central banks are assumed to adjust their short-term interest rate in response to economic conditions.

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[7] It is beyond the scope of this paper to describe the details of the variance-covariance matrix of the structural disturbances (that is, the relative size of the standard deviation of each shock and the correlation between the shocks). These are discussed in Taylor (1988d).

For the flexible exchange rate regime, the central bank in each country raises the short-term interest rate (the federal funds rate in the case of the U.S. Federal Reserve, the call money rate in the case of the Deutsche Bundesbank and the Bank of Japan) if the domestic price level (the GNP deflator) rises above a given target. Each central bank lowers the short-term interest rate if the price level falls below a given target. (The price targets need not be constant, and in these simulations some trend in the target price is permitted, although the results do not depend on the path for the target price level.) This adjustment of the nominal interest rate is relative to the expected rate of inflation, which is to be the forecasted rate of inflation from the model. Effectively, therefore, the central bank raises the real interest rate in response to deviations from target of the price level. For the first set of results, the response coefficient is assumed to be 1.6; that is, the interest rate is raised by 1.6 percentage points when the GNP deflator rises above the central bank's target by 1 percent. (Recall that this is a quarterly model so that the response rule for each of the central banks refers to quarterly averages.)

For the fixed exchange rate regime, the central banks cannot adjust their interest rates independently. Because of the perfect capital mobility assumption, sterilized intervention by the central banks has no effect on the exchange rate. Hence, in order to keep exchange rates fixed, the central banks must keep their interest rate differentials fixed. In other words, the short-term interest rates in each country must move in tandem, and effectively there is only one interest rate policy for all the central banks. This "world" interest rate policy is also assumed to be a "price rule" in which the interest rates in all short-term markets are moved up and down together depending on the behavior of an average of the price levels in the different countries. In particular, all interest rates are moved up by 1.6 percentage points if a weighted average of prices in the seven countries moves up by 1 percent. We start with weights of 0.3 for the United States, 0.2 for Germany, 0.3 for Japan, and 0.05 for the other four countries. (The high weight for Japan is chosen to ensure relatively good performance in Japan in this first case; alternative weighting schemes are discussed below.) As in the flexible exchange rate regime, the interest rate adjustments are made relative to a forecast of inflation (in terms of the same weighted average of individual country prices) and are, therefore, effectively real interest rate rules.

Table 1 shows estimates of economic performance under the two exchange rate regimes. Each regime is assumed to be in operation for ten years (40 quarters), from the first quarter of 1987 through the fourth quarter of 1996. Each regime is subjected to the same set of stochastic disturbances, except that there are no "risk premium" shocks to the exchange rate equations in the case of fixed exchange rates while such shocks are assumed to remain in the case of flexible exchange rates. This differentiation is an attempt to model the potential for a credible fixed exchange rate system to eliminate volatile shifts in risk premiums between countries. Given these shocks, the main difference be-

Table 1. Two Exchange Rate Systems: Ten Stochastic Simulations and Their Effects on Major Variables

	United States	Germany	Japan
Real GNP			
Fixed	3.5	6.0	8.0
Flexible	2.1	2.8	4.6
GNP Deflator			
Fixed	2.8	4.2	9.1
Flexible	1.3	1.8	4.0
Nominal GNP			
Fixed	5.6	8.7	11.5
Flexible	2.5	3.1	3.9
Short-Term Interest Rates			
Fixed	2.1	2.1	2.1
Flexible	1.9	2.2	4.4
Money (M1)			
Fixed	9.6	11.2	10.9
Flexible	9.2	5.1	6.5
Velocity			
Fixed	10.0	6.6	6.6
Flexible	9.1	5.9	7.4
Dollar Exchange Rates			
Fixed		0	0
Flexible		23.3	19.7
Real Investment			
Fixed	15.6	22.8	22.0
Flexible	10.0	13.0	13.3
Real Exports			
Fixed	6.5	9.3	10.5
Flexible	6.3	9.7	11.3
Real Imports			
Fixed	8.4	10.8	7.9
Flexible	5.5	5.2	7.8
Real Net Exports[1]			
Fixed	1.3	3.2	2.6
Flexible	1.0	2.7	2.7

[1] As a ratio to real GNP.

Note: Each entry shows the standard deviation of the percentage deviation of the variable from the baseline. The policy rule has interest rates responding to prices with a reaction coefficient of 1.6. The weights for each country in the fixed exchange rate case are 0.3 for the United States, 0.2 for Germany, 0.3 for Japan, and 0.05 for the other countries.

tween the macroeconomic performance under the two regimes is that the policy rule is different. In Table 1 these disturbances are drawn from a random number generator as described above. Each 40-quarter period is run 10 times, and the data in Table 1 represent the average performance over these 10 runs. In each case the number in the table is a measure of economic stability; it is the standard deviation over the 40 quarters of the percentage deviation of the variable from a given baseline. High values of these numbers represent a poor performance.[8]

The most striking feature of Table 1 is that the flexible exchange rate system seems to work better than the fixed exchange rate system according to almost all measures of internal economic stability. The volatility of both real output and the aggregate price level is less under flexible exchange rates in all three countries. The volatility of nominal GNP is at least twice as high under the fixed as under the flexible exchange rate system. The individual components of real GNP, especially investment and consumption, also have a smaller variance under the flexible exchange rate system.

Note that the volatility of net exports is slightly reduced under the flexible exchange rate system in Germany and the United States, but slightly higher in Japan. (An examination of real imports and exports individually reveals an improvement in import stability and a slight reduction in export stability for these countries.) These results suggest that the exchange rate is playing some role in helping to achieve stability in the external accounts in Germany and the United States, but the effect is fairly small, or even nonexistent, in Japan. In fact, exchange rates are far more volatile under the flexible exchange rate system; much of this volatility comes from the risk premium shocks. Hence, it is not surprising that the greater flexibility of exchange rates since the early 1970s has not reduced external instability as much as some had hoped.[9] According to these calculations, one should not expect to see a great improvement on the external side. But, on the other hand, external instability should not worsen under flexible exchange rates. Furthermore, there are large gains associated with the reduction in internal instability. On balance, therefore, the flexible exchange rate system works better.

Why Does the More Flexible Rate System Work Better?

There are almost 100 different shocks that cause the economy to fluctuate in the stochastic simulation of the multicountry model. This makes it difficult to explain, intuitively, why the flexible exchange rate system works better.

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[8] This measure would better be described as the root mean square percentage difference of the variable from the baseline. In other words, if there is a non-zero mean in the difference, its square is included in the size of the measures in Table 1. Because the shocks have a zero mean, this difference will be negligible over many stochastic draws

[9] Krugman's (1988) rejection of the flexible exchange rate system is based largely on the absence of improvement in external instability

Open-economy macroeconomic theory suggests that there are advantages and disadvantages to flexible exchange rates. On the one hand, the flexibility of the exchange rate affords the central bank more independence to use monetary policy to stabilize prices and output when the economy is shocked out of equilibrium. Because the structure of different economies varies, the appropriate response of the central banks to shocks may differ. On the other hand, large swings in the exchange rates, which owe either to demand disturbances or to speculative activity in the financial markets, can cause instability in exports and thereby increase both internal and external volatility.

For the set of disturbances considered in these simulations, the gain from monetary independence outweighs the loss associated with exchange rate volatility. The net gain would be even larger if the risk premium shocks remain under the fixed exchange rate system or are smaller under the flexible exchange rate system. But why is the gain from monetary independence so large? And why is the loss associated with exchange rate volatility so small?

The importance of monetary independence is best understood by comparing the policy rule for the central banks under the two exchange rate systems. Consider the Bank of Japan. Under the flexible exchange rate system, the policy rule for the Bank of Japan depends only on the Japanese domestic price level. When the rate of inflation rises in Japan, the Bank of Japan promptly raises the call money interest rate. This interest rate rise reduces investment spending and slows down the growth of aggregate demand, thereby reducing inflationary pressures. When exchange rates are fixed, however, the Bank of Japan cannot raise the call money rate without a coordinated rise in interest rates by the U.S. Federal Reserve and the Deutsche Bundesbank. The policy rule under fixed rates allows for some rise in interest rates because the rise in prices in Japan raises the average of world prices. However, the increase is necessarily smaller than if the Bank of Japan had operated independently. For this model, the ability of the central banks to move independently proves to be important for internal stability. The requirement that the Bank of Japan wait for the U.S. Federal Reserve and the Deutsche Bundesbank to see a rise in world inflation means that the response in Japan is too little and too late. The rise in inflation is not cut off quickly enough, and this apparently leads to a large swing in inflation and an even larger recession later on.

Theoretically, one might argue that fixed exchange rates would serve as guides for domestic prices and money wages, and that with a fixed exchange rate system the kinds of swings in inflation described above would not occur. McKinnon (1988), for example, argues that "with exchange rates known to be fixed into the indefinite future, international commodity arbitrage and mutual monetary adjustment would insure convergence to the same rate of commodity price inflation (preferably zero) in all three countries. Tradeable goods prices (PPIs) would then be aligned close to purchasing power parity and relative growth in national money wage claims would eventually reflect differences in productivity growth. . . ." In my view, this theoretical effect is allowed for in the multicountry model; goods prices are influenced by exchange rates, and the model's long-run homogeneity properties will eventually force nominal wages to reflect productivity growth. The forward-looking behavior of the model allows expectations of future stability of exchange rates to have a particularly strong effect on current prices and wages. But, empirically, the effect is not strong enough. The inertia of domestic wages and prices in these large countries cannot be influenced sufficiently by exchange rates to permit the central banks to postpone or mitigate strong monetary policy reactions when needed (because they are tied to an international monetary policy rule).

Finally, consider the exchange rate fluctuations themselves. The calculations show that these fluctuations are large yet they do not have a large destabilizing effect on net exports. Net exports are even more stable in Germany and the United States under flexible exchange rates. Judging from the parameters of the model, the explanation for this phenomenon is that import prices adjust very slowly to fluctuations in exchange rates and that import demand adjusts slowly to changes in import prices. The small elasticities indicate that the fluctuations in the exchange rates do less damage to the real economy than if the elasticities were large. The low elasticities reflect the actual data for the Group of Seven countries during the period of flexible exchange rates, including the behavior of imports and import prices after the sharp fall in the U.S. dollar in early 1985. Much has been written about why these elasticities appear to be so small; hysteresis in trade and pricing to market are clearly part of the explanation, and the empirically estimated import equations and import price equations in the multicountry model are empirical approximations of these theoretical arguments.

It is interesting that Krugman (1988) focuses on the small effects of exchange rate changes as one reason to move back to a system of fixed exchange rates. The intuitive argument I make is exactly the opposite: according to the model used here, the smaller elasticities are one of the reasons that the fluctuations in the exchange rate are not a cause of external instability. The shorter-term fluctuations in the exchange rate, which are due mostly to shifts in risk premiums, have only small effects on import prices and on import demands. On the other hand, it appears that the longer-run changes in the exchange rate do affect trade flows and can thus achieve some external adjustment. Krugman's (1988) discussion focuses entirely on the problem that flexible exchange rates do not do much for external stability. He therefore rejects the flexible exchange rate system. However, the important gains to internal stability from exchange rate flexibility stressed here must also be taken into account in evaluating the international monetary system.

Nevertheless, the fluctuations in nominal exchange rates shown in Table 1 should not be taken lightly. The arguments made by McKinnon (1988) that such fluctuations can lead to protectionist actions are clearly correct. Two caveats are relevant, however. First, although it is not clear in Table 1, the fluctuations in the exchange rates in the simulations are short term (say, within a year) and are due largely to the risk premium shocks. To the extent that the fluctuations are short term, they might be effectively hedged even with the relatively short-horizon futures and forward markets in foreign exchange. This possibility for hedging is not included in the model and could reduce the real effects of the exchange rate fluctuations even further. Second, there are reasons to believe that the exchange rate fluctuations would be less than shown in Table 1. The policy rule under the flexible exchange rate system treats domestic price stability in each country as an important goal. To the extent that such a rule is credible, the expectation of domestic price stability in each country would lead to expectations of more exchange rate stability. If so, the size and volatility of the risk premiums would clearly be reduced, perhaps to levels far below the last 15 years that are implicit in the stochastic simulations in Table 1.

How Robust Are the Results?

The discussion of the results thus far has focused on a particular policy rule (one with a specific reaction coefficient) and a particular method of calculation (stochastic simulation with a random number generator). Are the results robust to alternative policy rules and to alternative methods of calculation?

Table 2 shows the effects of the two exchange rate regimes on real GNP, the GNP deflator, and the exchange rate when the shocks are the actual structural residuals over 40 quarters of the sample period: the first quarter of 1975 through the fourth quarter of 1984. In other words, it is assumed from these simulations that the shocks to the economy during the period from the first quarter of 1987 through the last quarter of 1996 are identical, and in the same order as the shocks that hit the economy during the late 1970s and early 1980s. Unlike the random number generator, the shocks drawn in this way are not normally distributed; they have a somewhat smaller variance because the effects around the period of the first oil crisis are omitted.

In addition, an alternative weighting scheme for the interest rate reaction function in the case of fixed exchange rates is examined in Table 2. The weight for the Japanese price is raised to 0.5, the weight for the U.S. price is reduced to 0.2, and the weight for the German price is lowered to 0.1.

The results are qualitatively similar to those in Table 1. The variance of the price level and real GNP is less under the fixed exchange rate regime, especially in Germany and Japan, compared with Table 1, but in most cases, the flexible exchange rate regime still shows a better macroeconomic performance. The higher weight for Japan helps Japanese performance but hinders the German and U.S. performance. With a high weight for Japan, the Japanese fixed exchange rate performance can actually beat the flexible exchange rate, but this is at the expense of deterioration of performance in Germany and the United States. The effect of changing the weights on the average price in the

Table 2. Two Exchange Rate Systems: Actual Structural Shocks and the Effect of Changing Weights on the Fixed Exchange Rate Rule

	United States	Germany	Japan
Real GNP			
Fixed (JA = 0.5)	4.1	5.7	3.3
Fixed (JA = 0.3)	4.1	5.4	4.2
Flexible	2.2	3.2	3.4
GNP Deflator			
Fixed (JA = 0.5)	3.4	4.1	1.5
Fixed (JA = 0.3)	3.2	3.8	3.3
Flexible	1.3	1.8	2.6
Dollar Exchange Rate			
Fixed (JA = 0.5)		0	0
Fixed (JA = 0.3)		0	0
Flexible		12.7	11.5

Note: Each entry represents the standard deviation of the percentage deviation from the baseline. The policy rule has interest rates reacting to prices with a reaction coefficient of 1.6. The weights for each country in the fixed rate case are either 0.5 for Japan, 0.2 for the United States, and 0.1 for Germany, or 0.3 for Japan, 0.3 for the United States, and 0.2 for Germany as shown (0.05 for the other countries).

policy rule confirms the intuition stated above about the importance of monetary independence.

The volatility of exchange rates under the flexible exchange rate regime is considerably less for these shocks than for the shocks in Table 1. This is because the risk premium shocks are smaller. This volatility does not appear excessive. Some proposals for target zones for exchange rates (see Miller and Williamson, 1988) have bands that are not much smaller than plus or minus one of these standard deviations.

Table 3 considers two alternative policy rules using the same set of actual structural residuals. In the case examined in Table 1, the reaction coefficient was 1.6. In Table 3, the reaction coefficient is either 1.0 or 2.5. Again, the interest rate reacts to deviations of the price level from some target in these simulations. In these simulations the weight for the Japanese price is 0.3 when exchange rates are fixed.

The results are qualitatively similar to the previous results. Regardless of the reaction coefficient, the macroeconomic performance under flexible exchange rates dominates fixed exchange rates. The change in the reaction coefficient does affect the size of the fluctuations in most cases, but the variances are always smaller with flexible exchange rates.

The results with two other policy rules are also noteworthy. *First*, if the central banks follow money supply rules, rather than interest rate rules, the

Table 3. Two Exchange Rate Regimes: Actual Structural Shocks and the Effect of Changing a Reaction Coefficient

	United States	Germany	Japan
		(reaction coefficient equals 1.0)	
Real GNP			
Fixed	4.4	5.3	4.8
Flexible	2.4	3.3	3.4
GNP Deflator			
Fixed	3.4	3.7	5.1
Flexible	1.4	2.2	3.4
		(reaction coefficient equals 2.5)	
Real GNP			
Fixed	3.9	5.3	4.7
Flexible	2.0	3.3	3.8
GNP Deflator			
Fixed	3.2	3.9	3.0
Flexible	1.1	1.6	2.2

Note: Each entry represents the standard deviation of the percentage deviation from the baseline. The policy rule has interest rates reacting to prices with a reaction coefficient of either 1.0 or 2.5 as shown. The weights for each country under the fixed rate regime are 0.3 for Japan, 0.2 for Germany, and 0.3 for the United States.

relative ranking of fixed and flexible exchange rates remains. This type of policy rule was considered at the preliminary stage of this investigation (see Taylor, 1986). Under the flexible exchange rate system, each central bank followed a constant growth rate rule for the money supply. Under the fixed exchange rate system, the central banks coordinated their monetary policies to generate a constant growth rate for the world money supply (a weighted average of the money supplies in the Group of Seven countries) according to an earlier proposal of Ronald McKinnon. It was generally found that the fixed rate system performed relatively poorly. However, both systems performed worse than with the interest rate rules discussed thus far in this paper. The large velocity shocks with fixed money growth translated into huge interest rate fluctuations, which tended to be destabilizing in either regime. For this reason, I focused my research on policy rules that automatically offset velocity shocks, as with the interest rate rules described above.

Second, the poor results for fixed exchange rates suggest that I also investigate a "leaning against the wind" policy in which the central banks do not commit to fix exchange rates exactly (or within a narrow band), but instead raise interest rates to counteract exchange-rate movements. To investigate this policy, I simulated the model with an interest rate rule in which the differential interest rate between the United States and Japan or between the United States and Germany was adjusted to move the exchange rate toward a given target.

This is similar to the proposal outlined by McKinnon (1988): "To keep the potentially volatile exchange rates within their prescribed bands, the three central banks must control *relative* short-term interest rates. . . ." The problem with this type of rule, however, is that shocks to exchange rates will tend to cause large changes in interest rate differentials. For example, if I simulate such a rule with the exchange rate equations shocked by the same set of shocks as in the flexible exchange rate cases described above, the volatility of interest rates is large (three or four times higher than the pure price rules for the United States and Germany) and does not lead to a better macroeconomic performance. For this type of policy, it does not seem reasonable to set the exchange rate risk premium shocks to zero because some fluctuations in exchange rates would occur. But in the absence of this, an exchange rate smoothing rule will generate large swings in interest rates and the reduction in exchange rate volatility will be small (about 25 percent).

Given the results described here, it would appear best not to focus monetary policy on the exchange rate. In the next two sections I examine a broader policy question: can central banks improve economic performance by choosing a policy rule other than the price rule considered thus far? In answering this question, I will maintain the flexible exchange rate regime and focus the monetary policy rule on domestic indicators.

IV. The Effects of a Monetary Policy Rule on Economic Performance Abroad

The search for better policy rules in the Group of Seven countries would be computationally, if not politically, easier if the choice of a policy rule in one country had little or no effect on economic performance in the other. If so, we could search across policy rules in each country individually and not simultaneously consider reaction functions in other countries.

Table 4 considers this issue. It shows the effect on price and output stability in each country when the policy rule in another country is changed. The policy rules examined in Table 4 are nominal GNP rules. The interest rate is increased or decreased according to whether nominal GNP is above or below a target. Of course, a nominal GNP rule differs from a price rule in that real output appears in the reaction function along with the GNP deflator and with the same coefficient.

The nominal GNP rules in Table 4 have reaction coefficients of either 1.5 or somewhat higher. For example, in the top part of Table 4, Germany and Japan have reaction coefficients of 1.5, and the United States has either 1.5 or 2.5. In the bottom part of Table 4, the United States and Germany have reaction coefficients of 1.5, and Japan has one of either 1.5 or 1.8. The table, therefore, shows what happens to the other countries when either the United States or Japan changes its policy rules. What is most striking about Table 4 is that a change in the policy rule within these ranges has a small impact

Table 4. Effect of U.S. and Japanese Policy Rule Changes on Economic Performance Abroad: Actual Structural Residuals

U.S. Policy Parameter	United States	Germany	Japan
Real GNP			
1.5	1.7	1.7	3.8
2.5	1.5	1.7	3.8
GNP Deflator			
1.5	1.3	2.1	6.1
2.5	1.2	2.1	6.1
Japanese Policy Parameter	**United States**	**Germany**	**Japan**
Real GNP			
1.5	1.7	1.7	3.8
1.8	1.7	1.7	3.3
GNP Deflator			
1.5	1.3	2.1	6.1
1.8	1.3	2.1	5.2

Note: Each entry represents the standard deviation of the percentage deviation from the baseline. The policy rule calls for interest rates reacting to nominal GNP with a reaction coefficient of 1.5 in the United States, Germany, and Japan with higher coefficients in either the United States or Japan, as shown. (The response coefficient is 0.5 in France and the United Kingdom, and 1.5 in Canada and Italy.)

abroad.[10] For example, raising the Japanese reaction coefficient to 1.8 from 1.5 reduces both output and price variability in Japan but has virtually no effect on either Germany or the United States. Even changing the U.S. policy rule has little effect on Germany and Japan.[11]

These results suggest that there is not much need to coordinate the choice or design of monetary policy rules among countries. Of course, it is important for each central bank to communicate with other central banks about what policy rule—at least approximately—is guiding policy.

The robustness of this result is not nearly as well established as the exchange rate results described in Section 1. The evidence presented here pertains to nominal GNP rules only. Similar results are found when we vary the reaction coefficients of price rules, but the effect of more drastic changes—such as changing the functional form of the rule—has yet to be examined.

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[10] A similar result was found in the two-country simulation model of Carlozzi and Taylor (1985). However, stronger cross-country effects were found using a different approach in Taylor (1985).

[11] There is a small effect, but it only shows up in the third significant figure and is rounded off in Table 4.

V. Improvements in Macroeconomic Performance

The results discussed above indicate that, for flexible exchange rate systems, nominal GNP rules that weigh output deviations, as well as price deviations, in the central banks' reaction function frequently perform better than price rules. Compare Tables 3 and 4. For Germany and the United States, macroeconomic stability is improved when these countries use nominal GNP rules rather than price rules. The improvement in real output stability is especially large. Although a similar improvement is not observed for Japan, this finding suggests that by examining a wider array of policy reaction functions we could find improvements in macroeconomic stability.

In principle, the optimal policy objective is to find policy rules for the central bank, out of a general class, that minimize the loss in terms of both internal and external stability.[12] Computationally, such a general search is not yet possible with a nonlinear rational expectations model of the size used for this research. It is still expensive to compute extensive stochastic simulations. For this reason, I take a less ambitious approach.

Rather than optimize across a general class of policies, I examine a more limited class in which both price and real output appear in the interest rate reaction function for each central bank. However, the weights on output and the price level need not be the same. This is a more mixed class of rules than either price rules (where all the weight is on the price level) or nominal GNP rules (where the weight is the same for both price and output).

A summary of the results of this type of research is presented in Table 5. I focus on the stability of real GNP and the price level. The results show that it is possible to improve on either the price rule or the nominal GNP rule in Germany and the United States. Compared with the nominal GNP rule, a mixed rule seems to work better in the United States, but a heavy weight on the price level deviations still seems to work better in Japan. The mixed rule reduces output variability in Japan, but price variability increases somewhat, compared with the price rules. For these simulations the shocks are equal to the actual structural disturbances, and the weight on the price level is higher than the weight on real output (2.5 and 0.8, respectively).

A general conclusion from these results is that placing some weight on real output in the interest rate reaction function is likely to be better than a pure price rule. In addition, a mixed rule is likely to work better than a nominal GNP rule. Finally, all of these rules seem to result in exchange rate fluctuations that are not excessive, even though the exchange rate equations are being shocked by time-varying risk premiums. Although these policies focus the

[12] This is the approach used in Taylor (1979) and Taylor (1985), where formal dynamic optimization methods are employed to find optimal rules for monetary policy in simple linear models.

Table 5. Improvements in Economic Performance with a More Flexible Rule

	United States	Germany	Japan
Real GNP			
Price Rule	2.2	3.2	3.4
Nominal GNP Rule	1.7	1.7	3.8
Mixed Rule	1.7	2.2	3.2
GNP Deflator			
Price Rule	1.3	1.9	2.7
Nominal GNP Rule	1.3	2.1	6.1
Mixed Rule	1.1	1.8	3.2
Dollar Exchange Rate			
Price Rule		12.7	11.5
Nominal GNP Rule		12.7	12.0
Mixed Rule		12.6	11.4

Note: Each entry represents the standard deviation of the percentage deviation from the baseline. The policy rule calls for interest rates to react to both price and output with different elasticities. For the mixed rule, the elasticity for price is 2.0, and the elasticity for output is 0.8 in each country, except the United States where the weight is 2.5 on price and 0.8 on output. For both the price rule and for the nominal GNP rule, the elasticity is 1.5, except in France and the United Kingdom where it is 0.5.

reaction functions on domestic indicators, they have the potential for achieving a surprising amount of exchange rate stability.

VI. Concluding Remarks

The objective of this paper has been to report findings based on the use of a multicountry model for monetary policy evaluation. Unlike much recent policy evaluation with multicountry models, this research focuses on the performance of alternative reaction functions for the monetary authorities, rather than on the effects of one-time changes in the instruments of policy. Evaluating how different reaction functions stand up in the face of exogenous shocks to the economy appears to be a more realistic way to approach many policy problems, certainly questions about the design of the international monetary system.

Some of the results discussed above are more robust than others. The most robust finding, in my view, is that an agreement to fix exchange rates between Germany, Japan, and the United States has serious problems with respect to internal macroeconomic stability and achieves little, if anything, with respect to external stability (that is, the stability of net exports).

An important subject for future research might be to check the robustness of these results in a way that a single group of researchers cannot do by trying the same types of experiments in other multicountry econometric models with rational expectations. The models of Helliwell and others (1988) and Masson and others (1988), as well as a new model being developed at the U.S. Federal Reserve, would be excellent models on which to base a consideration of these policy issues. A comparison of the stochastic simulation results across such models would be a helpful way to assess the reliability of such results for practical monetary policy work.

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