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Don E. Roper

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Macroeconomic Policies and the Distribution of the World Money Supply

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Macroeconomic Policies and the Distribution of the World Money Supply

In recent years interdependence between national economies has grown, and this growth has increased the importance of incorporating the interdependence into macroeconomic policy formation. To do so requires that we use a theoretical model that includes at least two countries in which the "foreign country" might be regarded as the rest of the world. In this paper a Keynesian model that has received widespread use in the literature[1/] is extended to two countries in order to determine the effects of macroeconomic policies in a general-equilibrium framework.

One important interdependence between economies in a world of fixed exchange rates is the link between their money supplies. In the act of stabilizing the rate at which one currency is exchanged for

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This paper is part of a dissertation in progress at the University of Chicago. The author would like to express his appreciation to his thesis advisor, R.A. Mundell, for his frequent advice and encouragement. He would also like to thank Ralph Bryant, Richard Cooper, and Don Tucker for their helpful suggestions. Useful comments were also received from members of the International Economics Seminar at the University of Chicago in April, 1969 on an earlier draft of the paper.

1/ V. Argy, "Monetary Variables and the Balance of Payments," International Monetary Fund Staff Papers, XVI, (July, 1969); J.M. Fleming, "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates," Staff Papers, IX, (Nov., 1962); H.G. Johnson, "Some Aspects of the Theory of Economic Policy in a World of Capital Mobility," in T. Gagiottil (ed.); Essays in Honor of Macro Fanno, Vol. II, (Padova, Italy: Cedma, 1966); "Theoretical Problems of the International Monetary System," Journal of Economic Studies, II, (Autumn, 1967); A.O. Krueger, another, central banks increase the surplus country's monetary base and decrease the monetary base of the deficit country. Thus, a balance of payments disequlibrium (ex post) redistributes the supply of world liquidity unless central banks undertake further actions to offset this effect. The analysis here will be limited to the fixed exchange rate system and particular consideration will be given to this redistributive process and its implications for macroeconomic policies.

Since the relaxation of exchange controls over a decade ago, there has been an increasing interest in the determinants of capital movements and, more recently, a growing concensus that capital flows depend upon the rate of change of the interest rate differential as well as the differential itself.[2/] An attempt has been made in this

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Footnote 1/ from page 1 -- continued.

"The Impact of Alternative Government Policies Under Varying Exchange Rate Systems," Quarterly Journal of Economics, Vol. 79, (May, 1965); R.A. Mundell, International Economics, (New York: Macmillan, 1968), Chapters 15-18; J. Patrick, "The Optimum Policy Mix-Covergence and Consistency," in P. Kenen and R. Lawrence (eds.) The Open Economy (New York: Columbia University Press, 1968); T.P. Quirk and Z.M. Zarley, "Policies to Attain External and Internal Balance: A Reappraisal," in Quirk and Zarley (eds.), Papers on Quantitative Economics, (Lawrence: University of Kansas Press, 1968); E. Sohmen, "Fiscal and Monetary Policies under Alternative Exchange Rate Systems," Quarterly Journal of Economics, Vol. 81, (Aug., 1967); E. Sohmen and H. Schneeweiss, "Fiscal and Monetary Policies Under Alternative Exchange Rate Systems: A Correction," Quarterly Journal of Economics, Vol. 87 (May, 1969); and A.K. Swoboda, Outer Currency Uses, Capital Mobility, and the Euro-Dollar Market, Ph.D. dissertation (Yale, 1967).

Several other articles have incorporated the foreign country: R.N. Cooper, "Macroeconomic Policy Adjustment in Interdependent Economies," Quarterly Journal of Economics, Vol. 83, (Feb., 1969); M.C. Kemp, "Monetary and Fiscal Policy Under Alternative Assumptions About Capital Mobility," Economic Record, (Dec., 1966); R.A. Mundell, op.cit., Chapter 18 Appendix. However, each of these sidestepped (only Mundell did so successfully) a stock-flow problem which will be discussed below. Consequently, this paper can be considered an extension of these two-country models as well.

2/ See the recent article by T.D. Willett and F. Forte, "Interest Rate Policy and External Balance," Quarterly Journal of Economics, Vol. 83, (May, 1969) and the references cited therein.

paper to include both determinants in the flow-of-capital function and to examine their different implications for macroeconomic policies, especially sterilization policy.[3/]

In Section I the two-country model of the international monetary system is constructed as a linear system of first-order differential equations and a solution is given. Time enters the system explicitly (i.e., differential equations were required) because the balance of payments is equal to the rate of change of the monetary base. The solution of this stock-flow problem[4/] brings out an important distinction between the effects of macroeconomic policies in the short-run and their final effects after both countries have adjusted to external balance.

In Section II several implications of the model are discussed. Differences in liquidity preferences between countries are shown to affect the distribution of the burden of adjustment. It is demonstrated

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3/ "Sterilize," "neutralize," and "offset" are some of the terms frequently used to describe the action taken by a central bank to counteract the effect of a balance of payments disequilibrium upon domestic liquidity. The methods of sterilization vary from country to country. For instance, the Federal Reserve relies primarily upon open market operations whereas the Bundesbank uses forward swaps with commercial banks, discount policy, and variable reserve requirements on bank liabilities to foreign residents. Canada has an automatic sterilization mechanism to the extent that foreign exchange operations, financed out of the Treasury's Exchange Fund Account at the Bank of Canada, do not induce the Bank to purchase or sell securities to the Treasury in order to replace or reduce the Canadians dollars depleted or acquired in the Account. For our purposes it is best to assume that sterilization policy is achieved only through open market operations.

4/ After Section I was completed, an article appeared by Sohmen and Schneeweiss, op.cit., which contains a solution to the stock-flow problem for the single-country case with a different approach than the one used here.

If a reader is not interested in the mathematical details, he may skip most of Section I and begin reading with the discussion of Figure I.

that a (naive) stock theory of capital movements (the theory that the of foreign owned capital in a model without growth can be explained by the interest rate differential) fails to yield the redistribution of liquidity which we would expect to occur through the capital account following a monetary disturbance. The effect of fiscal policy upon the distribution of international reserves is derived. The transmission of the business cycles is examined; and it is shown that, under certain conditions, fiscal policy can have a negative effect on foreign income which, if larger than the positive effect on home income, can cause world income to decline.

The solution of the system in Section I facilitates the examination of an argument recently advanced by Professor R.N. Cooper.[5/] After simulating a version of the two-country model in which macroeconomic policy variables are endogenous, Cooper argued that as international interdependence increases, the efficiency of the international monetary system declines unless international coordination of monetary and fiscal policies is increased. In Section III it is shown that the mathematical interpretation Cooper gives to "international coordination of monetary policies" is a Classical prescription for monetary policy, namely, sterilizing less. It is also demonstrated that much of the inefficiency that Cooper attributed to international interdependence and the lack of international coordination was, in fact, due to his assumption that monetary authorities offset balance of payments disequilibria with a lag. Further simulations of his policy-endogenous model under the alternative assumptions that capital movements are induced by the interest rate

5/ "Macroeconomic Policy Adjustment in Interdependent Economies," op.cit.

differential and by its rate of change, support another proposition -- that the case for sterilization rests, in part, on the determinant of capital movements. The case for sterilization is improved to the extent that the interest rate differential determines the stock of foreign assets rather than the rate of change in the stock.

I. The Model and Its Solution

The version of the model used here assumes fixed exchange rates, constant prices, no speculative capital movements, and unemployed resources. There are four equations which are assumed to hold at all times. They are the equilibrium conditions for goods and money in the home country and the rest of the world and are written as follows:

(1) $Y = E(Y,r) + I'(Y') - I(Y) + G$

(2) $L(Y,r) = D + R$

(3) $L'(Y',r') = D' + R'$

(4) $Y' = E'(Y',r') + I(Y') + G'$

where Y = national income; E = domestic expenditures

r = interest rate; G = government expenditures

M = supply of high-powered money = D + R

L = demand for high-powered money

D = central bank holdings of domestic assets

R = central bank holdings of international reserves

b = I' - I + T = balance of payments

T = net inflow of capital

I = imports

Primed variables denote the foreign counterparts to domestic variables, and taxes are assumed constant such that dG represents the change in government deficit or surplus. The world's international reserves will be assumed constant such that $dR = -dR' = \int_0^t b(\tau)d\tau$. Throughout the paper, "liquidity" and "money" will be used for "high-powered money" unless the context makes it clear that money includes deposits at commercial banks.

The stock and flow characteristics[6/] of capital mobility are built into the specification of the balance of payments equation which is assumed to be expressible in the form

$$(5) \qquad b = I'(Y') - I(Y) + T(r-r', \dot{r}-\dot{r}'),$$

where dots above variables indicate their derivatives with respect to time. When (5) is differentiated we obtain

$$(6) \qquad db = m'dY' - mdY + T_f(dr-dr') + T_s(\dot{r}-\dot{r}')$$

where $m = \partial I/\partial Y$, $T_f = \partial T/\partial(r-r')$, $T_s = \partial T/\partial(\dot{r}-\dot{r}')$, $\dot{r}_o = \dot{r}'_o = 0$ by

6/ There are two "stock-flow problems" which must be kept separate. One problem is to relate the balance of payments (a flow) with the demand and supply of money (a stock). The other problem is whether to allow the interest rate levels to influence the stock of foreign owned assets or the capital flow. The view which prevails in the literature at this time (and which is discussed in footnote 19) is that capital movements are a stock adjustment process but $(\dot{r}-\dot{r}')$ does influence T in a growing world as portfolios grow. According to this view, $(\dot{r}-\dot{r}')$ should be eliminated from (5) since this paper deals with a non-growth model. However, it seems useful to retain $(\dot{r}-\dot{r}')$ in order to contrast its effect with $(\dot{r}-\dot{r}')$.

assumption, and $db = b - b_o$ under the assumption that $b_o = b(Y_o, Y'_o, r_o, r'_o, \dot{r}_o, \dot{r}'_o) = 0$ (an equation which can be regarded as defining the exchange rate whose value is taken as unity). All derivatives are assumed to be evaluated at the initial equilibrium position which is denoted by the zero subscript. When (6) is substituted in the linearized version of (2) we obtain

$$
\begin{aligned}
L_y dY + L_r dr &= dD + \int_o^t [m'dY' - mdY + T_f(dr-dr') + T_s(\dot{r}-\dot{r}')]d\tau \\
\text{(7)} \qquad &= dD + T_s(dr-dr') + \int_o^t [m'dY' + T_f(dr-dr') - mdY]d\tau
\end{aligned}
$$

where subscripts indicate partial derivatives and $\int_o^t \dot{r}(\tau)d\tau = dr$. After substituting (6) into (3) in the same manner, the linearized version of the equations (1) through (4) can be written as

$$
\begin{vmatrix} h & -E_r & o & -m' \\ L_y & L_r & o & o \\ o & o & L'_r & L'_y \\ -m & o & -E'_r & h' \end{vmatrix} \begin{vmatrix} dY \\ dr \\ dr' \\ dY' \end{vmatrix} = \begin{vmatrix} dG \\ dD \\ dD' \\ dG' \end{vmatrix} + \begin{vmatrix} o & o & o & o \\ o & T_s & -T_s & o \\ o & -T_s & T_s & o \\ o & o & o & o \end{vmatrix} \begin{vmatrix} dY \\ dr \\ dr' \\ dY' \end{vmatrix} + \int_o^t \begin{vmatrix} o & o & o & o \\ -m & T_f & -T_f & m' \\ m & -T_f & -T_f & -m' \\ o & o & o & o \end{vmatrix} \begin{vmatrix} dY \\ dr \\ dr' \\ dY' \end{vmatrix}
$$

or in more compact form as

$$\text{(8)} \qquad S_o dy = dx + Kdy + \int_o^t Bdy$$

where

$$h = s + m \qquad\qquad s = 1 - \partial E/\partial Y$$

$$dy = (y - y_o), \qquad\qquad dx = (x - x_o),$$

$$y = \{Y \;\; r \;\; r' \;\; Y'\}^{7/}, \qquad\qquad x = \{G \;\; D \;\; D' \;\; G'\}.$$

7/ Braces denote a column vector.

The values of the parameters h, h', m, m', s, s', L_y, and L'_y are assumed to be positive, T_f and T_s non-negative, and the values of other parameters negative.

At this point it is useful to introduce sterilization policy in (8) by splitting dD into dD_s and dD_p where

dD_s = open market operations used to neutralize the effect of balance of payments disequilibrium on the money supply.

dD_p = open market operations used for any other policy.

The vector dx becomes

$$dx = \begin{vmatrix} dG \\ dD_p \\ dD'_p \\ dG' \end{vmatrix} + \begin{vmatrix} o \\ dD_s \\ dD'_s \\ o \end{vmatrix} = dp + dv$$

If both monetary authorities completely sterilize the balance of payments as it occurs, then we can set $dv = -Kdy - \int_o^t Bdy$ such that (8) becomes

$$S_o dy = dp + dv + Kdy + \int_o^t Bdy = dp$$

Consequently, as long as all countries completely neutralize their balance of payments, the effect of macroeconomic policies on y is given by $dy = S_o^{-1} dp$.

When there is no sterilization dy(t) will change over time as the balance of payments redistributes the world money supply. Before deriving the complete solution of (8) which describes the time path taken by dy(t), it is useful to derive dy(∞), the values of endogenous variables obtained when the balance of payments has corrected itself. When external equilibrium has been reached we need not impose equations (2) and (3) but only the condition that the world money supply, W, is equal to its demand. Consequently, we can add equations (2) and (3) and, after differentiating, obtain

(9) $$L_y dY + L_r dr + L'_r dr' + L'_y dY' = dD_p + dD'_p = dW$$

assuming $dD_s + dD'_s = 0.$[8/] The conditions that the system was initially in flow equilibrium ($b_o = 0$) and that the balance of payments has returned to equilibrium after the initial disturbance imply

(10) $$-mdY + T_f dr - T_f dr' + m'dY' = 0.$$

The linearized version of equations (1), (9), (10), (4) can be written as

$$\begin{bmatrix} h & -E_r & o & -m' \\ L_y & L_r & L'_r & L'_y \\ -m & T_f & -T_f & m' \\ -m & o & -E'_r & h' \end{bmatrix} \begin{bmatrix} Y_n - Y_o \\ r_n - r_o \\ r'_n - r'_o \\ Y'_n - Y'_o \end{bmatrix} = \begin{bmatrix} 1 & o & o & o \\ o & 1 & 1 & o \\ o & o & o & o \\ o & o & o & 1 \end{bmatrix} \begin{bmatrix} dG \\ dD_p \\ dD'_p \\ dG' \end{bmatrix} = \begin{bmatrix} dG \\ dW \\ o \\ dG' \end{bmatrix}$$

or in more convenient form as

(11) $$F(y_n - y_o) = Qdp$$

8/ The equation $dD' = -dD_s$ reflects the assumption that any sterilization policy by one country is matched by an equal and opposite policy by the other country.

where y_n and y_o represent the new and old equilibrium vectors. Thus, the final effects of policy upon the endogenous variables is given by[9/]

$$y_n - y_o = F^{-1}Qdp.$$

To solve (8) under the assumption of no sterilization we first need to remove the integral sign by differentiating with respect to time to obtain

(12) $$(S_o - K)\dot{y} = \dot{x} + Bdy \qquad \text{or} \qquad \dot{y} = S^{-1}Bdy$$

where $S = S_o - K$ and $\dot{x} = 0$ by assumption. The solution of (12) is

(13) $$dy(t) = S^{-1} - F^{-1}Q)dpe^{-\lambda t} + F^{-1}Qdp$$

where $e^{-\lambda t}$ is a scalar and $\lambda = |F|/|S| > 0$ since $|S|$ and $|F|$ are

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9/ The multipliers given by the elements of $F^{-1}Qdp$ are generalizations of those found by Mundell, op.cit., Chapter 18 Appendix, for the two-country model under perfect capital mobility. That is, they reduce to his as $T_f \rightarrow \infty$.

Equation (9) makes it clear that y_n-y_o is independent of who initiated monetary policy -- it is dW rather than its composition which affects the final equilibrium position. Mundell referred to this characteristic as the "generalization" of monetary policy, op.cit., p. 427. It is important to note that the condition of balance of payments equilibrium and not his assumption of perfect capital mobility produced this result.

unambiguously positive.[10/] By setting t equal to zero and infinity, inspection of (13) shows that

$$dy(0) = S^{-1}dp \qquad \text{and} \qquad dy(\infty) = F^{-1}Qdp.$$

10/ The solution of this differential equation system is too cumbersome to present here but can be obtained by writing the author.

In "Macroeconomic Policy Adjustment in Interdependent Economies," op.cit., R.N. Cooper gave the solution of this two-country model as $dy = (S-B)^{-1}dp$ (using the terminology of this paper). This solution can be derived by assuming that the monetary authorities sterilize their current external imbalances after the balance of payments has been allowed to redistribute liquidity for some length of time, γ. Following Cooper's assumption that $T_s=0$, this lagged sterilization assumption can be written as $dv = -\int_{\gamma}^{t} Bdy$ such that (8) becomes

$$(8') \qquad Sdy = dp - \int_{\gamma}^{t} Bdy + \int_{0}^{t} Bdy = dp + \int_{0}^{\gamma} Bdy.$$

By defining the length of the lag, γ, with the equation $Bdy = \int_{0}^{\gamma} Bdy$, the solution of which is $\gamma = \lambda^{-1}\ln(1+\lambda) < 1.0$, we can solve (8') as

$$Sdy = dp + Bdy \qquad \text{or} \qquad dy = (S-B)^{-1}dp$$

However, this solution is not invariant to the units in which time is measured. If the units for time are changed from, say, quarters to years, the value of λ increases by four but the numerical value of $\gamma = \lambda^{-1}\ln(1+\lambda)$ fails to decrease fourfold. Consequently the time during which the balance of payments is allowed to redistribute liquidity, depends upon the units in which time is measured. As a result, his solution $dy = (S-B)^{-1}dp$, falls between $S^{-1}dp$ and $F^{-1}Qdp$ and it approaches the former (latter) as the units for measuring time are decreased (increased).

Cooper states that his solution is based upon the assumption that sterilization operations are begun after a one full period lag, an assumption which is consistent with the solution when the model is interpreted for discrete time. Under this discrete time interpretation also, the solution is not invariant to the units for measuring time since the length of "one period" will be, for instance, a day or decade if time is measured in days or decades, respectively.

These two sets of multipliers differ and y changes over time when a policy or disturbance causes a balance of payments disequilibrium.[11/] Since $\lambda > 0$, the two-country system has a stable adjustment mechanism -- the balance of payments corrects itself.

A graphical exposition of the above mathematics is given in Figure I which shows the effects of an expansionary monetary policy on home and foreign incomes.

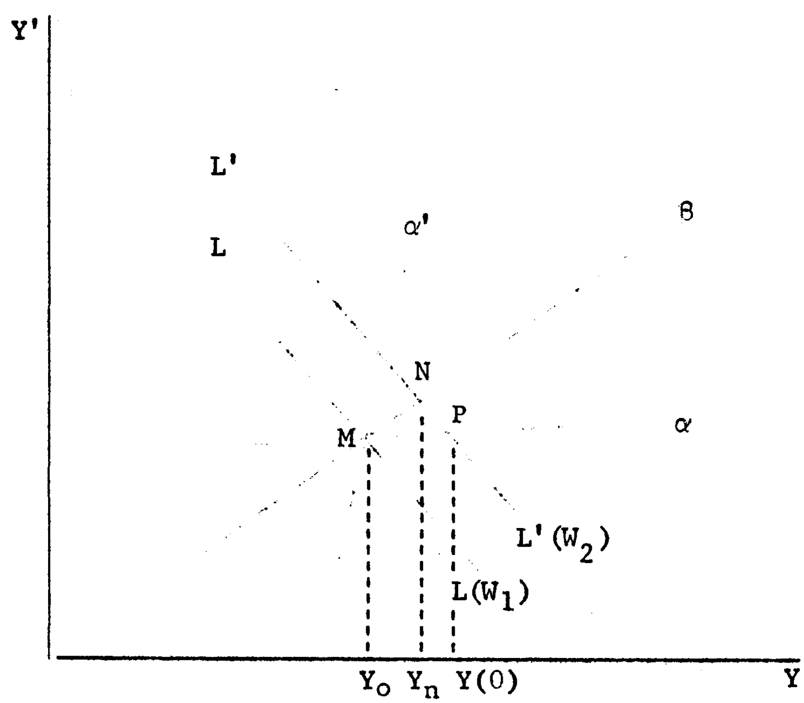

Figure I: Monetary Policy and Incomes

11/ M.C. Kemp, op.cit., formulated two two-country models which he said "differ from each other only in the assumptions made about the international mobility of capital." p. 559. But an examination of his models reveals that they differ in another important respect. When he assumes $T_f=0$, he uses a version (with $T_s=0$ and interest rates in the important functions) of the short-run model, and, when he assumes $T_f=\infty$, he uses a version of the flow-equilibrium model. These models are the same (i.e., the stock-flow problem disappears) only when the policy disturbance vector, dp, does not induce any payments imbalance.

The downward sloping line is drawn for a given level of world liquidity, W, and it locates the values of Y and Y' for different distributions of the world money supply. For instance, to move southeast on LL means that liquidity is increased in the home country and decreased in the foreign country by the same amounts. The positively-sloped heavy line, β, represents balance of payments or flow equilibrium. The dotted lines, α and α', show the initial effects of monetary policies by the home and foreign country, respectively.[12]

[12] If T_s is not too large -- where "large" must be defined relative to some index (which has the same dimensions as T_s) of the economic size of the world, like L_r+L_r' -- the slopes of α, β, and α' will be $S_{34}/S_{31} > F_{24}/F_{21} > S_{24}/S_{21} > 0$. If we define $\sigma = T_s/(L_r + L_r')$, then these relative slopes will be maintained if and only if σ is less than

$$\text{(i)} \qquad \frac{mE_r(E_r'L_y' + s'L_r') - T_f\, L_r'(hh' - mm') + L_y'(mE_r + hE_r')}{(L_r+L_r')(m'E_r's - mE_rs')}$$

or the primed version of (i), whichever is larger. With similar economies $(mE_rs' - m'E_r's)$ will approach zero and (i) or its primed version will approach infinity. If σ violates this criterion, α and α' will rotate toward each other until they both lie on one side of the β line.

It will be assumed that σ is not so large as to violate this criterion. The possibility that the relative slopes might differ from that shown in Figure I only arises as a result of the assumption that the actual stocks of foreign assets held by domestic residents and domestic assets held by foreign residents adjust to the desired levels instantaneously. If a lag were included in the stock adjustment mechanism, the stock adjustment parameter would not influence the slope of the alpha lines. Although a lag was not incorporated into the model because of the difficulty of doing so, we should not let its absence alter the relative slopes of the alpha and beta lines.

The derivation and slope of the liquidity line, LL, will be discussed in Section II.

Suppose the home country expanded its money supply such that world liquidity increased from W_1 to W_2 and Y moved from M to P. This initial impact on home income is given by 13/

$$(14) \qquad dY(0) = Y(0) - Y_o = (S_{21}/|S|)dD_p > 0.$$

But point P is a disequilibrium position and can be maintained only so long as both monetary authorities are willing and able to keep the balance of payments (deficit in the home country) from redistributing world liquidity. 14/ Without sterilization, Y and Y' slide along L'L' from P to N as determined by (13). The final impact of the open market purchase on domestic income is

$$(15) \qquad dY(\infty) = Y_n - Y_o = (F_{21}/|F|)dD_p.$$

Both (14) and (15) are found from (13) by substituting the vector $(0 \quad dD_p \quad 0 \quad 0)$ for dp and setting t=0 and ∞, respectively.

13/ The distinction between y(0) and y_o is a result of the assumptions that (1) the policy or distrubance term is a step function and (2) there are no lags in the process which equilibrates demand and supply in the money and output markets. If either of these assumptions were removed, there would be no discontinuity and y(0) and y_o would be identical.

S_{ij} and F_{ij} will be used to denote the cofactors of the ijth elements in S and F, respectively.

14/ There has already been some redistribution of world liquidity by the time the system has reached P. That is, the open market purchase changed the interest rate differential and induced a capital movement of the magnitude $T_s \frac{dr(0)-dr'(0)}{dD_p} = T_s \frac{S_{22}-S_{23}}{|S|} < 0$. If the monetary authorities sterilized the effects of this capital movement on domestic and foreign money supplies, the initial effect of expansionary monetary policy would have moved the system to a point on L'L' further from β than point P.

Section II: Economic Implications of the Two-Country Model

The Burden of Adjustment

Anytime the system is in payments imbalance, the path back to external equilibrium is (assuming constant world liquidity, $\bar{W}$) given by the liquidity line, LL. The distribution of the burden of adjustment is given by the slope of this line,15/

$$\frac{dY'}{dY} = -\frac{S_{34} - S_{24}}{S_{21} - S_{31}} = \frac{m(E_r' L_r - E_r L_r') + E_r' s L_r + E_r' E_r L_y}{m'(E_r L_r' - E_r' L_r) + E_r s' L_r' + E_r E_r' L_y'} . \tag{16}$$

As equation (14) shows, the slope of LL is very sensitive to the derivative of the demand for money with respect to both the interest rate and income. For instance, the greater domestic liquidity preference, the more the burden of adjustment is thrown upon the rest of the world.16/

15/ Equation (16) is found by dividing

$$dY' = \frac{S_{24}}{|S|}dM + \frac{S_{34}}{|S|}dM' \quad \text{by} \quad dY = \frac{S_{21}}{|S|}dM + \frac{S_{31}}{|S|}dM'$$

and setting $dW = dM + dM' = 0$.

According to equation (16), the liquidity line could slope upwards if the structure of the two economies were sufficiently dissimilar. In particular, if one country were very classical (or Keynesian) relative to the other (where these classifications are defined in terms of the sensitivity of expenditures and, especially, hoarding with respect to the interest rate), a positive sloping liquidity line would be possible. However, even if LL slopes upwards, its position relative to α and α' remains unchanged. I will assume that the countries are sufficiently similar that the liquidity line slopes downward in both Figures I and II.

16/ This is the same conclusion L.A. Metzler obtained with a two-country model under full employment and flexible prices. See "The Process of International Adjustment Under Conditions of Full Employment: A Keynesian View," in R.E. Caves and H.G. Johnson (eds.), Readings in International Economics, (Irwin, 1968).

The major reason is clear: The greater an economy's liquidity preference the smaller the money multiplier -- it can lose or absorb a larger amount of money for a given change in income.17/ Consequently, if the domestic country loses the same amount of money the rest of the world gains, then, the larger L_y/L'_y and L_r/L'_r, the steeper LL, and the greater the adjustment burden upon the rest of the world.

Casual empiricism might suggest that this theorem would be applicable to the distribution of the adjustment burden between the developed versus the less-developed regions of the world. With well-developed capital markets and financial institutions, the developed countries' demand for money should be relatively more sensitive to interest rates. Ceteris paribus, this would tend to rotate LL and L'L' clockwise in Figure I and shift the adjustment burden toward the less-developed countries. However, further casual observation would suggest that, with a more extensive banking system, the developed countries would have a relatively higher ratio of (non-high powered) money to money, and this factor tends to shift the adjustment burden towards the developed countries.

Another interesting implication of the slope of LL is the relation between the distribution of adjustment and relative country sizes. If the countries are identical except for the size,18/ then equation (16) reduces to $dY'/dY = 1$. This in turn yields the elasticity formula $\eta_{Y',Y} = Y/Y'$. That is, the distribution of adjustment, measured as the ratio of percentage income changes, is determined by relative

17/ Mathematically, this sentence means that $\partial(S_{21}/|S|)/\partial L_y < 0$ and $\partial(S_{21}/|S|)/\partial L_r > 0$.

18/ When the countries are identical except for size, $L_r/L'_r = E_r/E'_r$, $L_y = L'_y$, and $s = s'$.

country sizes. If the optimal distribution of adjustment is defined as that which keeps world income constant, the model implies that the distribution will be optimal if countries are identical except for size.

Capital Mobility and the Transfer of Liquidity

Disequilibrium in the balance of payments redistributes world liquidity from the deficit to the surplus country as shown by the movement from P to N in Figure I. The extent to which this redistributive process takes place through the capital account rather than the current account is determined largely by whether capital flows are induced by the interest rate differential or its rate of change. In the event of a monetary disturbance, the stock adjustment parameter, T_s, induces an initial transfer of liquidity, but if the interest rate differential returns to its original value, the initial capital movement is completely reversed. That is, shifts of the capital stock caused by changes of the interest rate differential will be reversed (to the extent that the interest rate differential returns to its original value) whereas those flows induced by the differential do not return.

The fact that capital flows induced by the rate of change of the interest rate differential are reversible raises a problem for its use as the only explanatory variable in a non-growth model.[19] We would

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19/ The view which prevails in the literature at this time is that $G_1=f(d,Z_1)$ where G_1 is the stock of foreign assets held by domestic residents .. Z_1 is the aggregate size of domestic portfolios (which include money), and d is the interest rate differential, r-r'. If we use G_2 and Z_2 as the foreign counterparts of G_1 and Z_1, we can write $G_2=g(d,Z_2)$ such that the net inflow of capital is

$$\dot{G}_2 - \dot{G}_1 = (g_1 - f_1)\dot{d} + g_2\dot{Z}_2 - f_2\dot{Z}_1 \qquad \text{(i)}$$

where g_i and f_i represent the partial derivatives with respect to the ith variable. Without portfolio growth, $\dot{Z}_1 = 0 = \dot{Z}_2$ which leaves $(g_1-f_1)\dot{d}$ as the sole determinant of net capital flows. The discussion in the text assumes that d and f are linear in d such that g_1 and f_1 are expect that the excess domestic liquidity caused by, say, an open market purchase in one country, would be transmitted around the world partly through the capital account of the balance of payments. With well integrated capital markets we might expect most of the liquidity transfer to be accomplished by capital movements, and we would not expect it to be returned by the time the balance of payments had corrected itself. But any attempt to explain capital flows with the rate of change of the interest differential alone implies that, after the system has returned to balance of payments equilibrium following a monetary disturbance in one country, the net capital movement may be positive or negative. If the two countries are identical, the net capital movement will be zero and all the transfer of liquidity will have occurred through the current account.

This argument can be best explained with the aid of Figure II. As in Figure I, α and α' represent the initial effects of domestic and foreign monetary expansion (or contraction) lines.[20/] Interest rate

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Footnote 19/ from page 17 -- continued.

independent of d. If the (absolute value of the) exponent of d in g and f is greater than or less than unity, then the problem posed in the text will be less or more severe, respectively. The genesis of equation (i) starts with H.G. Grubel "Internationally Diversified Portfolios," American Economic Review, Vol. 58, (December, 1968), and Willett and Forte, op.cit.; and it is stated explicitly by R.C. Bryant and P.H. Hendershott "Capital Flows in the U.S. Balance of Payments: The Japanese Experience, 1959-67," presented at the 1968 meetings of the Econometric Society.

One possible solution of this problem is to incorporate the composition of portfolios as well as their size in the function. The final answer rests with a more complete theoretical derivation of the flow-of-capital function.

20/ When T_s=0, the alpha lines have negative slopes. If the value of T_s is steadily increased, α' and α will rotate until they assume the positive slopes $S_{34}/S_{31} > 1 > S_{24}/S_{24} > 0$. As in Figure I it will be assumed that T_s is small enough such that the β-line lies between α and α'.

values above the β-line represent balance of payments deficit for the home country (but not necessarily a capital account deficit 21/). An open market purchase in the domestic country moves the system from M to P to N. If the countries are identical, the β-line has a unitary slope 22/ and the difference between r and r' will be zero at points M and N. Consequently, the stock of assets issued by one country but owned by the other remains the same at points M and N if such stocks are a function only of the interest rate differential.

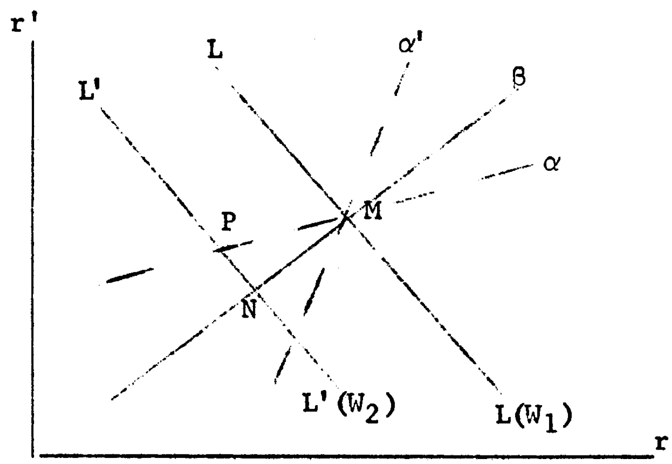

Figure II: Monetary Policy and Interest Rates

21/ It might be useful to point out that Figures I and II are not found by taking a cross-section in four-dimensional space holding two of the four endogenous variables constant. For every point on a curve in Figure I there corresponds a unique point on the corresponding curve in Figure II and vice versa. For instance, P represents the same point although it is portrayed in two different graphs. For this reason the same symbols have been used in both graphs.

22/ The slope of the β-line is

$$\frac{dr'}{dr} = \frac{F_{22}}{F_{23}} = \frac{s'(hT_f - E_r m) + sm'T_f}{s(h'T_f - E_r' m') + s'mT_f}$$

Inspection of this formula shows that the slope is unity if the two countries are identical (i.e., s=s', m=m', and $E_r = E_r'$). The additional assumption that $b_0 = 0$ implies that β crosses the origin such that the interest differential is zero as well as constant along β.

The mechanism which drives the system from P to N is a trade deficit. In this Keynesian model, incomes are determined by the interest rates. If the countries are identical such that the relation between interest rates and incomes are the same, then a trade deficit will continue as long as r' is greater than r -- as long as the system is above the β-line in Figure II. The trade deficit will lower the interest rate differential and that induces a capital inflow. But, of course, the capital inflow will always be smaller than the trade deficit; otherwise, liquidity would be moving in the opposite direction causing the interest rate differential to grow rather than decrease.

Whether or not capital movements are reversible is important for the issue of sterilization -- the more likely capital flows will return, the better the case for sterilization. One of the arguments for sterilizing balance of payments disequilibria is that today's deficit may turn into a surplus tomorrow, and vice versa. The likelihood of such turnarounds is enhanced the greater the proportion of capital flows which are returnable.

Fiscal Policy and International Reserves

Fiscal policy is usually regarded as having an ambiguous effect upon the distribution of international reserves since it generates a capital inflow by raising interest rates but a trade deficit by expanding income. It is worthwhile to know as precisely as possible the key parameters which determine the direction in which fiscal policy influences the balance of payments and international reserves.

The total shift in reserves is found by integrating the balance of payments, a task which is computationally difficult. This difficulty can be considerably reduced if we note the following: Any disturbance which creates a balance of payments disequilibrium induces a sufficient redistribution of world liquidity to correct the imbalance. The stock adjustment parameter, T_s, helps determine how fast liquidity is redistributed, or the time path of adjustment, but not the amount of liquidity which must be transferred. Therefore, the integral (from zero to infinity) of the balance of payments is independent of T_s although the time-path of b(t) is not. The fact that $\int_0^\infty b(t)$ is independent of the value of T_s is fortunate since, as it turns out, the difficulty of integrating b(t) is reduced when T_s is set to zero.

The balance of payments is the second element of the vector $Bdy(t) + K\dot{y}(t)$. When T_s and, therefore, K are set equal to zero, the balance of payments becomes the second element of the vector

$$Bdy(t) = B\,(S^{-1} - F^{-1}Q)dpe^{-\lambda t} + F^{-1}Qdp \;=\; BS^{-1}dpe^{-\lambda t}$$

since (as the interested reader can show for himself) $BF^{-1}Q = 0$. Setting $dp = [dG \;\; 0 \;\; 0 \;\; 0]$, we obtain the fiscal policy multiplier

$$\text{(17)} \qquad \frac{db(t)}{dG} = \frac{a_o\phi - a_1\phi'}{|S|}\, e^{-\lambda t}$$

where a_o and a_1 are positive coefficients ($a_o = -L_r'h' - E_r'L_y'$, $a_1 = -L_r m$) and $\phi = T_f L_y + mL_r$. To find the total effect on reserves, integrate (17) to obtain

$$\frac{dR(\infty)}{dG} = \frac{a_o\phi - a_1\phi'}{|F|} \gtrless 0.$$

Other authors[23/], using single-country analysis, have found the direction of the effect of fiscal policy on the shift of reserves to depend on the sign of $\emptyset$. The reasoning is that a positive value of $\emptyset$ means that the capital inflow generated by the expansionary fiscal policy is greater than the trade deficit (or smaller trade surplus). But when the feed back from the rest of the world is incorporated in the analysis, (18) shows the value of $\emptyset$ is neither necessary nor sufficient to determine $dR(\infty)/dG$.

Equation (18) also yields an interesting relation between capital mobility and $dR(\infty)/dG$. If $T_f = 0$, then $dR(\infty)/dG$ is unambiguously negative. On the other hand, if the structure and size of the econcmies is sufficiently similar, a large value of T_f assures that $dR(\infty)/dG$ is positive. Since T_s does not enter equation (18), there is a presumption that the relation between fiscal policy and reserve shifts between similar economies is more likely to be negative the larger role one attributes to the stock adjustment parameter, T_s, than the flow parameter, T_f.

Foreign Trade Multiplier

Until now we have only considered the effects of changes in world liquidity and its distribution between countries. As we turn our

23/ $\emptyset$ is used in Rudolf Rhomberg, "A Model of the Canadian Economy Under Fixed and Fluctuating Exchange Rates," Journal of Political Economy, (Feb., 1964), p.3; V. Argy, op.cit., p.269; R.N. Cooper, The Economics of Interdependence, (New York: McGraw Hill, 1968) p.180; A.O. Krueger, op.cit., p.203; E. Sohmen, op.cit., p.349; and Sohmen, "The Assignment Problem," in R.A. Mundell and A.K. Swoboda (eds.), Monetary Problems of the International Economy, (Chicago: University of Chicago, 1969). H.G. Johnson, op.cit., p.349, uses an expanded version of $\emptyset$ in which m is replaced by $-\partial b/\partial Y$ and the latter includes the responsiveness of capital flows to changes in income. A.Takayama, "The Effects of Fiscal and Monetary Policies Under Flexible and Fixed Exchange Rates," Canadian Journal of Economics, II, (May, 1969), expanded Johnson's version of $\emptyset$ to include additional terms due to a variable price level.

attention from monetary to fiscal policy, it is interesting to explore the mechanism which relates an autonomous change in domestic debt-financed expenditures and foreign income, i.e., the foreign trade multiplier.

The relation between domestic fiscal policy and foreign income is found from the general solution, (13), by substitution dG 0 0 0 for dp:

$$\frac{dY'(t)}{dG} = \left(\frac{S_{14}}{|S|} - \frac{F_{14}}{|F|}\right)e^{-\lambda t} + \frac{F_{14}}{|F|} \gtrless 0.$$

Both S_{14} and F_{14} can be either negative or positive and the reason for this sign ambiguity is due to the possibility of an induced redistribution of world liquidity toward the domestic country.24/ An expansionary fiscal policy can generate either a balance of payments deficit or surplus. If it creates a deficit for the rest of the world and if the balance of payments disequilibrium is allowed to affect countries' money supplies, then the liquidity transfer can reverse the positive effect which fiscal policy would have had on foreign income in the absence of the liquidity movement. If the domestic boom causes domestic reserves to decline (i.e., $dR(\infty)/dG < 0$), then S_{14}, and dY'/dG will all be positive. Consequently, a final shift of reserves toward the expanding country is a necessary but not sufficient condition for a perverse foreign trade multiplier.

Since the foreign trade multiplier can be negative, the question naturally rises whether the drop in foreign income can ever be

24/ If $T_s=0$ such that S_{14} did not include the effects of fiscal policy on the distribution of the world money supply, then $dY'(0)/dG = S_{14}/|S| > 0$.

sufficient to outweigh the increase in home income such that the effect of fiscal policy on world income is negative. The answer implied by this model is yes. The criteria for the effects of fiscal policy on world income, both initially and after balance of payments has worked itself out, are

$$|S| \frac{(dY(0)+dY'(0))}{dG} = -(L_r+L_r')(h'+m)T_s + L_rE_r'(m'+m) - E_r'T_s(L_y'-L_y) \gtrless 0$$

$$|F| \frac{dY(\infty)+dY'(\infty))}{dG} = -(L_r+L_r')(h'+m)T_f + L_rL_r'(h'+m)+E_r'L_y' - E_rT_f(L_y'-L_y) \gtrless 0.$$

Since the only negative terms contain L_y while most other terms contain L_r or L_r', a negative world multiplier would be possible under circumstances like the following: Suppose an extreme version of the Quantity Theory of Money were true such that L_r and L_r' are negligible. Since L_y and L_y' refer to the demand for high-powered money, then, even if the derivative of the demand for money with respect to income were the same in both countries, L_y could be several times larger than L_y' if the ratio of money to high-powered money were higher in the foreign country. Under such circumstances, fiscal policy in the home country could have a contractionary effect on the world as a whole. The same analysis might be applied to regions within a country like the United States if the reserve ratio were much higher in country than in city banks. Of course, the possibility is not symmetric; it is not possible in this model for fiscal policy in both countries (whether taken together or one at a time) to have a contractionary effect on the world economy.

III. Policy Coordination, Capital Mobility, and Sterilization

In several recent publications,[25/] Professor Richard Cooper has argued that the growth of international interdependence increases the need for international coordination of macroeconomic policies. In his words[26/]

> If policy decisions are truly decentralized among nations, in the sense that the authorities in each nation pursue only their own objectives with their own instruments without taking into account the interactions with other countries, then the more interdependent the international economy is, the less successful countries are likely to be in reaching and maintaining their economic objectives . . . countries must either reconcile themselves to prolonged delays in reaching their objectives or they must coordinate their policies more closely with those of other nations.

In a more recent publication, Cooper presented the theoretical argument which lies behind the above proposition.[27/] The argument employs the two-country model of Section I (with T_s=0 and a lagged-sterilization policy) combined with rules for other monetary and fiscal policies. The result is a policy-endogenous[28/] model which is too cumbersome for analytical solution. Therefore, using the United States and the rest of the world as the domestic and foreign countries, Cooper suggested (on the basis of his own knowledge and intuition) a set of values for the parameters and provides us with numerical evidence. By

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25/ Economics of Interdependence, op.cit.; "National Economic Policy in an Interdependent World Economy," The Yale Law Journal, No. 7, Vol. 78, (June, 1967); "The Assignment Problem: A Comment," in R.A. Mundell and A.K. Swoboda, op.cit.

26/ Economics of Interdependence, op.cit., p. 158.

27/ "Macroeconomic Policy Adjustment in Interdependent Economies," op.cit.

28/ "Policy-endogenous" means that the money supplies, interest rates, and government deficits are endogenous variables although the policy rules are, so to speak, still exogenous.

rewriting the system for discrete time periods he presented some results of simulation studies[29/] under different combinations of international interdependence and policy rules.

In this section Cooper's evidence will be examined. His simulation evidence will be compared to the results generated under the alternative assumptions of no-sterilization and sterilization-without-a-lag. Since Cooper did not include the stock adjustment mechanism, T_s, we will proceed with further simulations to compare the effects of the capital function parameters, T_s and T_f, in Cooper's policy-endogenous model.

Cooper's Discrete Model and Policy Rules

Cooper's policy-endogenous model for discrete time can be written, using the notation of Section I as

$$Sdy_t = dp_t + dv_t + \sum_{o}^{t} Bdy + z_t \tag{19}$$

29/ Simulation studies are usually employed to derive the implications and evaluate the performance of econometric models. Cooper is one of the first to use simulations to study the implications of a theoretical model. Simulation of a theoretical model with parameter values representing the "real world" is a tool of analysis which seems to lie somewhere between empirical work and pure theory. Although there may be some difficulties in the use of this tool (viz., the problem of identifying the functions responsible for particular results), I have high expectations for its future employment, especially in multi-country analysis. If this expectation is fulfilled, Cooper's paper will be important, not only for its economic content, but for introducing this method of analysis in international monetary theory.

where z_t is an exogenous disturbance vector.[30/] Taking first differences we obtain

(20) $$S\Delta y_t = \Delta p_t + \Delta v_t + Bdy_t + \Delta z_t$$

where $\Delta y_t = y_t - y_{t-1}$. Under Cooper's assumption that the balance of payments is sterilized, we can set $\Delta v_t = -Bdy_{t-1}$ and rewrite (20) as

(21) $$S\Delta y_t = \Delta p_t - Bdy_{t-1} + Bdy_t + \Delta z_t$$

To complete the model we must specify the policy vector, Δp, and Cooper gives us three sets of policies distinguished by their degree of coordination.[31/] Under "no coordination" the monetary authorities focus their attention toward their own interest rates and fiscal authorities use national income as a target variable. If C is used for Cooper's coordination matrix, then

$$\Delta p_t^n = C_n dy_{t-1} = -\alpha \begin{vmatrix} a_{11} & 0 & 0 & 0 \\ 0 & a_{22} & 0 & 0 \\ 0 & 0 & a_{33} & 0 \\ 0 & 0 & 0 & a_{44} \end{vmatrix} \begin{vmatrix} dY_{t-1} \\ dr_{t-1} \\ dr'_{t-1} \\ dY'_{t-1} \end{vmatrix}$$

30/ In the terminology of this paper, Cooper used the model $Sdy_t = dp_{t-1} + dv_t + \sum_0^t Bdy + z_t$ which implies that some open market operations have an impact after a one period (outside) lag whereas sterilization has an immediate impact. This inconsistency has been removed from (19) while retaining Cooper's assumption that last period's payments imbalance is sterilized in the current period, by assuming that all policy actions have an inside or recognition lag of one period. The final equations, such as (21f), are exactly the same as Cooper's.

31/ The reason Cooper selected these policy rules is given in Cooper, op.cit., p. 11.

where Cooper sets a_{ij} equal to the ijth term of S and $\alpha = 1/2$. For "internal coordination" he uses

$$\Delta p_t^i = C_i dy_{t-1} = -\alpha \begin{vmatrix} a_{11} & a_{21} & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ 0 & 0 & a_{33} & a_{34} \\ 0 & 0 & a_{43} & a_{44} \end{vmatrix} \begin{vmatrix} dY_{t-1} \\ dr_{t-1} \\ dr'_{t-1} \\ dY'_{t-1} \end{vmatrix}$$

"Internal coordination" means that policies are coordinated within each country but not between countries; all authorities are concerned with both of their domestic targets but not the values of any foreign variables. For "full coordination" Cooper uses

$$\Delta p_t^f = C_f dy_{t-1} + \alpha\, Bdy_{t-1} = -\alpha\, Sdy_{t-1} + \alpha\, Bdy_{t-1}. \tag{22}$$

In words, C_n contains the diagonal elements of S, C_i contains the block-diagonal elements of S, and C_f is ($-\alpha$ times) S itself. More coordination means (neglecting the $\alpha\, Bdy_t$ term in (22)) that more interdependencies or off-diagonal elements are incorporated in the formulation of policy.

Before presenting the simulation evidence, it is important to explore the implication of the Bdy_t term in equation (22). When (22) is substituted into (21), we obtain

$$S\Delta y_t = (C_f dy_{t-1} + 1/2\ Bdy_{t-1}) - Bdy_{t-1} + Bdy_t + \Delta z_t. \tag{21f}$$

There are three Bdy terms in (21f): The right-hand term is the normal effect of the balance of payments on domestic and foreign money supplies. The middle term, $-Bdy_{t-1}$, reflects Cooper's lagged-sterilization assumption. The left-hand term, $1/2\ Bdy_{t-1}$, is due to international coordination; it serves to offset (one half of) the lagged sterilization policy. In other words, the α Bdy term in (22) and (21f) implies that (lagged) sterilization policy should be (partially) eliminated. A comparison of Δp^i and Δp^f will reveal that less-sterilization is the only difference between monetary policy under internal and full coordination.

Since Cooper has devoted so much of his recent published work advocating the international coordination of macroeconomic policies, it is surprising that he failed to make explicit that his prescription for monetary policies was so radical (i.e., contrary to the practices of central banking) and Classical. However, it can be regarded as consistent with his views on policy coordination. According to Cooper[32/] "'Coordination' means that national policies are geared to common over-all objectives." The bilateral reduction of sterilization can be regarded, from an international viewpoint, as a means of decreasing payments imbalances. The unilateral continuance of sterilization policy can be regarded, from a national viewpoint, as a means of forcing the burden of adjustment upon other countries. Thus, less sterilization on the part of all countries is a way to gear monetary policies to "common over-all objectives."

32/ Economics of Interdependence, op.cit., p. 183.

Simulation Evidence[33/]

Cooper's basic proposition -- that the need for international coordination of policies becomes greater as interdependence between national economies grows -- is an implication of more detailed propositions which can be directly related to the simulation results:

(I) Given the level of coordination between monetary and fiscal authorities, the growth of international interdependence decreases the effectiveness of policy actions unless they are fully coordinated.

(II) Given the degree of international interdependence, the more monetary and fiscal policies are coordinated both (a) within and (b) between countries, the greater the effectiveness of macroeconomic policies.

Proposition (IIb) is an argument for international policy coordination which, in conjunction with (I), assumes added importance as interdependence between nations increases. "Interdependence" is defined in

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33/ Cooper also gives some numerical evidence (viz., characteristic roots) when the system is interpreted for continuous time. But such evidence is not admissible for two reasons.

In the first place, Cooper implicitly has time moving at two different speeds. His basic model, $dy = (S-B)^{-1}dp$ was derived in footnote 10 under the assumption that the balance of payments was allowed to redistribute liquidity for some length of time, γ. But when this model is combined with a set of continuous policy rules like $\dot{p} = Cdy$, the resulting policy endogenous model, $y = (S-B)^{-1}Cdy$, assumes either that (i) the length of the lag on sterilization policy approaches zero such that (S-B) approaches S or (ii) time in the equations

$$Sdy = dp - \int_{\gamma}^{t} Bdy + \int_{0}^{t} Bdy$$ moves infinitely fast relative to time in the equations $\dot{p} = Cdy$. As shown in footnote 10, the time lag on sterilization policy approaches (from below) one time period when the time units approach zero, but Cooper precludes this possibility by using years as his time dimension. Consequently, his continuous policy-endogenous model assumes (ii) which is inconsistent since time is one variable, not two.

Even if assumption (i) could be used, characteristic roots alone are inadequate for the derivation of inferences useful for policy purposes. The size of characteristic roots does have clear implications for asymtotic properties of the system. But to be able to infer that the system is closer to equilibrium for all values of time (or after a specified period of time) one generally needs the characteristic vectors as well.

terms of the marginal propensities to import and the responsiveness of capital movements to interest rates. "Effectiveness" is defined in terms of (i) the time periods requried for macroeconomic policies to return target variables (Cooper uses income and interest rates) within a reasonable distance of their desired values and (ii) the shift of international reserves during the adjustment period.

The system is assumed to be in equilibrium before it is disturbed such that the initial value of y is the target value. Expenditure and monetary disturbances are introduced by setting z_t equal to $[20 \quad 0 \quad 0 \quad 0]$ and $[0 \quad 20 \quad 0 \quad 0]$ (for $t \geq 0$), respectively. The parameter values which Cooper uses are

$$s = .35 \qquad E_r = -15. \qquad L_y = .1 \qquad L_r = -6. \qquad m/m' = 1.5$$
$$s' = .30 \qquad E_r' = -15. \qquad L_y' = .24 \qquad L_r' = -12.$$

and the values of m, m', T_f, and T_s are varied to represent different levels of international interdependence. Time periods are measured in years and (constant-value) dollars are measured in billions.

The simulation evidence is presented in three tables. Each table has six boxes and each box has three triads of numbers. For convenience, we can number the boxes from one to six going from left to right and top to bottom. We can also number the triads of each box from one to three as we go from left to right and top to bottom. Consequently, the middle number of the second triad of the second box in the first table is 34.

The triads differ according to the degree and kind of interdependence. The first triad of numbers in each box is generated under the assumption of little or no interdependence (viz., m=.01, m'=.007, $T_f=0=T_s$). The second and third triads assume extreme interdependence but different capital functions. That is, the second and third triads of each box are based on the assumption that m=.2, m'=.3, $T_f=20$, $T_s=0$ and m=.2, m'=.3, $T_f = 0$, $T_s=20,8$, respectively.[34/]

The numbers in each triad differ by the underlying sterilization assumption. The left-hand numbers of each triad are generated under the assumption of immediate sterilization, the middle numbers are based on lagged sterilization, and the right-hand numbers are based on no sterilization.

TABLE I

Periods of Adjustment to Income Targets
(Periods Until $|dY| + |dY'| \leq .2$)

	Expenditure Disturbance			Monetary Disturbance		
	Top	Bottom left	Bottom right	Top	Bottom left	Bottom right
No Coordination	17,17,18	17,16,17	17,47,39	21,22,21	20,34,19	20,69,30
Internal Coordination	9,10,8	11,11,11	11,21,19	10,11,10	13,45,7	13,25,15
Full Coordination	9,9,9	9,9,9	9,15,19	10,10,10	10,10,10	10,17,17

34/ The capital function in the third triad is $T=20\ (\Delta r_t - \Delta r'_t) + 8(\Delta r_{t-1} - \Delta r'_{t-1})$. The numbers 20 and 8 were selected to produce capital movements comparable in magnitude to Cooper's $T_f=20$. Since these capital movements are so large, it was thought appropriate to lag them over a two year period.

It is useful to first review the kind of evidence which Cooper used for propositions (I) and (II).[35/] Proposition (I) is a generalization of the fact that for a given type of disturbance and a given set of policies (other than full coordination), the middle numbers of the second and third triads are larger than the middle numbers in the first triad. For instance, the periods to adjustment to income targets rise from 11 to 25 under a monetary disturbance, internal coordination, lagged sterilization, and a stock adjustment mechanism. Proposition (II) is a generalization of the fact that, for a given disturbance and level of interdependence, the middle number decreases as coordination rises (as we go to the corresponding number in the box immediately below). For instance, the time required to reach interest rate targets under an expenditure disturbance among interdependent economies with a capital flows determined by interest rate levels drops from 22 to 7 as we go from no coordination to internal coordination.

35/ The only numbers reported here which were also reported by Cooper are those middle numbers in triads one and two since he assumed throughout that sterilization occurred with a lag and that $T_s=0$. However, the simulations results found under lagged sterilization and $T_s > 0$ (i.e., the middle numbers in the third triads) support (I) and (II) and could have been used by Cooper had he introduced the stock adjustment mechanism. Consequently, I have taken the liberty to speak as if all the middle numbers were used by Cooper in order to simplify the exposition.

Cooper reported other simulation evidence for (I) and (II) found by distinguishing between two kinds of interdependence. He ran simulations when the marginal propensities to import are high with no capital mobility and others when m and m' were low with $T_f=20$. This approach has not been followed here because it would be so cumbersome to present all the results and they do not alter any of the conclusions drawn above.

TABLE II

Periods of Adjustment to Interest Rate Target
(Periods Until $|dr| + |dr'| \leq .02$)

	Expenditure Disturbance		Monetary Disturbance	
No Coordination	12,12,12		16,17,16	
	13,22,13	13,39,70	17,39,13	17,70,62
Internal Coordination	6,6,7		8,8,8	
	7,7,7,	7,19,15	9,34,8	9,22,10
Full Coordination	7,6,7		8,8,8	
	6,6,6	6,13,17	7,8,7	9,15,15

However, part of this evidence -- the comparisons of middle numbers in the first four boxes of Tables I and II -- is misleading. Much of the time required to reach income and interest rate objectives, which Cooper attributed to the lack of international coordination in an interdependent world, is actually due to the lag on his sterilization policy. Evidence for the destabilizing effect of the lag is found by comparing all three numbers in either triad two or three in any of the first four boxes in Tables I and II. For instance, under internal coordination and a monetary disturbance with $T_s > 0$, it takes 22 periods to reach the interest rate target with a lag on sterilization, but without sterilization the time periods are 9 and 10, respectively.[36/]

36/ Another indication that the sterilization lag is destablizing is that the middle numbers generated under the lagged sterilization assumption are sensitive to the units for measuring time. When the system is simulated for quarters, the lag is smaller and the middle numbers move closer to those found under immediate sterilization. Results for alternative time dimensions are not given here because it would be so cumbersome to do so, but the conclusions in the paper conform to the unreported as well as the reported results.

The reason the lag on sterilization policy increases the adjustment periods is as follows: The monetary and fiscal policies which will have their impact next period are based upon current incomes and interest rates, y_t; and y_t is influenced by the current balance of payments b_t. But with lagged sterilization, the effect of b_t on domestic and foreign money supplies will be removed next period. Thus, current policy decisions are based upon levels of interest rates and incomes which have been influenced by a variable, b_t, whose influence will be removed next period. It is as if policy makers are divided into two groups and one group, those in charge of policies other than sterilization, acts as if there will not be <u>any</u> future sterilization of imbalances which have already had their effect. If they knew that the other group was going to sterilize the current imbalance next period, they should take that into consideration in formulating fiscal and (other) monetary policies. This is just the sort of the-left-hand-doesn't-know-what-the-right-hand-is-doing approach to policy formation which most appropriately falls under the heading of "decentralized policy making" of which Cooper is critical.

TABLE III

Total Reserve Change (Billions) During Ten Periods

No Coordination		-1.2(-1.2)-1.2			0(.1)-.1	
	-16.7(-6.8)-1.5		-19.6(-18.4)-6	-139(-74)-12		-2.9(-33.7)-8.5
Internal Coordination		-.7(-.7)-.6			-1.6(-1.6)-1.5	
	1.4(5.7)1.4		-13(-11)-3.4	-130(-74)-12		-32.8(-40)-10.2
Full Coordination		-.6(-.6)-.6			-1.5(-1.5)-1.5	
	-2.0(-.3)-.2		-10.8(-4.8)-3.1	-138(-23.8)-13		-27.6(-15.8)-10
		Expenditure Disturbance			Monetary Disturbance	

The lag on sterilization policy frustrates policy makers in their attempts to reach their targets, but their targets do not include the balance of payments under no coordination and internal coordination. And when they do assume a balance of payments target under full coordination, they (partially) desterilize such that the lag is no longer important. Consequently, the destabilizing effects of the lag are manifested only in the first four boxes of Tables I and II. Since these middle numbers contain an unwanted element of instability, they will be disregarded in the subsequent discussion.

Taking into consideration all the rest of the simulation results, the evidence on propositions (I) and (II) is mixed. To draw implications from the numbers, it is useful to distinguish between Cooper's two measures of effectiveness, the periods of adjustment to targets and the size of reserve shifts. For instance, Tables I and II give strong support to proposition (IIa). That is, the speed of adjustment to income and interest rate targets is much faster if policy makers focus upon both targets rather than completely specializing as they do under no coordination. However, focusing upon both rather than just one target variable does not generally reduce the reserve shifts.

Proposition (IIb) -- which says that full coordination will increase the effectiveness of macroeconomic policies -- does not receive support from Tables I and II, but it is confirmed by Table III. The reason why, becomes clear if we note that the bilateral reduction of sterilization policies is quantitatively the most important difference between internal and full coordination.[37/] As we might expect, the effect of desterilization is to lower the movements of international reserves but it does not speed up the adjustment to income and interest rate targets.

Proposition (I) receives some support from Table III. Under no coordination and internal coordination, the size of reserve movements increase with interdependence. But that is hardly a surprise; without interdependence you cannot have a payments imbalance regardless of how uncoordinated policies might be. Under full coordination, interdependence continues to cause reserve shifts although they are smaller since sterilization is relaxed.

The evidence in Tables I and II gives little support to proposition (I) but there are systematic changes in the numbers which suggests another proposition. As we go from the first to the second and third triads of a given box, whether the speeds to adjustment increase or stay the same depends more upon the particular sterilization assumption and causes of capital movements than the level of coordination.

37/ Desterilization is Cooper's method of coordinating monetary policies between countries, and it is more important than the international coordination of fiscal policies. The influence of monetary and fiscal coordination have been separated by not reducing sterilization policy in the right-hand and left-hand numbers of each triad as we go from internal to full coordination. Consequently, as we go from -13 to -10.8 (in the left-hand numbers of the third triads in Table III under an expenditure disturbance), the reduction in reserve loss only reflects the coordination of fiscal policies between countries. The effect of monetary coordination is found by going from the left-hand to the right-hand number, from -10.8 to -3.1. This example is typical and it shows that monetary coordination (desterilization) has a greater impact than fiscal coordination in Cooper's policy rules.

If T_s rather than T_f is responsible for capital movements, then increased interdependence without sterilization[38/] always increases the periods to adjustment. Greater interdependence does not significantly increase the adjustment periods in any other cases (still disregarding the middle numbers found under lagged sterilization in boxes one through four). This suggests a new theorem: The case for sterilization depends, in part, upon the determinants of capital movements. The case is improved to the extent that the interest rate differential determines the flow rather than the stock of assets issued by one country and owned by residents of the other.

The reason that adjustment periods depend upon the determinant of capital movements when there is no sterilization is as follows: If the flow parameter, T_f, rather than the stock parameter, T_s, is operative, large imbalances correct themselves within a few periods. Thereafter, as y is guided back to its target value, the structure of endogenous variables remains near payments equilibrium because any imbalance continually corrects itself. If only the stock parameter, T_s, is operative, every movement of r and r' induces a capital flow. Such a capital account imbalance does not correct itself but only inhibits movements of interest rates. Consequently, efforts to guide y (which includes r and r') back to its target value induces imbalances which place a drag on the effects of such policy actions.

38/ "Without sterilization" can be broadly interpreted here to include the case of partial sterilization with a lag.

It is important to notice that whether a change in sterilization policy (in either direction) promotes efficiency depends not only upon the role of T_s relative to T_f, but upon other macroeconomic policies as well. It would be possible to construct other policy-endogenous models in which sterilization was always more efficient or always less efficient than no sterilization. Nevertheless, the degree to which it is more or less efficient would still depend upon the determinants of capital movements.

In summary, the least ambiguous implications of the simulation results are as follows: The time required to reach approximate economic objectives is lowered if monetary and fiscal authorities include more than one of the target variables in their policy formulations. Reduction of policies used to offset external imbalances will decrease the cumulative effect of these imbalances on international reserves. But the elimination of neutralization policies can have an effect on the speeds to adjustment. It is most likely to cause delays if one of the determinants of capital flows is dominated by the rate of change of the interest rate differential rather than the level of the differential itself.