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THE SOURCES OF DISAGREEMENT AMONG INTERNATIONAL MACRO MODELS AND IMPLICATIONS FOR POLICY COORDINATION

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ABSTRACT

This paper makes use of the simulation results of 12 leading large international econometric models, as to the effects of commonly specified changes in monetary and fiscal policy, conducted under the Brookings exercise "Empirical Macroeconomics for Interdependent Economies." The first half of the paper examines disagreement among the models on the signs of policy multipliers, and how such disagreement compares to the ambiguities appearing in the theoretical literature. There turns out to be relatively little disagreement as to the effects on output, prices and the exchange rate. The greatest disagreement is rather over the question whether a monetary expansion worsens or improves the current account.

The second half of the paper examines the implications for international macroeconomic policy coordination. The existing literature makes the unrealistic assumption that policy-makers all know the true model, from which it follows that the Nash bargaining solution is in general superior to the Nash competitive solution. But everything changes once we recognize that policy-makers' models, as the models in the Brookings simulations, differ from each other and therefore from the "true" model. When the central bank and fiscal authorities subscribe to conflicting models, it is still true that (1) the competitive equilibrium is sub-optimal, and that (2) the two authorities will in general be able to agree on a cooperative policy package that each believes will improve the objective function; however, (3) the bargaining solution is as likely to move the target variables in the wrong direction as in the right direction, in the light of a third true model. Out of 1,210 possible combinations of different models subscribed to by the two policy authorities and models representing reality, bargaining raises welfare in only 819 cases. The conclusion is that disagreement as to the true model may be a more serious obstacle to successful policy coordination than is institutional failure to enforce Pareto-improving solutions.

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An easy way for an outsider to tell when an academic discipline has not yet ascertained "the truth" of a question is when its practitioners each give different answers. We know that we as macroeconomists have not yet ascertained "the truth," if there was previously any doubt on this score, when we look at the great divergence in forecasts as to the effects of carefully-specified policy changes in the Brookings simulation exercise "Empirical Macroeconomics for Interdependent Economies". The probability that a given model is correct is small when the number of models giving different answers is large. Furthermore it is unlikely that we will <u>ever</u> discover the true model; the number of different models and the way models keep changing over time is evidence of this proposition, and it seems inherent in the nature of social science.

There are three ways research can proceed. The first is for the researcher at each point in time to maintain that he or she has now discovered the one true model, and that all other models are wrong. The second is for the researcher, while continuing to speak the language that suggests his model is the one true one, to recognize implicitly that this language is merely a convenient shorthand. The third is to focus explicitly on the simultaneous co-existence of conflicting models.

The second research strategy is the best one to pursue for most economic problems. The econometrician knows that his parameter estimates are not exactly correct. More generally, all modellers know that their models must be incomplete and misspecified. Nevertheless, if the economist is good, the errors in his model will be such that, even if they could be correctly handled, it would not much change his forecasts (in the case of an econometric forecasting model) or the conceptual point he is trying to make (in the case of a theoretical model). While it may be useful for the modeller to have explored as many extensions as possible in appendices and such, there is not a need for him to be able to claim that he has exhausted the truth. Nor is there a need for him, on the other hand, to make frequent disclaimers; the readers will understand that the model is not to be taken as literal truth.

These issues become most salient where, as in most modern macroeconomic models, agents in the proposed model must make decisions based on expectations formed on the basis of some model of their own. The rational expectations assumption is, of course, the assumption that the model used by the agents is the same as the proposed larger model. As soon as we admit that--because intelligent people are observed to believe in conflicting models--we cannot claim that the proposed larger model necessarily is literal truth, it follows that we cannot claim that agents' models must necessarily be literally identical to the proposed larger model. But, again, for most economic problems, especially those involving the microeconomic decisions of private agents, one can make a case that there is little to be gained by explicitly focusing on divergent models. The assumption that the agents know the one true model will continue to be an attractive modelling strategy.

When the decision makers are governments and the decision variables are macroeconomic policies, the case for assuming that everyone knows the one true model is less compelling. In the first place, there is no powerful force like the marketplace to discipline governments who use incorrect models. In the second place, the Federal Reserve Board's MCM model, the Japanese EPA model, the OECD Interlink model, etc., are the best that these government agencies have, and we can see that these models conflict. One can argue that microeconomic agents have access to specific knowledge of a common model unavailable to the macroeconomist. It would be more difficult for a macroeconomist at a government agency to argue that his or her own agency has access to knowledge of a common model unavailable to the macroeconomist himself.[1]

The subject of this paper is the international econometric models' conflicting estimates of the effects of macroeconomic policies. To focus the discussion, we limit the policy variables to each country's money supply and level of government expenditure. The framework of policy variables and targets can thus be represented:

$$Y = U + V[M_a \; G_a \; M_b \; G_b]'$$

[1]This is not to make the naive mistake of thinking that policy makers put complete faith in the models of the macroeconomists at their own agencies, nor that the latter necessarily have access to the latest data and thoughts of the former. But policy makers, at best, base their thinking on models--whether developed by government, academic or corporate institutions--similar to those in the Brookings modelling exercise. (For example, British macroeconomic policy under Thatcher may have been based on a model closer to the Liverpool model, which appears in this exercise, than to any models previously existing at the U.K. Treasury or Bank of England.) Policymakers, more likely, base their thinking on "models" that conform even less to each other or to truth than do the models of macroeconomists.

where Y is a vector of output levels and other policy variables of interest to the two countries, V is a matrix of policy multipliers, M_a and G_a are the domestic money supply and government expenditure and M_b and G_b are the foreign money supply and government expenditure.

The project is divided into three major parts. Part I examines how the reduced form policy multipliers, the entries in matrix V above, are determined by more fundamental economic parameters such as the degree of capital mobility, money demand elasticities, etc. This examination includes (a) the divergent multipliers one would expect to get from the standard theoretical models that appear in the literature, (b) the divergent multipliers that emerge from the simulations in the Brookings modelling simulation exercise, (c) an attempt to interpret (b) in terms of (a).

The other two parts of the project show what can happen in standard policy-making problems when one policy maker bases his actions on one of the available macroeconomic models, and another policy maker bases his on another model, neither of which is necessarily the correct model. It is shown that the usual finding of the popular literature on macroeconomic policy coordination--that is, that policy-making is necessarily improved if policy makers coordinate--does not hold if policy makers base their actions on conflicting models.

In Part II we consider two domestic policy makers: the monetary authority and the fiscal authority. We also limit the policy targets at first to output and the current account balance to get a two-target, two-instrument framework. We begin with the case in which the policy makers have common goals and the only coordination issue arises out of divergent models. If the fiscal authority can believe any of the N models, the monetary authority can believe any of the N models, and the true world can be represented by any of the N models, then there are N^3 possible combinations. We show that when the two policy makers coordinate, the common welfare function is improved relative to the Nash competitive equilibrium in only 98 out of 180 combinations. Then in the appendix we move to the usual case where goals diverge. The fiscal authority seeks to maintain internal balance and the monetary authority external balance or vice versa. This is the classic assignment problem. As in the case of common goals, the qualitative answer changes when the policy makers disagree on the correct model.

In the third part of this project, which will appear as a separate paper, we consider the more complex problem of international policy coordination. In studying coordination among four sets of policy makers, monetary and fiscal authorities both domestically and abroad, the policy targets will have to include three target variables, such as output, the current account and inflation, the same three used by Oudiz and Sachs (1984).[2] Again, when models diverge, it is possible that everyone will be worse off when policy makers do coordinate than when they do not. Perhaps the main lesson of the paper is that when, for

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[2]An alternative for the two-target, two-instrument framework would be output and the exchange rate, which could be argued to span the three targets.

example, U.S. and European authorities fail to adopt an economist's plan for improving joint welfare by adopting a specific coordinated combination of policies, it may be because of divergent views as to what the effects of those policy changes will be, rather than because of competitive maximization of divergent goals.

I. THE SOURCES OF CONFLICTING POLICY MULTIPLIERS

We focus on the models' conflicting implications for the effects of a change in fiscal policy, and the effects of a change in the money supply, in each case with the other policy variables (domestic and foreign) held constant. The most well-known ambiguity is the question of whether a fiscal expansion causes the domestic currency to appreciate or depreciate. The other ambiguity that appears most commonly in the theoretical literature is the effect of the exchange rate, and therefore the effect of domestic fiscal (and monetary) policy, on foreign income. The issue of whether transmission is positive or negative is of course crucial to questions of international policy coordination. Somewhat surprisingly, neither of these issues is the one on which the simulations in the Brookings interdependent modelling exercise show the most conflict. Most of the models show a fiscal expansion appreciating the domestic currency and raising foreign output. The models are in much greater disagreement on an issue that much of the literature considers unambiguous: the effect of a domestic monetary expansion on the current account and, via the trade linkage, on foreign output.

We begin by considering the standard theoretical two-country model.

I. 1. The Standard Two-Country Model

Since the model is so familiar, we circumscribe the algebra tightly. Though we specify the equations in relatively general form, we then proceed to consider only special cases.

(1) $M/P = L(Y, i; i^*)$ $\qquad \phi \equiv L_y > 0 \quad \lambda \equiv L_i < 0 \quad L_{i^*} < 0$

(2) $M^*/P^* = L^*(Y^*, i^*; i)$ $\qquad \phi^* \equiv L^*_{y^*} > 0 \quad \lambda^* \equiv L^*_{i^*} < 0 \quad L^*_i < 0$

(3) $Y = A(Y, i; SP^*/P) + G + TB$ $\qquad A_y > 0 \quad A_i < 0$

(4) $Y^* = A^*(Y^*, i^*; SP^*/P) + G^* - TB$ $\qquad A^*_{y^*} > 0 \quad A^*_{i^*} < 0$

(5) $TB = X(SP^*/P) + \mu^* Y^* - \mu Y$ $\qquad X_S > 0$

(6) $TB = -KA = -K(i - i^*; s - \bar{s})$ $\qquad k \equiv K_{i-i^*} > 0$

(7) $Y/\bar{Y} = (P/\bar{P})^{\sigma}$

(8) $Y^*/\bar{Y}^* = (P^*/\bar{P}^*)^{\sigma^*}$

where M $\equiv$ money supply

P $\equiv$ price level (domestic goods, unless otherwise stated)

Y $\equiv$ output

i $\equiv$ interest rate

S $\equiv$ exchange rate

G $\equiv$ government expenditures

TB $\equiv$ trade balance

Equations (1) and (2) give the money demand equations for the domestic and foreign countries, respectively. We allow for the possibility that foreign bonds compete with domestic bonds as an alternative to domestic money in portfolios by including the other country's interest rate after the semi-colon. Equations (3) and (4) show the demands for goods. We allow for the possibility of a Laursen-Metzler effect, that a worsening of the terms of trade would raise expenditure measured in domestic units, by including the real exchange rate after the semi-colon. Equation (5) gives the trade balance. Equation (6) gives the capital outflow as a function of the nominal interest differential, and possibly of expected depreciation, where the latter is assumed to be a function of the spot rate relative to its equilibrium level. Under floating exchange rates the trade balance and capital outflow are equal. Finally, in equations (7) and (8) the supply of output is seen to be a function of the price level relative to an equilibrium value, which can be thought of as either the expected price level or as the cost of labor and other variable factors of production.

The above model leaves out many factors. Perhaps the most notable omissions are the stocks of government and international indebtedness.[3] Such omissions might be justified by an appeal to the short run, over which the stocks cannot change much: our focus in the

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[3]Also omitted are some so-called "supply side" effects, such as the possibility that a balance budget reduction in tax rates and government expenditure would stimulate output and appreciate the currency. Such effects have been important in the thinking of the Reagan Administration and a few private economists, but they do not seem to be incorporated into any of the 12 models involved in the Brookings simulation exercise.

simulations will be on the effects in the second year after a policy change (just long enough for the trade balance to get past the negative part of the "J-curve"). In models with forward-looking expectations, of which the MSG, Liverpool, and Taylor models among the Brookings twelve are examples, long-run effects can be passed back through time to the short run. But even then, the effect is generally quantitative rather than qualitative. This paper concentrates on the more blatant of contradictions: those in the sign of an effect. These are less likely to be affected by the omission of such factors as stocks of indebtedness.[4]

We consider first the case when supply is infinitely elastic ($\sigma = \sigma^* = \infty$) so that the price levels P and P^* are fixed in the short run, and all variables that appear after the semi-colon are omitted. This is the standard Mundell-Fleming model.[5] Equation (6) for the trade balance can be substituted into equations (3) and (4); these two together with equations (1) and (2) determine four endogenous variables--Y, Y^*, i, and i^*--as a function of the four policy variables--G, M, G^*, and M^*. (Equation (5) then determines the exchange rate.)

A fiscal expansion in the Mundell-Fleming model has the following

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[4]It is possible to get reversals of sign. For example, in some models a fiscal expansion could be contractionary if expectations of future debt drive up expected future short-term interest rates and current long-term interest rates, and therefore crowd out investment, enough. The Liverpool model appeared to show this effect for the case of a U.S. expansion in earlier work (Minford 1984, 100, 114, 133).

[5]Citations for the two-country Mundell-Fleming model are Mundell (1964), Mussa (1979), and Swoboda and Dornbusch (1973). An early two-country version of the portfolio-balance model, with the degree of substitutability between domestic and foreign bonds filling in for the Mundell-Fleming model's degree of capital mobility, is Girton and Henderson (1976).

well-known effects. It increases domestic income Y and therefore the domestic interest rate i.[6] The differential between the domestic and foreign interest rates attracts a capital inflow which, ex post, corresponds to a trade deficit. If capital mobility is sufficiently high (if the slope of the BB curve μ/k is less than the slope of the LM curve ϕ/λ), then the balance of payments would improve at an unchanged exhcange rate, which implies that the domestic currency appreciates under floating rates. The currency appreciation may be as important a cause of the trade deficit as the increase in income. The counterpart foreign trade surplus increases foreign income Y^*. For monetary equilibrium to hold, it also must increase the foreign interest rate i^*. The primary ambiguity in the above story is whether capital mobility is high enough (or the LM curve steep enough) for the fiscal expansion to appreciate the currency; the reverse case appears as a prominent possibility in textbooks and in many of the large econometric models. Some of these models have been said to exhibit an asymmetry: fiscal expansion in the U.S. appreciates the currency but--whether because of lower capital mobility, a flatter LM curve, monetary accommodation, or other factors--fiscal expansion in Europe or Japan depreciates their currencies.

A monetary expansion has unambiguous effects in the Mundell-Fleming model. It reduces the domestic interest rate and therefore in-

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[6] In the limiting case of perfect capital mobility ($k = \infty$) and an exogenous foreign interest rate (small country), these effects vanish.

creases domestic income. The differential between domestic and foreign interest rates induces a capital outflow. The currency unambiguously depreciates, all the more if capital mobility is high. As a result the trade balance improves, notwithstanding the higher level of income; we know this because of the ex post net capital inflow. The improvement in the trade balance may constitute a larger amount of the increase in output than the stimulus to investment and other interest-sensitive sectors. The corresponding worsening in the foreign trade balance reduces foreign income. (For monetary equilibrium to hold, it must also reduce the foreign interest rate.) Thus we get the classic Mundell-Fleming result of inverse transmission: a contractionary monetary policy such as the United States adopted in 1980-82 is expansionary for Europe, via the trade balance.

The theoretical literature features at least five ways that the foregoing transmission results can be reversed, via effects of the exchange rate on variables other than the trade balance.[7] The exchange rate S can enter the saving/expenditure decision via the terms of trade in equation (4), can enter money demand via the price level in equation (2), can enter expenditure via real wealth in equation (4), can enter supply via the price of imported inputs in equation (8), and can

[7]There is also a way that the standard Mundell-Fleming result of negative transmission of monetary policy can be reversed via a reversal of the trade balance. It is if net capital inflows respond to expected future appreciation which, in turn, depends on the current level of the spot rate relative to its equilibrium level, as indicated in equation (6). Because discussion of this effect does not for the most part occur in the theoretical literature on international transmission, it is postponed to the following section.

enter supply via the nominal wage rate, also in equation (8). We consider each briefly.

First, according to the Laursen-Metzler-Harberger effect, a worsening in the terms of trade, i.e., an increase in SP^*/P, should affect the saving/expenditure decision similarly to any other decline in real income. In the traditional Keynesian literature, this means a reduction in saving to protect living standards, as measured in domestic terms: $A_s > 0$.[8] The point of the original Laursen-Metzler (1950) article was that, when a domestic expansion depreciates the domestic currency, the foreign country would respond to the improvement in its terms of trade by decreasing expenditure, giving the result of negative transmission under floating exchange rates. In the case of a monetary expansion, the Mundell-Fleming model's introduction of capital flows gave the negative transmission result anyway, so the Laursen-Metzler effect changes little. But in the case of a fiscal expansion (with low capital mobility, so that the domestic currency depreciates), this negative effect on foreign output could conceivably reverse the standard transmission result. This case does not seem relevant to the U.S. fiscal expansion of 1983-85, as the dollar appreciated strongly. For the purposes of the following discussion of each of the remaining four effects, we assume for simplicity that a fiscal expansion appreciates the currency.

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[8] On the other hand, the modern theory of saving says that only if the currency depreciation is perceived as a <u>temporary</u> decline in real income or, in the case of a permanent decline, if the rate of time preference rises with a fall in welfare, will intertemporally-optimizing consumers react by reducing saving. See Obstfeld (1982) and Svensson and Razin (1983).

Though we have previously defined the price levels P and P^* to refer only to goods produced in the domestic and foreign countries, respectively, in the case of the money demand functions they could as easily be replaced by the consumer price indices, CPI and CPI^*, defined as a Cobb-Douglas weighted average of domestic goods and imports:

$$CPI = P^{\alpha}(SP^*)^{1-\alpha} \tag{9}$$

$$CPI^* = (P/S)^{\alpha^*}(P^*)^{1-\alpha^*} \tag{10}$$

(See, for example, Branson and Buiter, 1983, 256-58.) A depreciation of the foreign currency (S↓) will lower the real money stock M^*/CPI^*, exerting a contractionary effect on foreign output. If the fall in the exchange rate originated in a domestic fiscal expansion, this effect can reverse the standard Mundell-Fleming result of positive transmission. The effect on the real money stock is one of the lines of argument open to those Europeans who believe that the U.S. fiscal expansion and strong dollar of the early eighties had adverse effects on European growth. In the case of a domestic monetary expansion, the domestic currency depreciates, the foreign currency appreciates, CPI^* falls, the foreign real money stock rises and Y^* increases; transmission is positive. Thus both the positive transmission of fiscal policy and the negative transmission of monetary policy can be reversed.

Similar to the negative effect of the exchange rate on the real money stock is the negative effect on the real stock of domestic government bonds. It can be contractionary if real wealth enters the expenditure function. There is also a negative effect of the exchange rate on expenditure if the domestic country is in debt to foreigners in foreign currency. Either of those effects is capable of reversing the effects on income through the trade balance, i.e., turning the positive transmission of fiscal policy into negative transmission and vice versa for monetary policy. (If a country is in debt in its own currency, as the United States is rapidly becoming, then a depreciation has a positive effect on wealth and expenditure, reinforcing the expansionary effects through the trade balance.)

Until now we have assumed, for the short run, infinitely elastic supply ($\sigma = \sigma^* = \infty$) so that the output prices P and P^* are fixed (in their own currencies). Relaxing this assumption does not in itself change qualitative conclusions about movements in output, assuming the equilibrium price levels $\bar{P}$ and $\bar{P}^*$--whether interpreted as expected price levels or as markup functions of input costs--are constant in the short run. Where expansionary effects on Y were previously noted, they are replaced by increases in P and, as a result, smaller increases in Y. To be precise, only $\sigma/1+\sigma$ of an increase in aggregate demand will be reflected in higher output. All contractionary effects are similarly reduced. In a well-specified model, the changes in P should in the long run be large enough to eliminate any effects on Y. But we are concentrating on the short run, in which most models show increases in both P and Y.[9]

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[9]Of course, there exist models in which prices rise so quickly that there is no effect on output even in the short run. At the opposite extreme, a few of the large econometric models represented in the Brookings simulations, have the property that an expansion actually <u>reduces</u> prices in the short run. This may come as a consequence of highly procyclical productivity and the (more questionable) assumption that prices are determined as a markup over current unit labor costs. (cont. on next page)

The last two ways that the standard transmission results can be reversed operate via the equilibrium price levels in the supply relationships. Assume that $\bar{P}$ and $\bar{P}^*$ in the supply functions are determined as markups over input costs; i.e., their rate of change is a linear function of the rate of change of the prices of oil and other inputs, the rate of change of wages, and the long-run rate of productivity growth. An increase in input prices will shift the supply relationship adversely, reducing output. Thus, to the extent that the price of oil is determined in dollars, an appreciation of the dollar is contractionary for other countries. This effect of the exchange rate, like the effects on real money balances and real wealth, runs in the reverse direction from the standard trade balance effect in the Mundell-Fleming model: fiscal expansions that appreciate the currency can be transmitted negatively and monetary expansion transmitted positively, rather than the other way around. Thus, this route too is open to those who wish to argue that the strong dollar has hurt Europe.

The final variable that might depend on the exchange rate is the wage rate. (For simplicity, let $\bar{P}$ equal the wage rate.) If wages are fixed, or determined by the unemployment rate, then the standard results are not affected. On the other hand, if wages are fully indexed to the domestic price level, then equations (7) and (8) become $Y = \bar{Y}$ and $Y^* = \bar{Y}^*$: policy can have no effect on output in either country. The interesting case is when wages are indexed to the consumer price index,

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[9](Continued) Alternatively, in the case of a monetary expansion, prices may fall if capital costs (interest rates) are reflected in mark-up pricing: Hickman identifies such an effect for some countries (apparently France, Italy and Canada) in the Link model.

including import prices as in equations (9) and (10), because the exchange rate can open a gap between the CPI and P. Equations (7) and (8) then become

(11) $$Y/\overline{Y} = (P/SP^{*})^{(1-\alpha)\sigma}$$

(12) $$Y^{*}/\overline{Y}^{*} = (P^{*}S/P)^{(1-\alpha^{*})\sigma^{*}}$$

It is clear that one country's output can go up only if the other country's output goes down. In the case of a domestic fiscal expansion that appreciates the currency (reduces S), there is a contractionary effect on foreign income that is similar to those we saw for the effects via real money, real wealth, and oil prices; all four work to reverse the Mundell-Fleming result of positive transmission. One might expect that a domestic monetary expansion, because it increases S in equation (12), would have the opposite effect from a fiscal expansion, that it would increase foreign income. But from equation (11) the monetary expansion would then have to reduce domestic income; this perverse result can be ruled out by the recognition from equation (3) that Y cannot fall unless i rises and reduces A or the currency appreciates and reduces TB, neither of which will follow from a monetary expansion. The only possible solution is that P rises by the same proportion as S (the increase in the money supply) and there is no effect on either domestic _or_ foreign income.[10]

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[10]Sachs (1980, 737) and Argy and Salop (1977, 2-12; 1979, 228). However if real wages are rigid in Europe and nominal wages are rigid in the United States, U.S. monetary policy _can_ be transmitted positively. Argy and Salop (1977, 6-10), Oudiz and Sachs (1984, 13-14).

Table 1 summarizes the various possible transmission effects of the exchange rate. We now turn to the various results that appear in the Brookings simulations of large econometric models.

TABLE 1

THEORETICAL TRANSMISSION EFFECTS

	Fiscal Expansion with Low Capital Mobility	Fiscal Expansion with High Capital Mobility	Monetary Expansion
DOMESTIC CURRENCY:	Depreciates	Appreciates	Depreciates
EFFECTS ON FOREIGN OUTPUT:			
<u>Effects via Trade Balance = Capital Outflow</u>			
Interest Differential	Positive	Positive	Negative
Regressive Exchange Rate Expectations	Positive	Negative	Positive
<u>Effects via Domestic Demand</u>			
Laursen-Metzler Effect	Negative	Positive	Negative
Real Money Stock	Positive	Negative	Positive
Real Wealth	Positive	Negative	Positive
<u>Effects via Supply</u>			
Imported Inputs	Positive	Negative	Positive
Wage Indexation	Positive	Negative	Positive

I. 2. The Policy Multipliers in the Simulations

Table 2 summarizes the effects of a fiscal expansion (an increase in government spending, with the money supply and foreign policy variables held constant) according to the 12 models in the Brookings simulations. (The U.S. expansion is represented by Simulation B with all signs reversed. The non-U.S. OECD expansion is Simulation G.) For simplicity it shows the effects only in the second year.

The most well-known theoretical ambiguity, the effect on the exchange rate, turns out to generate relatively little disagreement. In the case of a U.S. fiscal expansion eleven models show an appreciation of the dollar. The only exception is the Wharton model, which reports a significant depreciation (evidently attributable to little or no capital mobility). In the case of a non-U.S. fiscal expansion there is a little more divergence. But seven out of eleven models still show the standard high capital mobility result, a domestic appreciation, with only the EPA, LINK, VAR and Wharton models showing the reverse. The asymmetry between the exchange rate effects of U.S. fiscal expansion and European or Japanese expansion, which here shows up only in these four models, has been attributed to a variety of possible reasons. One of them, a greater tendency to monetize government deficits abroad than in the United States, should have been ruled out by the careful specification of the Brookings experiment. Another reason suggested, lower capital mobility (k), could explain econometric findings for individual non U.S. countries but cannot explain the asymmetry in a well-specified two-country Mundell-Fleming model: capital mobility into the United States cannot be higher than capital mobility out of the rest of the world.

TABLE 2

SIMULATION EFFECT OF FISCAL POLICY IN SECOND YEAR

	Y	CPI	i	Currency Value	CA	CA*	i*	CPI*	Y*
Fiscal Expansion In U.S. (-Sim. B)			U.S.				Non. U.S.		
MCM	+1.8%	+0.4%	+1.7	+2.8%	-16.5	+8.9	+0.4	+0.4%	+0.7%
EEC[2]	+1.2%	+0.6%	+1.5	+0.6%	-11.6	+6.6	+0.3	+0.2%	+0.3%
EPA	+1.7%	+0.9%	+2.2	+1.9%	-20.5	NA	+0.5	+0.3%	+0.9%
LINK	+1.2%	+0.5%	+0.2	+0.1%	-6.4	+1.9	NA	-0.0%	+0.1%
LIVERPOOL	+0.6%	+0.2%	+0.4	+1.0%	-7.0	+3.4	+0.1	+0.6%	-0.0%
MSG	+0.9%	+0.1%	+0.9	+3.2%	-21.6	+22.7	+1.0	+0.5%	+0.3%
MINIMOD	+1.0%	+0.3%	+1.1	+1.0%	-8.5	+5.5	+0.2	+0.1%	+0.3%
VAR[1]	+0.4%	-0.9%	+0.1	+1.2%	-0.5	-0.2	-0.0	-0.0%	-0.0%
OECD	+1.1%	+0.6%	+1.7	+0.4%	-14.2	+11.4	+0.7	+0.3%	+0.4%
TAYLOR[1]	+0.6%	+0.5%	+0.3	+4.0%	NA	NA	+0.2	+0.4%	+0.4%
WHARTON	+1.4%	+0.3%	+1.1	-2.1%	-15.4	+5.3	+0.6	-0.1%	+0.2%
DRI	+2.1%	+0.4%	+1.6	+3.2%	-22.0	+0.8	+0.4	+0.3%	+0.7%
Fiscal Expansion in Non U.S. OECD (Sim. G)			Non U.S.				U.S.		
MCM	+1.4%	+0.3%	+0.6	+0.3%	-7.2	+7.9	+0.5	+0.2%	+0.5%
EEC[2]	+1.3%	+0.8%	+0.4	+0.6%	-9.3	+3.0	+0.0	+0.1%	+0.2%
EPA	+2.3%	+0.7%	+0.3	-0.7%	NA	+4.7	+0.6	+0.3%	+0.3%
LINK[3]	+1.2%	+0.1%	NA	-0.1%	-6.1	+6.3	+0.0	+0.0%	+0.2%
LIVERPOOL	+0.3%	+0.8%	+0.0	+3.3%	-17.2	+11.9	+0.8	+3.1%	-0.5%
MSG	+1.1%	+0.1%	+1.4	+2.9%	-5.3	+10.5	+1.3	+0.6%	+0.4%
MINIMOD	+1.6%	+0.2%	+0.9	+0.6%	-2.2	+3.2	+0.3	+0.2%	+0.1%
VAR[1]	+0.5%	-0.3%	-0.2	-2.4%	+1.7	-2.6	+0.2	-0.1%	+0.3%
OECD	+1.5%	+0.7%	+1.9	+0.9%	-6.9	+3.3	+0.3	+0.2%	+0.1%
TAYLOR[1]	+1.6%	+1.2%	+0.6	+2.7%	NA	NA	+0.4	+0.9%	+0.6%
WHARTON	+3.2%	-0.8%	+0.8	-2.4%	5.5	+4.7	+0.1	-0.0%	+0.0%
DRI	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1]U.S. CPI NA. U.S. GNP deflator reported instead.

[2]Non-U.S. short-term interest rate NA; long-term reported instead.

[3]Appreciation of non-U.S. currency NA; depreciation of dollar reported instead.

The same applies to the argument that non-U.S. countries are more open to trade than the United States; given that the non-U.S. economy is larger than the U.S., it must be less open in the aggregate. One explanation that works is a steeper LM curve in the United States so that U.S. interest rates are more easily driven up.[11]

For either U.S. or non-U.S. fiscal policy the simulations show that changes are transmitted positively to the rest of the world, in all the structural models but one. This is not surprising. Including even the few cases where a fiscal expansion depreciates the currency, the domestic current account is observed to worsen in all the structural models (as it must in standard theory; it is the worsening of the trade balance, if it is big enough, that is the cause of any downward pressure on the currency under Mundell-Fleming). The foreign current account and foreign income therefore increase.[12] In the majority-case where a fiscal expansion appreciates the currency, the positive transmission to

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[11]Oudiz and Sachs (1984, 7, 19, 22) find the asymmetry present in the MCM and EPA models, and attribute it to the slopes of the LM curve and the importance of dollar assets in the world portfolio. Yoshitomi (1984, 34-37, 62) explains that the asymmetry in the EPA model is due to the slopes of the LM curve and the degree of bond substitutability. A general discussion of the various possible reasons for the asymmetry occurred in a Brookings-World Bank conference in October 1984. (Volume edited by Fleisig.)

[12]In the VAR results, a fiscal expansion in either country produces a current account deficit in the other country. In the case of a U.S. fiscal expansion, the non-U.S. current account worsens slightly in the second year even though U.S. output rises, non-U.S. output falls, the dollar rises against foreign currencies, and the U.S. current account worsens! Such results suggest limitations to the usefulness of using non-structural models to answer questions about the likely effects of changes in policy. Cooley and Leroy (1985) consider this methodological issue.

foreign output provides a preliminary indication that the four theoretical contractionary effects of a currency depreciation discussed above (via money balances, real wealth, imported input prices or wages) either are not operating, or at least are not powerful enough to reverse standard transmission results.

The one exception among the eleven structural models is the Liverpool model. Though lining up with the majority on the positive effect of a fiscal expansion on the value of domestic currency, the negative effect on the domestic current account, and positive effect on the foreign current account, the Liverpool model nevertheless produces the unique result of a negative effect on foreign output. The reverse transmission holds both from the United States abroad and in the opposite direction. Evidently one or more of the four contractionary exchange rate effects is operating. Minford (1984, eq. 2, pp. 88-89) specifies an adverse supply effect from depreciation, apparently justified along the lines of the last of the four effects enumerated above: an increase in wages, in nominal or own-product terms.[13] The Liverpool simulations show a sharper increase in the CPI of the country not undertaking the fiscal expansion, presumably as a result of the depreciation of its currency, than do the other models. This could explain the strength of the adverse supply effect in that model.

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[13]However, Marston (1984, 136) specifically describes Minford's exchange rate effect on supply as coming from imported inputs, not labor costs. (Neither wages nor imported inputs appear explicitly in the model.) Hooper (1986, 7) identifies the contractionary effect of the exchange rate in the Liverpool model as the real wealth effect.

It is not surprising that the one model that shows the most dissimilar results is nonstructural: the Sims-Litterman VAR model. Like the Liverpool model it shows no positive transmission from U.S. fiscal policy to non-U.S. output (the effect appears to be inverse in the first two years, but insignificant to the third digit). More anomalously it shows a fiscal expansion in either country reducing the price level P in both countries (GNP deflator).[14]

To sum up the results of fiscal expansion, all structural models show positive effects on the domestic price level and negative effects on the domestic current account. All but one show positive effects on both domestic and foreign output. Several show a negative rather than positive effect on the value of the currency, especially when it is the non-U.S. OECD that is expanding. But the one case of negative transmission to foreign output is not one of the few, like the Wharton model, in which the domestic currency depreciates and thereby weakens the transmission link through the trade balance. Rather, it is the Liverpool model, in which the domestic currency appreciates, raising the other country's CPI sharply with adverse effects on supply.

These conflicts regarding the exchange rate and transmissions findings are relatively few and within the bounds of standard theoretical results. (This does not include the VAR model which features anomolous effects on price levels, interest rates and current accounts.)

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[14]The LINK model also shows a U.S. fiscal expansion reducing the domestic price level, for the reasons mentioned in footnote 9.

Table 3 displays the effects of a monetary expansion (Simulation D for the United States and H for the rest of the OECD). The simulation findings for the effects of monetary policy show more conflict among the models, and the conflict is less in line with well-known theoretical ambiguities, than for the effects of fiscal policy. The models divide almost evenly on the transmission of a U.S. monetary expansion to the rest of the OECD. All models show a clear depreciation of the dollar.The MCM, EPA, LINK, Liverpool, Minimod, Taylor and DRI models show the standard Mundell-Fleming result that the appreciation of foreign currencies causes the foreign current accounts and incomes to decline. But the EEC, VAR, MSG, OECD and Wharton models show positive transmission instead. When the monetary expansion originates in the non-U.S. OECD, positive transmission occurs not only in those five models but also in EPA, LINK, Liverpool, MSG and Taylor.

The obvious explanation for a rise in foreign income in response to a domestic increase in the money supply and exchange rate is that the appreciation of the foreign currencies has one or more of the expansionary effects abroad enumerated above: increasing the real money supply and real wealth or decreasing wages and imported input costs. If any of these expansionary effects is strong enough to dominate the change in the trade balance, we could get the positive transmission. The primary obstacle to attaching this interpretation to the models is that in the Brookings simulations for the case of a non-policy depreciation of the dollar (Simulation F) eight of the ten models show a clear negative effect on foreign income. The only one to show a clear expansionary effect, despite the worsening in the foreign trade balance,

TABLE 3

SIMULATION EFFECT OF MONETARY POLICY IN SECOND YEAR

	Y	CPI	i	Currency Value	CA	CA*	i*	CPI*	Y*
Monetary Expansion In U.S. (Sim. D)	U.S.					Non. U.S.			
MCM	+1.5%	+0.4%	-2.2	-6.0%	- 3.1	-3.5	-0.5	-0.6%	-0.7%
EEC	+1.0%	+0.8%	-2.4	-4.0%	-2.8	+1.2	-0.5	-0.4%	+0.2%
EPA	+1.2%	+1.0%	-2.2	-6.4%	-1.6	NA	-0.6	-0.5%	-0.4%
LINK	+1.0%	+0.4%	-1.4	-2.3%	- 5.9	+1.5	NA	-0.1%	-0.1%
LIVERPOOL	+0.1%	+3.7%	-0.3	-3.9%	-13.0	+0.1	-0.1	-0.0%	-0.0%
MSG	+0.3%	+1.5%	-0.8	-2.0%	+2.6	-4.4	-1.2	-0.7%	-0.3%
MINIMOD	+1.0%	+0.8%	-1.8	-5.7%	+2.8	-4.7	-0.1	-0.2%	-0.2%
VAR[1]	+3.0%	+0.4%	-1.9	-22.9%	+4.9	+5.1	+0.3	+0.1%	+0.4%
OECD	+1.6%	+0.7%	-0.8	-2.6%	-8.4	+3.1	-0.1	-0.1%	+0.3%
TAYLOR[1]	+0.6%	+1.2%	-0.4	-4.9%	NA	NA	-0.1	-0.2%	-0.2%
WHARTON	+0.7%	+0.0%	-2.1	-1.0%	-5.1	+5.3	-1.3	-0.1	+0.4%
DRI	+1.8%	+0.4%	-2.3%	-14.6%	-1.4	+14.5	-1.1	-1.3%	-0.6%
Monetary Expansion in Non U.S. OECD (Sim. H)	Non U.S.					U.S.			
MCM	+1.5	+0.6	-2.1	-5.4%	+3.5	+0.1	-0.2	-0.2%	-0.0%
EEC[2]	+0.8%	+1.0%	-1.0%	+2.3%	-5.2	+1.9	+0.0	+0.1%	+0.1%
EPA	+0.0%	+0.0%	-0.1	-0.1%	NA	+0.1	-0.0	-0.0	+0.0%
LINK[3]	+0.8%	-0.6%	NA	-2.3%	-1.4	+3.5	+0.0	-0.0%	+0.1%
LIVERPOOL	+0.4%	+2.8%	-0.9	-8.4%	+7.1	-8.2	-1.1	-3.4%	+1.6%
MSG	+0.2%	+1.5%	-0.7	-1.4%	-15.9	+12.0	-1.2	-0.6%	+0.3%
MINIMOD	+0.8%	+0.2%	-1.8	-4.8%	+3.6	-1.4	-0.6	-0.5%	-0.3%
VAR[1]	+0.7%	-0.5%	-3.0	-5.5%	+5.2	-10.0	+0.6	-0.7%	+1.2%
OECD	+0.8%	+0.3%	-1.3	-2.1%	-1.6	+2.3	-0.2	-0.1%	+0.1%
TAYLOR	+0.8%	+0.7%	-0.3	-3.5%	NA	NA	-0.2	-0.5%	+0.1%
WHARTON	+0.2%	-0.1%	-0.8	+0.2%	+2.6	+0.5	+0.0	+0.0%	+0.0%
DRI	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1]U.S. CPI NA. U.S. GNP deflator reported instead.

[2]Non-U.S. short-term interest rate NA; long-term reported instead.

[3]Appreciation of non-U.S. currency NA; depreciation of dollar reported instead.

is the Minimod model, which is not one of those showing positive transmission of monetary expansion.[15] This suggests that the positive transmission of a U.S. monetary expansion to foreign income occurs through a channel other than the exchange rate.

In the case of the EEC, OECD and Wharton models, the channel of the transmission of a U.S. monetary expansion is easily identified: despite the depreciation of the dollar, the U.S. current account worsens and the foreign current account improves. Surprisingly, the worsening in the U.S. current account occurs not only in the three models in which non-U.S. output rises, but also in five of the models in which non-U.S. output falls: the MCM, EPA, LINK, Liverpool, and DRI models.[16] In the case of the MCM model, the non-U.S. current account worsens even though the U.S. current account worsens, while in the other four, non-U.S. output falls even though the non-U.S. current account improves; either breaking of the trade transmission link seems difficult to explain.

The surprise contained in the deterioration of the U.S. trade balance in 8 out of 11 of the models is not the fact that the dollar depreciates. Higher U.S. income accounts for higher imports, and

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[15]The Taylor model is one that shows a small expansionary effect from a non-U.S. monetary expansion on U.S. output in the first two years, though the effect is substantially reversed thereafter. The Taylor simulations reported in Table 3 show the U.S. currency appreciating and the U.S. CPI falling, if only in the second year. But the positive transmission cannot be attributed to the real product wage, which rises slightly at first, despite the appreciation of the U.S. currency. Rather, the positive effect of an appreciation of the currency on real money balances and therefore output is reported to be important in Taylor (1985, 62), and to give positive transmission of a domestic monetary expansion to the foreign country.

[16]Oudiz and Sachs (1984, 20-22) report that monetary expansion worsens the domestic current account, for the EPA model as well as the MCM model (for either the U.S., Japan, or West Germany). Yoshitomi (1984, 347-350, 396) confirms this property of the EPA model.

Simulation F, the "non-policy exogenous depreciation of the dollar," reveals that several of the models have a prolonged enough J curve that the trade balance does not respond positively to the exchange rate until the third or fourth year (Wharton, OECD, and LINK). The puzzle is rather how the net capital inflow, which must equal the trade deficit under floating exchange rates, can increase after a monetary expansion. The monetary expansion should decrease the U.S. interest rate (except, of course, in models where there are lags in neither expectations nor price adjustment). In the simulations, the interest rate does indeed decrease, though for most models the nominal interest rate has already begun to start back up by the second year.[17] The Mundell-Fleming theory under floating exchange rates says that the lower interest rate should induce a capital outflow, implying a sufficiently strong currency depreciation to improve the current account correspondingly.[18] The models in the simulations seem to be behaving more like models of fixed (or managed) exchange rates, where an increase in the money supply flows out of the country through a trade deficit financed out of foreign exchange reserves, than like models with no

[17] Again the Liverpool model is the exception: the interest rate rises in the first year and falls in the second. But even in this model, it is lower in the second year relative to the zero baseline.

[18] In models of perfect capital mobility, the ex ante decrease in demand for dollar assets, which leads to the depreciation of the currency, is not the same thing as an ex post decrease in the net capital account balance. But if perfect capital mobility ties the domestic interest rate to the foreign interest rate, then it means the trade balance must improve even more (by enough so that the higher transactions demand absorbs all the increased money supply with no help from lower interest rates, except via large-country effects).

intervention in the foreign exchange market.

Helliwell and Padmore (1985, 1130-31) and Helliwell (1986, 15) have identified why the large econometric models have the property that a monetary expansion causes a net capital inflow. Capital flows respond not only to interest rates but also to expectations of future exchange rate changes. If the instantaneous depreciation of the currency, which results from a monetary expansion, generates expectations of future appreciation, then it will have a positive effect on the attractiveness of domestic assets that runs counter to the lower interest rates. In Helliwell's terms, speculative capital flows fulfill the stabilizing "buffer stock" role that official intervention would play under a system of fixed or managed exchange rates. This regressive type of expectation has been found to be rational in the Dornbusch (1976) overshooting model and some other versions of the asset market approach to exchange rate determination. Its properties in the Mundell-Fleming flow approach to the capital account are somewhat less well-known, though stated by Mussa (1979, 191).[19] It is clear that many as yet unresolved research issues continue to fall under the heading of understanding the capital account.

One might think that showing how "speculative" capital inflows allow a domestic trade deficit in a small-country model would be

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[19]Yoshitomi (1984) emphasizes the importance of regressive exchange rate expectations in potentially reversing the direction of capital flows. Among the other models that now incorporate the regressive exchange rate expectations of Dornbusch (1976) are the MCM model (Haas and Symansky (1984)) and Minimod. The MSG model (Minford (1984, 90,97), and Taylor (1985, 56) make the assumption that efficient market arbitrage drives the interest differential to the rationally expected rate of depreciation; but Taylor (1985) reports no exchange rate over-shooting, implying that regressive expectations are not rational.

tantamount to showing how they allow a foreign trade surplus, and therefore positive transmission of the expansion, in the corresponding two-country model. But a problem remains. If a money market equilibrium condition like (2) holds in the foreign country, then foreign nominal income cannot rise unless foreign interest rates rise. It seems unlikely that foreign interest rates would rise at the same time that the domestic monetary expansion is reducing domestic interest rates. Indeed a U.S. monetary expansion reduces short-term non-U.S. interest rates in all ten of the reporting structural models, and a non-U.S. monetary expansion reduces U.S. short-term interest rates in seven of the nine reporting structural models. (In the case of the only exceptions, LINK and Wharton, the short-term interest rate is virtually unchanged.)[20]

It must be that in these models, the short-term interest rate is not determined by a simple money market equilibrium condition, but by a portfolio decision that considers a broader menu of assets. It would be enough to have the demand for foreign money depend on the domestic interest rate in addition to the foreign interest rate. If the U.S. monetary expansion drives down U.S. interest rates sufficiently far relative to European interest rates, or if European money demand is sufficiently sensitive to U.S. interest rates, then the unchanged

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[20]Gerry Holtham points out that a simple money market equation like (2) <u>is</u> consistent with a decline in the foreign interest rate and a rise in foreign real output, provided that the exchange rate change reduces the foreign price level by more than enough to offset the rise in output. This is the case--foreign <u>nominal</u> GNP falls in response to a U.S. monetary expansion--in the EEC, MSG and OECD models.

European money stock can support the higher level of European income implied by positive transmission.

To sum up the results of monetary expansion, almost as many models show positive transmission to the rest of the OECD as show negative transmission. Their reversal of the Mundell-Fleming result is not attributable to non-trade effects of the exchange rate on foreign income. Rather it appears to be due to a non-interest rate related capital flow into the domestic country, allowing a trade balance shift in favor of the foreign country. In terms of target variables of interest to the domestic country, the effect of a monetary expansion on the trade balance is the issue on which the models disagree the most. This disagreement among the models will play a key role in the next part of the paper.

II. THE IMPLICATIONS FOR COORDINATION BETWEEN THE DOMESTIC MONETARY AND FISCAL AUTHORITIES

It is a general principle that, when two policy makers both affect variables that each cares about, they can do better by cooperating than they would in the Nash competitive equilibrium, in which each acts to maximize his own welfare function taking the actions of the other as given.[21] This principle has led economists to propose increased coordination between different domestic policy-making agencies, and between domestic and foreign policy makers. An example of the first type from the 1980s is the argument that the Federal Reserve should agree to follow a looser monetary policy in return for the Administration (and Congress) agreeing to reduce the federal budget deficit. The point would be to reduce interest rates, the value of the dollar and the trade deficit, without losing anything in the output/inflation tradeoff. An example of the second type is the argument that the United States should agree to follow a tighter budget policy in return for Europe and Japan agreeing to move in the opposite direction.[22] The point, again, would be to reduce the trade imbalance without causing a world recession.

The existence of conflicting models gives the literature on international coordination a certain air of unreality. To begin with,

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[21]This paper is not the first to develop an exception to this principle. One counterexample (along very different lines) is offered by Rogoff (1985). For good introductions to the coordination literature, see Oudiz and Sachs (1984) or Cooper (1985).

[22]For example, Layard et al (1984) and Marris (1985).

the issue of the gains from coordination is subtle enough that, even among economists who agree on the broad outline of the correct model, small differences can lead to opposite recommendations as to the direction in which policy-settings must be moved to reap the gains from coordination. A possible example in domestic U.S. policy-making is that movement in the direction of a tight monetary policy and a loose fiscal policy, far from being the outcome of a destructive lack of coordination between the monetary and fiscal authorities, might be thought desirable from the national point of view: the high value for the dollar reduces the U.S. Consumer Price Index and thereby allows an improvement over the regular output/inflation tradeoff.[23] Examples in the international context abound. OECD countries are often urged to undertake a coordinated expansion; the argument is that each is reluctant to expand on its own for fear of worsening its trade balance and/or currency value.[24] On the other hand there has been talk about the need for coordinated monetary discipline (particularly in the 1970s) and coordinated budgetary discipline (particularly in the 1980s). It seems that every possible combination has been suggested: the Nash non-cooperative equilibrium is variously thought to result in competitive currency appreciation,

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[23]Sachs (1985), for example, has offered this interpretation of the U.S. monetary/fiscal mix in the early 1980s--that it might have been optimal given the objective function.

[24]One of many examples from the 1980s is Bergsten et al (1982). The gains from coordinated expansion by Europe, Japan and the United States were also behind the locomotive theory that led to the 1978 Bonn Summit.

competitive currency depreciation ("beggar-thy-neighbor"), insufficient expansion, or excessive expansion. It has even been suggested that the gains from international coordination lie in an agreement that one country will expand whenever others are contracting and vice versa.

If such contradictions are possible within the standard models of mainstream macroeconomists,[25] the situation is even worse once the more widely-scattered views of policy makers are acknowledged. In the context of 1983-1984, there was little point in trying to convince the U.S. Treasury that, to correct the exchange rate and trade imbalance, the United States should reverse its fiscal expansion in exchange for European and Japanese fiscal expansion. The Treasury view was that there had been no U.S. fiscal expansion to begin with, that fiscal expansion causes currencies if anything to depreciate, that the strength of the dollar was instead attributable to other factors (the safe-haven effect), that the trade deficit was in any case not attributable to the strong dollar (but rather to rapid U.S. growth), and--most relevantly--that the Administration did not want Europe and Japan to undertake fiscal expansion.

The purist will argue that if policy makers have different "information," then they "should" share it with each other and agree on

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[25]Some of the conflicting possibilities arise from uncertainty as to what are the variables that should enter the objective function and where the economy currently is relative to the optimum, rather than uncertainty as to the correct model or parameter values. The economist could plausibly argue that such questions can only be answered by the political process.

a common model. The proposition about gains from coordination holds regardless of which model is correct.[26] In practical terms, then, the purist is urging on economists a research strategy of first discovering and agreeing on the true model, and only then convincing policy makers that it is the true model (a task that would surely be less difficult if macroeconomists agreed among themselves) and pointing out the gains from coordination based on this true model.

Research will, and should, proceed with the aim of developing models that more closely reflect economic reality. Most of this research will, and probably should, proceed under the assumption that actors within the model act on the basis of the model itself. But there is also a need for research under the assumption that actors have different models. These are the only circumstances under which policy-making is likely to take place.

In this part of the paper, we consider the domestic problem in which the two policy makers are the monetary authority and the fiscal authority. In future work we will consider the international problem, in which the policy makers are the U.S. authorities on the one hand and European and Japanese authorities on the other. The findings in the international context are expected to be quite similar to the findings

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[26]Some authors, such as Canzoneri and Gray (1983) set up their theory in a framework general enough to encompass all of the possible positive or negative effects. The direction in which policies must be moved in order to reap gains from coordination can be viewed as a function of the parameter values, the latter presumably to be filled in later by the econometrician.

reported here. In both problems, the 12 models that participated in the Brookings simulations will be used to illustrate the conflicting beliefs that policy makers could have, and their implications for coordination.

We will consider here what happens when the monetary and fiscal authority have identical welfare functions, so as to focus on the role of divergent models in policy conflict and coordination. In the appendix we introduce divergent welfare functions, the usual basis for policy conflict and coordination.

II. 1. Competition and Bargaining When the Policy Makers Seek to Maximize the Same Goals Using Different Models

We begin by showing how the monetary and fiscal authorities will prefer a cooperative equilibrium to the Nash non-cooperative one despite an identical welfare function, if they subscribe to different models. We will also show how, if neither of the policy makers happens to have the correct model, the cooperative equilibrium could as easily be inferior to the Nash equilibrium as the other way around, that is, could result by the light of the true model in a lower value of the agreed-upon welfare function.

When we study international coordination, each country must have more than two goals; otherwise it can use its two instruments, domestic monetary and fiscal policy, to attain both goals regardless what the other country does, and no interesting issue of coordination arises. But here we consider domestic coordination and limit the welfare function to two goals for simplicity. Let y be the log of domestic output and x be the current account as a share of GNP, both expressed as deviations from their desired or sustainable long-run levels. (We have also tried the exchange rate and the CPI for the second goal). The framework shared by all is the familiar linear one of targets and instruments:

(12) $$y = A + Cm + Fg$$

(13) $$x = B + Dm + Gg$$

Subscripts on the upper case letters, the policy multipliers, will indicate the different values they can take depending on the model: a "c" to represent the perceptions of the central bank, and an "f" to represent the perceptions of the fiscal authority. We adopt the conventional assumption that policy makers seek to minimize a quadratic loss function w:

(14) $$w = y^2 + \omega x^2$$

To ascertain the behavior of the central bank we differentiate the loss function with respect to m, with subscripts on the multipliers. The first order condition is:

(15) $$m = -I_c - J_c g ,$$

$$\text{where} \quad I_c \equiv \frac{C_c A_c + \omega D_c B_c}{C_c^2 + \omega D_c^2}$$

$$\text{and} \quad J_c \equiv \frac{C_c F_c + \omega D_c G_c}{C_c^2 + \omega D_c^2}$$

To ascertain the behavior of the fiscal authority, we take the derivative with respect to g. The first order condition is

(16) $$g = -K_f - L_f m ,$$

$$\text{where} \quad K_f \equiv \frac{F_f A_f + \omega G_f B_f}{F_f^2 + \omega G_f^2}$$

$$\text{and} \quad L_f \equiv \frac{C_f F_f + \omega D_f G_f}{F_f^2 + \omega G_f^2}$$

If both policy makers knew the true model, all subscripts could be dropped. The optimal solution in terms of the true parameters would then follow by solving the two equations simultaneously for g and m. There would be no issue of conflict or coordination, each agency simply doing its agreed-upon part.

But if the policy makers believe in different models, the subscripts must remain. The first equation has been solved for m as a function of g and the second vice versa, so that they represent the two authorities' reaction functions to each other's policies. The Nash competitive equilibrium is:

$$m^n = \frac{-I_c + J_c K_f}{1 - J_c L_f} \tag{17}$$

$$g^n = \frac{-K_f + L_f I_c}{1 - J_c L_f} . \tag{18}$$

Assume the central bank believes in model 1. In Figure 1 we graph its reaction function CB1, as represented by equation (16). We draw it downward-sloping (a positive J_c); this would follow when, as in many of the models, m and g both have positive effects on income and both have negative effects on the current account. The central bank's perceived indifference curves radiate out from its perceived optimum, point 1. They are intersected by CB1 wherever they are flat, because along CB1 the central bank is optimizing with respect to m for a given g.

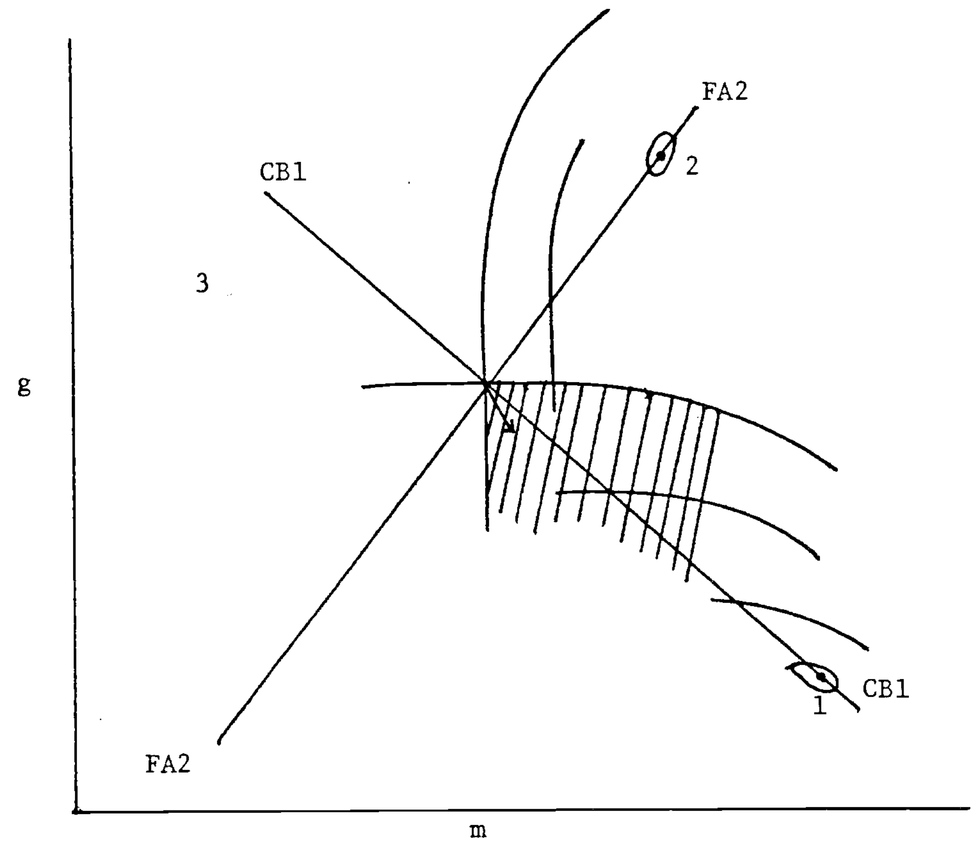

Figure 1: The Nash Competitive Equilibrium

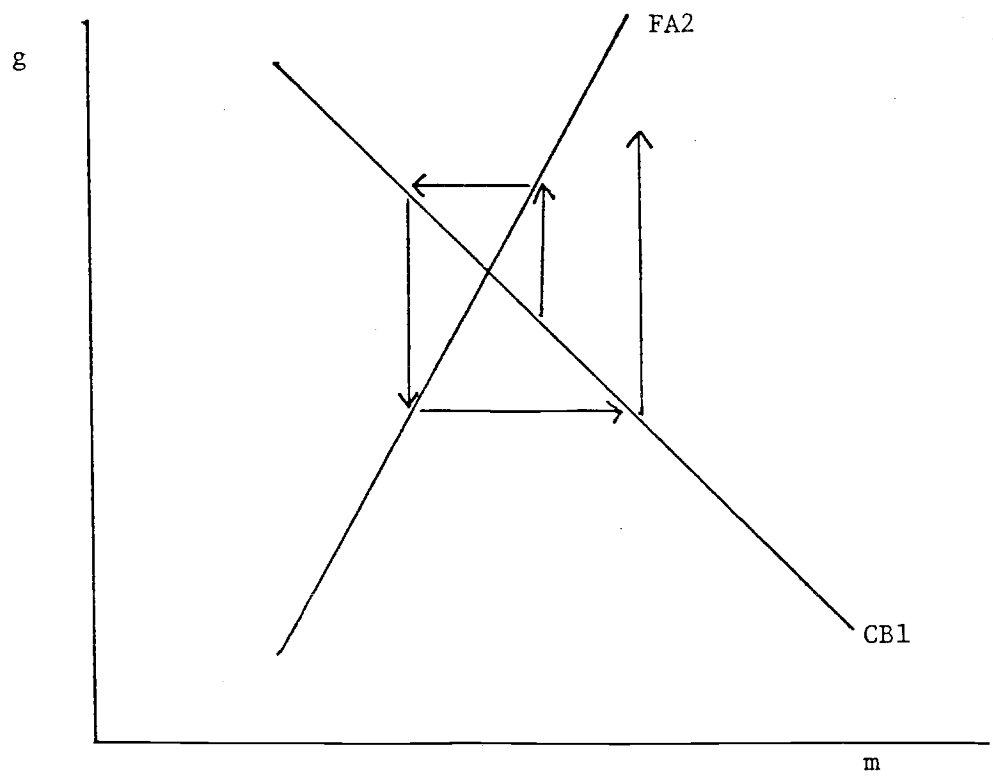

Figure 2: Stability of the Nash Equilibrium

Assume the fiscal authority believes in model 2. We draw its reaction function FA2 upward-sloping (a negative L_f). This slope might follow if the fiscal authority's model differs from model 1 by featuring a positive current account multiplier for the money supply D_f, as in the EPA, MSG, Minimod, and VAR models in the case of U.S. monetary policy (and the MCM, Liverpool, Minimod, VAR and Wharton models in the case of non-U.S. monetary policy). The positive slope also might follow if the fiscal authority's model differs from model 1 by featuring a negative output multiplier for fiscal policy (as in the Liverpool model in the case of non-U.S. expansion).[27]

The fiscal authorities' perceived indifference curves radiate from its perceived optimum, point 2. They are intersected by FA2 wherever they are vertical, because along FA2 the fiscal authority is optimizing with respect to g for a given m. The Nash competitive equilibrium is where the two reaction functions intersect, point N. If the two policy makers happen to have the same model, then point 1 = point 2 = point N.

There is a potential issue of stability. If the policy makers are thought of as taking turns reacting to each other according to (15)

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[27] If the second target variable were the exchange rate instead of the trade balance, then the ambiguous effect of a fiscal expansion discussed previously could change negative slopes to positive. If it were the price level, then the negative effect of a monetary expansion in the LINK model or of a fiscal expansion in the VAR model could have the same implication. However, the points to be made here, particularly that coordination need not improve welfare, require only that the parameter values differ, not that they differ enough to give opposite-signed slopes.

and (16), will they actually reach the Nash equilibrium point? If the slopes are as in Figure 2, then the process is unstable. Stability requires that the absolute value of the slope of CB1 exceed the absolute value of the slope of FA2. If the condition is satisfied, there is a second question of whether convergence to equilibrium will be slow or rapid. These are the first of the questions that will be analyzed below for different possible combinations of the models in the Brookings simulation exercise.

It is very easy to see that the Nash solution represented by (17) and (18) is not the optimum. (One would need $I_c = I$, $K_f = K$, $J_c = J$ and $L_f = L$, where the unsubscripted letters are defined analogously to the subscripted ones so as to represent parameter values in the true model, for the Nash solution to be the optimum.) Neither policy maker will be happy with this equilibrium, each cursing the stupidity of the other for not moving in the desired direction. As we have drawn Figure 1, the fiscal authority wishes that the central bank would increase money growth, so as to depreciate the currency and improve the current account. But the central bank's perception is different, that increasing money growth would worsen the current account. It wishes the fiscal authority would decrease government spending.

One might think that when two policymakers have conflicting views as to the effects of any proposed package of policy changes, they would simply fail to come to an agreement to coordinate. But even assuming that neither policymaker is willing to revise his beliefs, there will in general be a bargain they can make

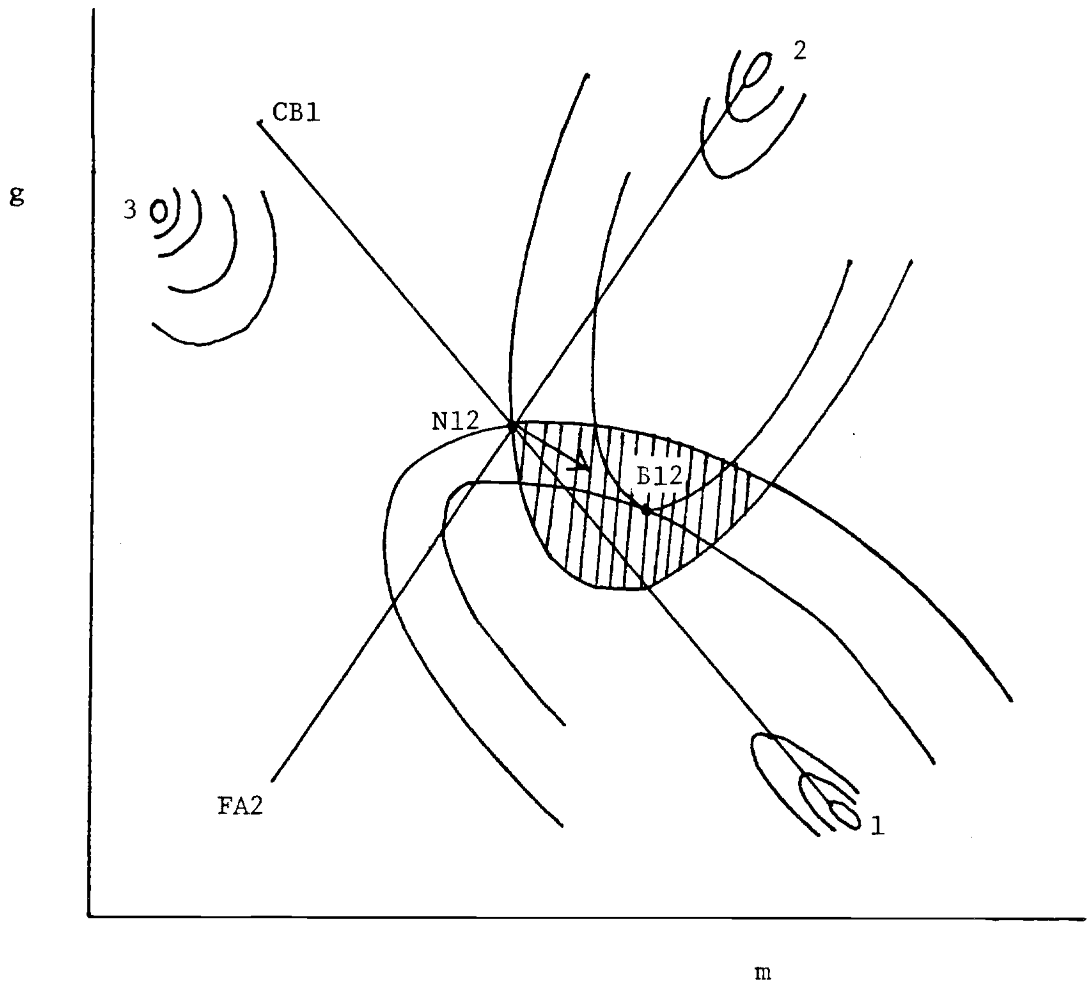

Figure 3: Policy Coordination

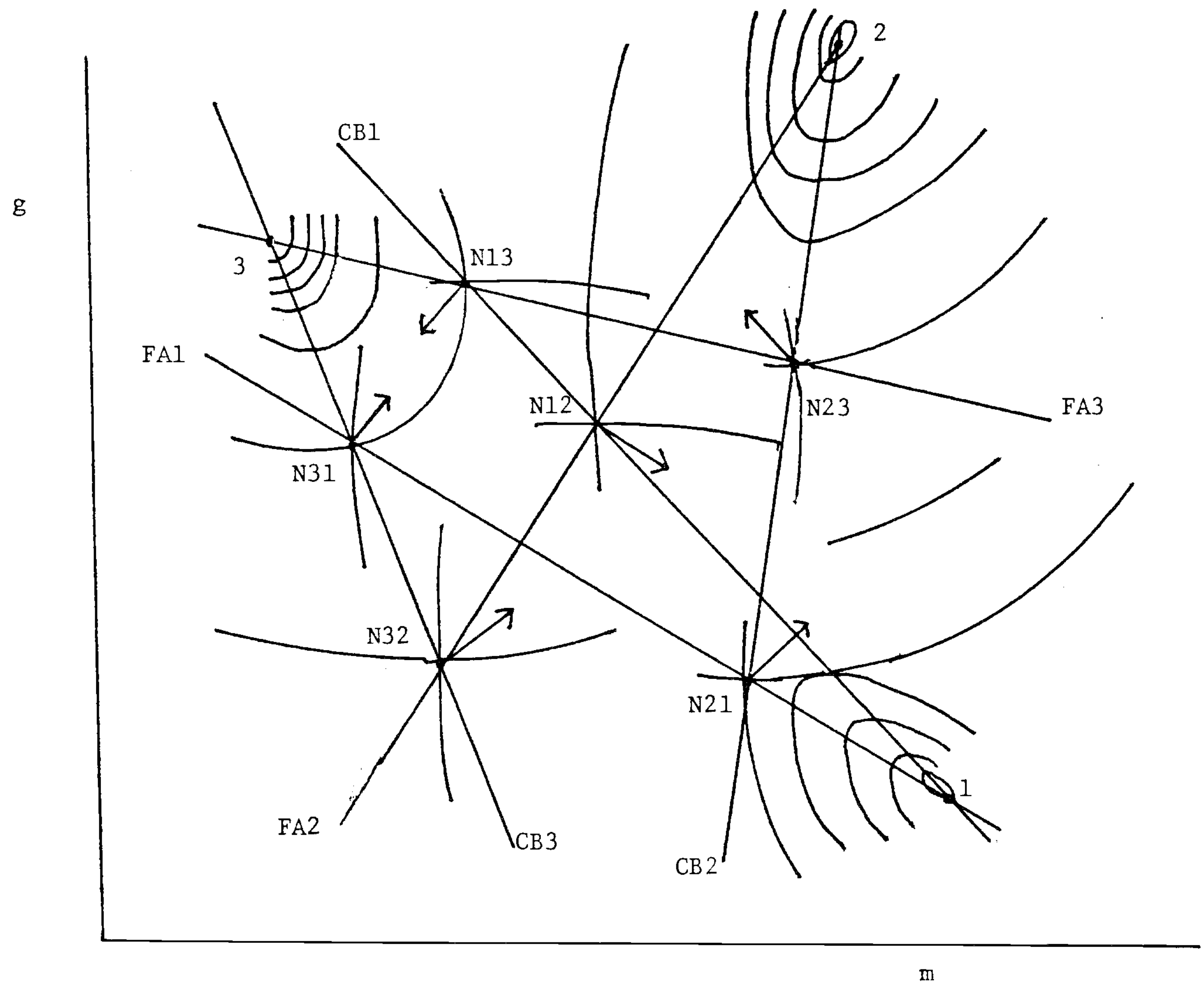

Figure 4: Possible Combinations of Three Models

that will raise the perceived welfare of each. In Figure 1 the authorities' indifference curves at N have slopes of zero and infinity, respectively, from which it follows that they are not tangent. They can both agree to move in the southeast direction. There is an entire range of points, those in the shaded "lens," that dominate N for both policy makers. Which point will they actually agree on? Much of the literature singles out the Nash bargaining solution, at which the product of the two agents welfare gains is maximized relative to what perceived welfare would be at the Nash competitive solution N12.[28] The bargaining solution is represented by a point on the contract curve like the one labelled B12 in figure 3. We would choose m and g to maximize

$$(19)\qquad \left(W_c(m,g) - W_c(m^n,g^n)\right)\left(W_f(m,g) - W_f(m^n,g^n)\right)$$

$$= \Big(\left[(A_c + C_c m + F_c g)^2 + \omega(B_c + D_c m + G_c g)^2\right] - \left[(A_c + C_c m^n + F_c g^n)^2 + \omega(B_c + D_c m^n + G_c g^n)^2\right]\Big)$$

$$\Big(\left[(A_f + C_f m + F_f g)^2 + \omega(B_f + D_f m + G_f g)^2\right] - \left[(A_f + C_f m^n + F_f g^n)^2 + \omega(B_f + D_f m^n + G_f g^n)^2\right]\Big)$$

Notice that the analytics of maximizing the two agents' welfare functions are the same as in the standard coordination problem. One

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[28]e.g. Oudiz and Sachs (1984, 36-37). When speaking of the product of the gains we mean them to be positive. And we rule out side-payments.

could not tell from equation (19), if one did not know, that the parameters refer to different perceptions of the same multipliers, rather than similar perceptions of different multipliers.

The usual enforcement problems exist as well: each would prefer to cheat on the bargain. We will ignore issues of repeated games, credible commitment, etc., and content ourselves for the purposes of this paper with comparisons of the static cooperative and non-cooperative solutions.

One alternative to the Nash bargaining point as a cooperative solution for the problem of conflicting models would be for the policy makers to "bargain" over what is the correct model. In the event of widely diverging Bayesian priors, it would probably take a prohibitively great amount of new data for the two to reach a genuine convergence of beliefs. But for the sake of compromise, in an attempt to improve on the competitive equilibrium N12, they could base their policy actions on a version of equations (12) and (13) in which the parameter estimates are taken as a weighted average of their individual parameter estimates. If one wished to preserve the symmetry that characterizes the Nash bargaining solution (19), the weights could be equal, although this seems ad hoc.

A priority for future research is to compare the implications of a strategy of averaging the parameter estimates to the implications of the usual Nash bargaining point. As a positive, rather than normative, solution concept, it has the disadvantage that it could lie outside the shaded lens, that is, it could result in one policy maker's perceived level of welfare being less than it would be at point N12. But if the average of two parameter estimates is a better estimator of the true parameter value than either alone, as is generally the case in statistics, then it might be possible to show that the averaging solution would result in a higher expected value of welfare as judged by the true model than the Nash bargaining solution. The prescriptive conclusion would be that ministers in OECD meetings should spend more of their time discussing the basic assumptions underlying their views of the world.

Our major question here is whether movement of the policy settings in the direction that raises each policy maker's perceived welfare, for example movement to the bargaining point B12, does in reality affect y and x in such a way as to improve welfare. The answer of course depends on the true model. If one or the other of the policy makers' models (1 and 2) happens to be the true model, then cooperation will necessarily improve welfare; otherwise that policy maker would not have agreed to the change. But, as we argued in the introduction, this is unlikely to be the case. More likely, reality is represented by some third model, say point 3 in Figures 1 or 3. The true welfare levels produced by various combinations of m and g are represented by the indifference curves radiating from point 3. As we have drawn it, cooperation turns out to reduce welfare, though it could as easily have been the reverse.

To see what other outcomes are possible, we can swap models. Figure 4 shows the possibilities. If the central bank believes model 3 instead of model 1 then its reaction function is given by line CB3. If the fiscal authority believes model 1, then the reaction line is given by FA1. The Nash competitive point is now N31 instead of N12. The two policy makers can raise the perceived welfare of each by agreeing to move in the northeast direction. If reality is represented by the same model 3 then cooperation necessarily improves welfare. But if reality is represented by model 2 instead of model 3, then the Nash point N31 must be judged by the standard of the indifference curves radiating from point 2. As we have drawn the graph, cooperation turns out to raise true welfare with this combination of models.

Altogether there are twenty-seven (= 3 x 3 x 3) combinations: the fiscal authority can believe any of the three models, the central bank can believe any of the three, and reality can be represented by any of the three. In the 9/27 combinations where the two agencies happen to share the same model, coordination is not an issue one way or the other. Out of the remaining 18 combinations there are 12 in which one of the two agencies' models coincides with the true model; here coordination necessarily improves welfare. The remaining 6 combinations could go either way; when all three models are distinct, it seems that coordination could reduce welfare (as from point N12) as easily as improve it (from point N31). This case becomes more important as the number of distinct models becomes larger. If there are q models, there are $q(q-1)(q-2)$ combinations in which three different models are featured, out of a total of q^3 combinations. The limit as q goes to infinity, in which the probability of divergent models goes to 1, seems to describe the actual state of affairs.

II.2 Evidence from the Simulations

How important is the issue of conflicting models likely to be in practice? For example, is the case where coordination reduces welfare as judged by the true model merely a pathological counterexample? In what follows we use the simulation results of the international macroeconometric models that participated in the Brookings exercise to see what might happen. If we used all 12 models there would be 1728 ($=12^3$) combinations. To keep the problem more manageable,[29] we concentrated on 6 models (giving 216 combinations): the MCM, EPA, LINK, Liverpool, VAR and OECD models. The models were chosen to be representative of the full range of models both with respect to geography--one might choose to associate the MCM with U.S. beliefs, the EPA with Japanese beliefs, and the OECD (or EEC) with European beliefs--and with respect to philosophy--the LINK model being considered the most Keynesian of the twelve, Liverpool the most monetarist/new classical, and VAR the only non-structural model.

This study follows the path blazed by Oudiz and Sachs (1984). Indeed they listed uncertainty (though not disagreement) as to the correct model as one of the topics remaining for future research:

> "A second difficulty in our treatment is the implicit assumption that the "true" model of the world is known with certainty and that exogenous shocks are absent during the planning period....We have not yet investigated the implications of such uncertainty for the logic of policy cooperation, but it is important to do so. We

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[29] It is as easy to program the computer to do 1728 combinations as fewer. But the output would be too much to digest.

think Feldstein is correct when he says that such uncertainty is a major practical impediment to greater policy coordination." (p. 56)

Oudiz and Sachs calculated the effects of international coordination taking the policy multipliers from the MCM and EPA models. They noted differences between the models, but maintained the usual assumption that the models used by both policy makers coincided with each other and with reality. If our results on international coordination are viewed in a three dimensional $q \times q \times q$ matrix, then the Oudiz-Sachs results should be the entries appearing on the diagonal (MCM-MCM-MCM and EPA-EPA-EPA).

We take policy multipliers from the simulation results reported in Tables 2 (government expenditure) and 3 (money supply). These are the effects in the second year, chosen to represent the relatively short run, but allowing enough time to get past the negative part of the J-curve. For those of our experiments that envision the policy makers taking turns in real time, one can imagine using dynamic multipliers, that is, the entire time profile of policy effects that was produced in the simulations; but this complication is left for future research. Table 4 reports the policy multipliers for the percentage effect on the level of GNP (the cumulated change over the two years) and the effect on the current account as a percent of GNP; these are the terms in which Oudiz and Sachs treat the target variables.

Computing the reaction functions (15) and (16) requires knowing not only the perceived policy multipliers, but also the relative welfare weight (ω) placed on the trade balance, and the perceived constant terms (A and B).[30] Though we have decided here to attribute

TABLE 4

US MULTIPLIERS IN THE SECOND YEAR

	Percentage effect on the level of income		Effect on the current account as a percentage of GNP	
	y		x	
	from a 1% increase in money	from an increase in govt. spending of 1% of GNP	from a 1% increase in money	from an increase in govt. spending of 1% of GNP
	C	F	D	G
Models				
MCM	0.4765	3.4288	-0.0198	-0.4217
EPA	0.6036	3.3272	-0.0102	-0.5233
LIVPOOL	0.1751	1.3042	-0.0832	-0.1791
VAR	0.9045	0.4000	0.0311	-0.0127
OECD	0.6540	2.6165	-0.0537	-0.3628
LINK	0.2752	2.4144	-0.0380	-0.1647
EEC	0.4015	2.5156	-0.0180	-0.2990
DRI	0.6027	4.1420	-0.0089	-0.5577
MCKIBB	0.7019	1.7072	0.0167	-0.5540
MINIMOD	0.4015	2.1110	0.0179	-0.2172
WHARTON	0.2757	3.1238	-0.0331	-0.3993

Source: Brookings simulation results.

Monetary multipliers from simulation D, divided by 4 to go with second-year changes in the level of M; fiscal multipliers from simulation B, with sign reversed to go with fiscal expansion; effects on growth rate cumulated to get effect on second-year level of income; effects on current account divided by baseline GNP to get effect as a proportion of GNP.

the same ω to both policy makers, in order to concentrate solely on conflicts in models, the value judgment remains an exceedingly difficult and arbitrary task. It seems that the calculation as to the location of the Nash point can be as sensitive to the choice of welfare weights and constant terms as to the choice of policy multipliers.[31] Oudiz and Sachs made their choices based on the calculation of what the welfare weights would have to have been for policy makers, optimizing in Nash equilibrium, to produce the values of output, inflation and trade balance actually observed in the 1980s. There are problems with this methodology. To use it in our context would require the computation of different weights, not only for the two policy makers, but for every possible combination of models. Instead we simply take weights from the EPA case of Oudiz and Sachs and apply them uniformly to all models.[32]

One point regarding the constant terms can easily escape notice. In assuming that the policy makers react directly to each other's policy-settings g and m rather than to the target variables y and x, we have implicitly assumed that they ignore observed deviations of y and x from what they would have expected based on their models, or treat them as purely random disturbances.[33] An

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[31]This is not to say that the calculation as to whether cooperation improves on the Nash point is as sensitive to the choice of the welfare weights as to the choice of policy multipliers.

[32]We do not use their weights for the MCM case because the reported weight on the U.S. current account is zero.

[33]A complete Bayesian analysis would have agents ascribe only part of the observed discrepancy to the error terms, and part to a revision of the parameter values. But the premise of this paper is that it is realistic to assume that policy-makers revise their models to a negligible extent.

alternative would be to assume that they treat such observed discrepancies as following a random walk, that is, as permanent revisions in the constant terms A and B. This would be equivalent to a perpetual updating of the intercepts of the reaction functions to insure that they always pass through the target optimum $y = x = 0$. This alternative assumption is applied in the appendix, in the context of the classic "Assignment Problem."

Table 5 reports the results for the Nash equilibrium when the two goals are output and the current account balance, under 36 possible combinations of models to which the monetary and fiscal authorities can subscribe. If one chooses, one can think of the policymakers taking turns in real time. The first entry in each cell reports whether the Nash equilibrium is stable, and the second reports the number of iterations required to reach convergence (of both target variables, to within a tolerance of 1.0 percent). Only 14/36 combinations exhibit technical instability (most of them models in which the fiscal authority is acting on the basis of either the VAR, or OECD models). Another 6/36, though technically stable, require more than 20 iterations to converge. However one may choose instead to think of the policymakers instantly jumping to the Nash equilibriumm.

The main focus of interest in Table 5 is the nature of the coordination that the two policy makers will view it as in their interest to undertake, under each combination of models. Two lines in each cell indicate the change, relative to the Nash equilibrium, in

Table 5 : Nash Competitive Solution and Bargaining Solution

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
NASH POINT: STABLE?	YES	YES	YES	YES	YES	NO
STEPS	99	7	11	2	4	99
BARGAINING CHANGE IN POLICY						
M	0.00	61.80	1.71	0.47	19.44	-5.29
G	0.00	-6.95	0.25	-0.20	-3.53	0.69
PERCEIVED CHANGE IN TARGETS						
CB: Y	0.00	7.51	0.63	0.35	3.49	0.22
CA	0.00	4.06	-0.19	0.02	0.24	0.09
FA: Y	0.00	-1.25	1.68	-0.46	-2.63	-0.15
CA	0.00	2.55	-0.14	0.07	1.10	-0.19
PERCEIVED GAIN FOR:						
CB	0.0000	0.0138	0.0001	0.0000	0.0013	0.0008
FA	0.0000	0.0057	0.0002	0.0000	0.0016	0.0000
EPA						
NASH POINT: STABLE?	NO	YES	YES	YES	YES	NO
STEPS	99	99	99	3	10	99
BARGAINING CHANGE IN POLICY						
M	143.95	0.00	1.10	0.69	31.44	1.36
G	-20.47	0.00	0.37	-0.45	-6.57	0.26
PERCEIVED CHANGE IN TARGETS						
CB: Y	-1.59	0.00	0.67	0.45	3.37	1.05
CA	5.78	0.00	-0.16	0.03	0.70	-0.10
FA: Y	18.78	0.00	1.89	-1.06	-2.69	1.75
CA	9.24	0.00	-0.20	0.23	3.12	-0.16
PERCEIVED GAIN FOR:						
CB	0.0265	0.0000	0.0000	0.0000	0.0026	0.0001
FA	0.0808	0.0000	0.0011	0.0002	0.0051	0.0005
LIVPOOL						
NASH POINT: STABLE?	NO	YES	YES	YES	YES	NO
STEPS	99	99	99	3	15	99
BARGAINING CHANGE IN POLICY						
M	-1.74	-231.87	0.00	-0.35	-0.39	-65.80
G	-0.41	40.46	0.00	-0.52	-0.24	11.27
PERCEIVED CHANGE IN TARGETS						
CB: Y	-2.22	-5.35	0.00	-0.52	-0.69	3.60
CA	0.21	-16.60	0.00	-0.00	0.11	1.40
FA: Y	-0.83	12.15	0.00	-0.74	-0.38	-0.33
CA	0.22	12.04	0.00	0.12	0.08	5.12
PERCEIVED GAIN FOR:						
CB	0.0004	0.1576	0.0000	0.0000	0.0000	0.0052
FA	0.0002	0.2331	0.0000	0.0001	0.0002	0.0130

Table 5a: Nash Competitive Solution and Bargaining Solution (continued)

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK: MCM	EPA	LIVPOOL	VAR	OECD	LINK
VAR						
NASH POINT: STABLE?	NO	NO	NO	YES	NO	NO
STEPS	99	99	99	99	99	99
BARGAINING CHANGE IN POLICY						
M	2.05	2.52	0.83	0.00	2.37	0.84
G	-0.84	-1.93	0.67	0.00	-1.19	0.45
PERCEIVED CHANGE IN TARGETS						
CB: Y	-1.89	-4.89	1.02	0.00	-1.57	1.30
CA	0.31	0.98	-0.19	0.00	0.31	-0.11
FA: Y	1.52	1.50	1.02	0.00	1.67	0.93
CA	0.07	0.10	0.02	0.00	0.09	0.02
PERCEIVED GAIN FOR:						
CB	0.0005	0.0025	0.0018	0.0000	0.0005	0.0002
FA	0.0002	0.0003	0.0001	0.0000	0.0002	0.0001
OECD						
NASH POINT: STABLE?	NO	NO	NO	YES	YES	NO
STEPS	99	99	99	3	99	1
BARGAINING CHANGE IN POLICY						
M	28.65	55.29	-2166.06	0.67	0.00	0.92
G	-5.31	-12.03	516.14	-0.40	0.00	0.13
PERCEIVED CHANGE IN TARGETS						
CB: Y	-4.57	-6.65	293.77	0.44	0.00	0.57
CA	1.67	5.73	87.69	0.03	0.00	-0.06
FA: Y	4.83	4.68	-66.11	-0.61	0.00	0.94
CA	0.39	1.40	-71.04	0.11	0.00	-0.10
PERCEIVED GAIN FOR:						
CB	0.0034	0.0180	16.0323	0.0000	0.0000	0.0001
FA	0.0029	0.0066	3.8311	0.0001	0.0000	0.0001
LINK						
NASH POINT: STABLE?	YES	YES	YES	YES	YES	YES
STEPS	99	1	9	2	2	99
BARGAINING CHANGE IN POLICY						
M	-0.46	-1.53	-31.65	-0.20	-0.57	0.00
G	-0.13	-0.18	4.50	-0.10	-0.12	0.00
PERCEIVED CHANGE IN TARGETS						
CB: Y	-0.68	-1.54	0.33	-0.22	-0.68	0.00
CA	0.07	0.11	1.83	-0.00	0.07	0.00
FA: Y	-0.45	-0.87	2.16	-0.29	-0.44	0.00
CA	0.04	0.09	0.46	0.02	0.04	0.00
PERCEIVED GAIN FOR:						
CB	0.0000	0.0003	0.0015	0.0000	0.0000	0.0000
FA	0.0000	0.0001	0.0012	0.0000	0.0000	0.0000

* 99 INDICATES MORE THAN 20 STEPS REQUIRED FOR CONVERGENCE

which they can agree to move the money supply and government expenditure, respectively, in order to maximize the product of the two perceived gains in welfare. The next two lines indicate the effects that the two agents perceive such a package of policy changes will have on the target variables; they can be obtained by taking the product of the change in policy settings and the multipliers reported in Table 4. The last two lines in each cell indicate how much the central bank and fiscal authority, respectively, thinks that the country has to gain in terms of the welfare function (equation (14)) by the movement of the policy-settings in the indicated direction. If the policy makers happen to believe the same model (the diagonal cells), then there is no scope for coordination. This is a consequence of our ruling out conflicting welfare functions; each thinks that the country is at the optimum.

Otherwise, there will be scope for coordination. Consider the example where the central bank subscribes to the MCM model and the fiscal authority to the OECD model. Each perceives that they can accomplish relatively large welfare gains by an alteration of the mix in favor of more expansionary monetary policy and more restrictive government spending. This is the kind of coordination that has been suggested frequently for the United States in the 1980s; the Nash competitive solution results in too high a level of interest rates, value of the dollar, and size of the trade deficit. It shows up in 12 cases in Table 5. But all other combinations appear as well. Coordination could call for contractionary monetary policy and expansionary fiscal policy (5 cases, most of them cases where the monetary authority subscribes to the Liverpool or LINK model), or expansion on both fronts (6 cases, again cases where the monetary authority subscribes to the Liverpool, or LINK models), or contraction on both fronts (7 cases, most of them cases where the fiscal authority subscribes to the Liverpool or LINK models).

To find out whether a given plan for policy coordination raises welfare in truth, rather than only in the perceptions of the policy makers, we would have to know the true model. This we cannot do. But we can get an idea of the range of possibilities by judging it by the standard of each of the other models in the Brookings simulations. The 36 cells in Table 6 correspond to the same 6 x 6 combinations of subscribed-to models as in Table 5. Each gives the true welfare gains, under 6 possible models of reality. Consider again the example where the central bank subscribes to the MCM and the fiscal authority to the OECD model. If either the MCM or OECD models coincides with the true model, then there will necessarily be a true welfare gain, equal to .0034 or .0029, respectively, just as the central bank or fiscal authority, respectively, thought there would be. (The welfare units are expressed in terms of the variance of output.) It turns out that if the true model happens to be the EPA or VAR model, then there will also be a welfare gain. But if the true model is the Liverpool or LINK model, then there will be a welfare loss. The coordination plan moves policy settings in the wrong direction, and everyone would have been better off staying with the Nash competitive equilibrium. This conclusion is probably less alarming for those who are not fans of either of these two models, than for those who are. But such readers should recognize the possibility that the fiscal authority will subscribe to, say, the Liverpool model and the central bank to the LINK model; then the coordi-

Table 6a: TRUE GAINS FROM COORDINATION

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
MODEL REPRESENTING REALITY:						
MCM	0.0000	0.0057	0.0002	0.0000	0.0016	0.0000
EPA	0.0000	0.0138	0.0029	0.0007	0.0100	0.0027
LIVPOOL	0.0000	-0.0363	0.0001	-0.0001	-0.0092	0.0048
VAR	0.0000	-0.1770	0.0256	0.0000	0.0010	0.0632
OECD	0.0000	-0.0211	0.0087	0.0003	0.0013	0.0089
LINK	0.0000	-0.0076	-0.0009	-0.0000	-0.0024	0.0008
EPA						
MODEL REPRESENTING REALITY:						
MCM	0.0265	0.0000	-0.0017	-0.0016	-0.0161	0.0012
EPA	0.0808	0.0000	0.0011	0.0002	0.0051	0.0005
LIVPOOL	-0.0596	0.0000	0.0000	-0.0003	-0.0178	-0.0007
VAR	0.4121	0.0000	0.0201	0.0000	-0.0911	0.0049
OECD	0.0379	0.0000	0.0062	0.0000	0.0026	0.0017
LINK	-0.0103	0.0000	-0.0018	-0.0008	-0.0143	0.0001
LIVPOOL						
MODEL REPRESENTING REALITY:						
MCM	0.0004	0.2078	0.0000	-0.0038	-0.0024	-0.0236
EPA	-0.0019	0.1578	0.0000	-0.0016	-0.0009	-0.0981
LIVPOOL	0.0002	0.2331	0.0000	0.0001	0.0002	0.0130
VAR	-0.0229	4.1167	0.0000	0.0000	0.0012	-0.9132
OECD	-0.0085	0.1968	0.0000	-0.0010	0.0000	-0.1269
LINK	0.0013	0.1728	0.0000	-0.0016	-0.0011	0.0052
VAR						
MODEL REPRESENTING REALITY:						
MCM	0.0005	-0.0049	0.0193	0.0000	-0.0029	0.0009
EPA	0.0033	0.0025	0.0164	0.0000	0.0015	-0.0012
LIVPOOL	-0.0005	-0.0006	0.0018	0.0000	-0.0009	-0.0008
VAR	0.0002	0.0003	0.0001	0.0000	0.0002	0.0001
OECD	0.0012	0.0009	0.0103	0.0000	0.0005	-0.0008
LINK	0.0000	-0.0025	0.0066	0.0000	-0.0017	0.0002
OECD						
MODEL REPRESENTING REALITY:						
MCM	0.0034	-0.0197	82.2990	-0.0013	0.0000	0.0006
EPA	0.0164	0.0180	62.3113	0.0002	0.0000	-0.0001
LIVPOOL	-0.0128	-0.0284	16.0323	-0.0003	0.0000	-0.0006
VAR	0.0203	-0.0773	338.7696	0.0000	0.0000	0.0009
OECD	0.0029	0.0066	3.8311	0.0001	0.0000	0.0001
LINK	-0.0028	-0.0198	46.7237	-0.0007	0.0000	0.0001
LINK						
MODEL REPRESENTING REALITY:						
MCM	0.0000	-0.0007	-0.0092	-0.0001	-0.0003	0.0000
EPA	0.0013	0.0003	-0.0420	0.0004	0.0003	0.0000
LIVPOOL	0.0006	0.0010	0.0015	0.0002	0.0004	0.0000
VAR	0.0025	-0.0018	-0.4466	0.0000	-0.0006	0.0000
OECD	0.0018	0.0000	-0.0562	0.0003	0.0000	0.0000
LINK	0.0000	0.0001	0.0012	0.0000	0.0000	0.0000

Table 6b: BARGAINING DEVIATION OF Y FROM NASH

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
MODEL REPRESENTING REALITY:						
MCM	0.0000	-1.2544	1.6821	-0.4571	-2.8270	-0.1457
EPA	0.0000	7.5109	1.8732	-0.3766	0.0014	-0.8877
LIVPOOL	0.0000	-0.8538	0.6294	-0.1768	-1.1938	-0.0232
VAR	0.0000	52.3206	1.6446	0.3491	16.1692	-4.5038
OECD	0.0000	16.9960	1.7791	-0.2112	3.4865	-1.6459
LINK	0.0000	-4.6088	1.0816	-0.3504	-3.1622	0.2160
EPA						
MODEL REPRESENTING REALITY:						
MCM	-1.5940	0.0000	1.7688	-1.2099	-7.5542	1.6033
EPA	18.7815	0.0000	1.8918	-1.0763	-2.6898	1.7485
LIVPOOL	-1.4836	0.0000	0.6737	-0.4644	-3.0650	0.6015
VAR	122.0132	0.0000	1.1463	0.4465	25.8123	1.3455
OECD	40.5840	0.0000	1.6857	-0.7222	3.3664	1.6198
LINK	-9.7994	0.0000	1.1930	-0.8937	-7.2147	1.0467
LIVPOOL						
MODEL REPRESENTING REALITY:						
MCM	-2.2212	28.2354	0.0000	-1.9385	-1.0101	-2.2393
EPA	-2.4010	-5.3455	0.0000	-1.9302	-1.0359	-14.2894
LIVPOOL	-0.8343	12.1529	0.0000	-0.7352	-0.3818	-0.3289
VAR	-1.7354	-193.5415	0.0000	-0.5217	-0.4529	-73.0970
OECD	-2.2000	-45.7847	0.0000	-1.5804	-0.8854	-26.6235
LINK	-1.4592	33.8568	0.0000	-1.3440	-0.6675	3.5951
VAR						
MODEL REPRESENTING REALITY:						
MCM	-1.8946	-5.4073	2.6925	0.0000	-2.9562	1.9244
EPA	-1.5490	-4.8918	2.7302	0.0000	-2.5339	1.9853
LIVPOOL	-0.7331	-2.0721	1.0190	0.0000	-1.1389	0.7269
VAR	1.5193	1.5046	1.0208	0.0000	1.6667	0.9337
OECD	-0.8505	-3.3958	2.2963	0.0000	-1.5677	1.7111
LINK	-1.4577	-3.9592	1.8457	0.0000	-2.2244	1.3047
OECD						
MODEL REPRESENTING REALITY:						
MCM	-4.5658	-14.9026	737.6275	-1.0540	0.0000	0.8811
EPA	-0.3850	-6.6530	409.8804	-0.9286	0.0000	0.9647
LIVPOOL	-1.9113	-6.0054	293.7698	-0.4050	0.0000	0.3295
VAR	23.7862	45.1979	-1752.7476	0.4432	0.0000	0.8826
OECD	4.8346	4.6833	-66.1134	-0.6106	0.0000	0.9391
LINK	-4.9418	-13.8265	649.9707	-0.7624	0.0000	0.5650
LINK						
MODEL REPRESENTING REALITY:						
MCM	-0.6789	-1.3616	0.3530	-0.4273	-0.6718	0.0000
EPA	-0.7234	-1.5377	-4.1275	-0.4426	-0.7325	0.0000
LIVPOOL	-0.2554	-0.5066	0.3272	-0.1613	-0.2520	0.0000
VAR	-0.4676	-1.4599	-26.8295	-0.2180	-0.5631	0.0000
OECD	-0.6509	-1.4841	-6.9222	-0.3836	-0.6784	0.0000
LINK	-0.4505	-0.8664	2.1566	-0.2890	-0.4386	0.0000

Table 6c: BARGAINING DEVIATION OF CA FROM NASH

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
MODEL REPRESENTING REALITY:						
MCM	0.0000	2.5522	-0.1407	0.0746	1.1018	-0.1871
EPA	0.0000	4.0551	-0.1501	0.0994	1.6464	-0.3082
LIVPOOL	0.0000	-3.5360	-0.1873	-0.0037	-0.9849	0.3156
VAR	0.0000	2.0329	0.0498	0.0172	0.6483	-0.1729
OECD	0.0000	-0.0672	-0.1835	0.0468	0.2363	0.0325
LINK	0.0000	-0.8711	-0.1065	0.0148	-0.1571	0.0866
EPA						
MODEL REPRESENTING REALITY:						
MCM	5.7811	0.0000	-0.1772	0.1757	2.1491	-0.1443
EPA	9.2419	0.0000	-0.2040	0.2279	3.1186	-0.1594
LIVPOOL	-8.3049	0.0000	-0.1578	0.0229	-1.4377	-0.1633
VAR	4.7299	0.0000	0.0296	0.0272	1.0599	0.0389
OECD	-0.2971	0.0000	-0.1928	0.1258	0.6976	-0.1741
LINK	-2.0926	0.0000	-0.1026	0.0477	-0.1110	-0.0976
LIVPOOL						
MODEL REPRESENTING REALITY:						
MCM	0.2057	-12.4690	0.0000	0.2249	0.1089	-3.0535
EPA	0.2303	-18.8041	0.0000	0.2741	0.1295	-5.0218
LIVPOOL	0.2174	12.0364	0.0000	0.1216	0.0758	5.1167
VAR	-0.0489	-7.7137	0.0000	-0.0043	-0.0092	-2.8074
OECD	0.2407	-2.2375	0.0000	0.2062	0.1082	0.5145
LINK	0.1329	2.1379	0.0000	0.0984	0.0545	1.4005
VAR						
MODEL REPRESENTING REALITY:						
MCM	0.3126	0.7627	-0.2989	0.0000	0.4555	-0.2043
EPA	0.4173	0.9825	-0.3589	0.0000	0.5993	-0.2415
LIVPOOL	-0.0205	0.1359	-0.1892	0.0000	0.0164	-0.1492
VAR	0.0743	0.1025	0.0174	0.0000	0.0887	0.0203
OECD	0.1938	0.5640	-0.2876	0.0000	0.3051	-0.2063
LINK	0.0601	0.2218	-0.1419	0.0000	0.1063	-0.1050
OECD						
MODEL REPRESENTING REALITY:						
MCM	1.6730	3.9781	-174.7652	0.1555	0.0000	-0.0727
EPA	2.4876	5.7308	-247.9844	0.2026	0.0000	-0.0770
LIVPOOL	-1.4308	-2.4433	87.6864	0.0162	0.0000	-0.0996
VAR	0.9570	1.8896	-73.8117	0.0258	0.0000	0.0269
OECD	0.3904	1.3980	-71.0422	0.1094	0.0000	-0.0962
LINK	-0.2124	-0.1174	-2.7890	0.0406	0.0000	-0.0562
LINK						
MODEL REPRESENTING REALITY:						
MCM	0.0657	0.1080	-1.2715	0.0449	0.0605	0.0000
EPA	0.0750	0.1120	-2.0326	0.0528	0.0668	0.0000
LIVPOOL	0.0621	0.1604	1.8260	0.0339	0.0684	0.0000
VAR	-0.0125	-0.0453	-1.0401	-0.0049	-0.0163	0.0000
OECD	0.0733	0.1490	0.0651	0.0459	0.0729	0.0000
LINK	0.0395	0.0865	0.4600	0.0235	0.0409	0.0000

Table 6d: True Deviation of CA from Target under Bargaining Solution

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
MODEL REPRESENTING REALITY:						
MCM	0.0000	-0.6327	-6.1663	-2.7244	-2.0403	-0.0169
EPA	-0.1787	-1.3750	-10.2638	-4.6944	-3.7129	-0.2062
LIVPOOL	-11.1815	-9.3112	-1.1405	-6.4340	-6.8329	-11.1550
VAR	0.0280	-0.8968	-5.5179	-2.5541	-2.2416	0.0132
OECD	-4.2032	-3.6998	-3.3071	-3.6549	-3.4040	-4.2012
LINK	-5.0202	-4.4024	-2.3099	-3.6969	-3.7065	-5.0131
EPA						
MODEL REPRESENTING REALITY:						
MCM	-0.6337	0.4357	-7.1667	-1.9029	0.3305	-3.2830
EPA	-1.3538	-0.0000	-11.6688	-3.6610	-0.3682	-5.6880
LIVPOOL	-9.4281	-9.1138	-0.6106	-6.1562	-7.9220	-5.1078
VAR	-0.8475	-0.7561	-5.9523	-2.4985	-1.2828	-3.2329
OECD	-3.7577	-2.9063	-3.7000	-2.9840	-2.3911	-3.3696
LINK	-4.4499	-4.0889	-2.3145	-3.4056	-3.6300	-3.2829
LIVPOOL						
MODEL REPRESENTING REALITY:						
MCM	-5.6391	-1.5687	-7.6615	-1.5582	-0.8606	-6.4199
EPA	-9.4400	-3.1096	-12.7250	-3.2437	-2.1559	-10.9378
LIVPOOL	-1.7995	-6.7271	-0.0000	-5.9573	-6.6167	0.6212
VAR	-5.1283	-2.1874	-6.3567	-2.5112	-2.0008	-6.3171
OECD	-3.2860	-3.0446	-3.8541	-2.6607	-2.6267	-2.6096
LINK	-2.4610	-3.5625	-2.2197	-3.2490	-3.4438	-1.6532
VAR						
MODEL REPRESENTING REALITY:						
MCM	-2.7267	-1.8765	1.1962	37.7395	-1.9547	-2.6928
EPA	-4.6970	-3.6290	0.2242	46.1235	-3.7246	-4.6638
LIVPOOL	-6.4364	-6.1426	-5.0474	7.5930	-6.1835	-6.3760
VAR	-2.5536	-2.4995	-2.3183	-0.0000	-2.4986	-2.5721
OECD	-3.6576	-2.9591	-0.4184	29.6086	-3.0301	-3.6058
LINK	-3.6984	-3.3936	-2.2784	10.8278	-3.4272	-3.6665
OECD						
MODEL REPRESENTING REALITY:						
MCM	-2.0221	0.4800	5.7644	-1.9438	5.5925	-2.7203
EPA	-3.6916	-0.1690	7.2431	-3.7124	6.9994	-4.7699
LIVPOOL	-6.8184	-7.9296	-10.1319	-6.1720	-10.0475	-6.0126
VAR	-2.2439	-1.2481	0.7935	-2.5012	0.7216	-2.7316
OECD	-3.3850	-2.2974	0.0708	-3.0174	-0.0000	-3.4458
LINK	-3.6966	-3.6005	-3.3345	-3.4202	-3.3360	-3.5257
LINK						
MODEL REPRESENTING REALITY:						
MCM	-1.7602	-2.6251	-6.4038	-2.6954	-2.9093	-8.6446
EPA	-3.0689	-4.9464	-10.8757	-4.6671	-5.0488	-14.8975
LIVPOOL	-8.2563	-5.8470	0.4089	-6.3761	-5.8625	5.9143
VAR	-1.5801	-2.8238	-6.2238	-2.5725	-2.8349	-9.0253
OECD	-3.9165	-3.4330	-2.7030	-3.6076	-3.4955	-1.4580
LINK	-4.2227	-3.4816	-1.7354	-3.6671	-3.5063	-0.0000

Table 6e: True Deviation of Income from Target under Bargaining Solution

MODEL SUBSCRIBED TO BY FISCAL AUTHORITY	MODEL SUBSCRIBED TO BY CENTRAL BANK					
	MCM	EPA	LIVPOOL	VAR	OECD	LINK
MCM						
MODEL REPRESENTING REALITY:						
MCM	0.0000	-3.8828	-3.2908	-2.7671	-5.4201	-0.0351
EPA	14.7033	6.8945	-12.4072	0.8631	-0.4088	14.6346
LIVPOOL	-2.1882	-3.4907	-2.4077	-2.7593	-3.8246	-2.1874
VAR	68.3206	43.5759	-75.8370	0.9415	8.4617	67.9369
OECD	25.8781	14.6058	-25.8133	0.8288	1.4826	25.7432
LINK	-4.5264	-5.5356	3.3654	-1.7134	-4.1375	-4.5028
EPA						
MODEL REPRESENTING REALITY:						
MCM	-3.3833	-11.4870	0.8132	-9.1376	-15.8499	-4.8236
EPA	7.5992	0.0000	-10.2288	-5.1805	-6.5697	-4.0861
LIVPOOL	-3.3101	-6.4039	-0.7688	-5.1883	-7.9626	-3.4140
VAR	44.9564	45.6004	-86.2026	1.0284	31.0486	-17.0539
OECD	15.4393	9.7990	-26.3911	-3.7485	1.6661	-6.8141
LINK	-5.2777	-11.0968	7.0253	-6.2581	-13.1718	-1.9007
LIVPOOL						
MODEL REPRESENTING REALITY:						
MCM	-3.8515	-8.8557	2.6403	-12.1701	-12.9646	-9.1182
EPA	-11.2835	-3.5640	-10.1668	-8.2261	-6.8136	-21.5936
LIVPOOL	-2.6930	-5.1391	-0.0000	-6.3374	-6.7338	-4.4718
VAR	-65.8764	9.1339	-96.2746	0.0558	13.0883	-97.7467
OECD	-22.8117	-0.7720	-28.5151	-6.2743	-2.3909	-37.5222
LINK	2.2586	-6.6328	9.0421	-8.3495	-9.8409	0.7695
VAR						
MODEL REPRESENTING REALITY:						
MCM	-2.7424	-9.3710	-33.4678	-318.4218	-8.7026	-3.2122
EPA	0.8898	-5.4153	-28.4014	-299.4691	-4.7521	0.3469
LIVPOOL	-2.7500	-5.2768	-14.4595	-123.0813	-5.0231	-2.9249
VAR	0.9605	0.9513	0.5241	0.0000	1.1166	0.3824
OECD	0.8532	-3.9437	-21.5164	-227.7715	-3.4038	0.3157
LINK	-1.6971	-6.4189	-23.5560	-226.5305	-5.9544	-1.9908
OECD						
MODEL REPRESENTING REALITY:						
MCM	-5.5965	-16.7647	-40.9647	-8.8200	-40.2311	-4.5711
EPA	-0.5927	-7.3226	-22.4051	-4.8789	-21.9907	-1.6799
LIVPOOL	-3.8911	-8.3164	-17.8838	-5.0672	-17.5919	-3.4112
VAR	8.3645	31.7517	79.4263	1.0254	77.7240	-4.0332
OECD	1.3218	1.2451	0.0518	-3.5199	0.0000	-2.1775
LINK	-4.2562	-13.8735	-34.4997	-6.0316	-33.8562	-2.6453
LINK						
MODEL REPRESENTING REALITY:						
MCM	-1.1882	-4.6061	-8.3245	-3.1955	-4.0070	-17.3547
EPA	6.6116	-2.1112	-20.4096	0.3613	-1.5682	-41.3703
LIVPOOL	-2.3407	-3.4074	-4.1878	-2.9185	-3.1779	-7.0961
VAR	26.4713	-6.4252	-95.1664	0.3736	-6.5862	-169.5495
OECD	10.7035	-3.0211	-36.0656	0.3247	-2.6429	-68.0402
LINK	-2.4013	-2.5004	1.1517	-1.9782	-2.0622	0.0000

nation plan (monetary contraction and fiscal expansion) will again worsen welfare as judged by the other four models.

Of course the proper strategy, if the true model could be discovered, would be simply for both policy makers to optimize subject to it. The point here is that one cannot, under conditions where policy makers subscribe to different models, make the blanket pronouncement that coordination must improve welfare.

Of the 216 (= 6^3) possible combinations in Table 6, 180 (= 216 - 6^3) involve disagreement between the policymakers, and therefore bargaining. Of the 180, welfare is improved by bargaining in 98 cases and worsened in 64 cases. (In 18 cases the effect is not perceptible: zero to four decimal places.) However in 60 (= 2 x 6 x 5) of these cases, one agency or the other has the true model, so that a non-negative welfare change is guaranteed. Of the 120 (= 6 x 5 x 4) cases where the agencies' models differ not only from each other but also from the true model, welfare is perceptibly improved in 52 and worsened in 64.

When all 11 available models are used (the Taylor model reports no results for the current account) there are 1331 (= 11^3) possible combinations. Of the 1210 (= 1331 - 11^2) that involve disagreement and bargaining, welfare is perceptibly improved in 667 cases and worsened in 477 cases. Of the 990 (= 11 x 10 x 9) cases where three distinct models are involved, welfare is perceptibly improved in 490 cases and worsened in 471 cases. As a sensitivity analysis with respect to targets, we tried redoing the analysis with a target level of GNP assumed to be 25 percent above the baseline. When all 11 models are used, 537 of the cases involving 3 distinct models show perceptible welfare gains from bargaining and 402 show losses. We also tried a target level of GNP assumed to be 5 percent below the baseline; 557 of the cases involving 3 distinct models show welfare gains and 408 show losses. It may not be a coincidence that coordination does, after all, produce welfare gains in a (slight) majority of cases. A convex combination of two sets of parameter estimates--even such a strange nonlinear "convex combination" as comes out of the coordination mathematics--may be closer to the true answer, and on average closer to any third set of parameter estimates, than either individually. But to the extent there are possible gains from coordination of this type, it might be more advantageous for the agencies to realize them by bargaining over the correct model rather than over the policies.

II. 3. Extensions

Quite a number of extensions have been left for future research, even after the same issues that have been investigated here for domestic policy making are repeated for international policy making. We could try different objective functions. For the exercises where the policy makers are viewed as taking turns in real time, we could use the more complete time profile of multiplier effects reported in the Brookings simulation. A high priority is to compare the results of two possible kinds of cooperation among policy makers: the Nash bargaining solution versus maximization of joint welfare based on a model with parameter values determined by averaging the estimates of the two.

More ambitious modeling is possible. We could study a Stackelberg equilibrium in which the U.S. policy makers are able to choose their preferred point on the other countries' reaction curve. It would be interesting to compare a naive Stackelberg equilibrium in which the U.S. authority assumes that the others' actions are based on the same model as its own, versus, the "rational expectations" Stackelberg equilibrium in which the U.S. authorities realize that the foreign governments will react on the basis of their own model, even though that model is different from the model that the U.S. authorities themselves believe to be correct. Other possibilities include having the policy makers update their parameter estimates each period to reflect new information in a Bayesian manner, evaluating institutional arrangements like fixed exchange rates that might substitute for coordination, and applying game theory concepts of repeated games and precommitment.

APPENDIX: WHEN THE POLICY MAKERS ARE ASSIGNED DIFFERENT GOALS

The preceding analysis was unusual in that issues of conflict and coordination among policy makers were assumed to arise solely out of divergent models. In this section we introduce the more usual divergences in goals as well. As a concrete example, it is sometimes observed that the fiscal authority cares more about output and employment, particularly in an election year, and the central bank more about other variables.[34]

We adopt the extreme assumption that the fiscal authority cares <u>only</u> about output and the central bank cares only about the other variable, or vice versa. This assumption is not necessary, but keeps things simple. It has the added advantage that when we compare the two possibilities--a Nash equilibrium with the fiscal authority monitoring output and the central bank monitoring the other variable, versus the reverse combination--we are doing the classic Assignment Problem. Under this interpretation the writer of a national constitution, resigned to the necessity of decentralization of policy-making, must decide which agency to make responsible for internal balance and which for external balance. As Mundell (1962) showed, the wrong assignment of responsibility could result in an unstable system. Mundell's solution was the principle of "effective market classification:" assign each agency

[34]This section could be viewed as a warm-up for studying international coordination, where the divergence in goals is clear.

responsibility for that goal for which its policy tool is comparatively more effective. We will see how the possibility of conflicting models changes the nature of the Assignment Problem, as we have seen that it changes the nature of gains from coordination.

We return to the targets-and-instruments equations (12) and (13), each perceived differently by the two authorities. But we add new objective functions. Under Assignment Rule I, the central bank seeks to minimize variation in output y and the fiscal authority to minimize variation in the current account x. Thus the central bank seeks to minimize

$$y^2 = (A_c + C_c m + F_c g)^2 \tag{20}$$

If we continue to assume that the constant terms are not revised in the light of new information, the first order condition implies

$$m = -\frac{A_c}{C_c} - \frac{F_c}{C_c} g \tag{21}$$

The fiscal authority seeks to minimize

$$x^2 = (B_f + D_f m + G_f g)^2 \tag{22}$$

The first order condition implies[35]

$$g = -\frac{B_f}{G_f} - \frac{D_f}{G_f} m \ . \tag{23}$$

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[35]Equations (21) and (23) are the same as equations (15) and (16), respectively, with $\omega = 0$ and $\omega = \infty$, respectively.

Equations (21) and (23), the two reaction functions under Assignment Rule I, are graphed in Figure 5. The central bank's reaction function CB_I, Equation (21), slopes downward as long increases in m and g are both thought to increase income. (The only exception among the 12 models is the Liverpool simulation, in which g can have a negative multiplier.) But the fiscal authority's reaction function FA_I, Equation (23), slopes upward if an increase in g is thought to have the opposite effect from m, that is to improve the current account (as in the EPA, MSG, MiniMod, and VAR for a U.S. fiscal expansion), and so we have drawn it that way. If the two agencies are thought of as taking turns in real time, then the system is stable if and only if the absolute value of the slope of CB_I is greater than the absolute value of the slope of FA_I:

(24) $$\left| {}^{C}c/F_c \right| > \left| {}^{D}f/G_f \right|$$

Under Assignment Rule II, the central bank seeks to minimize variation x^2 in the trade balance and the fiscal authority variation y^2 in output. The two reaction functions are then

(25) $$m = -\frac{B_c}{D_c} - \frac{G_c}{D_c} g$$

(26) $$g = -\frac{A_f}{F_f} - \frac{C_f}{F_f} m .$$

The system is stable under Assignment Rule II if and only if

(27) $$\left| {}^{D}c/G_c \right| > \left| {}^{C}f/F_f \right| .$$

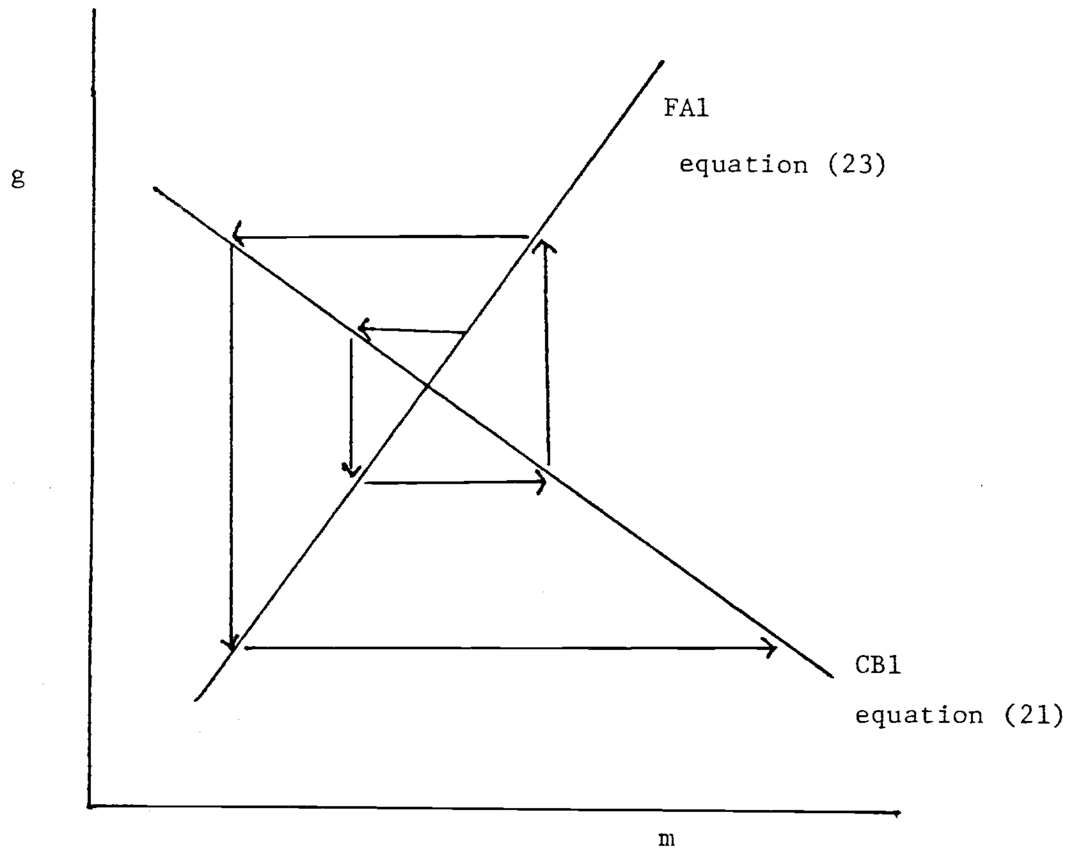

Figure 5: Assignment Rule I

If the two models coincide, as in the conventional Assignment Problem, then one of the two Rules must be stable and the other unstable.[36] But with conflicting models, it is possible that both rules are stable, or that neither are.

In general with conflicting models, the equilibrium point where the two reaction functions intersect will be different depending on the rule and on the perceived models. One has only to solve equations like (21) and (23) simultaneously and compare the solution with the simultaneous solution of equations like (25) and (26) to see the difference. One can evaluate the two solution points for m and g by the standard of the true model to see the values of y^2 and x^2 that they will in reality produce. The true value of the welfare function at the equilibrium point would probably be a more important criterion for evaluating the two possible assignment rules than is the criterion of stability. In the problem considered in this paper, where each policy-maker has only one goal, each will succeed in attaining his optimum ($y = 0$ and $x = 0$) regardless what the other does, so all equilibrium points coincide. Stability is the only relevant criterion. But the issue of different equilibrium points and different resulting welfare levels arises if the domestic policy-makers have multiple goals, or in the context of international policy-making.

The above equations have the property that the policy makers do not revise their views as to the values of the policy multipliers even

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[36] If the two slopes happen to be equal in absolute value, then convergence will not be reached under either rule.

though they observe levels of y and x that are inconsistent with what their models would have predicted from the current settings of m and g. In the previous section we made the assumption that such discrepancies were viewed by the policy makers as transitory error terms. In this section, since we are studying a problem in which each agency has a single target variable, we make the alternative assumption that each agency reacts directly to the observed value of the variable, making the policy change that would be best if its multiplier estimates were correct. Since its policy reaction line always runs through the optimum point $(y = 0, x = 0)$, and the slopes are functions of the multipliers, we are in effect assuming that the discrepancies are viewed as shifting the perceived constant terms in equations (12) and (13).

Under Assignment Rule I, the central bank and fiscal authority, respectively, react according to

(28)
$$\Delta m = -\frac{1}{C_c} y$$
$$\Delta g = -\frac{1}{G_f} x .$$

By substituting these policy rules in equations (12) and (13), the true model that determines y and x, we obtain the system

(29)
$$m_{+1} = -\frac{A}{C_c} + \left(1 - \frac{C}{C_c}\right)m - \left(\frac{F}{C_c}\right)g$$
$$g_{+1} = -\frac{B}{G_f} - \left(\frac{D}{G_f}\right)m_{+1} + \left(1 - \frac{G}{G_f}\right)g$$
$$= \left(-\frac{B}{G_f} + \frac{D}{G_f}\frac{A}{C_c}\right) - \frac{D}{G_f}\left(1 - \frac{C}{C_c}\right)m + \left(\frac{D}{G_f}\frac{F}{C_c} + 1 - \frac{G}{G_f}\right)g$$

In specifying the reaction equation for g_{+1}, we have assumed that the central bank has taken its turn first. The roots of the system of the two difference equations are the solutions λ to the equation

$$(30) \qquad \begin{vmatrix} \tilde{C}_c - \lambda & \frac{-F}{C_c} \\ (\frac{-D}{G_f})\tilde{C}_c & (\frac{D}{G_f}\frac{F}{C_c} + \tilde{G}_f) - \lambda \end{vmatrix} = 0$$

where we have defined the proportional deviations of perceptions from reality

$$(31) \qquad \tilde{C}_c \equiv (1 - \frac{C}{C_c}) \quad \text{and} \quad \tilde{G}_f \equiv (1 - \frac{G}{G_f}) \; .$$

Then

$$\lambda^2 - (\tilde{C}_c + \frac{D}{G_f}\frac{F}{C_c} + \tilde{G}_f)\lambda + \tilde{C}_c(2\frac{D}{G_f}\frac{F}{C_c}\tilde{G}_f) = 0$$

$$(32) \quad \lambda = \frac{(\tilde{C}_c \frac{D}{G_f}\frac{F}{C_c} + \tilde{G}_f) \pm \sqrt{(\tilde{C}_c + \frac{D}{G_f}\frac{F}{C_c} + \tilde{G}_f)^2 - 4\,\tilde{C}_c(2\frac{D}{G_f}\frac{F}{C_c} + \tilde{G}_f)}}{2}$$

The system is stable if both roots are within the unit circle. In the special case where the two agencies have the correct models,

$$(C_c = C,\ G_f = G,\ \tilde{C}_c = 0,\ \tilde{G}_f = 0)$$

the condition for stability reduces to

$$\frac{D}{G}\frac{F}{C} < 1$$

which is the standard relative-slopes solution to the Assignment Problem.

Under Assignment Rule II, the policy authorities' swap target is variables. They react according to

$$\Delta m = -\frac{1}{D_c} x \qquad (33)$$

$$\Delta g = -\frac{1}{F_f} y$$

By substituting into equations (12) and (13) we obtain a system, with roots that can be solved for in the same way.

We took the approach of using the multiplier estimates from Table 4, in simulations of the two policy makers alternating turns, to find out the number of steps needed for convergence in addition to the answer as to whether the system converges at all. Table 7 reports the results for all 216 possible combinations of the 6 models. Each of the 6 panels represents one true model. Within each panel are 36 cells representing the possible combinations of models subscribed to by the two policy makers. Within each cell is reported, first, convergence under Rule 1 (a "1" if the system is stable, followed by the number of steps required for convergence), and then convergence under Rule II (a "2" for stability, followed by the steps to convergence).

Consider the case when the true model is the MCM. If the central bank subscribes to the MCM, EPA or VAR, the system is stable only under Rule 1, and otherwise it is stable only under Rule II, with the added result that it is often unstable under either rule if the central bank subscribes to the OECD or LINK models, and is always unstable if the fiscal authority subscribes to the VAR. Unlike in the standard problem,

TABLE 7

STABILITY UNDER ASSIGNMENT RULES I AND II

True Model: 1

	1	2	3	4	5	6
1	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	2	2
	99	99	2	99	2	2
2	1	1	99	1	99	99
	3	3	99	3	99	99
	99	99	2	2	2	2
	99	99	2	2	2	2
3	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
4	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
5	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	99	99
	99	99	3	99	99	99
6	1	1	99	1	99	99
	7	5	99	26	99	99
	99	99	2	99	99	99
	99	99	3	99	99	99

True Model: 2

	1	2	3	4	5	6
1	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	2	2
	99	99	2	99	2	2
2	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	2	2
	99	99	2	2	2	2
3	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
4	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	99	99	99	99
5	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	99	99
	99	99	3	99	99	99
6	1	1	99	1	99	99
	7	5	99	26	99	99
	99	99	2	99	99	99
	99	99	3	99	99	99

Key to Models:
1. MCM 2. EPA 3. LIVERPOOL 4. VAR 5. OECD 6. LINK

Key to Cells:

"1", if converges under Rule I. "99" otherwise.
Number of steps to convergence. "99" if more than 90.

"2" if converges under Rule II. "99" otherwise.
Number of steps to convergence. "99" if more than 90.

TABLE 7 (continued)

True Model: 3

	1	2	3	4	5	6
1	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	2	2
	99	99	2	99	2	2
2	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	2	2
	99	99	2	2	2	2
3	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	99	99
	99	99	2	99	99	99
4	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	2	99	2	99
	99	99	4	99	64	99
5	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	99	99	99
	99	99	3	99	99	99
6	1	1	99	1	99	99
	7	5	99	26	99	99
	99	99	2	99	2	99
	99	99	3	99	4	99

True Model: 4

	1	2	3	4	5	6
1	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	2	2
	99	99	2	8	2	2
2	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	2	2
	99	99	2	2	2	2
3	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	99	99
	99	99	2	4	99	99
4	99	99	99	99	99	99
	99	99	99	99	99	99
	99	99	2	2	2	99
	99	99	4	18	64	99
5	1	1	99	1	99	99
	2	2	99	2	99	99
	99	99	2	2	99	99
	99	99	3	5	99	99
6	1	1	99	1	99	99
	7	5	99	10	99	99
	99	99	2	2	2	99
	99	99	3	5	4	99

Key to Models:
1. MCM 2. EPA 3. LIVERPOOL 4. VAR 5. OECD 6. LINK

Key to Cells:

"1", if converges under Rule I. "99" otherwise.
Number of steps to convergence. "99" if more than 90.

"2" if converges under Rule II. "99" otherwise.
Number of steps to convergence. "99" if more than 90.

TABLE 7 (continued)

True Model: 5

		1	2	3	4	5	6
1		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	8	2	2
2		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	2	2	2
3		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	4	6	5
4		99	99	99	99	99	99
		99	99	99	99	99	99
		99	99	2	2	2	2
		99	99	4	18	64	60
5		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	3	5	2	2
6		1	1	99	1	99	99
		7	5	99	10	99	99
		99	99	2	2	2	2
		99	99	3	5	2	2

True Model: 6

		1	2	3	4	5	6
1		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	8	2	2
2		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	2	2	2
3		1	1	99	1	99	99
		2	2	99	2	99	99
		99	99	2	2	2	2
		99	99	2	4	6	5
4		99	99	99	99	99	99
		99	99	99	99	99	99
		99	99	2	2	2	2
		99	99	4	18	64	60
5		1	1	99	1	99	99
		2	2	99	2	99	99
		2	99	2	2	2	2
		2	99	2	5	2	2
6		1	1	99	1	99	99
		2	5	99	2	99	99
		99	99	2	2	2	2
		99	99	2	5	2	2

Key to Models:
1. MCM 2. EPA 3. LIVERPOOL 4. VAR 5. OECD 6. LINK

Key to Cells:

"1", if converges under Rule I. "99" otherwise.
Number of steps to convergence. "99" if more than 90.
"2" if converges under Rule II. "99" otherwise.
Number of steps to convergence. "99" if more than 90.

where both agencies know the true model, it frequently happens that neither Assignment Rule is stable, or that both are.[37]

[37]The standard problem can produce this result if policy actions are taken in continuous time instead of discrete time.

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