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SPECIFICATION OF POLICY RULES AND PERFORMANCE MEASURES IN MULTICOUNTRY SIMULATION STUDIES

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ABSTRACT

Much recent analysis of international monetary and fiscal policy issues, such as the choice of an exchange-rate regime or the design of a policy coordination scheme, has been conducted by stochastic simulations with multicountry econometric models. In these studies it has become standard practice to consider alternative policy rules of a particular form that calls for departures of a policy instrument, from some "baseline" reference path, that are proportional to deviations of a specified target variable from its own baseline path. The present paper argues, however, that this standard rule form is seriously defective for evaluating such issues because the implied rules (1) often fail to be operational and (2) have associated performance measures that can be misleading in important cases. An example is presented that concerns the international "assignment problem" of optimally pairing instruments with policy objectives.

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I. Introduction

A burgeoning field of research in recent years has been the study, by means of stochastic simulations with aggregative econometric models, of alternative rules for the conduct of monetary and fiscal policy. This type of exercise is of particular importance in the context of international issues, such as the choice of exchange-rate regimes or the design of multicountry policy coordination schemes, since they tend to be exceedingly complex and to hinge on quantitative magnitudes of various effects. Consequently, ongoing research projects involving stochastic simulation studies have been undertaken by a number of prominent research groups.[1] Indeed, there have been a few major cooperative ventures that have brought together the efforts of various modeling groups in ways designed to yield new knowledge concerning the effects of alternative policy rules, exchange rate regimes, and coordination schemes.[2]

In these projects it has become reasonably standard to consider alternative policy rules of a particular form, a simplified version of which can be represented as follows:

$$(1) \qquad r_t - r_t^b = \lambda(x_t - x_t^b).$$

Here r_t denotes some controllable policy instrument, such as a nominal interest rate or the monetary base, while x_t represents some target variable, such as nominal (or real) GNP or a comprehensive price index.[3] Critically, the superscript b denotes "baseline" values, so that r_t^b and x_t^b refer to <u>reference paths</u> for r_t and x_t in some specified baseline simulations with the model at hand. Thus, the typical rule calls for the policy authority (monetary or fiscal) to adjust its operating instrument relative to a baseline path in response to departures of the target variable--or variables--from its baseline path(s). The desirability of alternative instrument assignments or policy rules is then gauged on the basis of variability measures for $x_t - x_t^b$ such as its variance, root-mean-square value, or mean absolute value. These measures are calculated from the simulation output for target variables like $x_t - x_t^b$ and also for other important aggregative variables measured relative to their own baseline values. In many instances, the reference baseline values are simply chosen to match actual historical values for the variables in question, a choice that is equivalent to using a simulation in which the generated "shocks" happen to match the historical residuals (i.e., estimated shocks) with the model at hand. This choice is not inevitable, however, so our discussion will proceed under the more general baseline concept. For some explicit discussion of the procedure, see Frenkel, Goldstein, and Masson (1989), Taylor (1988), or Bryant et.al. (1988, Supp. Vol., pp. 1-16).

The purpose of the present paper is to argue that the "standard" form of policy rule expressed in equation (1) is seriously defective for issues of the types referred to above--i.e., evaluating the properties of different instruments, targets, regimes, etc. One reason is that for many specifications of x_t, rules of form (1) are not operational, i.e., could not be implemented by an actual policy authority, essentially because requisite information would not be available with sufficient promptness. A second reason that is somewhat less obvious involves the variability measures that correspond to the rules: these measures may be highly misleading with respect to the rules' relative merits. In both cases, the argument pertains strictly to the rules or measures or to the use of baseline reference paths; it is assumed for the sake of discussion that the models employed are accurate and the target variables appropriate. It should be emphasized that the paper's argument is not intended to cover all major issues relating to simulation-study methodology. Nothing is said or implied, for example, about the desirability of conducting numerous simulations, with shocks drawn randomly from frequency distributions designed to match those of historical residuals, rather than relying upon a single counterfactual simulation (for each investigated rule) possibly with estimated historical shocks. This limited purpose will be apparent to some readers but perhaps warrants explicit mention so as to avoid possible misunderstanding by others.

Organizationally, the paper's design is as follows. First, the two classes of criticism of rules of type (1) are developed in Sections II and III, respectively. Then, in order to emphasize the importance of these criticisms, a substantive application is presented in Section IV. This application involves a basic topic in the area of international macroeconomics, the so-called "assignment problem" of optimally pairing instruments with policy objectives. In Section IV it is argued that some anomalous results in the recent literature are quite likely a consequence of the inappropriate use of rules of form (1). In Section V, finally, some brief suggestions for more appropriate rule specifications are put forth.

II. Operationality

There are two distinct ways in which monetary or fiscal policy rules of the general form expressed in (1) fail to be operational. The more obvious of these stems from the presence on the right-hand side of the <u>current-period</u> value of the target variable x_t. It is reasonable to presume that contemporaneous observations are available on interest rates, exchange rates, and other financial market prices. But it is not reasonable to make such an assumption for frequently-used target variables such as real or nominal GNP, the current-account balance, the economy-wide price level, or (arguably) even the monetary aggregates M1 or M2. Data on these variables is simply not produced promptly enough for the policy authorities to respond to their movements without an appreciable lag. And procedures for "forecasting" current-period values of the GNP and price level variables are seriously inaccurate, as was recently emphasized and documented by Meltzer (1987).

In response, it might be argued that the foregoing discussion implicitly assumes that the model under consideration is one that utilizes quarterly (or monthly) data. Thus, it might be suggested that in the case of annual models, such as the IMF's MULTIMOD, it would be appropriate to treat current-period values of GNP, the price level, etc., as known by the policy authorities. But that suggestion would be incorrect, for the following reason. While it is true that the authorities will have considerable information about a year's GNP (or whatever) by the end of the year, they are still responding to target movements with a lag. The fact that lags exist is not eliminated by the use of a model that is coarse in terms of temporal aggregation. Furthermore, it is important to keep in mind that actual monetary policy authorities respond to new information and reset their instrument values much more frequently than once a year. In the United States, for example, the Federal Open Market Committee meets to discuss monetary policy actions at intervals of approximately six weeks.[4] So the short-run dynamics of the policy process, and the economy's response to policy actions, cannot be accurately represented in models of the annual type.[5] And for issues of the sort that are under discussion--choice of targets, instruments, or exchange rate regimes, for example--short-run dynamic properties of the systems are of great importance. Indeed, one of the main difficulties in the design of policy response rules is the avoidance of "instrument instability," that is, the tendency for strong instrument responses to lagged values of target variables to result in systems that are dynamically unstable--i.e., explosive. Analysis with annual models would therefore be misleadingly optimistic concerning this difficulty if they were to treat current-period values as known. To the extent that annual models are utilized in policy evaluation simulations, therefore, it is essential that they incorporate policy-rule specifications that relate instrument settings to previous-period values of target variables (except when these are asset prices.) The same statement applies, of course, to quarterly models.

It should perhaps be mentioned explicitly that the foregoing argument should not be interpreted as a claim that <u>expectations</u> of current or even future variables are inappropriate for inclusion on the right-hand side of policy rules. There would be no objection of the type under discussion to rule (1), for example, if $E(x_t|\Omega_t)-x_t^b$ were used on the right-hand side in place of $x_t - x_t^b$, provided that the information set Ω_t were specified realistically. But the foregoing argument does suggest that Ω_t should include period-t values only for asset prices, with measures of GNP, etc., pertaining only to observations dated t-1 or before.[6]

The second way in which rules of type (1) fail to be operational is slightly less obvious. It stems from the presence in expression (1) of baseline values, r_t^b and x_t^b, of the instrument and target variables. One way to express the problem is to note that rule (1) cannot be handed over to an actual policymaker for implementation even with λ and the identity of r_t and x_t specified. To use the rule with his choice of a path for x_t^b, which would in this case represent his target values, the policymaker would also need to have values of r_t^b given by some process about which (1) is entirely silent. Indeed, a r_t^b path would be chosen by the designer of a rule of form (1) to be such that, in the absence of shocks, x_t would be kept close to x_t^b when r_t values are close to x_t^b. But such a property is model-specific, i.e., the path of r_t^b that promises to be useful in keeping x_t close to its target will depend on the analyst's model of the economy's responses to instrument settings. But any formula for instrument settings that is model specific will not be operational from the perspective of a policymaker, who will be highly unlikely to subscribe to the analyst's model of the economy. Furthermore, a formula that is model-specific cannot be regarded as a rule capable of being evaluated for robustness with respect to different models of the economy.

Some arguments in favor of the use of baseline values in policy rules have been put forth by Frenkel, Goldstein, and Masson (1989, pp. 207-9). One suggestion is that the use of baseline values, rather than target values specified by the analyst, places constraints on the analyst that make it more difficult to misleadingly promote some favored policy rule by the choice of a target path--one that gives the appearance of effectiveness to the rule. But it is unclear that the same type of distortion could not be accomplished by the choice of a baseline path. This would not be true if baseline paths were always specified to conform to historical realizations. But, as mentioned above, the concept does not require any such specification; Frenkel, Goldstein, and Masson (1989, p.209) refer to "an arbitrary baseline." In any event, the more serious problem is, arguably, that <u>some</u> rule can always be found that will perform misleadingly well in simulations with a single given model. The effective safeguard against misleading analysis would then seem to be the examination of any proposed rule's performance in a variety of models. But such comparisons cannot be sensibly conducted, as explained above, when baseline values appear in the policy rules as in (1). A second suggestion of Frenkel, Goldstein, and Masson (1989, pp. 208-9) concerns their desire to distinguish between the responses to shocks implied by specified rules (on the one hand) and effects due to the specification of target paths (on the other hand). But this suggestion presumes that a rule's performance in terms of stabilization relative to a baseline path would provide a reliable measure of its stabilization performance relative to target paths of actual policy relevance or interest. That this presumption is not in general correct will be argued in some detail in the next two sections of the present paper.

III. Performance Measures

The second category of criticism of policy rules of type (1) pertains to the target variability measures that are naturally associated with the rules. These measures are statistics such as the variance, root-mean-square, or absolute value of $x_t - x_t^b$ values generated by the stochastic simulations.[7] In addition, similar values are often reported for aggregates other than the ones explicitly targeted, with these variables also measured relative to their baseline magnitudes. The argument of the present section is that such measures can be distinctly misleading as indicators of the merits of a particular rule, policy regime, or instrument assignment.

For an illustration of the problem involved, first consider an example in which a monetary policy instrument m_t is used in an attempt to influence a real aggregate target variable y_t, perhaps representing real output (in logarithmic terms). We begin with a starkly clear-cut case by supposing that the economy at hand is one in which the infamous "policy ineffectiveness" proposition obtains,[8] with deviations of y_t from exogenous natural-rate values $\bar{y}_t$ determined by m_t surprises plus realizations of a white noise technological disturbance u_t with $Eu_t = 0$ and $Eu_t^2 = \sigma_u^2$:

$$(2) \qquad y_t - \bar{y}_t = \alpha(m_t - E_{t-1}\, m_t) + u_t \qquad\qquad \alpha > 0.$$

Here $E_{t-1}m_t$ denotes the conditional expectation $E(m_t|\Omega_{t-1})$ with the information set Ω_{t-1} now specified to include observations on all relevant variables in periods t-1, t-2, ..., but not in t. Suppose, finally, that in fact the monetary authority has no usable information on y_t or u_t during period t and must base m_t settings only on elements of Ω_{t-1}. In this case, m_t is, of course, a useless instrument for the targeting of y_t; the evolution of y_t would be independent of any systematic component of a policy rule that determines m_t as a response to Ω_{t-1}.[9]

Now consider a simulation exercise based on an accurate model of the economy referred to in (2), but conducted under the incorrect assumption that m_t could be set by a rule of form (1), now denoted

(3) $$m_t - m_t^b = \lambda(y_t - y_t^b).$$

Under this assumption, the stochastic simulation exercise will result in variability measures for $y_t - y_t^b$ that will incorrectly suggest the conclusion that rule (3) is a useful one. For with (3) determining m_t, surprises will be given by[10]

(4) $$m_t - E_{t-1} m_t = \frac{\lambda}{1-\alpha\lambda} u_t$$

and output in the various simulations will accordingly be governed by the relation

(5) $$y_t - \bar{y}_t = \frac{\alpha\lambda}{1-\alpha\lambda} u_t + u_t.$$

But baseline y_t^b values are related to $\bar{y}_t$ values as in

(6) $$y_t^b = \bar{y}_t + \alpha e_t^b + u_t^b$$

where e_t^b are the m_t surprises in the baseline path, which might be the historical path but in any case is one that is a given piece of data from the perspective of the simulations. From (5) and (6) we then readily obtain

$$(7) \qquad y_t - y_t^b = \frac{1}{1-\alpha\lambda} u_t + z_t^b$$

where $z_t^b = -(\alpha e_t^b + u_t^b)$ represents baseline terms that are constants from the perspective of the simulation exercise. From (7), then, it follows that the variance of $y_t - y_t^b$ equals[11]

$$(8) \qquad V(y_t - y_t^b) = \frac{1}{(1-\alpha\lambda)^2} \sigma_u^2$$

and this value clearly depends on the feedback parameter λ. Indeed, the expression in (8) for $V(y_t - y_t^b)$ can be made arbitrarily small by policy choice of λ at an arbitrarily large negative (or positive!) value. So the simulation exercise with policy rule (3) suggests that monetary policy would permit highly effective stabilization of y_t when in fact feasible monetary rules would be entirely ineffective. More generally, simulation exercises based on rules like (1) can give highly misleading results if it is unrealistic to attribute knowledge of current target values to the policy authority.

In this regard, it is important to emphasize that the message of the foregoing example does not require that the policy ineffectiveness proposition be valid. The results would be qualitatively similar, though less dramatic, if the example employed in place of (2) a Fischer-style specification in which $y_t - \bar{y}_t$ depends on two-period forecast errors $m_t - E_{t-2}m_t$ as well as on $m_t - E_{t-1}m_t$.[12] The extent, that is, of plausible stabilization would be overstated by the use of a rule of form (1) when in fact current y_t values are not observable.

Now let us turn to a second example, one that illustrates in a very different way the potentially misleading nature of simulation exercises based on rules like (1). In this case, the use of such a rule will be misleading even if it is true that the policy authority can observe current-period variables when setting its instrument value. For this example, let us suppose that real government purchases, denoted g_t, is used as the instrument variable in an attempt to hit target values for a nominal variable such as the price level p_t or nominal income, $x_t = y_t + p_t$, with these values chosen to achieve a desired path for the price level. (Here, as above, the lower case symbols denote logarithms of the indicated variable.) To make the point as simply as possible, let us assume that $\alpha = 0$ in (2) so that output is given by

$$(2') \qquad y_t - \bar{y}_t = u_t.$$

Aggregate demand, on the other hand, is now determined as

$$(9) \qquad y_t = \beta_0 + \beta_1(m_t - p_t) + \beta_2 g_t + v_t,$$

where $\beta_1 > 0$, $\beta_2 > 0$, and v_t is a white noise demand disturbance with $Ev_t = 0$ and $Ev_t^2 = \sigma_v^2$. Here equation (9) can be thought of as resulting from IS and LM functions with the nominal interest rate solved out and the effects of expected inflation--the difference between the nominal and real rates of interest--ignored for simplicity. In this setting it makes no difference for the purpose at hand whether we treat p_t or x_t as a target variable, so let us assume that the policy rule under discussion is as follows:

$$(10) \qquad g_t - g_t^b = \lambda_1(p_t - p_t^b) \qquad \lambda_1 < 0.$$

Here government spending departs from its baseline value in a manner designed to keep the price level from straying away from its baseline path.

In this example equations (2´), (9), and (10) determine time paths for g_t, y_t, and p_t in response to u_t and v_t realizations if a process for m_t is specified. For present purposes it will be convenient and not misleading to proceed under the supposition that m_t is kept equal to m_t^b, perhaps at its historical values, in each of the simulations. In that case, we can solve for the price level and obtain the following expression:[13]

$$(11) \qquad p_t = p_t^b + \frac{v_t - v_t^b - (u_t - u_t^b)}{\beta_1 - \lambda_1\beta_2}.$$

With the baseline paths for v_t^b and u_t^b given, therefore, it is a simple matter to find that the variance of $p_t - p_t^b$ equals[14]

$$(12) \qquad V(p_t - p_t^b) = \frac{\sigma_v^2 + \sigma_u^2}{(\beta_1 - \lambda_1\beta_2)^2}$$

Once again the derived variability measure depends on the magnitude of the policy parameter, in this case λ_1. The sense in which this "finding" is misleading is, however, quite different than in the previous example. In this case it _is_ possible to use the g_t instrument to keep p_t close to p_t^b, since we are pretending that (10) is legitimate.[15] But nevertheless there is no possibility, within the confines of rule specification (10), of using the fiscal instrument g_t to control the average growth rate of p_t, that is, the trend in the path of p_t. Since g_t cannot forever grow at a rate different from that of y_t, the average growth rate of p_t is fully determined in the structure at hand by the trend growth rate of $m_t = m_t^b$. Consequently, the criterion $V(p_t - p_t^b)$ is entirely uninformative--or, rather, misleading--concerning the suitability of g_t as an instrument for the control of inflation. This flaw depends on no misspecification of the model or the policy rule, but instead on the manner in which baseline values are used in rules of form (1).

To this point it has been argued that specification (1) can be highly inappropriate for use in simulation studies of the effectiveness of alternative policy rules. In the next section we turn to an application of the argument, one that illustrates in a substantive context the points developed above.

IV. Application: The Policy Assignment Problem

A topic of perennial interest in the international macroeconomics literature is the policy "assignment problem" involving the association of monetary and fiscal policy instruments with target variables reflecting internal and external imbalance. To a considerable extent, the most recent outburst of interest in this topic is apparently attributable to the extended target zone (ETZ) "blueprint" proposal for international monetary reform that was put forth by Williamson and Miller (1987). In order to defuse criticism of Williamson's (1983) earlier target zone proposal, the 1987 ETZ blueprint recommends that monetary policy be assigned to achieve real exchange rate targets with fiscal policy used to control inflation by keeping nominal aggregate demand close to a specified target path.[16] The appropriateness of this assignment was disputed by Genberg and Swoboda (1987) and Boughton (1988), who suggested that the reverse pairing would be appropriate--monetary policy for nominal demand control and fiscal policy for the real exchange rate targets. As these arguments and counterarguments were put forth on the basis of inconclusive theoretical notions and informal empirical results, the issue seemed ready-made for analysis by means of stochastic simulations with multicountry econometric models.[17]

Consequently, simulation results explicitly intended to bear on the assignment problem have been generated by Frenkel, Goldstein, and Masson (1989) and by Currie and Wren-Lewis (1989).[18] While the authors of the former study found some scope for possible disagreement, the bulk of their results tended to agree with those of Currie and Wren-Lewis, which indicated that the ETZ assignment would evidently yield better performance, in terms of measures such as $V(x_t - x_t^b)$, than the alternative assignment (AA) scheme preferred by Genberg-Swoboda (1987) and Boughton (1988).[19]

In considering these competing policy schemes, it is relevant to note that in both studies--as in the original proposals--the fiscal instrument employed is a measure of real government expenditures on goods and services.[20] From the perspective of neoclassical monetary economics, accordingly, the ETZ assignment appears almost bizarre since it assigns a real instrument to a nominal target (real government expenditures to nominal demand) and a nominal instrument to a real target (monetary policy to the real exchange rate). This point is slightly blurred as both groups use an interest rate as their monetary instrument, but that does not invalidate the point so long as it is a nominal interest rate that is utilized.[21]

The main point, consequently, is that in both of the cited papers the policy rules studied have some significant similarities with equation (1) above. In the case of the Frenkel-Goldstein-Masson (1989) paper, the rule is basically the same as (1), as can be readily verified by reference to the discussion of policy rules on their pp. 231-2. The only difference is that, under the ETZ scheme, nominal interest rates respond to world nominal income deviations as well as to real exchange rate deviations.[22] In the Currie and

Wren-Lewis paper, the correspondence with (1) is less complete. First--as mentioned in footnote 20--matters are complicated by the fact that a measure of a short-term real interest rate is taken to be the monetary instrument. But, as footnote 20 says, one can interpret the specification as pertaining to a nominal interest rate instrument with inflation expectations entering on the right-hand side as a conditioning variable. The more significant difference is that the Currie and Wren-Lewis rules focus on growth rates rather than deviations from a baseline path. Thus their results are open only to the first type of nonoperationality discussed in Section II. (An entirely different criticism might be based on the model's use of adaptive rather than rational expectations.)

In any event, once one looks past the mentioned complications, it becomes evident that there is a substantial degree of correspondence between the two rules used to represent the ETZ assignment and the two examples presented above in Section III. Specifically, the ETZ use of a real fiscal instrument to achieve nominal demand or inflation targets is exactly the situation represented in the example built upon the model of equations (2´), (9), and (10). And the use of a monetary instrument to hit real exchange rate targets is analogous to the example of equations (2) and (3). It is true that the econometric models used in the cited studies do not have the policy ineffectiveness property that obtains in our example, but as explained above that property is not essential to our result.[23]

To establish this claim more explicitly, and also to add some generality to the examples presented above, it will be useful to consider a small but conventional model of a small open economy that uses fiscal and monetary instruments to aim for nominal income and real exchange rate targets. The model consists of policy rules and the four following behavioral relations:[24]

$$(13) \qquad y_t = b_0 + b_1(R_t - E_tp_{t+1} + p_t) + b_2(e_t - p_t + p_t^*) + b_3g_t + v_t$$

$$b_1<0, b_2>0, b_3>0$$

$$(14) \qquad m_t - p_t = c_0 + c_1y_t + c_2R_t \qquad c_1>0, c_2<0$$

$$(15) \qquad y_t - \bar{y}_t = \alpha(p_t - E_{t-1}p_t) + u_t \qquad \alpha>0$$

$$(16) \qquad R_t = R_t^* + E_te_{t+1} - e_t.$$

Here R_t denotes a nominal interest rate and e_t the log of the price of foreign exchange. Asterisks indicate foreign variables and other symbols have the same meaning as in the examples of Section III; thus u_t and v_t are white-noise disturbances. Equation (13) is a log-linearized IS relation for an open economy, with $e_t - p_t + p_t^*$ representing the real exchange rate, while (14) is the LM relation under the simplifying assumption that imports have negligible weight in the general price index and in the measure of transactions relevant for money demand. Finally, (15) is a Lucas-style aggregate supply function and (16) posits uncovered interest parity. It is worth noting that the appearance of E_tp_{t+1} in (13) implies that the policy-ineffectiveness property does <u>not</u> obtain--see McCallum (1980, p. 736).

To simplify the discussion without any distortion of the points of concern, let us treat R_t^* and p_t^* as constants (with the latter normalized to zero), suppose that $\bar{y}_t$ is constant as well as exogenous, and limit our attention to policy rules that yield stationary stochastic processes for the variables g_t, Δm_t, Δp_t, and Δe_t. With these provisos, it makes sense to discuss the system's "long run" properties in terms of unconditional means such as Ey_t, $E\Delta e_t$, etc. Then we can immediately observe from (15) and (16) that $Ey_t = \bar{y}$ and $ER_t = R^* + E\Delta e_t$. Under these conditions equation (14) readily yields the implication $E\Delta p_t = E\Delta m_t$, i.e., that the unconditional mean of the inflation rate is governed by the money growth rate. Furthermore, equation (16) implies $0 = b_2(E\Delta e_t - E\Delta p_t)$, so that we can define $q_t = e_t - p_t$ and consider the determinants of Eq_t. In particular, we can substitute (16) into (13) and apply the E operator to obtain

$$(17) \qquad \bar{y} = b_0 + b_1 R^* + b_1 E(e_{t+1} - p_{t+1} - e_t + p_t) + b_2 E(e_t - p_t) + b_3 Eg_t.$$

But since $Eq_{t+1} = Eq_t$, the latter may be written as

$$(18) \qquad \bar{y} = b_0 + b_1 R^* + b_2 Eq_t + b_3 Eg_t,$$

which shows that Eq_t is influenced by Eg_t but not by monetary policy in the model at hand.

The crucial properties of the system, therefore, are that from a long-run perspective the real exchange rate is governed by fiscal and unaffected by monetary policy while the growth rate of nominal income, $\Delta x_t = \Delta p_t + \Delta y_t$, is governed by monetary and unaffected by fiscal policy. On a period-by-period basis, nevertheless, both q_t and Δx_t are to some extent responsive to policy actions of both types.

Now suppose that the following policy rules were appended to the model (13) - (16):

$$(19) \qquad m_t - m_t^b = \lambda(q_t - q_t^b)$$

$$(20) \qquad g_t - g_t^b = \lambda_1(x_t - x_t^b).$$

Here (19) and (20) represent assignments of the same general type as the ETZ scheme. In these rules, the baseline paths m_t^b, q_t^b, g_t^b, and x_t^b are, by construction, feasible and consistent with the model for some baseline realization of the shocks, u_t^b and v_t^b. If these are taken to equal historical residuals from equations (13) and (15), then the baseline paths m_t^b, q_t^b, g_t^b, and x_t^b will be identical to those of the historical record for the variables m_t, q_t, g_t, and x_t. Be that as it may, our main analytical task is to develop solution values for the performance measures based on these rules, namely, $V(q_t-q_t^b)$ and $V(x_t-x_t^b)$. To do so, let us introduce the notation $\tilde{z}_t \equiv z_t - z_t^b$ for any variable z_t, and write the system of equations as follows:

(13′) $\tilde{y}_t = b_1(\tilde{R}_t - E_t\tilde{p}_{t+1} + \tilde{p}_t) + b_2(\tilde{e}_t - \tilde{p}_t) + b_3\tilde{g}_t + \tilde{v}_t$

(14′) $\tilde{m}_t - \tilde{p}_t = c_1\tilde{y}_t + c_2\tilde{R}_t$

(15′) $\tilde{y}_t = \alpha(\tilde{p}_t - E_{t-1}\tilde{p}_t) + \tilde{u}_t$

(16′) $\tilde{R}_t = E_t\tilde{e}_{t+1} - \tilde{e}_t$

(19′) $\tilde{m}_t = \lambda\tilde{q}_t = \lambda(\tilde{e}_t - \tilde{p}_t)$

(20′) $\tilde{g}_t = \lambda_1\tilde{x}_t = \lambda_1(\tilde{p}_t + \tilde{y}_t)$

This set of six equations constitutes a model with endogenous variables $\tilde{y}_t$, $\tilde{p}_t$, $\tilde{e}_t$, $\tilde{R}_t$, $\tilde{m}_t$, and $\tilde{g}_t$. By inspection it can be determined that the minimal-state-variable or bubble-free solution expresses each of these variables as a homogeneous linear combination of $\tilde{u}_t$ and $\tilde{v}_t$. To solve the system it is necessary to obtain values for the expectations $E_t\tilde{p}_{t+1}$ and

$E_t\tilde{e}_{t+1}$. But with u_t and v_t white noise, these are simply equal to zero.[25] Consequently, we can by simple substitution reduce the system to the following pair of equations expressed in terms of $\tilde{p}_t$ and $\tilde{q}_t = \tilde{e}_t - \tilde{p}_t$:

$$(21) \qquad \alpha\tilde{p}_t + \tilde{u}_t = (b_2 - b_1)\,\tilde{q}_t + b_3\lambda_1\tilde{p}_t + b_3\lambda_1(\alpha\tilde{p}_t + \tilde{u}_t) + \tilde{v}_t$$

$$(22) \qquad \lambda\tilde{q}_t = \tilde{p}_t + c_1(\alpha\tilde{p}_t + \tilde{u}_t) - c_2(\tilde{q}_t + \tilde{p}_t)$$

Solution then yields for $\tilde{p}_t$ the expression

$$(23) \qquad \tilde{p}_t = \frac{\Psi}{\theta}\,\tilde{u}_t - \frac{1}{\theta}\,\tilde{v}_t,$$

where $\Psi = [1-b_3\lambda_1-c_1(b_2-b_1)/(\lambda+c_2)]$ and $\theta = \{b_3\lambda_1(1+\alpha) - \alpha + (1+\alpha c_1 - c_2)(b_2 - b_1)/(\lambda+c_2)\}$. This expression will be used in what follows.

Given (23), solutions expression for $\tilde{q}_t = \tilde{p}_t - \tilde{e}_t$ and $\tilde{x}_t = \tilde{p}_t + \tilde{y}_t$ can be found using (22) and (15'), respectively. They are:

$$(24) \qquad \tilde{q}_t = \frac{c_1 + (1+\alpha c_1-c_2)\Psi/\theta}{\lambda+c_2}\,\tilde{u}_t - \frac{(1+\alpha c_1-c_2)/\theta}{\lambda+c_2}\,\tilde{v}_t$$

$$(25) \qquad \tilde{x}_t = [1+(1+\alpha)\Psi/\theta]\,\tilde{u}_t - (1+\alpha)/\theta\,\tilde{v}_t$$

Thus the performance measures $V(q_t-q_t^b) = V(\tilde{q}_t)$ and $V(x_t-x_t^b) = V(\tilde{x}_t)$ are seen to be, under the assumption that u_t and v_t are independent,[26]

$$(26) \qquad V(\tilde{q}_t) = \frac{[c_1+(1+\alpha c_1-c_2)\Psi/\theta]^2}{(\lambda+c_2)^2}\,\sigma_u^2 + \frac{[(1+\alpha c_1-c_2)/\theta]^2}{(\lambda+c_2)^2}\,\sigma_v^2$$

and

$$(27) \qquad V(\tilde{x}_t) = [1+(1+\lambda)\Psi/\theta]^2 \sigma_u^2 + [(1+\alpha)/\theta]^2 \sigma_v^2.$$

The values of these clearly will depend via Ψ and θ on the policy feedback parameters λ and λ_1.

In fact, it is shown in the Appendix that in the limit, as $\lambda \to -\infty$ and $\lambda_1 \to -\infty$, the expressions in (26) and (27) both approach zero. Thus in the model at hand the performance measures $V(q_t - q_t^b)$ and $V(x_t - x_t^b)$ associated with rules (19) and (20) give the appearance that the ETZ assignment, of monetary and fiscal instruments to real exchange rate and nominal income targets, respectively, will be highly successful provided that feedback is applied strongly. But the model in hand is, by construction, one in which the long-run behavior of the real exchange rate is dependent upon fiscal policy and independent of monetary policy actions with the opposite holding for nominal income.[27] Thus the rules would actually work very badly unless by chance the chosen target values happened to correspond to average instrument realizations from rules that are directed to the other targets.

Consequently, it seems appropriate to conclude that the variability measures reported by Frenkel, Goldstein, and Masson (1989) and by Currie and Wren-Lewis (1989) cannot reasonably be viewed as providing useful evidence on the assignment problem as described above. Even if the economic models were highly accurate depictions of the international economy, the policy simulation results of the cited studies would be systematically vitiated by their inappropriate specification of the alternative policy rules.

V. Concluding Remarks

The foregoing sections have developed an argument to the effect that policy rules of the form (1), because they assume knowledge of current-period aggregate variables and express instruments and targets in terms of deviations from baseline paths, are inappropriate for simulation studies intended to investigate the performance characteristics of alternative strategies for macroeconomic policy. Of course, such rules would also be inappropriate in the same way for use in analytical studies of these issues. In conclusion, it may be useful to put forth a few constructive suggestions for alternatives to specification (1).

In that regard, the main desideratum is simply that the rules be specified so as to be potentially operational. One requirement, accordingly, is that the variables designated as instruments be ones that policy authorities can actually control with high accuracy, and without major institutional change, over periods of the duration implied by the model at hand. In a quarterly model, for example, it would be reasonable to designate a short-term nominal interest rate or the monetary base, but not a measure like M1 or M2, as the monetary instrument. A second requirement is that the target variables--or information variables if any are utilized--to which the instruments respond should typically be ones pertaining to previous time periods. Only in the case of asset prices is it reasonable to suppose that current-period values could be observed when setting current-period instrument values.

These first two requirements are quite straightforward and would probably be agreed to in principle by most modelers, although there is perhaps room for disagreement about details of specific cases.[28] But there is also a third requirement for full operationality that is somewhat more subtle and might be resisted by some analysts. This third requirement is that all variables appearing in a rule should be measured in terms of raw data. In particular, variables whose construction depends upon the model at hand should not be employed because rules including such variables would not be used by actual policymakers and (more importantly) are not usable for performance comparisons across models--e.g., for robustness studies. In addition, variability measures based on deviations from baseline paths can provide highly misleading indications concerning the merits of alternative policy schemes, as in recent studies of the international policy assignment problem.

As examples of operational specifications, it may be useful to mention two monetary policy rules that have been employed in a recent study--one conducted, by chance, by the present author (McCallum, 1990). The analysis is conducted with extremely small models and pertains to a single economy that is treated, inadequately, as essentially closed. But those features of the work are not germane to the issues at hand; the two alternative policy rules could be utilized in large multicountry models provided that they use quarterly data. Both of the rules are designed to keep nominal GNP for the United States close to a prespecified path (starting in 1954.1) that grows steadily at a rate of three percent per year. In logarithmic terms this amounts to growth of 0.00739 per quarter, so the target path for the log of nominal GNP is

$$(28) \qquad x_t^* = x_{t-1}^* + 0.00739$$

with an initial value of $x_t^* = 5.9086$ in 1953.4.

The first of the two rules sets quarterly values for the log of the monetary base, b_t, so as to keep x_t (log of nominal GNP) close to x_t^*. Since base velocity is not constant over time, there is a term that subtracts the average growth rate of base velocity over the past 16 quarters from 0.00739 as well as a term that responds to the previous quarter's targeting error. Thus the rule can be written as

$$(29) \quad \Delta b_t = 0.00739 - (1/16)[x_{t-1} - b_{t-1} - x_{t-16} + b_{t-16}] + \lambda(x^{*}_{t-1} - x_{t-1}).$$

To make (29) operational it is necessary to assign a value to the feedback parameter λ; the value that is emphasized in McCallum (1990) is $\lambda = 0.25$. It is also necessary to be explicit about the specification of b_t and x_t as average values over the quarter, seasonally adjusted. But with those specifications, and the argument that b_t can be accurately controlled over any period of more than a few days, rule (29) would be fully operational if x_{t-1} were observable at the start of period t. In fact it is not, in the U.S. or other actual economies, so the argument that (29) is operational depends on the contention that the value of x_{t-1} become available early enough during period t for the <u>average</u> value of b_t to be adjusted as specified. This contention might be disputed by some, but clearly (29) is an order-of-magnitude closer to full operationality than (1).[29]

The second rule considered in McCallum (1990) has the same nominal GNP target but uses a short term interest rate R_t as the instrument. In the reported study the three-month treasury bill rate (average value over the quarter) is used for convenience; in principle the federal funds rate would be a more realistic choice. In any event, it was found that integral as well as proportional feedback was needed for reasonable control in this case. Thus the rule in question can be written as

$$(30) \quad R_t = R_{t-1} - \lambda_1(x^{*}_{t-1} - x_{t-1}) + \lambda_2(x^{*}_{t-2} - x_{t-2})$$

where the policy parameter magnitudes that seem most promising are in the vicinity of $\lambda_1 = 1.00$ and $\lambda_2 = 0.90$. The important feature of rule (30), from the perspective of this paper's argument, is that--like (29)--it includes current-period values of no variables other than the policy instrument and makes reference to no model-specific "baseline" values.

Each of these monetary policy rules needs to be accompanied , of course, by a fiscal policy rule that conforms to the same three requirements as those listed above. An appropriate target variable might be the real exchange rate or the real current-account balance. Or, another possibility would be the real full-employment surplus in the government's budget. This last possibility, finally, brings to mind the obvious but important point that all of the basic arguments of this paper are straightforwardly applicable to analyses pertaining to a single closed economy as well as in the multicountry applications that have been emphasized.

Appendix

The object here is to find the limiting values, as $\lambda \to -\infty$ and $\lambda_1 \to -\infty$, of the expressions in (26) and (27), where

$$\text{(A-1)} \qquad \Psi = 1 - b_3\lambda_1 - c_1(b_2-b_1)/(\lambda+c_2)$$

$$\text{(A-2)} \qquad \theta = b_3\lambda_1(1+\alpha) - \alpha + (1+\alpha c_1-c_2)(b_2-b_1)/(\lambda+c_2).$$

As a preliminary matter, note that as $\lambda \to -\infty$ we have $\Psi \to 1-b_3\lambda_1$ and $\theta \to b_3\lambda_1(1+\alpha) - \alpha$. Also note that the derivatives with respect to λ_1 of these last two expressions are $-b_3$ and $b_3(1+\alpha)$, respectively. Accordingly, we see from l'Hopital's rule that the limiting value (as λ_1 and $\lambda \to -\infty$) of Ψ/θ is $-1/(1+\alpha)$. Separately, we have $\Psi \to \infty$ and $\theta \to -\infty$.

From those results we readily see that the coefficients in (26) both approach zero in the limit as λ and $\lambda_1 \to -\infty$. The result is also obvious for the coefficient on σ_v^2 in (27). For the coefficient on σ_u^2, finally, we have

$$\text{(A-3)} \qquad \lim\,[1+(1+\alpha)\Psi/\theta]^2 = \{\lim[1+(1+\alpha)\Psi/\theta]\}^2$$

$$= [1+(1+\alpha)\lim(\Psi/\theta)]^2 = [1+(1+\alpha)(-1/(1+\alpha))]^2$$

$$= [1-1]^2 = 0.$$

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Footnotes

[1]At a March 1990 conference held at the Brookings Institution, for example, groups (or individuals) presented simulation studies generated with the following multi-country models: GEM, INTERMOD, MSG, MX3, MULTIMOD, MPS, LIVERPOOL, and TAYLOR.

[2]Resulting conference volumes include Bryant, Henderson, Holtham, Hooper, and Symansky (1988) and Bryant, Currie, Frenkel, Masson, and Portes (1989).

[3]More generally, instrument settings may reflect responses to deviations of several variables from their baseline paths, with different weights for the different variables.

[4]Also the open-market desk may make significant adjustments between FOMC meetings.

[5]That there are certain advantages to the use of annual models is not being disputed. The argument is only that one cannot escape the policy response problem by recourse to annual data.

[6]That contemporaneous observation of some variables is not plausible but that expectations can nevertheless be incorporated is recognized, and applied in some of the simulation experiments, by McKibbon and Sachs (1988).

[7]In most studies, mean values over a large number of simulation experiments would be reported for these measures.

[8]For an extensive discussion of this proposition, which attracted much attention during the 1970s but little in recent years, see McCallum (1980, pp. 724-738).

[9]It is not being claimed that all models including "surprise" supply functions possess the policy ineffectiveness property; that they do not is demonstrated explicitly in McCallum (1980, p. 736). The point being made here simply begins with a case in which, by assumption, this property holds.

[10]From (3) $m_t - E_{t-1}m_t = m_t^b + \lambda(y_t - y_t^b) - E_{t-1}[m_t^b + \lambda(y_t - y_t^b)]$. But the baseline values are given data from the perspective of each simulation so $m_t - E_{t-1}m_t = \lambda(y_t - E_{t-1}y_t) = \lambda[\alpha(m_t - E_{t-1}m_t) + u_t]$. Solving the latter for $m_t - E_{t-1}m_t$ yields (4).

[11]Similar conclusions would clearly hold for root-mean-square or mean-absolute measures of $y_t - y_t^b$.

[12]It is well-known from Fischer (1977) that the ineffectiveness proposition will not hold when this modification is adopted.

[13]To do so, first eliminate y_t between (2′) and (9). Then take the difference between the resulting equation evaluated at simulated and baseline values and insert (10) to eliminate $g_t - g_t^b$. Then rearrangement yields (11).

[14]For simplicity of exposition, expression (12) assumes--unnecessarily--that u_t and v_t are uncorrelated.

[15]Expression (12) is misleading, however, in its apparent suggestion that $V(p_t - p_t^b)$ could be made arbitrarily small, for a very large value of λ might drive g_t outside of its feasible range. This was pointed out to me by Paul Masson.

[16] Williamson (1988, p. 114) summarizes the rules as follows. "Each participating country would have an endogenous target rate of growth of nominal income.... This would provide one intermediate target for each country. The other would be a target for the (real effective) exchange rate.... This set of (2n-1) intermediate targets would be pursued by the following set of assignment rules: (1) the average level of world interest rates [is dedicated to average nominal income growth]; (2) differences in interest rates among countries would be revised when necessary to prevent exchange rates from deviating from their target levels by more than, say, 10 percent; (3) national fiscal policies would be revised with a view to achieving national target rates of growth of nominal income."

[17] According to Edison, Miller, and Williamson (1987, p.201), this suggestion was made by John Taylor at a Brookings conference in March 1986.

[18] Also see Currie and Wren-Lewis (1990). The earlier study of Edison, Miller, and Williamson (1987) was concerned with evaluation of the ETZ proposal but not its comparison with the alternative scheme. The points developed in the present paper are nevertheless germane to the Edison, Miller, and Williamson analysis.

[19] I do not mean to suggest that Frenkel, Goldstein, and Masson (1989) are persuaded by their own findings. On the contrary, they express some skepticism regarding the merits of the ETZ proposal (pp. 229-230). From a substantive (rather than methodological) perspective, therefore, I would view the arguments of the present paper as generally supportive of the views of Frenkel, Goldstein, and Masson.

[20] See Frenkel, Goldstein, and Masson (1989, pp.231-2) and Currie and Wren-Lewis (1990, pp.116-118).

[21] In fact, Currie and Wren-Lewis (1989) (1990) describe their monetary instrument as a real interest rate. But the latter is implemented as a nominal rate less an expected inflation rate, so the rule can be rewritten with the latter variable on the right-hand side. That makes their rule fall into form (1) less cleanly, but it does not alter the aspects of rule (1) that are relevant for the issues of concern in the present paper.

[22] Thus the ETZ scheme actually assigns monetary policy partly to a real target and partly to a nominal target.

[23] McKibbin and Sachs (1989) have found that, in simulations with the MSG model, the ETZ proposal has "a long-run stability problem" and have suggested that "the apparent contradiction" in comparison with Currie and Wren-Lewis (1990) and Edison, Miller, and Williamson (1987) stems from the MSG model's "strict adherence to all intertemporal budget constraints" (1989, p. 191). Another difference is the treatment of expectations, which are rational in the MSG model. Although representing no contrast with the just-mentioned models, it should be noted that the MSG model's policy rules do not rely in the standard way upon baseline values.

[24] The model is similar to that in Flood (1981).

[25] In this step we take $E_t u^b_{t+1}$ and $E_t v^b_{t+1}$ to equal zero, not u^b_{t+1} and v^b_{t+1}, since we are assuming that expectations are rational but not omniscient in the baseline simulation.

[26] Here use is made of the fact that $V(u_t - u^b_t) = V(u_t) = \sigma^2_u$ and $V(v_t - v^b_t) = V(v_t) = \sigma^2_v$ since the paths u^b_t and v^b_t are "given" from the perspective of the variance calculations.

[27]The example of this section, like the two of Section III, is clearly one in which there are no dynamics--no effects on current endogenous variables of their own lagged values. Thus the problems generated by inappropriate instrument choice are not ones that manifest themselves necessarily in terms of dynamic instability. But the absence of dynamics does not imply that the problems are in any sense unrealistic; clearly, they would continue to exist if the models were elaborated so as to bring in adjustment costs, lagged responses, etc. Such features have been excluded from the examples only to keep the analysis simple and uncluttered.

[28]A few analysts, for example, might contend that the monetary base is not fully controllable within each day and so should not be regarded as a legitimate instrument.

[29]An important feature of this rule is that the policymaker can use it for arbitrary values of the target growth rate of nominal GNP by simply changing the 0.00739 values in (28) and (29) to the desired magnitude. If a five percent annual inflation rate were desired for instance, then nominal GNP should be made to grow at eight percent per year and the 0.00739 figures should be changed to 0.01924.