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SIMULATING THE EFFECTS OF SOME SIMPLE COORDINATED VERSUS UNCOORDINATED POLICY RULES

ABSTRACT

Effects of different policy rules are simulated: uncoordinated targeting of the money supply or nominal income, use of monetary policy to achieve coordinated targets for nominal or real exchange rates, and the use of monetary and fiscal policies to hit targets for internal and external balance.

The following conclusions emerge: rules which performed best for some shocks performed poorly for others; monetary policy was ineffective in limiting movements in real exchange rates; unconstrained use of fiscal policy was quite powerful in influencing real variables; and dynamic instability was a potentially serious problem. Robustness to different specifications and to constraints on instruments remains to be examined.

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I. Introduction

Ever since the introduction of generalized floating of exchange rates in 1973, there have been proposals for various policy rules intended to improve the functioning of the international monetary system. Two popular ones are McKinnon's proposal (McKinnon [1984]) for targeting the world money supply and Williamson's proposals for target zones for major-currency exchange rates (Williamson [1983], Williamson and Miller [1987]). There are many related strands to the literature on policy choice, particularly as regards the exchange rate regime. This includes the early literature on optimum currency areas (Mundell [1961], McKinnon [1963], and Kenen [1969]), more recent discussions of the optimal degree of exchange rate flexibility (Frenkel and Aizenman [1982], Boyer [1978], and Henderson [1979]), papers on the theme of rules versus discretion (Fischer [1988]), comparisons of optimal uncoordinated versus optimal coordinated policies in simple macroeconomic models (Buiter and Marston [1985]), and the literature on assignment of instruments to targets and on the policy mix (Tinbergen [1952], Mundell [1962, 1971], and Sachs [1985]). 1/

Though the theoretical literature has succeeded in isolating the factors that are most important in influencing the attractiveness of various policy regimes--ranging from the nature of shocks (real versus monetary), to the structural characteristics of economies (the degree of wage indexation, the degree of capital mobility, the degree of openness,

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1/ For more recent discussion of the assignment problem in the context of floating rates, see Genberg and Swoboda [1987] and Boughton [1988].

etc.), and to the elements of the objective function (stabilizing real output, consumption, etc.), the evaluation of different policy rules is ultimately an empirical question. To date, there have been relatively few examples of the use of empirical models to evaluate different policy rules. 1/ This reflects both some skepticism about the reliability of the models themselves, and a recognition of the very serious methodological problems involved in simulating different policy regimes in standard models. 2/ In this connection, early applications of optimal control theory to empirical macroeconomic models were more successful in isolating implausible features of the models than in yielding insights into policy design (Chow [1980]). Fully optimal rules (or optimal time-consistent rules) also have the disadvantage of being very complex and model dependent, making it less likely that they could be implemented. 3/ Methodological problems relating to regime changes have been most clearly identified by Lucas [1976], who makes the point that the behavior of the private sector will be affected by changes in governments' policy rules.

1/ Some early work, Fischer and Cooper [1973] and Cooper and Fischer [1974], considered monetary and fiscal policy choice in the MPS and St. Louis models.

2/ Friedman [1953] argued early on that, given the imperfections of models, the fine-tuning associated with optimal policies could in the real world destabilize the economy. In addition, there is the issue of the time consistency of the resulting policies; see Kydland and Prescott [1977]. Because a path for policies that is optimal at t may not be optimal at t+1, private agents may not believe that the policies announced at t will actually be carried out. The issue of credibility can be treated in the context of repeated games between the government and the private sector; see, for instance, Barro and Gordon [1983].

3/ Hence the search for simple, robust rules that perform well in all models; see Currie and Levine [1985].

In particular, a change in the policy regime can change the way the private sector forms expectations of important variables.

Recent applications of empirical models to simple international policy rules include Edison and others [1987], Currie and Wren-Lewis [1987, 1988a, 1988b], Taylor [1985a, 1986], McKibbin and Sachs [1985, 1988] and Frenkel, Goldstein, and Masson [1989]. The first two sets of papers use models--namely, the Federal Reserve's MCM and the National Institute's GEM model--in which expectations are of the adaptive, backward-looking, variety. In these models, changes in policy regime have no direct effect on private sector behavior; instead, their effects operate through changes in market prices and in aggregate demand. In contrast, Taylor's model and the McKibbin-Sachs MSG model, and our own work, use models that have forward-looking expectations which are consistent with the solution to the model in future periods. In these models, a change in policy rule will change the relationship between expectations and other endogenous variables.

This paper will evaluate some simple rules for aggregate monetary and fiscal policies using MULTIMOD, a global macroeconomic model developed in the Research Department of the Fund. Unlike the MSG model, whose parameters are calibrated to plausible values and to base period levels for variables, MULTIMOD is estimated using annual data beginning in the mid-1960s. 1/ MULTIMOD also includes all of the industrial countries,

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1/ MULTIMOD is described in Masson and others [1988].

either separately or aggregated with others, and the developing countries; it is thus a closed, global system, unlike the MCM or the Taylor model. Given these features, MULTIMOD is likely to be a useful tool for policy analysis of international monetary arrangements, though we would not suggest that the answers it gives should be taken to be definitive. In the light of the discussion above, it is clearly important to examine the robustness of rules across different, plausible models.

In this paper, MULTIMOD will be used to compare several simple policy rules. We have classified these policy rules into two categories. One set, which we call uncoordinated policies, envisages monetary policy being aimed at either the monetary base or nominal GNP. The second set, which we have labelled coordinated policies, envisages monetary policy being used to target either a real or a nominal exchange rate; coordinated policies also encompass some more ambitious rules that use both monetary and fiscal policies to target both an external variable (either the real exchange rate or the current account balance) and a domestic variable (nominal domestic demand). Policy coordination has been variously defined, for instance: "... a significant modification of national policies in recognition of international economic interdependence" (Wallich [1984], p. 85) and "... agreements between countries to adjust their policies in the light of shared objectives or to implement policies jointly" (Horne and Masson [1988], p. 261). The rationale for regarding the second set of policies as "coordinated" derives from the well-known "N-1 problem" which implies that targets for external variables cannot be set independently. Therefore, targets for nominal or real exchange rates or for current account balances would have to result from some coordination process. Note, however, that the coordination considered here is limited in scope, and should not in particular be confused with joint utility maximization, which is the subject of much of the coordination literature. 1/

Before proceeding to the model simulations, it is useful to consider several methodological issues that have, in our view, received insufficient attention.

The first one relates to the distinction between a policy rule and a path for some target variable. In Edison and others [1987] and Currie and Wren-Lewis [1987, 1988a, 1988b], a model is simulated over a given historical period with a different policy rule than the one which was actually in place; in this way, the modeler can "rerun history." In practice, this involves replacing the policy reaction function in the model with a new policy rule. However, the effect of this new rule depends both on the target that is imposed for that variable relative to its historical path, and on the shocks in the historical data. The effect of the new rule will thus depend on two sets of factors whose effects cannot be disentangled by examining the final outcomes alone. Ex post, it is easy to find a target path that, when simulated with a new policy rule, would have given a better result on the basis of some objective function.

1/ See the papers in Buiter and Marston [1985].

But the relevance for policy of such simulation results is dubious. A preferable procedure is to distinguish the effect of the choice of values for the target variable(s) from the structural part of the new rule--i.e., the response of policy instruments to shocks. In the simulations that follow, the target path is chosen to be the baseline path, and the behavior of each rule in response to shocks is studied explicitly.

The second issue concerns the desirability of stochastic simulations versus historical ones. Edison and others [1987] and Currie and Wren-Lewis [1987, 1988a, 1988b], because they examine a particular historical period, evaluate their policy rules only on the basis of a short sample of drawings for the errors in behavioral equations. The evaluation is, therefore, specific to a particular historical experience. 1/ A more robust procedure is to take many drawings from the joint distribution describing the errors. In what follows, we do simulations both with the historical shocks and with shocks drawn from their estimated distribution. The results should help to indicate which rules perform well in a variety of circumstances.

The third issue is the importance of isolating the influence of shocks to endogenous variables from expectations errors. The latter are properly endogenous, and depend on the policy rule. In the simulations that follow, drawings are made from the joint distribution describing

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1/ Currie and Wren-Lewis [1987] are conscious of this limitation; in order to examine the sensitivity of their results, they look at the behavior in 1985-86 of rules with parameters chosen to optimize the 1975-84 period.

innovations to structural residuals, while expectations errors depend on the particular rule that is assumed for policy. 1/

The rest of the paper is organized as follows. Section II discusses the appropriate methodology for simulating and evaluating alternative policy rules in a model with forward-looking expectations. Section III describes the rationale of each of the policy rules, as well as the precise form that each rule takes in the simulation exercise. Section IV presents the results--first for the single-shock simulations, and then for the full stochastic simulations. Finally, Section V draws some conclusions and outlines a few possible extensions for future work. The detailed procedures used in simulating MULTIMOD outlined are in two appendices.

II. Simulation Methodology

On first thought, it might seem that if one had a "structural" model--in the sense of Lucas and Sargent [1979]--it then would be straightforward to evaluate different policy rules. One might simply simulate the model over the historical period of interest, changing the structure of the model by the substitution of one policy reaction function

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1/ There are, however, at least two cases in which the distribution describing structural residuals might also be affected by the policy rule. First, the errors may contain speculative bubbles that may be more or less important under different rules. For instance, there may be bandwagon effects in exchange rates. Second, if the variances of say, exchange rates and interest rates, change, then unless agents are risk neutral, their demands for assets and goods will change. To the extent that the model does not capture these features, they will be reflected in equation residuals which will not be invariant to the policy regime.

for another. Simulated values could then be compared to the historical data, and outcomes could be evaluated using some implicit or explicit criterion function. The policy producing the best results could then be argued to be the appropriate guide for policymakers.

This is the procedure essentially followed by Edison and others [1987] and by Currie and Wren-Lewis [1987, 1988a, 1988b]. The former paper argues, for instance, that target zones--based on the fundamental equilibrium exchange rates calculated by Williamson [1985]--would have led to "better" macroeconomic outcomes than observed historically since generalized floating. Currie and Wren-Lewis calculate optimal feedback coefficients for various policy rules, and then evaluate the counterfactual if these rules had been in effect in the period since generalized floating. They conclude that, compared to history, the Williamson-Miller [1987] blueprint rule would have led to a substantial pareto-welfare improvement.

Such results are hard to interpret, for several reasons. One pitfall, suggested earlier, is that the models may not be "structural" after all; in that case, the change in policy will not leave unchanged the behavior captured in the rest of the model. In this situation, the model could not be used correctly for policy evaluation--as argued strongly by Lucas [1976] and Lucas and Sargent [1979]. In particular, if the model generates expectations in a mechanistic fashion, then the model will not allow expectations to reflect the change in policy as it should.

Even if a model is structural, it may be difficult to judge the implication of replaying history for future policy. Typically, the model is first constrained to track history exactly by including the appropriate residuals in each behavioral equation; next, the policy reaction function that relates a policy instrument to one or more intermediate or final target variables is modified or replaced. The following step is the key one: specifying values for the target variables. If historical values are specified as the target values, the model will reproduce the historical data exactly; on the other hand, if different values are given, and if deviations from these targets appear in the criterion function, then (almost necessarily) the "new" policy rule will be judged superior because it tries to resist deviations from the targets. In any case, the evaluation of rules will be specific to one historical episode, and to <u>one</u> set of drawings from the residuals.

Moreover, the reasons <u>why</u> a target variable departs from its desired level are not identified in such historical simulations. The deviations from target are the result of a combination of factors: innovations to structural equations, expectations errors, changes in other policy variables, and shocks to exogenous (non-modeled) variables. The evaluation of rules should depend on the relative importance of these factors.

In an earlier paper, 1/ we followed the same procedures as Edison and

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1/ See Frenkel, Goldstein and Masson [1989] hereafter referred to as FGM [1989].

others [1987] and Currie and Wren-Lewis [1987, 1988a, 1988b]: alternative policy rules were simulated by altering the reaction functions for various policy instruments, by imposing target paths that were consistent with those advocated by the proponents of specific rules, and by keeping other exogenous variables at their historical values. Given the forward-looking nature of expectations in MULTIMOD, there was a problem with this methodology: by giving agents knowledge of the future values of exogenous variables, the simulation did not tell us how the economy would respond to shocks. This limited the inferences one could draw from such experiments about the respective policy rules.

There is an alternative procedure that should permit a clearer interpretation of simulation results: it is not tied to a particular historical episode, and it can identify the source of deviations from targets. Conditional on the model being correct, it is possible to identify the innovations to structural residuals in the historical data. This procedure, which is followed in the simulations of MULTIMOD described below, poses the following well-defined question: how would the economy perform under different policy rules, given that innovations to structural residuals are drawn from the same distribution? Such a procedure abstracts from other special factors that may affect the historical data. It also abstracts from the choice of the target value, since the target is just set equal to the value of the variable in the baseline solution to which the shocks are applied. 1/ In short, this procedure provides a more straightforward way to evaluate how a given feedback rule responds to shocks.

In the simulation exercises discussed in Section IV, policy rules are compared by focussing on differences in root mean square errors for major macroeconomic variables (real output, prices, current account balances and exchange rates) relative to an arbitrary baseline. The shocks to the major behavioral relationships in the model are consistent with the estimated covariance matrix. A wide variety of shocks is considered. On the industrial-country side, shocks are applied to the equations for each country's consumption (oil and non-oil), investment, commodity imports, manufacturing export and import volumes and prices, non-oil output prices, and money demand. Shifts in portfolio preferences are also assumed to arise, and to explain deviations from uncovered interest parity; the distribution of these shocks is also made consistent with historical data. Finally, shocks to residuals in equations for developing-country exports of manufactures and their supply of commodities are also generated. The serial correlation properties of the errors and the covariance matrix of the innovations are discussed in Appendix II.

1/ The choice of target levels may depend on other considerations--for instance distortions that may raise measured unemployment or inflation--but are not well captured by macroeconomic models. Moreover, the use of baseline values or targets presupposes a degree of knowledge on the part of the policymaker, concerning such things as the level of capacity output or the equilibrium real exchange rate, that may not in fact exist.

As an alternative to performing stochastic simulations, Taylor [1985a] and McKibbin and Sachs [1986,1988] calculate asymptotic variances of endogenous variables that result from shocks to the errors in the model's equations. While convenient, this procedure is applicable only to linear models. Though MULTIMOD is probably sufficiently linear for coefficients to be little changed from period to period (and hence expectations for the following period can be formed by setting residuals to zero), over the extended horizon that we consider (1988-2044) asset stock accumulations are a potentially important source of non-linearity. Therefore, we have chosen not to linearize the model but rather to use the more computer-intensive technique of stochastic simulations.

III. Alternative Policy Rules

The policy rules that we consider in this paper fall into three groups. The first group is characterized by uncoordinated monetary policies and freely flexible exchange rates. The rules that are compared are money targeting and nominal GNP targeting. The second group encompasses two rules that use monetary policy to limit the flexibility of exchange rates. The first rule is a Bretton-Woods-like regime of nominal exchange rate parities; the second rule is a target zone plan that targets a real effective exchange rate. Whereas the first two groups of rules have assumed that fiscal policy is exogenous, the third group contains rules that use both monetary and fiscal policy to hit domestic and external variables.

1. Uncoordinated rules: money versus nominal income targeting

During the 1970s, many central banks moved from a more discretionary monetary policy to explicit targets for monetary aggregates. Money targeting was seen as a way of avoiding destabilizing fine-tuning, and of counter-acting the alleged bias of central banks to aim for over-full employment. In a well-known article, Poole [1970] showed that in the face of shocks to the IS curve, stabilizing the nominal money supply stabilizes output. In contrast, if shocks are primarily to money demand, the appropriate policy is to accommodate them, and to stabilize interest rates.

The widespread evidence that money demand had shifted in the early 1980s as a result of financial innovations and of deregulation led to disenchantment with monetary targeting. Concern for the inflationary consequences of pegging interest rates led to a search for another nominal magnitude that could serve as an intermediate target. Tobin [1980] argued that nominal GNP had several advantages over monetary aggregates: it was less sensitive to the shocks facing money demand, and it was not affected by the positive relationship between velocity and the nominal interest rate. The latter feature of money demand could lead to a fall, rather than a rise, in real interest rates in the face of an inflationary shock. The disadvantage of nominal GNP targeting, however, is that hitting a preset nominal GNP path exactly implies a linear, one-for-one tradeoff between changes in the price level and output (Fischer [1988], p. 17).

Moreover, although both monetary and nominal GNP targeting are susceptible to the problem of instrument instability (Holbrook [1972]), the problem is thought to be most severe for nominal GNP targeting. Consider the case where the short-term interest rate is the instrument for hitting a target for nominal GNP. The lags in the effects of interest rates on real activity and prices are likely to be "long and variable", and contemporaneous effects to be small. An attempt, therefore, to hit a given target in the current period will require the central bank to respond to shocks with very large movements in interest rates. In subsequent periods, these interest rate movements will have much larger effects on nominal income. In the absence of further shocks, interest rates will therefore have to move in the opposite direction, possibly by more than their initial change. The bottom line is that there is clearly the potential for undesirably large--even explosive--movements of policy instruments.

The following algebraic example may make the basic point more concrete. Suppose that nominal income, Y, responds to the interest rate, R, according to the following reduced-form relationship:

$$Y = - aR - bR_{-1} + u \qquad (1)$$

where a, b > 0 and where u includes the effects of all other exogenous variables and shocks. Forcing nominal income to track exactly some target path, $\bar{Y}$, would imply the following reaction function for monetary policy:

$$R = (u-\bar{Y})/a - (b/a)R_{-1} \qquad (2)$$

If the contemporaneous effect of interest rates is smaller than the lagged effect, so b/a is greater than unity, then this reaction function implies an unstable, oscillatory pattern for R in response to a shock to Y. Even if $b/a < 1$, it is still the case that there is overshooting of interest rates; that is, in response to a permanent positive shock δ, the interest rate money moves more on impact (dR_0) than in the long run ($d\bar{R}$):

$$d\bar{R} = \delta/(a+b) < dR_0 = \delta/a$$

In order to avoid both instrument instability and overshooting, the central bank could choose not to achieve its target period-by-period. Instead, it could adjust the interest rate gradually to the level consistent in the long run with the nominal income target; for instance,

$$\Delta R = \alpha(\bar{R}-R_{-1}) \qquad \text{(where } 0 < \alpha < 1\text{)} \qquad (3)$$

Alternatively, it could simply resist moments of nominal income away from its target:

$$\Delta R = \beta(Y-\bar{Y}) \qquad \text{(where } 0 < \beta < \infty\text{)} \qquad (4)$$

The interest-rate rule in equation (3) is guaranteed to produce a <u>smooth</u> adjustment in response to a shock to u; substitution for $\bar{R}$ in (3) yields:

$$R = \alpha(u-\bar{Y})/(a+b) + (1-\alpha)R_{-1} \qquad (5)$$

In contrast, depending on the value given to β, the interest-rate rule in equation (4) may also involve problems of instability or oscillation. Substitution for Y in (4) yields:

$$R = \beta(u-\bar{Y})/(1+\beta a) + [(1-\beta b)/(1+\beta a)]R_{-1} \qquad (6)$$

The coefficient on lagged R has to be greater than -1 to rule out instability; this will be true if and only if

$$\beta b < \beta a + 2 \tag{7}$$

To rule out oscillations, we require the stronger condition that the coefficient on lagged R be greater than zero; this is the case if

$$\beta b < 1 \tag{8}$$

In complicated models it is however not straightforward to calculate appropriate values of the feedback parameters. In implementing various policy rules, we have therefore proceeded by trial and error to establish reaction functions of form (3) or (4) that: (i) permit the tightest control over target variables; and (ii) do not simultaneously produce either large swings in instruments or dynamic instability more generally. When interest rates were used to target nominal GNP, or the real exchange rate, or domestic demand, the feedback parameters had in particular to be carefully set. 1/

2. Simple coordinated rules: real and nominal exchange rate targets

Target zones for real effective exchange rates, to be defended through changes in monetary policies, have been proposed by Williamson [1983] in order to limit exchange rate misalignments and associated current account imbalances.

> "The basic focus of exchange rate management should be on estimating an appropriate value for the exchange rate and

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1/ Concern for instrument instability also influenced the way money targeting is specified in the model. The standard version of MULTIMOD includes a reaction function that makes changes in interest rates a function of the gap between the long-run demand for base money and its target. This specification is admittedly a stylized representation of monetary policy, but it has the advantage of being simple and transparent.

> seeking to limit deviations from that value beyond a reasonable range [p.47]... While other techniques, like sterilized intervention, may be able to give limited assistance, a serious commitment to exchange rate management leaves no realistic alternative to a willingness to direct monetary policy at least in part toward an exchange rate target." [p. 56]

We use a similar monetary reaction to the one employed by Edison and others [1987] to simulate target zones, but augment it with a term that resists movements away from a target for the aggregate nominal GNP of industrial countries. 1/ In the absence of such a term, or of some other way of providing a nominal anchor to the system, real exchange rate targeting does not have any mechanism for ensuring price stability (see Adams and Gros [1986]).

3. Coordinated monetary and fiscal policy rules: the Williamson/Miller "blueprint" and reversed assignment

Williamson and Miller [1987] have proposed a "blueprint" for international monetary reform that goes beyond the original target zone proposal by supplementing the rule for monetary policies with a fiscal policy rule that uses government spending to target domestic demand in each of the major industrial countries. In addition, in order to avoid inflationary or deflationary pressures and to provide a nominal anchor for the price level, they proposed that the average level of interest rates be shifted up or down depending on whether industrial-country nominal income exceeds or falls short of a target for nominal demand.

1/ Such a mechanism forms part of Williamson and Miller's [1987] "extended target zone scheme"--discussed in more detail below.

Some have argued, however, that Williamson and Miller have the answer to the assignment problem upside-down. Specifically, Genberg and Swoboda [1987] and Boughton [1988] reason that if the concern of external balance is to limit the magnitudes of current account surpluses and deficits, then monetary policy should not be assigned to external balance because it has only small and ambiguous effects on the current account. The intuition here is that a monetary expansion will stimulate demand (which will tend to worsen the current account), but also depreciate the currency (which will tend to improve it). The net effect could be either positive or negative. In contrast, the expenditure-reducing and expenditure-switching effects of fiscal policy reinforce each other: a fiscal contraction will decrease spending on foreign goods (improving the current account), and will also--at least for countries facing perfect capital mobility--be associated with currency depreciation (which likewise strengthens the current account).

Following the principle of effective market classification which says that each policy instrument should be assigned to the target on which it has the largest effect, a "reversed assignment" would pair fiscal policy with the current account and monetary policy with domestic demand growth. According to its supporters, this revised assignment would limit external imbalances, while at the same time leaving scope for domestic stabilization and anti-inflation policy. 1/

IV. Simulation Results

We first consider the behavior of each of the rules in response to individual shocks (i.e. to shocks to individual residuals). Each shock is assumed to be unanticipated when it occurs, and to be an innovation that applies to a single period. Though temporary, such shocks will nevertheless have persistent effects because errors in the model are serially correlated and because the various structural equations of the model contain dynamic effects. 2/ Expectations are assumed to be formed in the model in a way that properly takes into account the subsequent dynamics; that is, once the shock has occurred, perfect foresight is assumed to prevail.

The results from single shocks do not of course allow a complete

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1/ The literature on assignment of instruments to targets will not be surveyed here; it is well known that, depending on the slopes of excess demand schedules, a particular assignment may be stable, while another may be unstable. For instance, Kenen [1985, p. 654] shows that in a very open economy with a marginal propensity to import larger than its marginal propensity to save, the conventional assignment of exchange-rate policy to external balance and expenditure policy to internal balance will be unstable.

2/ Error properties are discussed in Appendix II. The standard version of the model (Masson and others [1988]) ignores this feature. Two other modifications to the standard model were made for the purposes of the simulations reported in this paper: the stock of debt owed by developing countries was made exogenous, and tax rates in industrial countries were made more responsive to government debt accumulation.

evaluation of policy rules. In general, the relative variance of different kinds of shocks should influence the choice among policy rules. 1/ Nevertheless, single-shock exercises can be useful because they allow a characterization of when particular rules are likely to perform better than others.

As suggested earlier, we follow the single-shock simulations with some stochastic simulations under which errors are consistent with their estimated distribution. One advantage of these stochastic simulations is that the variances of the shocks reflect their relative importance. A formal ranking of the policy rules would require an explicit objective function that specifies the weights to be given to output fluctuations, inflation, and to other objectives. We do not attempt to provide such a ranking, but rather suggest some strengths and weaknesses of each of the rules.

1. The form of the reaction functions

As a prelude to the simulation results, it is necessary to specify exactly how we implement the various policy rules in MULTIMOD. In brief, implementation took the form of imposing reaction functions for the short-term interest rate, assumed to be the instrument for monetary policy, and for real government spending on goods and services, assumed to

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1/ Poole [1970]; see Henderson [1979] for a treatment of the open economy case.

be the fiscal policy instrument. 1/ Details of the feedback rules are given in Appendix I.

The form of the policy rules requires some explanation in that there is inevitably some element of arbitrariness in the way they are specified. In general, we have attempted to follow as closely as possible the intentions of their advocates. The final form chosen resulted from some experimentation that identified inadequacies with alternative specifications or with feedback parameters. 2/

Rule (1), for money targeting, used the same specification as in the standard version of MULTIMOD. Exactly achieving a money target would produce large swings in short-term interest rates. For that reason, the model includes an equation in which interest rates equate the long-run

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1/ Equivalently, the monetary policy instrument could be considered the domestic component of the monetary base; however, this variable does not appear explicitly in the model. An additional fiscal instrument, a tax rate, is already endogenous to the model, and is assumed to change in order to assure the government's long-run solvency. Tax rates in the model depend positively on deviations of both the government debt to GNP and the deficit to GNP ratio from their baseline values, with coefficients chosen to stabilize the debt ratio without causing oscillations. (See Masson and others [1988]). Different parameter values for this reaction function could also affect the properties of the policy rules considered for interest rates and government spending.

2/ For some parameter values, target zones, nominal income, blueprint, and reversed assignment simulations became explosive and could not be made to converge. However, it is possible that other combinations of parameters could have been simulated. For instance, under reversed assignment a tighter control of domestic demand could have been achieved if current account targeting had been made less precise. In the light of the discussion in Kenen [1985], it is also possible that the assignment of targets to instruments should depend on the degree of openness of the economy, in order to avoid instability; such hybrid systems have not been explored here, however.

demand for money, conditional on observed GNP, with the money stock target.

Nominal GNP targeting, rule (2), was specified in terms of a target for the level of nominal income, rather than its rate of change, because of the potential instability from targeting the latter discussed in Taylor [1985b]. Some experimentation with feedback coefficients led to a value which yields a flatter aggregate demand schedule (in real output, price space) under nominal income targeting than under money targeting, again as in Taylor [1985b].

Fixed nominal exchange rates, rule (3), were implemented by putting a large feedback coefficient on the deviation of the actual from the targeted nominal rate in the equation for short-term interest rates. Variations of exchange rates are thereby kept within narrow margins. It should be stressed that there is an asymmetry in the implementation of this rule as between the United States and other industrial countries. The latter are assumed to subordinate their monetary policies to maintaining dollar parities, while the United States is assumed to target monetary aggregates independently of exchange rate considerations, thereby providing a nominal anchor for the system.

Target zones, rule (4), follow as closely as possible the guidelines described in Williamson and Miller [1987] and simulated earlier (using the MCM model) by Edison and others [1987]. We experimented with various values of the feedback coefficients in order to achieve the closest control over the targets without producing explosive behavior in the model. As in Edison and others, there is nothing that ensures that the real exchange rate will not in fact depart from the zone (if shocks are large enough). As described in Williamson and Miller [1987], a target for the level of world nominal income serves as the nominal anchor for prices. Note however that it is the level, not the rate of change, of world nominal income that appears in our equation; 1/ the latter is subject to the criticisms made by Taylor [1985b] for domestic targeting and did in practice produce problems of non-convergence in MULTIMOD. The feedback coefficient on world nominal income implies that a 10 percent deviation from baseline raises world interest rates by 1 percentage point.

The extended target zones or "blueprint" proposal, rule (5), contains a policy reaction function for government spending as well as the target zone assignment of monetary policy to the real exchange rate. The equation that endogenizes fiscal expenditures is a feedback rule that aims to close a gap between domestic absorption and its target value. 2/ This rule does not hit domestic absorption exactly, but with the feedback coefficient that is imposed, deviations from absorption targets are typically small.

In implementing reversed assignment, rule (6), we have specified that the short-term interest rate responds to the proportional gap between

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1/ Williamson and Miller [1987] are not specific as to the form that this term should take.

2/ The reason that absorption, and not GNP, is targeted by fiscal policy is that external imbalances in the form of current account surpluses and deficits should be lessened by such a rule, supplementing the role of the real exchange rate.

nominal absorption and its target, while government spending responds strongly to the gap between the current account (as a ratio to GNP) and its target. Instrument instability does not seem to be a problem in the latter case; indeed, in principle, the feedback coefficient could be infinite, forcing deviations of current balances from targets to zero. However, the conclusions derived from the simulations are unlikely to be sensitive to the small deviations from current account targets that result from our specification. If anything, our simulations probably give too much weight to current account targets and not enough to nominal demand targets, and closer control of the latter might have been possible otherwise.

2. Simulations of individual shocks

Four individual shocks are considered:

a. an aggregate demand shock in the United States: a positive innovation in consumption equal to 1 percent.

b. an aggregate supply shock in the United States; in particular, the residual in the equation for the rate of change in the non-oil GNP deflator is increased by 2 percent.

c. a shift in demand towards U.S. goods, equal to 10 percent of U.S. exports.

d. a portfolio preference shift out of U.S. dollar assets, leading to an increase in the required rate of return on dollar assets by 10 percentage points.

Each of the rules is simulated subject to each of the four shocks, one at a time. The results are portrayed in Charts 1 to 4. 1/

The aggregate demand shock, namely a one percent increase in U.S. consumption, 2/ has quite different effects under the different policy rules (Chart 1). Absent any policy changes, such a shock will increase output and put upward pressure on prices, as well as appreciate the real exchange rate and lead to a decline in the current account. It also generates positive spillovers for the output of other countries. Since nominal GNP rises, as does the demand for money, both uncoordinated rules cause interest rates to rise; given the relative steepness of the aggregate demand curves, output and price increases are more moderate with nominal income targeting than under monetary targeting.

Under target zones, the real appreciation of the U.S. dollar leads to a smaller rise in interest rates in the United States than in other industrial countries. However, by limiting the interest rate increases in the United States in response to a demand increase, this rule builds in inflationary pressures, which persist longer than for other rules. Fixed nominal exchange rates yield a similar outcome. In contrast, the extra degree of freedom accorded by fiscal policy in both the blueprint and the reversed assignment rules allows the aggregate demand shock to be almost

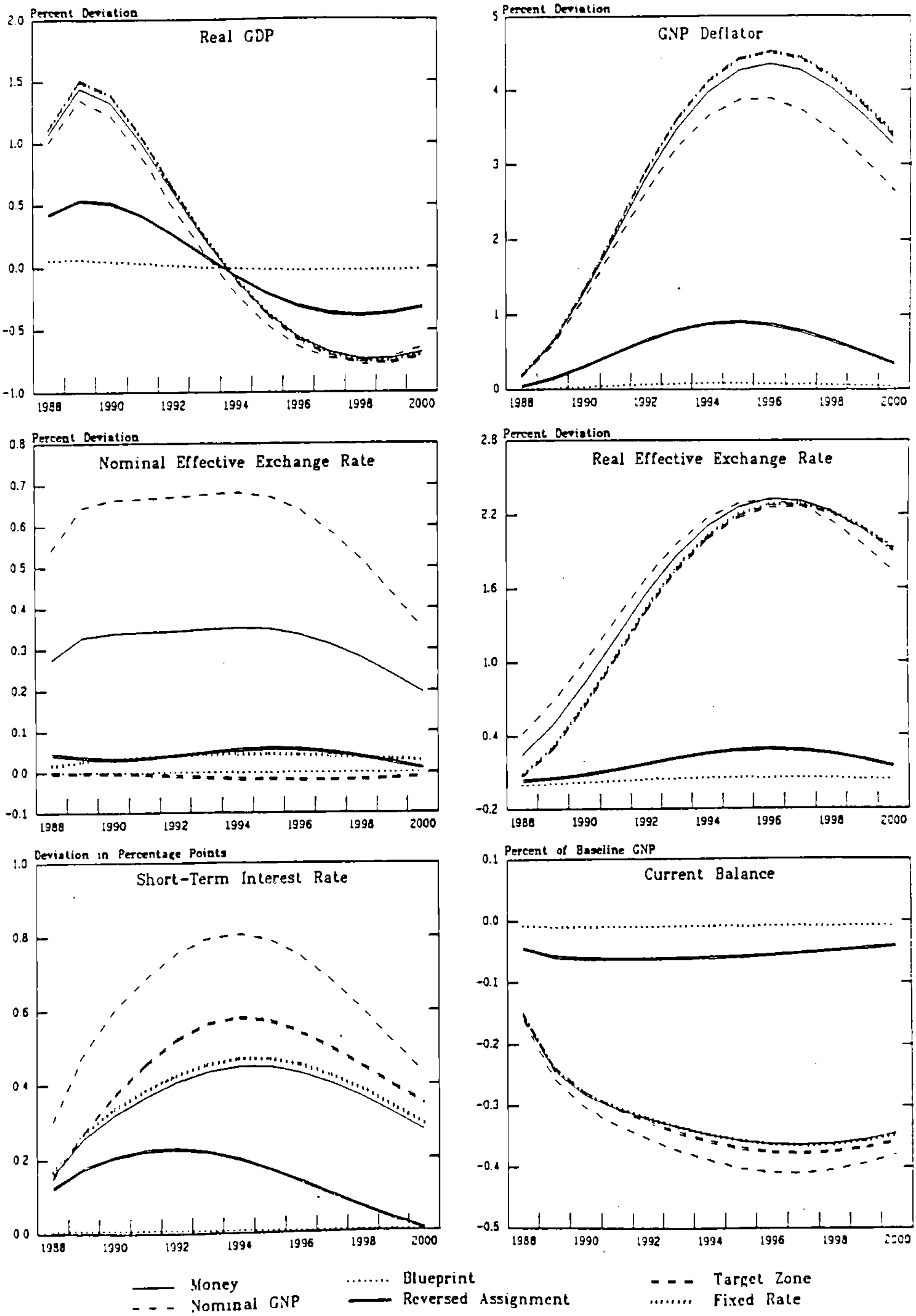
1/ The money, nominal income, target zone, and blueprint results are the same as those presented in FGM [1989]. In addition, there are two new rules, fixed rates and reversed assignment.

2/ The error in this equation has a serial correlation coefficient equal to 0.148, so that roughly 15 percent of the shock persists into the second year, 2 percent into the third year, etc. See Appendix Table 1.

Chart 1

Shock to U.S. Consumption

Deviations of U.S. Variables from Baseline



completely offset by lower government spending. As a result, the output, price and real exchange rate effects are smallest for these two rules. A comparison of the blueprint with the reversed assignment rule illustrates the relative effectiveness of monetary and fiscal policies. Government spending cuts can easily offset the effects of increased consumption on absorption, allowing the blueprint rule virtually to neutralize the shock. In contrast, control of nominal absorption through the interest rate is not as powerful, at least for values of feedback coefficients that do not produce large swings in interest rates or other variables.

The negative aggregate supply shock (or cost-push inflation shock) likewise yields a variety of responses (Chart 2). This shock has persistent effects because of considerable stickiness in the inflation process. 1/ In response to this stagflationary shock, nominal GNP targeting leads to a greater response of interest rates, and hence to greater short-run output losses but smaller increases in prices, than money targeting. Which of the two is preferable depends on the tradeoff between the two objectives of output and price level stability, as well as on the discount rate that captures intertemporal tradeoffs. 2/ Given the very small effects on exchange rates under all rules, fixed rates produce similar results to uncoordinated money targeting.

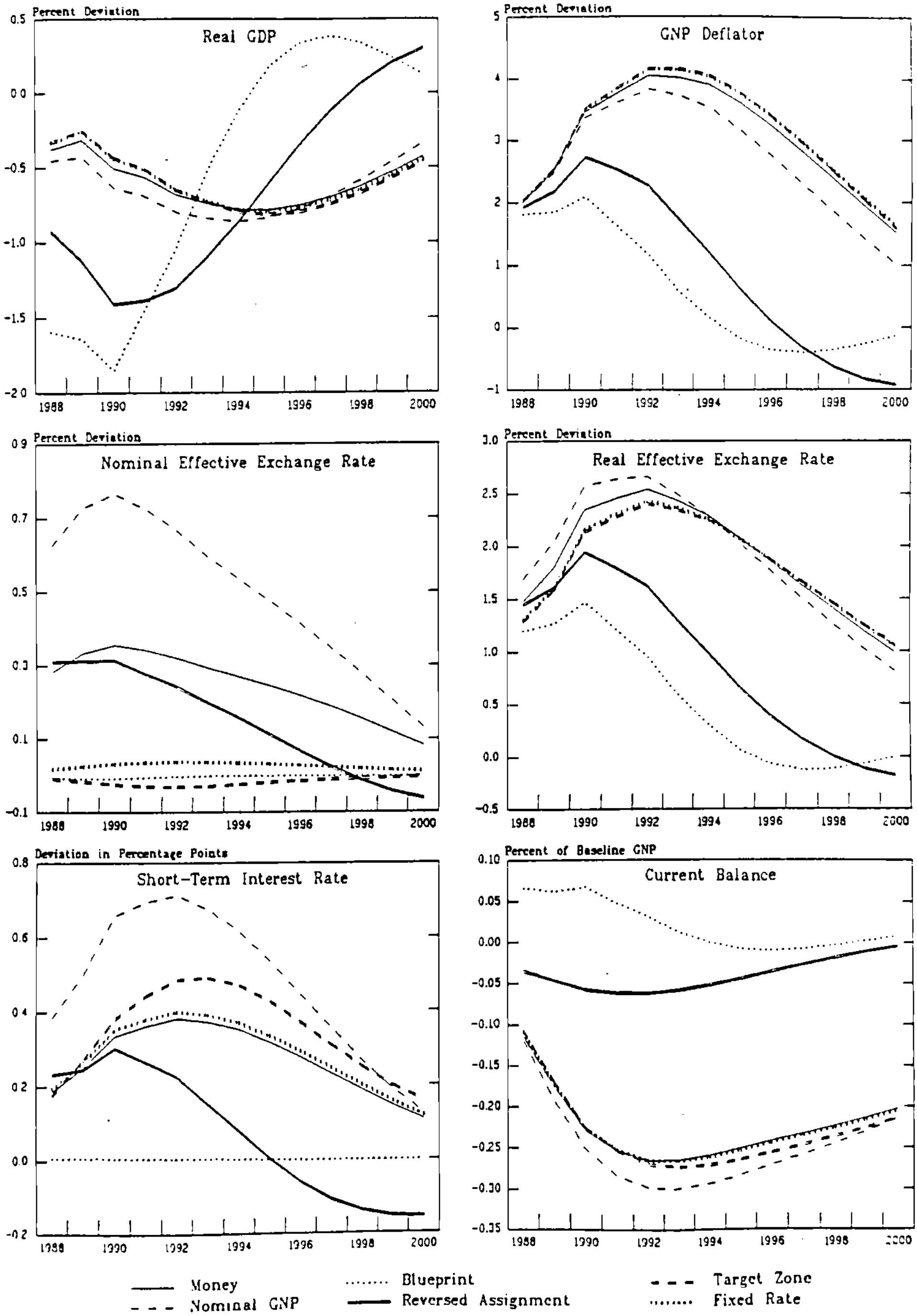
1/ The error in the equation for the rate of change in the non-oil output deflator is in fact negatively serially correlated, however (Appendix Table 1).

2/ As shown in Buiter and Miller [1982], if the model has a natural rate property then the cumulative output losses resulting from different disinflation policies are the same, when discounting is ignored.

Chart 2

U.S. Aggregate Supply Shock

Deviations of U.S. Variables from Baseline



The responses under target zones and blueprint rules are another story. Using monetary policy to counteract the real appreciation of the U.S. dollar requires lower, not higher, U.S. nominal interest rates. However, for both the target zones and blueprint rules there is an additional term that tends to raise interest rates in all countries if world nominal income grows too fast, which is the case here. The end result with target zones is that U.S. interest rates rise, but by somewhat less than interest rates in other industrial countries. Price level increases continue longer, and are larger in the medium-term, than for any other policy rule. It is also the case that interest rates have to continue increasing for six years in response to a purely transitory supply shock because of the inertia in the inflation process.

In contrast, interest rates have to rise much less under the blueprint rule because government spending contracts, helping to limit the real appreciation of the dollar. The contraction of government spending is required because the increase in U.S. prices yields an improvement in the terms of trade, which raises real disposable income and stimulates consumption. Though the net effect on output is negative in the short run, output is actually higher after seven years, by which time prices have returned to their baseline levels. It is clear that an aggregate supply shock causes a dilemma for target zones because one instrument, monetary policy, has to wear two hats--resisting inflationary pressures and limiting appreciation of the real exchange rate (in the country experiencing the shock). 1/ The reversed assignment rule behaves much like the blueprint: both yield relatively small current balance effects.

Chart 3 illustrates the effects of an expenditure-switching shock that corresponds to a shift towards U.S. goods and away from other countries' goods. The positive shock to U.S. exports of 10 percent shows up in lower exports of other countries in proportions that correspond to their shares in world trade. 2/ The U.S. current account improves by some 0.6-0.7 percent of GNP in the first period under all rules except reversed assignment, for which the current account change is smaller. For all policy rules, U.S. real output rises initially, and price increases are small. Neither real exchange rates nor industrial- country nominal GNP change much, so there is little effect on interest rates under either fixed rates, target zones, or the blueprint.

In contrast, under the reversed assignment rule, the increase in the U.S. current balance leads to increased U.S. government spending, adding to the stimulus to U.S. output; conversely, government spending declines in other countries. Higher U.S. nominal GNP has to be resisted by higher U.S. interest rates, so that shifts in preferences between countries' goods lead to a shift in the monetary/fiscal mix under reversed

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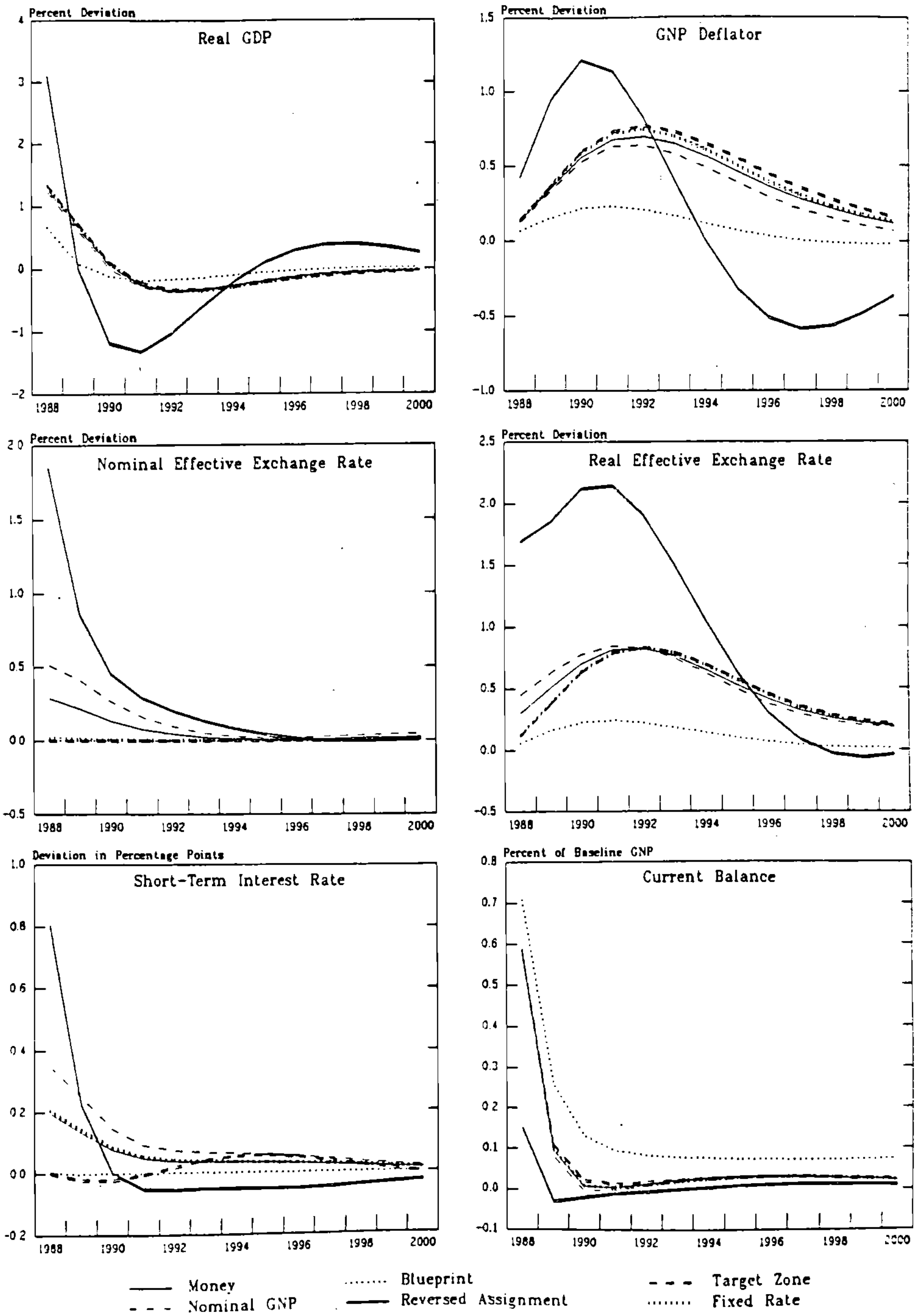
1/ If there is no feedback of inflation on monetary policy--such as through world nominal income--then the target zones rule cannot be simulated, given the absence of a nominal anchor.

2/ The shock is distributed using the weights that serve to allocate the world trade discrepancy in MULTIMOD. As a result, the shock to the United States is also reduced by the U.S. share, so that U.S. exports rise on impact by about 8.6 percent, not the full 10 percent.

Chart 3

Shock to U.S. Exports

Deviations of U.S. Variables from Baseline



assignment--to tighter monetary/looser fiscal policy in the country facing the increase in its exports, and conversely for those facing lower exports. The contrast between this rule and the others has been heightened by the large feedback coefficient on the current balance: attempts to exert tight control over the current account lead to large swings in other variables under reversed assignment.

The exchange rate shock (Chart 4) puts downward pressure on the dollar relative to the yen, to the deutsche mark, and to other industrial country currencies. The initiating factor is assumed to be a 10 percent increase in the required return on dollar assets. 1/ Output effects are largest under reversed assignment and under the two uncoordinated rules (money and nominal GNP targeting)--and are smallest under the blueprint rule and fixed rates. The exchange rate always overshoots except under fixed rates, with the U.S. nominal effective exchange rate depreciating by about 15 percent in the first year. Under target zones, despite an initial increase of 6 percentage points in the short-term interest rate, the real effective exchange rate still depreciates considerably. Moreover, the behavior of the GNP deflator suggests that target zones can generate price level instability--a point we return to below in the context of stochastic simulations. Under reversed assignment, government

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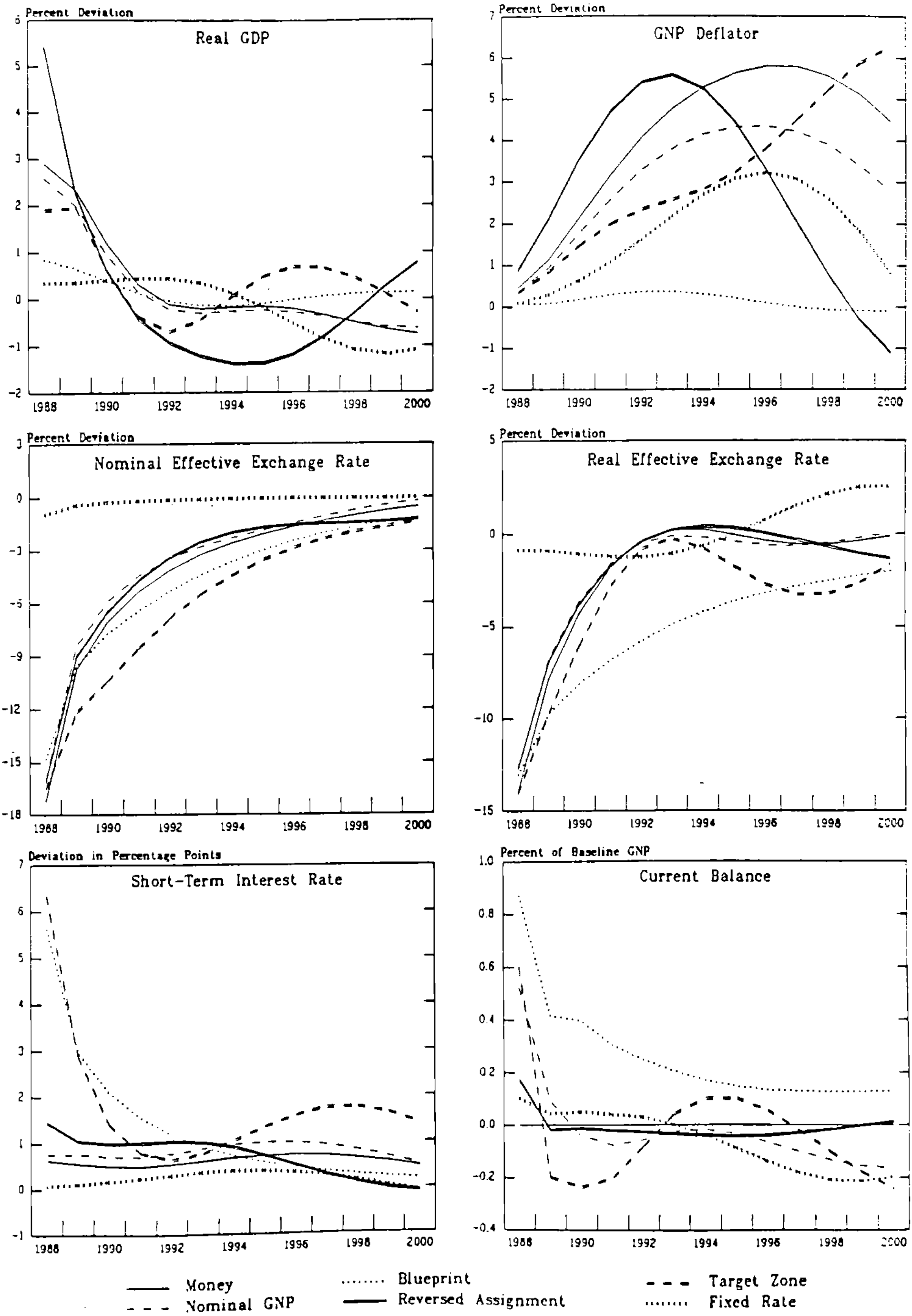
1/ As in the historical data, the risk premium shocks are quite persistent (due perhaps to speculative bubbles as well as shifts in portfolio preferences), with serial correlation coefficients equal to 0.43 for shocks to interest parity between the United States and Japan, and 0.75 between the United States and Germany.

Chart 4

Shock to the Value of the U.S. Dollar

Deviations of U.S. Variables from Baseline



spending rises because of the improvement in the U.S. current account; again, this tends to induce large movements in output.

A money demand shock was also examined. The results are not plotted because they are simple to describe. It is only in the case of money targeting that the money shock has any significant effect on policy settings and on other endogenous variables (there is a small effect of the money shock on consumption because money is a component of net wealth, but the magnitude is negligible). Under money targeting, the positive innovation to money demand leads to temporarily higher short-term interest rates, and as a consequence, to lower economic activity for a time. Other policy rules ignore the money demand shock and maintain policy instruments unchanged, allowing macroeconomic variables to remain at their equilibrium levels. This points up the superiority of these rules in the face of money demand shocks, an argument that has long been emphasized by advocates of nominal GNP targeting (Tobin [1980]).

3. Stochastic simulations

Simulations of individual shocks, though instructive, do not lend themselves to easy generalizations because no rule dominates the others for all kinds of shocks. It is clear that monetary policy rules (assumed to be credible, and fully understood by the private sector) are relatively ineffective, especially in affecting real variables. Rules using fiscal policy therefore have clear advantages in offsetting shocks, though the assumed flexibility for fiscal policy may be unrealistic. In addition, the proper assignment of monetary and fiscal policies to internal or external balance depends on the nature of shocks. We now turn to simulations where the variances of the shocks reflect their relative importance. Moreover, instead of applying shocks for one period only, we apply shocks in successive periods. By looking at a sufficient number of years, the model should provide useful information about the variances of endogenous variables under the alternative policy rules.

The simulations are performed on the assumption that expectations are formed rationally. The shocks (by definition) are unanticipated at the time they occur. In this context, rational expectations of variables in future periods are formed taking the expected value of those shocks--namely zero. 1/ In each period, however, a drawing is made from the covariance matrix describing the shocks. The realized values of endogenous variables are affected by the shocks, and in general will differ from the expectations for those variables formed in previous periods.

The stochastic simulations involve multiple simulations. Not only is it necessary to iterate to a terminal date in order to force expectations to be consistent with the model's solution conditional on information available to time t, but it is also necessary to redo the process each time a new drawing of shocks is made.

In the first set of stochastic simulations, for which root mean square deviations from baseline are presented in Table 1, we use a drawing

1/ In fact, the model has to be linear for this to be fully consistent with rationality.

Table 1. Root Mean Square Deviations from Baseline for Various Policy Rules, Historical Shocks

	Policy Rule						
	Money targeting	Nominal GNP targeting	Fixed Rate (1)	Fixed Rate (2)	Target Zone	Blueprint	Reversed Assignment
U.S. variables							
Real GDP 1/	3.6	3.2	3.0	2.8	2.7	1.4	7.9
Inflation	3.0	2.3	3.4	3.0	1.7	0.8	3.2
Current Balance 2/	0.7	0.7	0.6	0.6	0.4	0.5	0.2
Real Eff. Ex. Rate 1/	9.1	8.3	5.6	4.3	7.3	4.9	9.1
Nominal Eff. Ex. Rate 1/	7.2	8.1	0.3	0.1	7.0	5.8	5.8
Nominal Interest Rate	1.4	1.2	1.5	1.4	2.8	1.8	1.7
Japanese variables							
Real GDP 1/	3.8	3.2	4.0	4.1	3.7	1.6	5.2
Inflation	5.8	4.8	4.8	4.3	4.1	1.7	3.9
Current Balance 2/	0.6	0.6	0.5	0.5	0.5	0.8	0.2
Real Eff. Ex. Rate 1/	8.9	8.2	3.8	3.8	6.9	5.5	5.9
Nominal Eff. Ex. Rate 1/	11.9	9.8	0.5	0.1	11.8	10.1	11.8
Nominal Interest Rate	1.5	2.3	4.4	1.3	2.5	1.3	2.3
German variables							
Real GDP 1/	4.4	4.3	3.4	3.1	6.9	2.9	4.2
Inflation	3.7	3.0	4.9	4.2	2.9	2.4	2.2
Current Balance 2/	1.4	1.4	1.0	1.0	0.1	2.2	0.6
Real Eff. Ex. Rate 1/	8.2	7.6	2.1	2.2	10.4	7.4	8.0
Nominal Eff. Ex. Rate 1/	11.9	8.5	0.4	0.0	16.3	14.2	11.8
Nominal Interest Rate	2.7	1.8	5.9	1.4	3.3	1.1	1.1
Developing country variables							
real GDP 1/	3.4	3.4	3.2	1.3	2.1	1.6	1.5
terms of trade 1/	5.5	5.1	5.6	5.1	4.5	2.5	3.7

1/ Root mean square percent errors.
2/ As percent of GNP.

for the shocks that corresponds to residuals in the model's behavioral equations for 1974-85. These shocks are applied to a baseline for the period 1988-1999; the model is simulated another 20 years in order to minimize the effect of the terminal conditions on the period of interest (Appendix II gives more details on how the simulations were done). As with the single shocks exercise, the implicit objective is to minimize deviations of target variables from the baseline, so that shocks have as little disruptive effect as possible. We do not make a judgement about how target variables should be weighted in the objective function; however, we presume that macroeconomic performance would be evaluated using some subset of the variables presented in Table 1. 1/

Several conclusions emerge from examination of the results.

First, it appears that nominal GNP targeting produces smaller errors in response to typical shocks than money targeting. As noted earlier, nominal GNP targeting has a clear advantage over money targeting when there are shocks to velocity, that is, to the demand for money. For other kinds of shocks, the comparison between the two rules derives from small differences in the elasticity with respect to nominal income and in the speed with which the interest rate reacts to shocks. For the historical

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1/ It could be argued that the sole criterion should be the discounted present value of consumption, and the variances of variables would matter only insofar as they reduced the output available for consumption. The model as currently specified does not incorporate such effects, making it necessary to evaluate rules on the basis of their effectiveness in reducing the variability of key variables. Of course, the absence in the model of links between second and first moments of variables makes it subject to Lucas critique problems.

shocks considered here, the stabilization properties of the nominal income rule clearly dominated those of base money targeting.

Second, the two rules that ignore domestic variables in setting monetary policy in favor of targeting an exchange rate measure--while keeping fiscal expenditures exogenous--show mixed results: they have some success in reducing the variability of GDP for the United States and for developing countries, but yield no clear advantage for Germany and Japan.

Note also that the behavior of macroeconomic variables is quite different under fixed nominal exchange rates--column (1)--than under target zones. Recall that fixed rates are implemented here through changes in monetary policies of non-U.S. industrial countries. The United States is assumed to target the monetary base, as under monetary targeting. As a result, the variability of nominal interest rates is considerable higher abroad than in the United States. The fixity of nominal exchange rates is also associated with more variability of inflation in all industrial countries.

Some might argue that stochastic simulations of fixed rates using historical shocks overstate the need for movements in interest rates. Since the period 1974-85 was characterized by flexible exchange rates, a credible announcement of a set of nominal exchange rate targets could be seen as reducing shifts between currencies. Moreover, our earlier single-shock simulations suggested that target zones could be unstable under exchange rate shocks; response to such shocks could be unfavorably biasing the results against target zones. In order to examine this question, we also ran some simulations for which shocks to interest parity conditions were assumed to be absent. These results--shown in column (2) under fixed rates--exhibit only slightly less variability. It does not seem therefore that our results are strongly affected by changes in speculative behavior in currency markets that might be associated with the exchange rate regime.

The target zones rule, in contrast to fixed nominal rates, posits a symmetric assignment of monetary policies to real effective exchange rates. As hinted at earlier, achievement of tight target zones is difficult in the model, and root mean square (RMS) deviations from baseline for real exchange rates are quite high; on the other hand, real GDP, at least in the United States, and inflation generally, are quite stable. The policy reaction functions for target zones used here are based on Edison and others [1987]; our results suggest, however, that a more complicated rule for setting interest rates--perhaps using proportional, integral, and derivative control terms--would be more appropriate. 1/ Such rules may also be more robust to model mis-specification. At the same time, we would argue that the fact that a simple rule does not perform well suggests some skepticism about the practicality of real exchange rate targeting, given the uncertainty associated with the precise dynamics of the economy

1/ Such specifications have been used by Currie and Wren-Lewis [1987, 1988a, 1988b], among others.

<u>Third</u>, the blueprint rule produces considerably lower errors for most variables, 1/ but does so with the benefit of an additional policy instrument--namely, real government spending. Somewhat surprisingly, the reversed assignment rule does not succeed in stabilizing either real GDP (except for developing countries) or real effective exchange rates. 2/ Though current account targets are achieved closely under reversed assignment, they may not be the preferred measure of external balance because shocks that change the terms of trade will change the valuation of trade flows for given trade volumes. Stabilizing the current balance will therefore not be sufficient to neutralize the domestic demand effects of external shocks.

Our historical shocks comprise a small sample--only 12 observations. As discussed above, it does not seem appropriate to evaluate policy rules on the basis of one historical episode. Our second set of stochastic simulations therefore draws shocks for 61 residuals over 40 years from the distribution describing the historical shocks. The simulations were then performed as described above, one year at a time. Table 2 presents the root mean square deviations from baseline for the various policy rules.

1/ Though not for nominal effective exchange rates in Japan and Germany. It should be noted that nominal effective exchange rates use MERM weights, and include only industrial country currencies, while <u>real</u> effective exchange rates are calculated using relative manufacturing export prices weighted according to export shares; developing countries are included in this calculation.

2/ Currie and Wren-Lewis [1988a] also find that such a rule does less well than the blueprint assignment.

Table 2. Root Mean Square Deviations from Baseline for Various Policy Rules, Generated Shocks 1988-2027

	Policy Rule					
	Money targeting	Nominal GNP targeting	Fixed Rate	Blueprint (1)	Blueprint (2)	Reversed Assignment
U.S. variables						
Real GDP 1/	5.1	5.4	5.0	1.9	3.2	4.4
Inflation	3.7	3.3	3.4	1.2	1.3	2.3
Current Balance 2/	0.9	1.2	0.8	1.2	0.9	0.2
Real Eff. Ex. Rate 1/	11.6	12.8	11.8	6.3	5.7	7.6
Nominal Eff. Ex. Rate 1/	8.1	8.5	0.4	10.3	8.8	5.1
Nominal Interest Rate	2.0	4.0	1.6	1.4	1.7	1.7
Japanese variables						
Real GDP 1/	5.2	6.0	5.8	2.9	5.9	4.4
Inflation	5.3	4.9	4.9	2.4	2.7	3.6
Current Balance 2/	4.9	2.5	1.5	1.9	1.8	0.4
Real Eff. Ex. Rate 1/	7.8	10.1	5.7	5.0	5.0	6.8
Nominal Eff. Ex. Rate 1/	11.3	17.2	0.4	9.2	9.4	8.2
Nominal Interest Rate	2.3	2.8	3.7	0.9	1.1	2.0
German variables						
Real GDP 1/	5.1	4.5	3.8	3.5	4.4	4.8
Inflation	4.8	4.1	3.9	2.4	2.2	2.9
Current Balance 2/	3.9	1.6	2.4	3.5	3.2	0.4
Real Eff. Ex. Rate 1/	8.4	6.6	6.1	7.4	6.4	9.8
Nominal Eff. Ex. Rate 1/	14.2	11.9	0.5	15.9	14.0	11.8
Nominal Interest Rate	2.8	3.0	6.3	1.5	1.3	2.2
Developing country variables						
Real GDP 1/	2.4	3.7	2.1	2.3	2.5	2.0
Terms of trade 1/	4.9	6.4	3.9	2.8	2.8	3.1

1/ Root mean square percent errors.
2/ As percent of GDP.

There are several qualitative differences relative to the historical shocks of Table 1. First, the ranking of money and nominal GNP targeting has changed. The reason seems to lie in the timing of shocks to developing country supplies of commodities and manufactured exports. In the historical simulations, these shocks occur mainly at the end of the simulation period; they have persistent effects, but since the RMS deviations are calculated only over the 12 years of the shocks, some of those effects are not captured. In contrast, the generated shocks distribute those effects more evenly over the simulation, and nominal GNP targeting, with its steeper aggregate demand curve, performs more poorly than money targeting.

The second difference with Table 1 is that fixed rates no longer dominate the two uncoordinated rules with respect to real GDP in Japan, nor for the real effective exchange rate of the dollar. Unless a considerable premium is placed on nominal exchange rate stability, there seems little to choose among the first three rules--money and nominal GNP targets, and fixed rates. Unfortunately, the target zones proposal could not be simulated here; with the feedback parameters specified in Edison and others [1987], the target-zone rule suffers from dynamic instability that eventually prevents MULTIMOD from converging to a solution. The problem is exacerbated by the longer simulation period, as real shocks push the short-run equilibrium real exchange rate further from its long-run equilibrium value. 1/

Third, the blueprint rule--column (1)--again seems to yield for most variables lower RMS deviations than the other rules. Its superiority, however, with respect to reversed assignment is less marked than in Table 1. As discussed above, both of these rules assume that real government spending can be flexibly used in the current period to respond to deviations from targets--be it nominal domestic demand (blueprint) or the current balance (reversed assignment). A more realistic assumption, in our view, would be that fiscal spending can respond with a lag of a year to deviations from targets. Taking account of this inflexibility would mean that lower (higher) growth in nominal domestic demand under the blueprint rule would lead to higher (lower) government spending in the following year. In our first attempt to operationalize this constraint, we used the same feedback coefficients as in column (1); however, this produced dynamic instability. The results presented in column (2) use a feedback of nominal domestic demand onto government spending that is half of the contemporaneous effect: 0.5 instead of unity. Interestingly enough, the RMS deviations for this variant of the blueprint rule are now

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1/ Of course, given the assumption that agents know those values, policymakers could (in the model) have moving targets for exchange rates, trying only to offset current shocks, and not the lagged effects of past shocks. Such an experiment--which would in effect involve starting each period's simulation at baseline values--was not performed, however.

closer to those for the other rules. 1/ It is a topic for further research to examine the constrained use of fiscal policy to hit other targets--for instance, under the reversed assignment rule.

V. Summary and Conclusions

A theme running through the results from the individual-shock simulations is the relative ineffectiveness of monetary policy under rational expectations, despite the existence of price stickiness in MULTIMOD. One implication is that target zones that rely solely on a monetary policy instrument do not seem capable of maintaining real effective exchange rates within bands that are even 10 percent on either side of the target. Conversely, fiscal policy--in particular, variations in government spending--seems to be quite powerful in influencing output, real exchange rates, and current accounts. But there is an important catch: fiscal policy may simply not have the flexibility assumed for it in the blueprint and reversed assignment rules. It may be constrained by other objectives--budget deficits 2/ or the desire to reduce the importance of government in the economy--and result from a lengthy political process. It may therefore not be able to react immediately to shocks.

1/ Except for current account balances. It seems that because of J-curves, the lagged response of government spending actually does better in offsetting the current account effect of most shocks.

2/ Indeed, tax policy in MULTIMOD is varied in order to prevent unbounded accumulation of debt; however, simulated effects on budget deficits in the short to medium run are still substantial.

Simulations of individual shocks also illustrate the point emphasized in much of the theoretical literature that the performance of simple policy rules varies with the nature of the shocks facing the economy. Rules that perform "best" for some shocks may perform least well for others. In some cases it is clear which rule(s) dominate; for example, if money demand shocks are prevalent, targeting of monetary aggregates will produce inferior results. However, in the real world there is a variety of shocks. Any evaluation of rules must take into account their relative variances and the covariances among them. The stochastic simulations reported above attempt to meet that requirement. When all is said and done, our results lead us to be cautious in drawing strong conclusions about the dominance of one rule or another. This caution is rooted in several features of our results.

To begin with, we found that some rules that on the surface seem quite straightforward, could not in fact be simulated easily. In particular, we found that dynamic instability was a serious problem when monetary policy was used to achieve close control over either nominal GNP or real exchange rates. Though we have isolated rules that are stable in MULTIMOD, our experience suggests that rules may not be robust across models, and hence may in practice cause instability problems.

In a similar vein, we discovered that the intuition of some simple models did not tell the whole story. In particular, the notion that fiscal policy should be assigned to an external target--the current account--because of its stronger effect on that target needs to be weighed against its apparent tendency to generate greater fluctuations in other macroeconomic variables. Terms of trade effects, J-curve dynamics, and asset accumulations may make the outcome more complex than suggested by the simple models.

A third factor--and in our view, a crucial one--concerns the need to model the constraints on the use of policy instruments, particularly on fiscal policy. While we have reported some exploratory work on this point, our results suggest that rules that rely on a fiscal instrument are substantially affected by lags in its operation. This consideration suggests that fiscal policy should be assigned to variables that move slowly and for which short-term control is not necessary.

Differences in model specification also need to be taken into account in evaluating simulation results. In models like MULTIMOD where expectations formation is affected by the policy rule, the effects of a regime change are complex and are very sensitive to the precise way in which private-sector behavior--and the policies themselves--are modeled. Indeed, this sensitivity of the results makes us skeptical of claims that model simulations--at this stage in our knowledge--can provide an unambiguous ranking of policy rules.

Last but not least, we want to stress that simulation results for simple coordinated and uncoordinated policy rules should not be used to draw inferences about the effects of judgmental (discretionary) coordinated policies, including the ongoing coordination exercise among the largest industrial countries. In this connection, the differences between the effects of coordinated policy rules and judgmental coordinated policies may be as large as those between uncoordinated policy rules and coordinated policy rules. A key task of future research in this area should be to learn about the effects of judgmental policies--even though such policies do not lend themselves easily to simulation exercises.

Reaction Functions

The precise forms ascribed to the various policy rules discussed in the body of the paper are given by the following equations. Lower case variables are in logs; upper case variables are in levels. Specifically, M is the monetary base (m its logarithm, and m^d is the log of long-run money demand), u is a money demand disturbance (in logs), Y is nominal GNP, WY is the dollar value (at current exchange rates) of aggregate nominal income of industrial countries taken together, Q is real GNP, P is the GNP deflator, A is nominal domestic absorption, G is real government expenditure on goods and services, B is the balance on current account, C is competitiveness (the relative price of domestic to foreign output), E the nominal exchange rate (U.S. dollars per local currency), and R is the short-term interest rate. A "b" superscript indicates baseline values, which are also assumed to be the target values of the relevant variables. Implicitly then, the simulations start from a position of equilibrium, which is disturbed by the shocks being considered; the goal of each of the rules should be to return the economy as quickly and smoothly as possible to the initial equilibrium.

1) Money targeting: $R = R^b + 13.5\ [m^d - m^b]$

where m^d is given by

$$m^d = p + .970\ q + 5.15\ u$$

This interest rate rule sets the long-run demand for money equal to its target (baseline) value, conditional on current values for prices, output, and the error in the demand for money. It can be derived as follows. The short run demand for money can be written (see Masson and others [1988], p. 60):

$$m = p + .1883\ q - .0070\ R - .0074\ R_{-1} + .8058\ (m - p)_{-1} + u,$$

where u is an error term. Therefore, the value of the interest rate that achieves $m = m^b$ once all lags have worked themselves out is

$$R = -13.5\ (m^b - p) + 13.1\ q - 69.4\ u$$

A rearrangement of this equation, on the assumption that the equation also holds in the baseline, gives rule 1)

2) <u>Nominal GNP targeting:</u> $R = R^b + 25\ [y - y^b]$

3) <u>Fixed Exchange Rates:</u>

for the United States: $R = R^b + 13.5\ [m^d - m^b]$

for other countries: $R = R^b + 1000\ [e^b - e]$

4) <u>Target zones:</u> $R = R^b + [(c - c^b)/.1]^3 + 10\ [wy - wy^b]$

5) <u>Blueprint:</u> $R = R^b + [(c - c^b)/.1]^3 + 10\ [wy - wy^b]$

$(G - G^b)/Q^b = (A^b - A)/A^b$

6) <u>Reversed Assignment:</u> $R = R^b + 25\ [a - a^b]$

$(G - G^b)/Q^b = 10\ (B^b - B)/Y^b$

Procedures Used for Simulating MULTIMOD

For convenience, the model is written as a linear function of endogenous variables y, exogenous variables x, and errors u. 1/

$$y = A\ y(-1) + B\ x + C\ y^e + u \qquad (1)$$

Current endogenous variables depend on values for the previous period, y(-1), as well as on expected values for the following period, $y^e = E(y(+1)|I)$, where I is information available in the current period. The vector of errors may include some that are identically zero, in particular, for equations that are identities. To perform the stochastic simulations, we need an estimate of the covariance matrix of the u's. This is complicated by the fact that y^e is unobservable.

In MULTIMOD, equations with expectations variables were estimated using McCallum's [1976] instrumental variables method. Therefore, errors from the first stage regression should capture the expectations errors. Let us call these errors v, so that

$$y(+1) = y^e + v \qquad (2)$$

Substitution of (2) into (1) permits decomposition of the equation residuals into two parts: the structural residuals u and the expectations errors v:

$$y = A\ y(-1) + B\ x + C\ y(+1) + u - C\ v \qquad (3)$$

1/ In fact, MULTIMOD is non-linear, but coefficients that correspond to a linearized version, as in (1), vary little from one period to the next. Therefore, expected values of the endogenous variables are calculated by simulations that set residuals equal to zero.

A slight problem arises because the y^e in (2) is not the same as what a model simulation would produce for the next period: the instrumental variables estimator does not impose the model's restrictions as a full information estimator would. 1/ Therefore, the model would not exactly track historical values of y with the estimation residuals.

In practice, the forecasts for y(+1) were not taken from the first stage of the instrumental variables estimation. For one thing, these were not easily recoverable. For another, expectations appear in some equations without estimated parameters, in particular in uncovered interest parity and bond rate arbitrage equations. Instead, time series equations were fit for the variables for which the model has expectations; the forecasts from these equations--call them yfit(+1)--were substituted into equation (1) in place of y^e. The structural residuals were calculated residually as

$$u = y - [A\ y(-1) + B\ x + C\ yfit(+1)] \quad (4)$$

A second problem concerns serial correlation of the residuals u. In principle, the process describing residual autocorrelation could be estimated jointly with the parameters in the equation. In practice, this was in most cases not done, mainly because the constraints that were imposed across equations did not allow separate autoregressions to be estimated for each country. In addition, the interest parity equation was not estimated, but there is no reason to expect deviations from uncovered

1/ In practice, given MULTIMOD's size, a full information estimator would not be feasible.

interest parity to be serially uncorrelated. Therefore, autoregressions of the following form were fit to the u's calculated by equation (4):

$$A(L)\ u = a + b\ t + e \qquad (5)$$

The e vector then constitutes the innovation in the model. In simulation, the model constituted by equations (1) and (5) was solved together, given a drawing for the vector e of innovations. It should be noted that these shocks have persistent effects for two reasons: first, a shock in period t will affect u in the current period and in subsequent periods, via $A^{-1}(L)e$; and second, shocks have persistent effects, because of the dynamics described in equation (1). Solution to the model in period t replaces y^e by the value calculated for y(+1), given information available at t (call it yhat(t,t+1)), which itself depends on x(+1) as well as y(+2), (which in turn is replaced by its model solution, yhat(t,t+2), etc). Some terminal condition is imposed on y(+T). The effects in future periods are thus assumed to be correctly anticipated; however, future shocks are of course not anticipated before they occur. This implies that the forward-looking simulations have to be redone for each time period in which a new shock is applied, so that, for instance, yhat(t+1,t+2) ≠ yhat(t,t+2) ≠ y(t+2). This greatly increases the number of simulations relative to the number needed for deterministic simulations.

To be specific, residuals calculated for the period 1974-85 were used to estimate the parameters of equation (5) and the 61x61 covariance matrix describing the e vector. In practice a first-order autoregression plus a time trend was estimated for each of the residuals u. Appendix Table 1 gives the results of these regressions, as well as the standard errors of the residuals e. These residuals e were then correlated, giving a covariance matrix V. Because of the small number of observations, V is singular. Rather than imposing a diagonal structure on the V matrix (since some of the correlations are substantial), a small number was added to the diagonal, creating a non-singular approximation V^* to the V matrix:

$$V^* = V + .000001\ I$$

The stochastic simulations were run by making repeated drawings from a random number generator, giving standard normal variates z, where

$$E(z) = 0$$

$$E(z'z) = I$$

A Cholesky decomposition was performed on the matrix V^*, yielding a matrix L such that

$$L\ L' = V^*$$

The generated shocks z were premultiplied by L, yielding shocks e^* with the same properties as the e's, that is with estimated covariance V^*:

$$e^* = L\ z$$

so $$E(e^*\ e^{*\prime}) = E(L\ z\ z'L') = L\ L' = V^*$$

Values for the e's were generated for the period 1988-2027, and the calculated e's were added to equation (5) in order to calculate the residuals u. The model was first calibrated to track a smooth baseline. For each year from 1988 to 2027, a drawing was made for the e's; using inherited y(-1), which depends on past e's, the model is solved forward to

Appendix Table 1. Estimated Autoregressions, and Standard Error of Innovations, 1974-85

$$u = \alpha + \rho u_{-1} + \beta t + e$$

(Coefficient standard error in parenthesis)

residual	ρ	σ_e	residual	ρ	σ_e
us_c	.148 (.321)	.013	gr_rl	.655 (.253)	.110
us_coil	.519 (.257)	.022	gr_pgnp	-.074 (.364)	.008
us_k	.265 (.334)	.004	gr_pxm	-.045 (.379)	.016
us_xm	.289 (.318)	.031	gr_ycap	.655 (.205)	.010
us_im	-.087 (.336)	.051	gr_a	.745 (.250)	.059
us_icom	-.412 (.277)	.040	li_c	.444 (.296)	.010
us_m	.159 (.273)	.019	li_coil	-.123 (.322)	.019
us_rl	.131 (.335)	.056	li_k	-.154 (.573)	.008
us_pgnp	-.546 (.280)	.012	li_xm	.084 (.323)	.026
us_pxm	.103 (.351)	.025	li_im	-.177 (.323)	.056
us_ycap	.706 (.229)	.006	li_icom	-.485 (.302)	.032
ja_c	.128 (.312)	.021	li_m	.006 (.267)	.030
ja_coil	.126 (.338)	.038	li_rl	.251 (.311)	.063
ja-k	.685 (.299)	.006	li_pgnp	-.543 (.291)	.028
ja_xm	.494 (.292)	.043	li_pxm	-.010 (.316)	.021
ja_im	.176 (.279)	.096	li_ycap	.592 (.124)	.006
ja_icom	.172 (.323)	.063	li_a	.038 (.357)	.031
ja_m	-.087 (.159)	.025	si_c	.352 (.318)	.012
ja_rl	.430 (.280)	.090	si_coil	-.010 (.332)	.028
ja_pgnp	-.008 (.312)	.021	si_k	-.375 (.252)	.004
ja_pxm	-.294 (.319)	.035	si_xm	-.043 (.352)	.016
ja_ycap	.628 (.112)	.006	si_im	.016 (.325)	.031
ja_a	.428 (.294)	.041	si_icom	.124 (.324)	.031
gr_c	.100 (.333)	.009	si_m	-.166 (.308)	.032
gr_coil	.012 (.355)	.007	si_rl	.104 (.207)	.035
gr_k	.161 (.392)	.002	si-pgnp	-.416 (.304)	.011
gr_xm	-.054 (.362)	.018	si_pxm	-.013 (.463)	.039
gr_im	.161 (.318)	.029	si_ycap	.868 (.142)	.010
gr_icom	-.365 (.309)	.031	si_a	.830 (.272)	.058
gr_m	.052 (.169)	.036	dc_xcom	.097 (.322)	.032
			rw_xm	.361 (.253)	.054

the terminal date, which in each case was taken to be 2044. No shocks were applied to the years 2028-2044; a sufficient period at the end was included so that the simulations over the period of interest, 1988-2027, would not be much affected by the terminal conditions on the expectations variables.

A project for subsequent work would be to include forecasting equations for the exogenous variables as well as for the residuals, and to shock innovations in those equations as well.

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