

Cooper, Richard

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MACRO-ECONOMIC POLICY ADJUSTMENT IN INTERDEPENDENT ECONOMIES

#35-

Richard Cooper

Yale University

This paper is concerned with the gains to be derived from coordination of economic policies, and with how those gains vary according to the degree of economic interdependence. It attempts to extend the discussion of economic policy formation in an open economy in two respects, by allowing for international capital movements and by exploring how well national policy-makers, acting independently, can be expected to perform as the economic interdependence among countries increases.

Interest in these problems derives from two sources. The first is the great increase in international capital movements which took place after 1958, and the high sensitivity of some of these capital movements to interest rates. This change put new burdens and new restraints on national monetary policies. Analysis of the economic interactions among countries, such as Metzler's classic paper [7], has generally been confined to trade flows, ignoring capital movements entirely. Those works which have incorporated the effects of international capital movements have been framed in terms of an "atomistic" country, one sufficiently small that the repercussions of its policies on the world economy, and hence back on itself, are negligible.<sup>1</sup> This assumption greatly simplifies the analysis, but it does so at the expense of relevance for a large economic area such as the United States, the European Economic Community, or the United Kingdom.

The second source of interest is the evident increase in international consultation and cooperation which has accompanied growing economic interdependence among nations, a growing interdependence that appears in trade flows as well as capital movements.<sup>2</sup> Why have these developments

apparently increased the pressure for international economic cooperation?

The question is especially pertinent in view of the observation by Mundell [10] that when national economic authorities have several policy objectives and several policy instruments at their disposal, a division of labor can be found which will permit attainment of the objectives.<sup>3</sup>

In a decentralized system of policy-making, each policy authority concentrates his attention on a single policy objective. Mundell's proposal concerns the division of labor between monetary and fiscal policies within a single country, but the "division of labor" principle would seem to be even more appropriate, and is certainly more evident, among countries; the same analysis should apply, and decentralization of policy-making should be successful. Close cooperation among policy-makers should be unnecessary.

The analysis here attempts to show that as economic interdependence increases, the effectiveness of decentralized policy-making in the sense just described will decline, and the case for coordination of policy-making, for directing all the policy instruments at all the targets, becomes more compelling. This conclusion is perhaps obvious and innocent enough as applied to policy-makers within a single country, but it also has implications for the coordination of economic policies among nations, with a corresponding reduction in national sovereignty, which are only beginning to be appreciated.

The analytical framework used here is similar to that introduced by J. Tinbergen [13], involving targets of economic policy, i.e. variables to which we attach some social importance, such as the level of unemployment or the rate of economic growth; and instruments of economic policy, i.e. those variables, such as government expenditures or open market operations, which can be controlled by a nation's economic authorities, and which in

turn influence the values taken by the target variables. "Effectiveness" of policy is measured both in terms of the speed with which policy-makers restore the target variables to their target values after they have been disturbed by some exogenous and unforeseen forces and in terms of the size of reserve movements required during the transition period.

The approach taken here is to specify a simple two-country model of the world economy. Each country is assumed to have two policy instruments at its disposal. A process of adjustment to deviations from policy targets is specified, and the resulting dynamic adjustment model is simulated for different values of the parameters--marginal propensities to import and the interest sensitivity of international capital movements--which represent the degree of economic interdependence among countries.

### I. The Model

The following macro-economic relationships describe the economy of a major country:

$$(1) \quad Y = C + I + G + X - M \quad (4) \quad M = M(Y) \quad (7) \quad L = V$$

$$(2) \quad C = C(Y) \quad (5) \quad L = L(Y, r) \quad (8) \quad B = dR = X - M + K$$

$$(3) \quad I = I(Y, r) \quad (6) \quad V = H + R \quad (9) \quad K = K(r - r')$$

where  $Y$  = national income

$C$  = consumption

$I$  = net domestic investment

$G$  = government expenditure

$X$  = exports of goods and services

$M$  = imports of goods and services

$L$  = demand for money

$V$  = supply of money

$R$  = central bank holdings of international reserves

H = central bank holdings of domestic bonds

B = balance of international payments

K = net inflow (+) of foreign capital

r = rate of interest on bonds

All of these variables (except r) are in money terms, but prices are assumed to be constant.<sup>4</sup> Relationships (1), (6), and (8) are identities, (2), (3), (4), (5) and (9) are behavioral relationships, and (7) is a market balance equation.

For simplicity it is assumed that all government expenditures are financed by the sale of bonds; there are no taxes. Thus there are three assets involved here, bonds, money, and real investment. But attention is focused on flows, and portfolio balance considerations are ignored.

A similar set of relations (1') - (9') apply to the second region, which can be considered to be the rest of the world, whose variables are indicated by a prime. Exchange rates are assumed to be fixed throughout, and without loss of generality currencies are assumed to exchange one for one, so we have the following identities:

$$(10) \quad X = M'$$

$$(10') \quad M = X'$$

$$(11) \quad K = -K'$$

Together these imply

$$(12) \quad B = -B'$$

Substituting (2), (3), (4), and (10) in (1) and (9) in (8), performing similar operations on the primed variables, differentiating totally the resulting equations, noting (12), defining  $s = 1 - C_y - I_y$  for the first country and  $s'$  similarly for the second, and rearranging, we get five independent equations (13) - (17):

$$\begin{aligned}
 (13) \quad (s + m)dY - I_r dr - m'dY' &= dG \\
 (14) \quad -L_y dY - L_r dr &+ dR = -dH \\
 (15) \quad mdY - K_r dr - m'dY' + K_r dr' &+ dR = 0 \\
 (16) \quad -mdY - (s' + m')dY' - I_r' dr' &= dG' \\
 (17) \quad -L_y' dY' - L_r' dr' &- dR = -dH'
 \end{aligned}$$

Here subscripts indicate partial derivatives with respect to the indicated variable, and the differentials can be taken to indicate differences from target values, e.g.  $dY = (Y - Y^*)$ , where  $Y^*$  is the target value of  $Y$ . It is also assumed that  $B = 0$  initially, so  $dB = dR$ . This trick will work only once, however. So long as  $B \neq 0$ , reserves will be changing and so will the money supply, unless offsetting action is taken. This formulation assumes therefore that the influence of past reserve changes on the money supply are neutralized by offsetting open market operations, but that  $B_t$  affects the money supply in the current period  $t$ . In other words, it is the balance of payments rather than the reserve level that is targeted:  $B^* = 0$ , and,

$$(18) \quad dR_t = dB_t = B_t = R_t - (R_o + \sum_{i=1}^{t-1} B_i)$$

Alternative formulations that avoid this stock-flow problem<sup>5</sup> are to assume 1) all reserve changes are immediately neutralized by open market operations or 2) incomes and interest rates always adjust fully and freely to assure balance of payments equilibrium ( $B_t = 0$  for all  $t$ ). With the first alternative  $dR$  would not appear in equations (14) and (17), while with the second alternative  $dR$  would not appear in equation (15). The model used here is thus a peculiar hybrid of the two alternative models, implying that the monetary authorities choose to neutralize the monetary effects of reserve changes, but they do so only with a one-period

lag.

Interest rate differentials are assumed to influence the period - to - period flow of capital from one country to another. It would be more appropriate, but unduly complicating, to represent capital movements as a combination of stock adjustment and continuing flow in response to interest rate differentials. The model assumes implicitly, therefore, that once an investor buys bonds he is "locked in" until maturity, so that only new saving plus the proceeds from (steadily) maturing bonds can be allocated between new domestic and foreign bonds in response to yield differentials.

Equations (13) and (16) concern the flow of goods and services in the two regions, equations (14) and (17) represent the monetary sectors of both regions, and equation (15) is the balance of payments between the two regions. Thus equation (13) indicates that changes in saving and imports must equal changes in government spending, investment, and exports, while equation (14) indicates that changes in the demand for money must equal changes in the supply, which in turn are made up of changes in international reserves plus open market transactions in bonds.

It is assumed that  $s$ ,  $m$ ,  $L_y$ , and  $K_r$  are all positive, while  $I_r$  and  $L_r$  are negative (similarly for primed variables). The equations have been arranged so that all the target variables ( $Y$ ,  $r$ ,  $B$ ,  $Y'$ ,  $r'$ ) are on the left hand side and all the policy instruments ( $G$ ,  $H$ ,  $G'$ , and  $H'$ ) are on the right hand side. This permits the use of economical matrix notation:

$$(19) \quad Ay = x$$

where

$$A = \begin{pmatrix} s+m & -I_r & 0 & -m' & 0 \\ -L_y & -L_r & 1 & 0 & 0 \\ m & -K_r & 1 & -m' & K_r \\ -m & 0 & 0 & s'+m' & -I'_r \\ 0 & 0 & -1 & -L'_y & -L'_r \end{pmatrix},$$

$y$  is the column vector of target variables, and  $x$  is the column vector of policy instruments. As we will see below, matrix notation makes it possible to see clearly which interdependencies are being ignored in a policy adjustment process.

Note that interest rates on bonds are here regarded as targets of policy rather than as instruments, as they have been in some models.<sup>6</sup> Interest rates cannot be regarded as instruments of policy in an open economy with international capital movements, since no country can control directly its interest rate. It is open market operations that are directly under the control of each country's monetary authorities.

Interest rates can be regarded as a proxy for the target of economic growth or the distribution of income, just as the level of income proxies for the target of employment.<sup>7</sup> For example, full employment can be achieved with various combinations of consumption and investment. Lowering the bond rate can alter the "mix" in favor of investment and hence

raise the growth in output. In this sense the rate of interest may be a proximate target of policy.

## II. Comparative Statics of the Model

How small changes in each of the policy instruments<sup>8</sup> affect the equilibrium values of each of the target variables can be found by inverting the matrix A, since

$y = A^{-1}x$  and  $\frac{dy}{dx}$  equals the transpose of  $A^{-1}$ . The elements of  $A^{-1}$ , even for this simple system involving only two countries, four instruments, and five targets, are formidably complicated.<sup>9</sup> For example, the normal foreign trade multiplier for a change in government expenditure, allowing for feedbacks from the other country and for monetary effects in both countries, is

$$(20) \quad \frac{dY}{dG} = \frac{(L_r - K_r)[(s'+m')L'_r + I'_r L'_y] - L_r[(s'+m')K_r - m'I'_r]}{\Delta}$$

$$\text{where } \Delta = [(s+m)L_r + I_r L_y][(s'+m')L'_r + I'_r L'_y] - L_r m m' L'_r \\ + m' I'_r (s L_r + L_y I_r) + m I_r (s' L'_r + L'_y I'_r) \\ - K_r [(s'+m')(s L_r + L_y I_r) + (s+m)(s' L'_r + L'_y I'_r) + m(s' L_r + L'_y I_r) \\ + m'(s L'_r + L'_y I'_r)]$$

Given the assumptions concerning signs made in Section I above, both the numerator and the denominator of this expression will always be positive.<sup>10</sup>

It would be tedious to examine all of the elements of  $A^{-1}$ . However, allowing for international capital movements between two regions does give rise to some possible outcomes which would not otherwise take place. We can consider three:

First, while an autonomous rise in domestic expenditure would normally be expected to hurt the balance of payments, if capital movements are

sufficiently sensitive to interest rate differentials a rise in domestic expenditure by raising interest rates may attract more than enough capital from abroad to finance the enlarged current account deficit. The inflow of capital serves not only to purchase the bonds issued to finance the larger expenditure, but also to help satisfy a larger transactions demand for cash.

Second, while a domestic boom in one country may normally be expected to "spill over" into the other country, raising incomes there as well as in the first country, it is possible that the flow of capital from the second to the first country, by raising interest rates in the second country, may induce a decline in investment more than enough to offset the stimulus from enlarged exports. This outcome will be more likely the higher is the interest sensitivity both of international capital movements and of investment in the second country, relative to the interest sensitivity of demand for money in both countries.

Third, tighter monetary policy (open market sales of bonds) in one country may be expected to lower interest rates in the other country if international capital movements are small, but to raise them if international capital movements are large. The first outcome results from the lower level of activity induced in the second country by a decline in exports to the first country. If capital is internationally mobile and interest sensitive, however, tighter monetary policy in the first country will pull funds out of the second country and raise interest rates there. This flow will mitigate the impact of a given open market sale on the first country, but it will aggravate the decline in money income in the second country.

These examples should serve to indicate that allowance for inter-

national capital movements introduces a new range of possible outcomes into the traditional analysis of foreign trade multipliers. It becomes especially important to specify the nature of the disturbance--whether it is an expenditure disturbance (e.g. a shift in the consumption function, an investment boom, or a change in government spending or taxation) or a monetary disturbance (e.g. central bank action or a shift in the public's portfolio between bonds and cash). Either type of disturbance may have quite different impacts on incomes and interest rates in the two countries, and on the balance of payments, depending on the relative size of the countries, on the relationship between the marginal propensities to import and the interest sensitivity of international capital flows, on the relationship between the marginal propensity to save and the transactions demand for cash, and on other factors.

### III. The Policy Adjustment Model

The preceding section was a digression on the comparative static properties of the model set out in Section I. Nothing was said there about the target values of the target variables. From the viewpoint of policy targets, the model of Section I is underdetermined. A well-known proposition of the theory of economic policy is that to achieve  $n$  targets (except by coincidence) there must be at least  $n$  instruments.<sup>11</sup> Here there are five policy targets and only four instruments,<sup>12</sup> so instruments are inadequate to secure any/arbitrary values for the five targets. Here we are not interested in reaching arbitrary targets, however, but in how this model responds to small disturbances from policy targets which are assumed to be compatible. We can make the five targets ( $y^*$ ) compatible by manipulating some parameter not a variable in this model, for example

the exchange rate, so as to make them all compatible. Thus the exchange rate is assumed to be correct for the levels of employment, the rates of growth (as reflected in the interest rates), and the balance of payments targets of the two countries. Initially  $y = y^* = 0$  and  $x = 0$ , by choice of scale.

Now suppose this harmonious state is subjected to some disturbance. Disturbances can be specified in several ways and can enter the system in a number of places. For simplicity, however, we assume that the structure in equation (19) remains unchanged, that the parameters remain unchanged as a result of any disturbance, and that disturbances are confined to once-for-all shifts in expenditure patterns or in portfolio preferences in either of the two countries.<sup>13</sup> Thus the disturbances ( $z$ ) are step functions which enter the model linearly, like the policy instruments:

$$(21) \quad Ay = x + z, \quad \text{where } z \text{ is a column vector.}$$

It is obvious from (21) that for  $y^* = 0$ ,  $x^* = -z$ , where  $x^*$  is the value of  $x$  required to assure  $y^* = 0$ .

The policy authorities do not generally know the value of  $z$ . As a rule, they cannot observe disturbances directly, but only/ deviations of target variables from their target values. They therefore must "grop" back toward policy equilibrium on the basis of signals from these deviations.

We assume that this groping process takes the form:

$$(22) \quad \dot{x} = B(y^* - y), \quad \text{where } \dot{x} \text{ is the time derivative of } x,$$

and  $B$  is a "coordination matrix".<sup>14</sup>  $B$  indicates the degree of coordination among policy-makers in their pursuit of the targets, where coordination refers to the extent to which policy-makers take into account the objectives

and prospective actions of other policy-makers in determining their own actions. Three cases can be distinguished.

- 1) B has only one element in each column. By rearrangement of the terms in equations (13) - (17), i.e. by rearranging the columns of A, B can then be made diagonal. In this case each instrument  $x_i$  is assigned to a single target  $y_i^*$ , and adjustment takes the form:

$$(23) \quad x_i = b_{ii}(y_i^* - y_i), \quad i = 1, \dots, 4$$

This is the case of no coordination, or full decentralization, in economic policy making. For example, the fiscal authorities are concerned only with the level of national income, not with the level of interest rates or the balance of payments. This is the case examined by Mundell [10] for two targets and two instruments.

- 2) B (after proper arrangement of A) is block diagonal. In this case the policy instruments of each country are devoted to simultaneous achievement of the objectives of each country. The fiscal and monetary authorities of each country are concerned with the simultaneous determination of national income and interest rates, say, but they are not concerned with the values of these variables in the other country. This is the case of internal coordination.
- 3) B is a full matrix, identifying each instrument with all target variables on which it has an impact. Here the policy-makers take into account all the interdependencies of the economic system in using their policy instruments. This is the case of full coordination. It seems natural to relate the elements of B to the elements of A, and in particular when  $b_{ij}$  is not zero to set  $b_{ij} = \alpha a_{ij}$ , where  $\alpha$  is a constant coefficient of adjustment. These values can be justified on the

ground that within this general form of adjustment the most direct approach to equilibrium would be:

$$(24) \quad \dot{x} = \alpha(x^* - x), \quad \text{where each } x \text{ is adjusted with a speed}$$

varying with the deviation from its (unknown) appropriate value. This seems to be an obvious standard for comparing speeds of adjustment under different degrees of coordination. But the system of full coordination reduces to this if  $B = \alpha A$ . Thus we have:

No coordination:

$$(25) \quad B = \alpha \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ 0 & a_{22} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{44} & 0 \\ 0 & 0 & 0 & 0 & a_{55} \end{bmatrix}$$

Internal Coordination:

$$(26) \quad B = \alpha \begin{bmatrix} a_{11} & a_{12} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{44} & a_{45} \\ 0 & 0 & 0 & a_{54} & a_{55} \end{bmatrix}$$

Full Coordination:

$$(27) \quad B = \alpha \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix}$$

Here  $a_{ij}$  are the elements of A. The zeros in the middle row merely remind us of the fact that there is no instrument to operate directly on the balance of payments, i.e.  $x_3 = 0$ .

Substituting equation (21) into (22) yields

$$(28) \quad \dot{x} = By^* - BA^{-1}(x+z), \text{ where the } z \text{ are given.}$$

The solution to this system of simultaneous differential equations in x takes the form:

$$(29) \quad \begin{aligned} x(t) &= Ay^* - z + We^{-\lambda t}W', \quad \text{and therefore} \\ y(t) &= y^* + A^{-1}We^{-\lambda t}W' \end{aligned}$$

where  $y(t)$  is the value of the target variables at time  $t$  after the initial disturbance,  $W$  and  $W'$  are matrices determined both by the structure of the model and by the nature of the initial disturbance, and  $\lambda$  is a vector of the characteristic roots of  $BA^{-1}$ . If the target variables are to converge to their target values ( $y^*$ ), the second term on the right must be transitory, which is assured if all the roots are positive. The smaller these roots are, the longer the transition period will last and the longer the target variables will be away from their targets. Thus in general an adjustment system with large roots will be more efficient than a system with small roots. The length of the transition period, defined as the time required for  $y(t) - y^*$  to reach some specified small value and stay below it in absolute value, will vary with the type of disturbance and the structure of the model, since these determine the weight to be associated with each root  $\lambda_i$ . But a system is more efficient with respect to many types of disturbance the larger is the smallest root, since this is the root whose term fades out least rapidly. Thus in evaluating the different types of coordination, we are concerned with the relative size of the characteristic roots of  $BA^{-1}$ , and in particular with the size of the smallest root.

#### IV. Numerical Examples

Unfortunately equation (28) cannot be solved analytically, even though it arises from a fairly simple model. It can be solved numerically, however, for particular values of the elements in A and B. Any set of values is somewhat arbitrary, but values have been selected here to correspond very crudely to the United States (region 1) and the rest of the world (region 2). All of the parameters have been fixed except for the two marginal propensities to import and the interest sensitivity of capital flows; these have been varied parametrically to allow for increasing degrees of economic interdependence between the two regions.

Thus the following numerical work is based on:

$$(30) \quad A = \begin{bmatrix} .35 + m & 15. & 0 & -m' & 0 \\ -.10 & 6. & 1 & 0 & 0 \\ m & -K_r & 1 & -m' & K_r \\ -m & 0 & 0 & .30 + m' & 15. \\ 0 & 0 & -1 & -.24 & 12. \end{bmatrix}$$

The marginal propensities to import,  $m$  and  $m'$ , were permitted to take on the following values in tandem, indicating a parallel rise in "openness" on current account in both regions:

$$(31) \quad \begin{aligned} m &= .01 & .06 & .15 & .30 \\ m' &= .007 & .04 & .10 & .20 \end{aligned}$$

The interest sensitivity of capital,  $K_r$ , was given the following values:

$$(32) \quad K_r = 0.0 \quad 2.0 \quad 10.0 \quad 20.0$$

These numbers, like the values for  $I_r$  and  $I'_r$  in (30),<sup>15</sup> indicates the change in billions of dollars per unit of time (say, a year) resulting

from a one percentage point change in the bond rate. Thus  $K_r = 2.0$  means that a one percentage point rise in  $r$  relative to  $r'$  would lead to an inflow of capital of \$2.0 billion per period. The values for  $K_r$  range from no interest-sensitivity of capital movements to very high (but not infinitely high) sensitivity.

Since there are five target variables and only four instruments, a choice must be made, for purposes of adjustment, among the target variables. It is assumed below that each of the two regions is primarily concerned with its level of employment and its rate of growth, and each directs its fiscal and monetary policies toward these ends. The balance of payments is thus left to follow the course dictated by the pursuit of these other objectives. Because of our assumption that all targets are compatible, the balance of payments will also adjust as the other target variables are brought to their targets.

An alternative assignment involves having one country, say the first, direct its monetary policy to keeping payments in balance, and allowing the rate of interest to adjust residually. Some remarks will be made below on this case, but attention will be focused on the first case.

Table 1 gives the smallest characteristic roots of  $BA^{-1}$ , where A is drawn from (30), (31), and (32) and B is constructed as indicated in (25), (26), and (27) above.

Table 1

Smallest Characteristic Root<sup>a</sup> of  $BA^{-1}$

		No Coordination		Internal Coordination	
		0	20	0	20
$\frac{K_r}{m}$	0	$.50 \pm .50i$	$.17 \pm .20i$	$.94$	$.26$
	.30	$.52 \pm .40i$	$.18 \pm .20i$	$.41$	$.18$
Full Coordination					
		0	20		
$\frac{K_r}{m}$	0	1.0	1.0		
	.30	1.0	1.0		

a All systems give rise to one root at zero, but this plays no role in the adjustment process so long as the disturbances do not affect the balance of payments directly, that is, so long as  $z_3 = 0$ .

Here  $\alpha = 1$ . For different  $\alpha$ , characteristic roots will be the product of  $\alpha$  and the roots shown.

Several things stand out. First, when policies are not coordinated at all, there is a considerable amount of "over-shooting", as indicated by (some not shown) the presence of complex roots, which lead to oscillatory behavior in (29). When policies are coordinated internally, this oscillatory behavior disappears; the strong interdependencies which when ignored led to oscillation were between monetary and fiscal policies in pursuit of the two domestic objectives in each region. Moreover, the smallest root is

higher with internal coordination than it is with no coordination, indicating that convergence toward objectives will be faster when policies are coordinated internally. The smallest roots are still below unity, however, indicating that convergence to targets after a disturbance may be slower with only internal coordination than it would be with full coordination of policies, which takes into account the interdependencies between nations as well as those within nations. However, with internal coordination there is also one root above unity (not shown), so for some types of disturbance convergence may actually be faster than it would be with full coordination.

The second point to note about the smallest roots for internal coordination is that they decline as the degree of economic interdependence between the two regions increases. This pattern suggests that as interdependence increases, the speed with which economic policy-makers can return to their targets after disturbance under a system of adjustment which ignores the interactions between national policies will decline as the economic interdependencies grow. Lack of coordination becomes more costly and the case for better coordination increases.

## V. Simulated Policy Responses

The speed of response to any disturbance depends in part on the nature of the disturbance. Two types of disturbance of particular interest involve shifts in expenditure patterns (e.g. an "autonomous" investment boom or a change in government expenditure) and shifts in preferences among financial assets. The policy adjustment model set out in Section III, modified to facilitate computer use, was simulated for the numerical values

of the parameters given in Section IV and for these two types of disturbance. Some results of these simulations are set out in Tables 2-4 below.

The policy model used for simulation was the system of difference equations (21') and (22') set out in footnote 14, rather than the differential equations (21) and (22). This change simplifies computation, but it also changes slightly the nature of the solution. The general solution to equations (21') and (22') is

$$(33) \quad y_t^* = y^* + A^{-1}W(1-\lambda)^t_W,$$

where, as before,  $W$  and  $W'$  are matrices determined both by the structure of the model and by the initial disturbances and  $\lambda$  is a vector of the characteristic roots of  $BA^{-1}$ . Here  $t$  takes on only integral values, representing discrete time periods. The second term on the right will be transitory so long as  $(1-\lambda)$  is less than unity in absolute value, i.e. so long as the real part of  $\lambda$  is between zero and two. Thus in this case  $\lambda$  can be too large for stability as well as too small; indeed, if any of the roots is greater than unity a cyclical response will be introduced; the policy responses taken together but without coordination will lead to overshooting the targets. Furthermore, roots which are near to zero or to two will lead to longer transition periods than roots which are close to unity. Thus, as before, the smaller the positive root, the slower the convergence to policy targets; but here the additional possibility is introduced that too large roots can also lead to slow convergence, as well as to overshooting.

Table 2 indicates the time required for national income to be put back on target following an expenditure disturbance and a monetary disturbance, under the three forms of policy coordina-

tion. The standard of performance was taken to be the number of time periods required to bring the sum of the deviations of national income (without regard to sign) in the two regions to within a specified distance from their target values, and to keep this sum below that figure. For concreteness, the initiating expenditure or monetary disturbance can be regarded as \$20 billion per period, and the standard of performance is to bring the combined national incomes to within \$200 million of their combined targets.

Table 2

Speed of Adjustment to Income Targets

(Periods until  $|dY| + |dY'| \leq .20$

		Expenditure Disturbance <sup>a</sup>		Monetary Disturbance <sup>b</sup>		
		0	20	0	20	
No		.01	17	17	22	38
Coordination		.30	24	16	29	34
Internal		.01	10	26	11	36
Coordination		.30	19	11	23	45
Full		.01	9	9	10	10
Coordination		.30	9	9	10	10

a  $z_t = (20, 0, 0, 0, 0)$ ,  $t \geq 0$

b  $z_t = (0, -20, 0, 0, 0)$ ,  $t \geq 0$

Table 3 gives similar results for the interest rate targets, where the measure of performance is the number of periods required to bring the sum of the interest rates in the two countries to within .02 percentage points of the sum of the targeted rates of interest.<sup>17</sup>

Tables 2 and 3 confirm the two generalizations made earlier. First, the time period required for adjustment generally rises as capital mobility and import propensities increase, except when there is full coordination. In general, higher interdependence slows down policy adjustment. Even with internal coordination, the delay in achieving income targets following an expenditure disturbance is increased 10 per cent in moving from the northwest to the southeast corner of the box in Table 2, for instance, and the delay following a monetary disturbance is quadrupled. In addition, as we will see below, larger reserves are required during the transition period.

Second, the delay in adjustment is reduced by increasing the degree of coordination, and the delay in adjustment from failure to coordinate policies rises with the degree of interdependence between regions. This conforms with common sense; if interactions are high, the losses from ignoring them will be larger than if interactions are low.

Table 3

Speed of Adjustment to Interest Rate Targets  
 (Periods until  $|dr| + |dr'| \leq .02$ )

	$K_r$	Expenditure Disturbance <sup>a</sup>		Monetary Disturbance <sup>b</sup>	
	$m$	0	20	0	20
No	.01	12	12	17	39
Coordination	.30	26	24	30	39
Internal	.01	6	15	8	25
Coordination	.30	13	7	17	34
Full	.01	6	6	8	8
Coordination	.30	6	6	8	8

a, b. See Table 2

In addition, although it is not evident in Tables 2-3, the degree of over-shooting targets is much greater in the case of no coordination than in the case of internal coordination, and overshooting is absent in the case of full coordination.<sup>18</sup>

These generalizations are not without exception. The tendency for high interdependence between countries to prolong the adjustment period is far less marked when there is no coordination than where there is internal coordination. This is because internal interdependencies--the influence of monetary policies on demand and of fiscal policies on interest rates--

are being ignored in the first case, and for the parameters tested here larger external interactions apparently do not add much; indeed, greater external interactions sometimes compensate in part for the ignored internal interactions.

Second, higher trade interdependence occasionally reduces the adjustment delay under the regimes of no coordination and internal coordination. High import propensities represent large leakages of demand, and if these are not quickly compensated by fiscal or monetary action abroad, they help to stabilize the disturbed economy by transmitting some of the disturbance to the other country. But of course this failure in both countries to take into account high leakages contributes to the overshooting of targets.<sup>19</sup>

Table 4 indicates even more clearly the impact of high but ignored interdependence on the process of policy adjustment. It shows the change in foreign exchange reserves (in billions of simulated dollars) during the first ten periods following an expenditure or a monetary disturbance amounting to \$20 billion. The choice of ten periods is wholly arbitrary, designed merely to provide a common basis for comparison.<sup>20</sup>

The case of monetary disturbances can be considered first, since it shows a straight-forward pattern. A shift in portfolio preference toward bonds and away from cash, or a series of open market purchases of bonds by the central bank, will lower the interest rate, stimulate domestic investment expenditure, and induce a capital outflow. A persisting shift in demand for bonds will cause reserve losses which generally decline as the degree of policy coordination increases and, for each coordination regime, increase both with the interdependence on trade and on capital account. Moreover, the difference between coordination regimes in the amount of reserve change increases with the degree of interdependence. Thus as inter-

Table 4

Reserve Changes during Adjustment

(Billions of simulated dollars, cumulative  
for ten periods following a disturbance)

		Expenditure Disturbance <sup>a</sup>		Monetary Disturbance <sup>b</sup>	
		0	20	0	20
No	.01	-1.2	+2.9	-0.1	-71.7
Coordination	.30	-20.3	-6.8	-6.0	-74.3
Internal	.01	-0.7	+15.1	-1.6	-57.3
Coordination	.30	-11.7	+5.7	-29.2	-74.4
Full	.01	-0.6	+5.3	-1.5	-20.8
Coordination	.30	-5.7	-0.3	-14.3	-23.8

a, b. See Table 2

dependence rises from  $(m, K_r) = (.01, 2)$  to  $(.30, 20)$ , the conservation of reserves over ten periods arising from a move to full coordination of policies from internal coordination rises from  $(16.8 - 10.9) = 5.9$  billion simulated dollars to  $(74.4 - 23.8) = 50.6$  billion dollars for a monetary disturbance of \$20 billion.

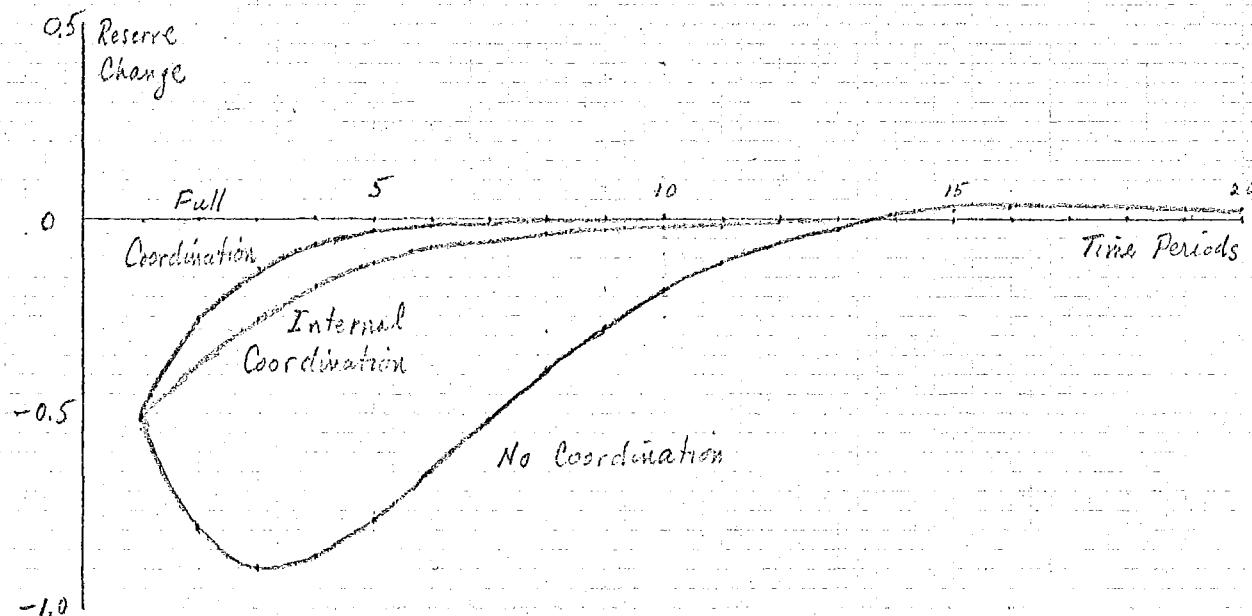
Reserve changes resulting from an expenditure disturbance also show a clear pattern, but a somewhat more complicated one than in the case of

a monetary disturbance. An autonomous rise in expenditure will worsen the current account, leading to reserve losses. But it will also raise interest rates, leading to capital inflows and reserve gains. Whereas in the case of a monetary disturbance the effects on current and capital accounts reinforce one another, in the case of an expenditure disturbance they work in opposite directions. As we saw in the comparative static analysis of Section II, a rise in government expenditure (analytically equivalent to an expenditure disturbance) can either help or hurt the balance of payments, depending on whether the effect on capital account outweighs or is outweighed by the effect on current account. The range of possibilities in a dynamic context can be seen in Table 4. For each coordination regime, reserve changes decline algebraically as the marginal propensities to import increase, and rise algebraically as the interest sensitivity of capital increases.

The fact that reserves rise with high capital sensitivity offers little consolation to an observer of the whole system, since a rise for one region means a fall for the other; and an autonomous drop in expenditure in the first region will lead to a loss of reserves by that region. The pattern of reserve changes does suggest, however, that as far as expenditure disturbances are concerned for each degree of coordination and for each level of the marginal propensities to import there is an optimum interest sensitivity of capital which minimizes the need for reserves. As the marginal propensity to import rises this optimum sensitivity also rises. Either higher or lower capital mobility would lead to larger reserve changes. Thus it is not generally true, as is sometimes claimed, that a perfect capital market will reduce greatly or even eliminate payments imbalances by permitting "equilibrating" flows of capital. Very high

Chart 1

Time Profile of Reserve Changes  
Following an Expenditure Disturbance  
( $m = .06$ ,  $m' = 104$ ,  $K_r = 2$ )



interest sensitivity of capital movements may aggravate rather than mitigate balance of payments swings.<sup>21</sup> There is no guarantee, moreover, that the same degree of capital mobility will also minimize the impact on reserves arising from expenditure disturbances in the second region;<sup>22</sup> or that it will minimize the time required to restore income targets; and monetary disturbances will always result in larger reserve changes the higher the international mobility of capital in response to interest rate differentials.

Chart 1 compares typical reserve changes in response to an expenditure disturbance under the three regimes of policy coordination. There is a clear trade-off between reserve requirements and coordination of economic policies, with greater coordination generally reducing reserve requirements.

The results presented so far rest on a particular assumption about monetary policy (delayed neutralization of reserve changes), on a particular assignment of instruments to targets, and on a particular set of numerical values for the relevant parameters. It is of interest to know how sensitive the results are to these various assumptions.

With full and immediate sterilization of the impact of reserve changes on the money supply, the interest-sensitivity of capital movements ceases to affect the time required after a disturbance to restore incomes and interest rates to their desired levels, since by assumption the effect of capital flows on domestic interest rates is neutralized. Nonetheless, the delays in reaching targets are lengthened by larger trade interdependencies, the delays decline with increasing coordination among policy-makers, and the pattern of reserve changes is similar to that recorded in Table 4, although the size of the swings is larger because of the immediate neutralization of effects on domestic monetary conditions.<sup>23</sup> Thus the conclusions above require little modification in this case.

The results presented so far for the case of no coordination (= each instrument associated with a single target) have been based on the assumption that monetary policy should be directed toward the objective of growth. Alternatively, monetary policy could be assigned the task of keeping international payments in balance.<sup>24</sup> In this case, broadly speaking, higher economic interdependence among regions speeds up the adjustment process rather than slowing it down. This result is not surprising, since the leverage of monetary policy on the balance of payments increases with higher interdependence. Restoration of income and growth targets at all levels of interdependence is much slower, however, than when monetary policy is directed toward the interest rate target. For an expenditure disturbance reserve requirements are diminished when the balance of payments is targeted; but for monetary disturbances reserve requirements are substantially increased.

Finally, separate simulations for substantially lower values of the marginal savings rates and the interest-sensitivity of investment, and for higher values of the income and interest-sensitivity of demand for money, suggest that the results reported in detail here continue to hold qualitatively and do not change radically in magnitude except in the last case, where raising the parameters reduces the leverage of the supply of money on the target variables.

#### VI. Conclusions from the Analysis

The model developed and simulated here has attempted to do several things at once. It has attempted to incorporate international capital movements in a systematic way, to allow for normal repercussion and feedbacks between two regions roughly equal in size, to explore the effects of coordination between policy-makers on the path of adjustment to economic

disturbances, and to suggest how the adjustment is affected by different degrees of economic interdependence between the two regions on both current and capital account.<sup>25</sup> It is a medium term Keynesian-type model, abstracting from longer term adjustments in the stock of capital and rates of return on capital, and it assumes exchange rates are in long-run equilibrium throughout.

The numerical examples and simulations suggest the generalizations that

- 1) lack of coordination among policy-makers
  - a) delays achievement of national objectives such as full employment and a targeted rate of growth, and
  - b) increases the requirements for international reserves when, under a regime of fixed but equilibrium exchange rates, the balance of payments is simply allowed to adjust passively to policy changes directed at other objectives; and
- 2) these delays in reaching targets and their calls on foreign exchange reserves are increased as the degree of economic interdependence among nations increases.

These generalizations are not without exception; but they seem to be sufficiently well-founded to suggest some implications for the "real" world of policy. Since the need to hold foreign exchange reserves entails a national cost, and since prolonged deviations from national objectives of economic policy lower national welfare, growing economic interdependence among nations calls for increased coordination between national policy-makers. It also raises the requirements for foreign exchange reserves, since given disturbances cause a larger drain on reserves when interdependencies are high even when policies are fully coordinated among countries.

There is little doubt that economic interdependence among nations--concretely, marginal propensities to import and the interest sensitivity of international capital movements--has increased sharply since the Second World War, the period in which government responsibility for the speed and direction of national economies has become widely accepted. Hence, the analysis here suggests a need for greater coordination of national policies and for additional foreign exchange reserves--or, alternatively, for steps to reduce the interdependencies--if welfare losses are to be avoided. Not surprisingly, both these forces can be recognized in official actions during the past ten years.<sup>26</sup>

The gains from coordination of policies here are "dynamic" gains, arising from better mutual timing. They should not be confused with the arguments for "harmonization" of economic policies on (static) efficiency grounds. Coordination of policies in the sense used here would be desirable under conditions of high interdependence even if one accepted the view that harmonization of economic policies beyond common agreement on maintenance of full employment is not necessary even in a free trade area.

As a description of reality, the model developed here is deficient in a number of respects, some of which can readily be corrected by further work. The model applies to only two regions rather than many. If coordination of policies takes place only within countries, many more interactions will be ignored when there are many regions. Second, the lag structure adopted here is far too simple. The only lag allowed is that arising from the need for policy-makers to grope toward their targets because they lack direct information about the disturbances.

Everything else adjusts instantaneously. Adjustment lags should be allowed for; and these lags may differ for different instruments of policy. Third, portfolio balance considerations have been wholly neglected. In particular, international capital movements are assumed to respond to interest rate differentials in a steady flow, with no allowance for a shift in stocks of private financial claims from one country to the other. Finally, for comparative purposes a uniform set of disturbances has been used throughout. But disturbances themselves may be influenced in size by the degree of interdependence among regions or by the degree of coordination among policy-makers.<sup>27</sup> If so, it is not possible to say that higher economic interdependence among nations will call for more coordination without knowing also the impact of this higher interdependence on the disturbances.

Footnotes

<sup>1</sup>See for example [4], [5], [8], [9], [10] and [13]. In [6] an attempt to allow for such feedbacks is made for a regime of flexible exchange rates.

<sup>2</sup>Tariffs, transportation costs, and other impediments to trade have declined, and in addition there has probably been a narrowing, at least among industrial countries, of differences in comparative costs. See Cooper [2].

<sup>3</sup>Mundell has called this division of labor "the principle of market classification" and I have called it the "assignment problem".[1] It has a formal analogy to the identification of each commodity in a general market system with its "own" price.

<sup>4</sup>Prices could be allowed to vary in this model without affecting the basic results, so long as price changes are reversible with pressures of demand, but to do so would complicate the model unnecessarily. Irreversible price changes would involve non-temporary disturbances to balance of payments equilibrium, and these are outside the framework developed here.

<sup>5</sup>I am grateful to Warren Smith and Jay Levin for raising questions about this "stock-flow problem" in an earlier draft.

<sup>6</sup>See Mundell [9]. Mundell modified this view of interest rates in [8].

<sup>7</sup>It is of course the level of real income, not money income, which in the short run determines the level of employment. In formulating the model in terms of money magnitudes I have assumed that money wages adjust to higher money national income far more slowly than the policy authorities do.

Footnotes (continued)

<sup>8</sup> Or indeed any other autonomous linear disturbance. See Section III below.

<sup>9</sup> There is a notational problem here. For small changes, the elements of  $A^{-1}$  indicate how each of the target variables  $Y$ ,  $r$ , etc. changes with a given change in policy, allowing all the target variables to adjust simultaneously but holding other policy variables unchanged.

<sup>10</sup> With the Keynesian assumption regarding accommodating monetary policy,  $dr = dr' = 0$ , and (20) becomes the familiar foreign trade multiplier with repercussions:

$$\frac{dY}{dG} = \frac{s' + m'}{(s + m)(s' + m') - mm'}$$

<sup>11</sup> Tinbergen [13].

<sup>12</sup> Actually there are potentially six targets, since each country may have a balance of payments target. But such targets might be inconsistent. We assume here that the balance of payments targets are consistent, and therefore the number of targets reduces to five since  $B^* = -B'^*$ .

<sup>13</sup> To preserve the assumption that the initial equilibrium exchange rate can be retained throughout the analysis, it is necessary to rule out disturbances affecting the balance of payments directly, e.g. a shift in import functions or a change in portfolio preferences between cash and foreign bonds. Such disturbances would lead to an indefinite loss or gain in reserves, and would require a change in the exchange rate or other measures acting directly on the balance of payments. In the notation used here, we require that  $z_3 = 0$ .

Footnotes (continued)

<sup>14</sup> It should be noted that this form of adjustment process follows naturally from a utility function quadratic in  $y$ ; instruments are changed in proportion to the marginal utility of  $y$  if  $B$  represents the quadratic coefficients in the utility function. Here, however,  $B$  is determined on the basis of economic structure without regard to different welfare weights that may attach to the different targeted variables.

The difference equation analogue is used for simulation in the next section. The system then becomes:

$$(21') Ay_t = x_{t-1} + z_{t-1}$$

$$(22') \Delta x = x_t - x_{t-1} = B(y^* - y_t)$$

<sup>15</sup> A one percentage point rise in the government bond rate is assumed to lower domestic investment by \$15 billion a year in both regions. This does not seem too high when housing is included in investment. A one point rise is assumed to lower the public's demand for (reserve bank) money, ceteras paribus, by \$6 billion in the first region and \$12 billion in the second. Finally, while a range of values is given for the interest-sensitivity of capital, of the values chosen a flow of \$2 billion perhaps comes closest to the situation prevailing in the mid-sixties.

Footnotes (continued)

16 Expression (33) is derived as follows: substitute equation (21') in (22'), which with reorganization becomes:

$$x_t = B(y^* - A^{-1}z_{t-1}) + (I - BA^{-1})x_{t-1}$$

Setting  $y^* = 0$ ,  $x_0 = 0$ ,  $z_t = \begin{cases} 0, & t < 0 \\ z, & t \geq 0 \end{cases}$

$$x_t = \left[ I + (I - BA^{-1}) + \dots + (I - BA^{-1})^{t-1} \right] (-BA^{-1})z$$

$$= \left[ I - (I - BA^{-1})^t \right] (BA^{-1})^{-1} (-BA^{-1})z$$

$$= -z + (I - BA^{-1})^t z$$

$$= -z + W(1-\lambda)^t W^{-1}z,$$

Setting  $W^{-1}z = W'$  gives (33)

Here  $\lambda$  are the characteristic roots of  $BA^{-1}$  and  $W$  is a matrix of characteristic vectors of  $(I - BA^{-1})$ .

This solution would have to be modified slightly for multiple roots different from unity, but the conditions for speed of convergence remain unchanged. For a discussion of simultaneous systems of difference equations, see Samuelson [11], pp. 418-429.

17 These standards of performance are of course arbitrary; the "acceptable" deviation from target could be either larger or smaller than those chosen here; and they should be calculated for each of the regions separately, rather than taking the two regions together. But these measures seem reasonable (neither region alone can find itself farther from target than \$200 million or .02 percentage points for national income and bond rates, respectively), and they serve to illustrate economically the relative speeds of adjustment under different coordination regimes and interdependence parameters.

Footnotes (continued)

18 The roots in Table 1 suggest no overshooting in the case of internal coordination when the adjustment process follows (21) and (22). The use of discrete adjustment periods in (21') and (22') introduces a cyclical response pattern for  $\alpha = 1$ , since in that case  $(1-\lambda) < 0$  for some roots not shown. The simulations reported here used  $\alpha = 1/2$ , which eliminates this cyclicity for the parameters tested.

19 High values of  $m$  raise the largest characteristic root. As noted above, a root above unity introduces cyclicity in the solution to equations (21') and (22'). High values of  $m$  thus increase the likelihood of overshooting. Here  $\alpha = 1/2$  lowers the largest root below unity; but  $\alpha = .8$  would lead to overshooting for  $m = .3$ ,  $m' = .2$ .

20 With no coordination and high  $K_r$ , the arbitrary choice of ten periods for measuring reserve changes seriously understates reserve requirements because reserves swing dramatically within the first ten periods and for a prolonged period thereafter.

21 For two regions that are similar in the sense that  $mL_r = m'L'_r$ , the formal condition for an expenditure disturbance to lead to no overall affect on the balance of payments (a worsened current account being exactly offset by an improved capital account) is that  $-mL_r = K_r L_y$ . If therefore  $K_r > \frac{(-mL_r)}{L_y}$ , a country experiencing a boom will increase its reserves at the expense of the other country. Under conditions of very high capital mobility, a boom could create large payments imbalances - due to "disequilibrating" capital movements.

Footnotes (continued)

21 (continued)

It is true, however, that monetary policy can be used to assure external balance, and that the required monetary action will be less the higher is  $K_r$ .

22 The condition that an expenditure disturbance in the second country have no effect on reserves is  $-m'L'_r = K_r L'_y$ , on the assumption  $mL_r = m'L'_r$ . This is obviously different from the condition in the preceding footnote if  $L'_y \neq L_y$ .

23 The condition for  $\frac{dR}{dG} = 0$  in this case is the same as that given in footnote 21.

24 This is an extension to two countries of the case considered by Mundell [10].

25 Fisher [3] has considered the question of ignored interdependence in a more general framework.

26 For empirical evidence on the growing interdependence and official response to it, see Cooper [2].

27 We are talking here about the "exogenous" disturbances,  $z$ , not the "disturbance" transmitted from one country to another through trade and capital movements. The latter are obviously influenced by the degrees of interdependence and coordination, and such influences are included in the simulations done here.

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