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A MODEL OF THE BALANCE OF PAYMENTS

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A model of the balance of payments is presented in this paper in which stock and flow effects are completely integrated. The model accounts for all flows of funds in the system and allows for the endogenous determination of the exchange rate. The model is first outlined in general terms and then a particular 'quasi-empirical' version of it is analyzed by means of simulation techniques. The results of analyzing this version show the likely importance of accounting for capital flows and price linkages among countries in the construction of multicountry econometric models.

1. Introduction

It is common in the literature to distinguish among the elasticity, absorption, and monetary approaches to the balance of payments, with recent attention focusing on the monetary approach.[1] Although, as Mundell (1968, pp. 150–151) has pointed out, these approaches all assert identical propositions in an accounting sense, they have provided a way of categorizing alternative theories or models of the balance of payments. An important question is whether this categorization provides a useful framework for further work. A model of the balance of payments is presented in this paper that indicates that it does not. The model does not fall naturally into any of the above categories, and furthermore it indicates that none of the three approaches provides a complete explanation of the balance of payments.

A useful way of distinguishing between the model developed in this paper and previous models is to consider the determination of the exchange rate. Recent studies that follow the monetary approach have stressed the stock market aspect of this determination. Dornbusch (1976, p. 276), for example, states that 'the exchange rate is determined on the asset market,' and Frenkel and Rodriguez (1975, p. 686) state that 'the equilibrium exchange rate is that

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[1]See, for example, Frenkel and Johnson (1976), Dornbusch (1976), Frenkel and Rodriguez (1975), and Kouri (1976). See also the recent survey by Myhrman (1976).

relative price of monies at which the existing stocks are willingly held.' This treatment is contrasted with the 'characterization of exchange-rate determination as arising in the market for foreign exchange with an emphasis on the financing of current trade flows' [Dornbusch (1976, p. 276)] and 'the popular notion that the exchange rate is determined in the flow market so as to assure a balanced balance of payments' [Frenkel and Rodriguez (1975, p. 686)]. A key difference between the monetary approach and the other two approaches is thus this question of stock-market determination versus flow-market determination of the exchange rate.[2] In the model in this paper, on the other hand, there is no natural distinction between stock-market and flow-market determination. The exchange rate is not in any rigorous sense determined either in a stock market or in a flow market. The exchange rate has an effect on many of the decisions of the economic agents in the model, decisions regarding both stock and flow variables, and these decisions in turn affect a number of different markets. The exchange rate, like the price level, the wage rate, and the interest rate, is merely one endogenous variable out of many in the model, and in no rigorous sense can it be said to be 'the' variable that clears a particular market. In short, the model presented in this paper is one in which stock and flow effects are completely integrated.[3]

The inspiration for the model in this paper came from my earlier work [Fair (1974, 1976)] on developing a macroeconomic model for a single country. The main feature of this single-country model that is relevant to the present discussion is the fact that all flows of funds are accounted for in it. This means that any financial saving or dissaving of an agent in a period results in the change in at least one of its assets or liabilities and that any asset of one agent is a corresponding liability of some other agent. The idea for the present model came from considering how one would link this single-country model to a similar model for another country so as to form a closed two-country model.

The outline of this paper is as follows. The 'basic' model is presented in section 2. This model is sufficient for seeing the principal differences between the present approach and previous approaches to the balance of payments. Various extensions and alterations of the basic model are then discussed in section 3. The properties of a particular 'quasi-empirical' version of the

[2]There are, of course, numerous other studies in the literature on international monetary economics in which the stock-flow distinction is important. For recent examples, see Allen (1973), Black (1973), Branson (1974), and Girton and Henderson (1976). See also again the recent survey by Myhrman (1976).

[3]Regarding the integration of stock and flow effects, Branson (1974, p. 48) at the end of his paper states: 'But the introduction of capital movements, with the value of the exchange rate being determined by both continuing flows and discontinuous stock shifts, raises some analytical problems that are yet to be solved.' As I understand this statement, these problems have been solved in this paper.

model, called model A, are then analyzed and discussed in section 4. The model as presented in sections 2 and 3 is too general to be analyzed directly, and so more specific versions are needed before any analysis can take place. Model A was obtained by linking the 84-equation econometric model of the U.S. economy in Fair (1976) to itself. This resulted, after the addition of a few equations to close the model, in a 180-equation, two-country model. Model A has the same structure as the basic model, although, as will be discussed in section 4, it is in a number of important ways a very restrictive version of the basic model. The analysis of model A in section 4 is thus meant primarily to be illustrative of what can be done in the future with a more realistic version of the basic model.

2. The basic model

The model is a two-country model. Capital letters will denote variables for country 1, lower case letters will denote variables for country 2, and an asterisk (*) on a variable will denote the other country's holdings or purchase of the variable. There are three sectors per country: household, firm, and government. Subscripts h, f, and g will be used to denote these sectors, respectively. Each country specializes in the production of one good (X, x). Labor (L, l) is homogeneous within a country, and there is no labor mobility between countries. Each country has its own money (M, m), which is issued by the government, and its own bond (B, b). The bonds are one-period securities. If a sector is a debtor with respect to a bond (i.e. a supplier of the bond), then the value of B or b for this sector is negative. The interest rate on B is R and on b is r; the wage rate for L is W and for l is w; and the price of X is P and of x is p. e is the price of country 2's currency in terms of country 1's currency, and e' is the (one-period) forward price of country 2's currency in terms of country 1's currency. The government of each country holds a positive amount of the international reserve (Q, q), whose price is 1.0, and it taxes its citizens using a vector (T, t) of tax parameters. For now, X and x, M and m, and B and b are assumed not to be perfect substitutes.

Another important feature of the single-country model mentioned in the Introduction is that the decisions of the individual agents or sectors in the model are assumed to be derived from the solutions of multiperiod optimization problems. This assumption has been carried over to the present model. Consider first the household sector for country 1. It is assumed to determine jointly through the solution of an optimization problem its labor supply and its demands for the two goods, the two moneys, and the two bonds. It takes as given the wage rate, the two prices, the two interest rates, the tax parameters, the exchange rate, the forward rate, and all lagged values. The vector of all relevant lagged values will be denoted Z_h. Expectations of various future values, which are needed for the optimization problem, are assumed to be a function of current and lagged values. The equations representing the decisions for the current period will be written as:

$$L_h = f_1(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[supply of labor]} \tag{1}$$

$$X_h = f_2(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[demand for the good of country 1]} \tag{2}$$

$$x_h^* = f_3(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[demand for the good of country 2]} \tag{3}$$

$$M_h = f_4(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[demand for the money of country 1]} \tag{4}$$

$$m_h^* = f_5(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[demand for the money of country 2]} \tag{5}$$

$$B_h = f_6(W, P, p, R, r, T, e, e', Z_h), \qquad \text{[supply of (−) or demand for the bond of country 1]} \tag{6}$$

$$b_h^* = f_7(W, P, p, R, r, T, e, e', Z_h). \qquad \text{[supply of (−) or demand for the bond of country 2]} \tag{7}$$

These seven equations are not independent, since they must satisfy a budget constraint. This constraint is as follows. First, the taxable income of the household sector (Y_h) is assumed to be

$$Y_h = W \cdot L_h + R \cdot B_h + e \cdot r \cdot b_h^*, \qquad \text{[taxable income]} \tag{8}$$

where the first term on the RHS is wage income and the second and third terms are interest income or interest payments. Second, net taxes paid by the household sector (V_h) is assumed to be a function of Y_h and T:

$$V_h = f_9(Y_h, T). \qquad \text{[net taxes paid]} \tag{9}$$

The financial saving of the household sector (S_h) is then

$$S_h = Y_h - V_h - P \cdot X_h - e \cdot p \cdot x_h^*, \qquad \text{[household saving]} \tag{10}$$

where the last two terms are expenditures on goods. Finally, the budget constraint is

$$0 = S_h - \Delta M_h - e \cdot \Delta m_m^* - B_h$$
$$- e \cdot \Delta b_h^*, \qquad \text{[household budget constraint]} \tag{11}$$

which says that any nonzero level of saving of the household sector must result in the change in at least one of its assets or liabilities. One further point about eqs. (1)–(7) should be noted, which is that the covered interest rate on the bond of country 2 is an implicit argument in these equations. From country 1's perspective the covered interest rate on the bond of country 2 is $(e/e')(1+r)-1$, and e, e', and r are arguments in the equations.

Consider next the firm sector for country 1. For simplicity, it is assumed that the firm sector does not purchase the good of the foreign country, does not hold the bond of the foreign country, and does not hold any money. The firm sector is also assumed to derive its decisions from the solution of a multiperiod optimization problem. It is assumed to determine jointly its demand for labor, its supply of the good net of the amount used for investment purposes, and its supply of or demand for the bond of country 1. It takes as given W, P, R, T, and all lagged values (Z_f). The equations representing the decisions for the current period will be written as:[4]

$$L_f = f_{12}(W, P, R, T, Z_f), \qquad \text{[demand for labor]} \tag{12}$$

$$X_f = f_{13}(W, P, R, T, Z_f), \qquad \text{[net supply of the good]} \tag{13}$$

$$B_f = f_{14}(W, P, R, T, Z_f). \qquad \text{[supply of } (-) \text{ or demand for the bond of country 1]} \tag{14}$$

These three equations also must satisfy a budget constraint. The value of taxes paid by the firm sector (V_f) is assumed to be a function of T and of variables that determine profits:

$$V_f = f_{15}(L_f, X_f, B_f, W, P, R, Z_f, T). \qquad \text{[taxes paid]} \tag{15}$$

The financial saving of the firm sector (S_f) is

$$S_f = P \cdot X_f + R \cdot B_f - W \cdot L_f - V_f, \qquad \text{[firm saving]} \tag{16}$$

[4]For present purposes, the production-function constraint on the firm sector should be assumed to be incorporated into the decision eqs. (12)–(14). It should also be noted that in order for eqs. (12) and (13) to be determinant, there must be diminishing returns in the economy, and this is assumed here. For an example of the introduction of diminishing returns into a model, see Frenkel and Rodriguez (1975), who assume for their model that gross capital formation is subject to increasing marginal cost.

and its budget constraint is

$$0 = S_f - \Delta B_f. \qquad \text{[firm budget constraint].} \tag{17}$$

The government is assumed to purchase labor from its own citizens (L_g) and both goods (X_g and x_g^*). The amount of money that it issues is M_g, and its net holdings of the bond of country 1 is B_g. It is also assumed to hold the money and the bond of the other country (m_g^* and b_g^*), in addition to the international reserve (Q). The financial saving of the government (S_g) is

$$S_g = V_h + V_f + R \cdot B_g + e \cdot r \cdot b_g^* - W \cdot L_g - P \cdot X_g - e \cdot p \cdot x_g^*, \qquad \text{[government saving]} \tag{18}$$

and its budget constraint is

$$0 = S_g + \Delta M_g - e \cdot \Delta m_g^* - \Delta B_g - e \cdot \Delta b_g^* - \Delta Q. \qquad \text{[government budget constraint]} \tag{19}$$

The first two terms on the RHS of (18) are tax revenue, the next two terms are interest income or interest payments, and the last three terms are purchases of labor and goods. Eq. (19) states that any nonzero value of government saving must result in the change in at least one of the government's assets or liabilities.

The equilibrium conditions for country 1 are the following:

$$L_h = L_f + L_g, \qquad \text{[equilibrium condition for the labor market]} \tag{20}$$

$$X_f = X_h + X_g + X_h^* + X_g^*, \qquad \text{[equilibrium condition for the goods market]} \tag{21}$$

$$M_g = M_h + M_h^* + M_g^*, \qquad \text{[equilibrium condition for the money market]} \tag{22}$$

$$0 = B_h + B_f + B_g + B_h^* + B_g^*. \qquad \text{[equilibrium condition for the bond market]} \tag{23}$$

Eqs. (1)–(23) also hold for country 2, with capital and lower case letters reversed and with $1/e$ replacing e. Call these equations (1)′–(23)′. The model is then closed by the following two equations:

$$0=\Delta Q+\Delta q, \quad \text{[no change in total world reverses]} \tag{47}$$

$$e'=f_{48}(\ldots). \quad \text{[forward price of country 2's currency]} \tag{48}$$

For present purposes the determinants of the forward price can be left unspecified, although this is admittedly an important issue.

Of the 48 equations, 5 are redundant. The redundant equations are: one from (1)–(11); one from (12)–(17); one from (1)′–(11)′; one from (12)′–(17)′; and one because the savings of all sectors sum to zero: $S_h+S_f+S_g+e(s_h+s_f+s_g)=0$. It will be convenient to drop (6), (6)′, (14), (14)′, and (47), leaving 43 independent equations. If all the government variables (i.e. all the variables with subscript g) except M_g, m_g, S_g, and s_g are taken to be exogenous and if all the lagged values are taken to be predetermined, then there are 44 variables left. One further variable thus must be taken to be exogenous. In the fixed exchange rate regime this variable is e, and in the flexible exchange rate regime the variable is Q.

It may be helpful to consider the matching of variables to equations to see that all the variables are accounted for. Eqs. (1)–(5), (7)–(10), (12), (13), (15), (16), (18), and the corresponding equations for country 2 can be matched to the LHS variables in the equations. To the four private budget-constraint equations, (11), (11)′, (17), and (17)′, can be matched B_h, b_h, B_f and b_f. To the government budget-constraint equations, (19) and (19)′, can be matched M_g and m_g. This latter matching shows the nature of the government budget constraint. For the government of country 1, for example, given m_g^*, B_g, b_g^*, e, and Q, any nonzero value of its saving must result in a change in the money supply. To continue the matching, W and w can be matched to (20) and (20)′, the equilibrium conditions for the labor markets; P and p can be matched to (21) and (21)′, the equilibrium conditions for the goods markets; and R and r can be matched to (22) and (22)′, the equilibrium conditions for the money markets. e' can be matched to eq. (48). This leaves three variables, q, Q, and e, and two equations (23) and (23)′, unaccounted for. q can be matched to (23)′, and either Q or e can be matched to (23), with the other one taken to be exogenous.

This completes the outline of the model. The point made in the Introduction about the determination of the exchange rate should now be clear. The exchange rate affects the decisions of the household sector and also enters a number of the definitions in the model. Although in the previous paragraph e was matched to eq. (23), it is not in any rigorous sense determined by this equation. Rather, it is simultaneously determined in the model, along with the other 42 endogenous variables. In this sense, e, like P, p, W, w, R, and r, affects both endogenous flow variables and endogenous stock variables. There is no natural distinction in the model between stock-market determination and flow-market determination.

3. Extensions and alterations of the basic model

3.1. The case where B and b are perfect substitutes

As noted above, the covered interest rate from country 1's perspective on the bond of country 2, say r', is $(e/e')(1+r)-1$. If for $R=r'$ people are indifferent as to which bond they hold, then the bonds are defined to be perfect substitutes. The model in this case is modified as follows. First, eqs. (7) and (7)′ drop out, since the household sectors are now indifferent between the two bonds. Second, arbitrage will insure that $R=r'$, and so a new equation is added:

$$R=(e/e')(1+r)-1. \tag{49}$$

Third, the model is underidentified with respect to B_h, B_h^*, b_h, and b_h^*, and so one of these variables must be taken to be exogenous.[5] The model in this case thus consists of one less equation and one less endogenous variable than before.

3.2. The case where M and m are perfect substitutes

This case is not realistic, but it is still of some interest to consider. If for $e=e'$ people are indifferent as to which money they hold, then the moneys are defined to be perfect substitutes. The model in this case is modified as follows. First, two equations drop out: either (4) and (4)′ or (5) and (5)′. Second, arbitrage will insure that $e=e'$, and so a new equation is added:

$$e=e'. \tag{50}$$

Third, the model is underidentified with respect to M_h, M_h^*, m_h, and m_h^*, and so one of these variables must be taken to be exogenous. (See footnote 5). There is thus one less equation and one less endogenous variable than before.

3.3. The case where X and x are perfect substitutes

In this case, $P=e\cdot p$, so one new equation is added to the model. Two

[5]This indeterminacy is analogous to the indeterminacy that arises in, say, a two-consumer, two-firm model in which the two consumers are indifferent between the goods produced by the two firms. It is not possible in this model to determine the allocation of the two goods between the two consumers.

equations drop out: either (2) and (2)′ or (3) and (3)′. The model is underidentified with respect to X_h, X_h^*, x_h, and x_h^*, and so one of these variables must be taken to be exogenous. (Again, see footnote 5.)

3.4. The case where the governments control the interest rates

In this case either R and r can be taken to be exogenous or equations explaining R and r can be added to the model and interpreted as government reaction functions.[6] If the latter is done, then two new equations are added to the model:

$$R = f_{51}(\dots) \tag{51}$$

$$r = f_{52}(\dots). \tag{52}$$

In order to close the model in this case, two variables that were exogenous before must now be taken to be endogenous. The obvious candidates for this in the present model are B_g and b_g.

3.5. The case where one of the governments controls the exchange rate

This case is like the case of a fixed exchange rate (e exogenous), although an equation explaining e can be added to the model and interpreted as a reaction function of one of the governments:

$$e = f_{53}(\dots). \tag{53}$$

In this case, as in the case of a fixed exchange rate, both Q and q must be endogenous in order to close the model.

3.6. Cases that are not possible to combine

The meticulous reader will have noted that it is not possible to combine the cases in which B and b are perfect substitutes, the governments control the interest rates, and there is a fixed exchange rate or a rate determined by eq. (53). Given e' from (48) and R and r from (51) and (52), (49) determines e. Therefore, e cannot be exogenous or determined by another equation. If M and m are perfect substitutes, then e is determined by (50), and so it is also not possible in this case to have e be exogenous or determined by another equation. Finally, even if eq. (53) is not postulated, one cannot combine the

[6]For my U.S. econometric model I have estimated an equation explaining the behavior of the Federal Reserve in which the LHS variable is a short-term interest rate and the RHS variables are variables that seem likely to affect Fed behavior. See Fair (1978) for a discussion of this.

cases in which B and b are perfect substitutes, M and m are perfect substitutes, and the governments control the interest rates.

3.7. The case where the labor and goods markets are not necessarily in equilibrium

Although the basic model is based on the assumption that the labor, goods, and financial markets are in equilibrium, it can be modified to incorporate disequilibrium effects. One possible modification with respect to the labor and goods markets, which is in the spirit of the model in Fair (1974), is as follows. Consider country 1. If W and P are not determined by the requirement that the labor and goods markets be in equilibrium, then some mechanism for their determination must be specified. Assume, therefore, that the firm sector jointly determines W and P along with its other decision variables, so that two new equations are added to the model:

$$W=f_{54}(\dots), \tag{54}$$

$$P=f_{55}(\dots). \tag{55}$$

If it is possible for firms to make expectation errors, then the values of W and P may not be equilibrium values, so that eqs. (20) and (21) may not hold. Some modification of the model must thus be made to account for the case in which the values of W and P are not equilibrium values.

Consider first eq. (12), which in the equilibrium case represents the firm sector's demand for labor, L_f. It will now be assumed that eq. (12) represents the maximum amount of labor that the firm sector will employ in the period. The maximum amount that the household sector can work is thus L_f+L_g. If it is further assumed that the firm and government sectors make their decisions regarding L_f and L_g before the household sector makes its decision, then the household sector can be assumed to take this possible labor constraint into account in making its decisions. Eqs. (1)–(7) can thus be taken to represent the household sector's decisions that incorporate the possible labor constraint, so that L_h in (1) is always less than or equal to L_f+L_g.

Consider now how the firm sector adjusts to a disequilibrium situation. If L_h is strictly less than L_f+L_g, then the firm sector is assumed to get only the amount L_h-L_g of labor in the period. Call this amount L'_f. In the case in which $L'_f<L_f$, the firm sector is assumed to change its decision regarding the net supply of the good, X_f, (but not regarding W and P) and so eq. (13) should now be interpreted as reflecting this possible change. The firm sector is also assumed to hold an inventory of the good, I. By definition

$$I-I_{-1}=X_f-X'_f, \tag{56}$$

where X_f is, as before, production and where X'_f denotes sales. Any difference between production and sales in a period results in a change in inventories, and the firm sector is assumed to adjust over time to an undesired level of inventories by changing production relative to sales.

The model in the disequilibrium case is thus as follows. Three new equations are added, (54)–(56), and three new endogenous variables are introduced, L'_f, X'_f, and I. Also, L'_f should replace L_f in (20), where the equation is now interpreted as determining the actual amount of labor that the firm sector gets in the period. This amount may be less than the maximum amount demanded, L_f. Likewise, X'_f should replace X_f in (21), where the equation is now interpreted as determining the actual sales of the firm sector. In addition, L'_f and X'_f should replace L_f and X_f, respectively, in (15) and (16). Finally, it should be noted that I_{-1} is now included among the lagged variables that affect the firm sector's decision, that X_f in (13) reflects the possible constraint $L'_f < L_f$, and that the household sector's decisions as represented by eqs. (1)–(7) reflect the possible labor constraint on it. Similar modifications can be made for country 2.

After the introduction of a bank sector into the model, which will be discussed next, one could introduce the possibility of disequilibrium in the financial market. Banks may at times constrain firms and households in how much they can borrow at the current loan rate. This issue, however, will not be pursued here. The interested reader is referred to the model in Fair (1974), where possible disequilibrium effects in the labor, goods, and financial markets are considered together.

3.8. *The case where there is a bank sector*

A bank sector is easy to add to the model. Assume for simplicity that the bank sector in each country hires no labor, buys no goods, pays no taxes, and holds no foreign bonds and money. Assume also that there is no currency in the system, and let M and m now denote demand deposits. Consider country 1. Let M_b denote the value of demand deposits of the bank sector, and let B_b denote the bank sector's net demand for the bond of country 1. M_b replaces M_g in eq. (22). Also, the government is assumed to hold no demand deposits, so that M_g is dropped from the model. Let BR denote bank reserves, BO bank borrowing from the government, RD the discount rate, and RR the reserve requirement ratio. Bank borrowing is assumed to be a function of R and RD:

$$BO = f_{57}(R, RD), \tag{57}$$

and the bank sector is assumed to hold no excess reserves:

$$BR = RR \cdot M_b. \tag{58}$$

The financial saving of the bank sector (S_b) is

$$S_b = R \cdot B_b - RD \cdot BO, \tag{59}$$

and its budget constraint is

$$0 = S_b - \Delta B_b + \Delta M_b - \Delta(BR - BO). \tag{60}$$

The model with a bank sector is thus as follows. Four new equations are added, (57)–(60); five new endogenous variables are introduced, M_b, BO, BR, S_b, and B_b; one endogenous variable is dropped, M_g; and two new exogenous variables are added, RD and RR. In addition, M_b should replace M_g in (22); $\Delta(BR - BO)$ should replace ΔM_g in the government budget constraint (19); $RD \cdot BO$ should be added to the government saving equation (18); and B_b should be added to (23). Similar modifications can be made for country 2.

3.9. Other possible extensions

There are a number of other additions that could be made to the model without changing its basic structure. Bonds with a maturity longer than one period could be introduced. This would require keeping track of the capital gains and losses on the bonds and of the possible effects of these gains and losses on behavior. The firm sector could be assumed to hold the bond of the other country and both moneys without changing the model's basic structure. Likewise, a more detailed specification with respect to the firm sector's investment and production decisions could be made without a basic change in structure.

3.10 Combining some equations

For purposes of the discussion in the next section, it will be useful to combine some of the above equations. Consider the case in which there is a bank sector. Adding the four saving equations, (10), (16), (18), and (59), yields

$$S = P \cdot X^* - e \cdot p \cdot x^* + e \cdot r \cdot b^* - R \cdot B^*, \qquad \text{[saving of country 1]} \tag{61}$$

where S is the total saving of country 1 ($S = S_h + S_f + S_g + S_b$), X^* is country 2's purchase of country 1's good ($X^* = X_h^* + X_g^*$), x^* is country 1's purchase of country 2's good ($x^* = x_h^* + x_g^*$), b^* is country 1's holdings of country 2's bond ($b^* = b_h^* + b_g^*$), and B^* is country 2's holdings of country 1's bond ($B^* = B_h^* + B_g^*$).

The last two terms in eq. (61) are, respectively, interest receipts and payments of country 1. Adding the four budget-constraint equations, (11), (17), (19), and (60), yields

$$0 = S + \Delta M^* + \Delta B^* - e \cdot \Delta m^* - e \cdot \Delta b^* - \Delta Q, \qquad \text{[country 1 budget constraint]} \qquad (62)$$

where M^* is country 2's holdings of country 1's money ($M^* = M_h^* + M_g^*$) and m^* is country 1's holdings of country 2's money ($m^* = m_h^* + m_g^*$). Finally, the government budget constraint (19) in the bank sector case is

$$0 = S_g + \Delta(BR - BO) - \Delta B_g - e \cdot \Delta m_g^* - e \cdot \Delta b_g^* - \Delta Q. \qquad \text{[government budget constraint]} \qquad (19)'$$

4. Model A

As mentioned in the Introduction, model A is a specific version of the model outlined in sections 2 and 3. It is 'quasi-empirical' in that half of it is an actual empirical model of the U.S. and half is completely made up. It is in many respects more detailed than the model outlined above, although it does retain the basic structure of the above model. In particular, model A accounts for all flows of funds between the two countries and allows for the endogenous determination of the exchange rate. It has a bank sector, and it accounts for possible disequilibrium in the labor, goods, and financial markets. It also has a more detailed specification of the firm sector than is outlined in section 2. Some capital gains and losses are also accounted for.

Although model A is in many respects more detailed than the above model, it is also in a number of other respects a very restrictive version. First, no equation explaining the demand for foreign securities [eq. (7)] has been estimated for the U.S. econometric model upon which model A is based. Because of this, the properties of model A have only been analyzed in the two cases where these equations are not needed: zero capital mobility and perfect capital mobility.[7] Second, no equation explaining e' [eq. (48)] has been estimated. e' appears in eq. (49), and so some explanation of it is needed in the perfect mobility case. For the results below e' was always assumed to be equal to e, which means from (48) that R is always equal to r in the perfect mobility case analyzed here. Third, interest payments and

[7]'Zero' capital mobility is defined here to be the case in which b_h^* and B_h^* are exogenous, and 'perfect' capital mobility is defined to be the case in which B and b are perfect substitutes.

receipts between countries are not explicitly accounted for, but are rather included in overall exports and imports, as in the national income accounts. Finally, no equation explaining the demand for foreign money [eq. (5)] has been estimated, and so m_h^* and M_h^* have been taken to be exogenous. Because of these limitations, especially the first two, and because model A is not an empirical model, the following results should not be taken too seriously. As noted in the Introduction, the following analysis is meant primarily to be illustrative of what can be done in the future with a more realistic version of the model outlined in sections 2 and 3.

Due to the editor's wishes, the complete list of the 180 equations of model A will not be presented in this paper. A detailed description and analysis of the 84-equation U.S. econometric model is contained in Fair (1976). In addition, an appendix is available from the author upon request that contains a complete discussion of the construction of model A and a list of the 180 equations. The following is a brief discussion of two of the key equations that relate to the linkages between the two countries. To avoid possible confusion between the notation in this paper and the notation in Fair (1976), the differences in notation will be explained in footnotes.[8]

Country 1's demand for the good of country 2 (x^*) is a function of the prices of the two goods (P and $e \cdot p$) and of the size of country 1 as measured by the total sales of its good (X'_f). The prices are lagged one and two quarters, respectively. The equation explaining x^* is

$$\log \frac{x^*}{POP} = -1.60 + 1.62 \log P_{-1} - 0.43 \log(e \cdot p)_{-2}$$

$$+ 1.17 \log \frac{X'_f}{POP} + \text{strike dummies}, \tag{i}$$

where POP is the population of country 1.[9] This equation was estimated using U.S. data for the 1954I–1974II period. The coefficient of $\log P_{-1}$ is about 3.8 times larger in absolute value than the coefficient of $\log(e \cdot p)_{-2}$, which means that the real value of U.S. imports is estimated to be more

[8]Eq. (61) above is equation 65 in Fair (1976). In equation 65, however, the two interest terms in eq. (61) are included in the export and import terms. There is also a term in equation 65 that is not in (61), namely transfer payments from the U.S. to the rest of the world. Ignoring these fairly minor differences, the notation matching between model A and the model in Fair (1976) is: $S = -SAVR$, $P = PEX$, $X^* = EX$, $e \cdot p = PIM$, and $x^* = IM$. Eq. (62) is equation 66, where $\Delta M^* = \Delta DDR$, $\Delta Q = \Delta GFXG$, and $\Delta B^* - e \cdot \Delta m^* - e \cdot \Delta b^* = \Delta SECR$. Finally, eq. (19)' is equation 69, where $S_g = SAVG$, $\Delta(BR - BO) = \Delta(BR - BORR)$, $-\Delta B_g^* - e \cdot \Delta m_g^* - e \cdot \Delta b_g^* = \Delta VBG$, and $0 = \Delta CURR$.

[9]Eq. (i) is equation 24 in Fair (1976), where $X'_f = X$ and $POP = POP$. Also, P in this case is PX rather than, as in footnote 8, PEX. PEX and PX are closely linked in the model, and so little is lost in the present discussion by treating them as the same variable.

responsive to the price of domestically produced goods than it is to the price of imports. The best results in terms of goodness of fit for this equation were obtained by lagging the price of domestically produced goods one quarter and the price of imports two quarters. An equation like (i) also explains country 2's demand for the good of country 1, with lower case letters and capital letters reversed and with $1/e$ replacing e.

Although eq. (i) is the best fitting import equation that I could find, some may object to the unequal price coefficients (in absolute value) and the lags. It thus seems to be of some interest to examine the properties of model A with (i) replaced by an equation with equal coefficients and no lags. Some results are thus reported below for (i) replaced by

$$\log\frac{x^*}{POP} = -1.60 + 1.00\log P - 1.00\log(e\cdot p) + 1.17\log\frac{X'_f}{POP} + \text{strike dummies}, \qquad (\mathrm{i}')$$

and for country 2's version of eq. (i) replaced by its version of (i)′.

The price of the good of country 1, which is assumed in the model to be set by the firm sector of country 1, is a function, among other things, of the price of the good of country 2:

$$\log P = 0.0795\log(e\cdot p) + 0.739\log P_{-1} + \text{other terms}. \qquad (\mathrm{ii})$$

This equation was also estimated using U.S. data for the 1954I–1974II period.[10] The price of imports is estimated to have an effect on the price of domestically produced goods, with, for example, a one percent increase in the price of imports resulting, other things being equal, in a 0.0795 percent increase in the price of domestically produced goods in the current quarter. An equation like (ii) also holds for country 2, again with lower case letters and capital letters reversed and with $1/e$ replacing e.

Two other features of model A with respect to prices should be noted. First, prices have, other things being equal, a negative effect on demand. One would expect this to be true for the usual microeconomic reasons, but it is not something that is true of all macroeconomic models. Second, the cost of capital has, other things being equal, a positive effect on the price level. This means that one channel through which interest rates affect demand is through the positive effect of interest rates on prices.

[10]Eq. (ii) is equation 9 in Fair (1976), where in this case $P=PF$ instead of $P=PX$ or $P=PEX$. PF is also closely linked in the model to PX and PEX, and so little is lost in this discussion by treating all three as the same variable. In the actual experiments with model A, however, these three variables are treated separately.

The properties of model A were analyzed in four different regimes:

$(0,0)$ = zero capital mobility and a fixed exchange rate,
$(\infty,0)$ = perfect capital mobility and a fixed exchange rate,
$(0,\infty)$ = zero capital mobility and a flexible exchange rate,
(∞,∞) = perfect capital mobility and a flexible exchange rate.

The experiments were performed as follows. For each of the four regimes and for each of the two versions of the import equations, model A was first simulated using the actual values of all the exogenous variables.[11] The simulation was dynamic and began in 1971I. The length of the prediction period was four quarters. The predicted values of the endogenous variables from this simulation were recorded. A second simulation was then run in which B_g was decreased each quarter by 1.25 (a sale of the bond of country 1 by country 1's government). The predicted values of the endogenous variables from this simulation were then compared to the predicted values from the base simulation to see the effects of the decrease in B_g.

The results of these eight experiments are presented in table 1. Each number in the table is the difference between the predicted value of the variable after the policy change and the predicted value of the variable before the change. Results for 20 variables for the first three quarters of the simulation period are presented in the table.[12] The rest of this section is a discussion of the results in table 1. An attempt has been made in what follows to provide enough discussion of the results in each column so as to make the rest of the results in that column self explanatory. In the following discussion, reference is sometimes made to a change in one endogenous variable 'causing', 'leading to', or 'resulting in' a change in another endogenous variable or variables. It should be realized that this discussion, while useful pedagogically, is not rigorous, since the model is simultaneous.

4.1. *Regime* (0,0)

Consider first the results in column 1 for quarter t. The decrease in B_g in this case led to a decrease in output in both countries and an increase in the interest rates in both countries. The interest rates increased because, speaking loosely, a decrease in B_g takes funds out of the system. Bank reserves fell in both countries. The price levels in both countries were higher because of the higher interest rates. In this case the positive effects of the increase in the interest rates on the price levels were large enough to offset the negative

[11]As noted in section 3, in the case of perfect capital mobility one of the variables B_h, B_h^*, b_h, and b_h^* must be taken to be exogenous. For the work here, B_h^* was taken to be exogenous.

[12]The variables for country 1 in table 1 in the notation in Fair (1976) are: $X_f = Y$, $R = RBILL$, $P = PEX$, $e \cdot p = PIM$, $x^* = IM$, $S = -SAVR$, $Q = GFXG$, $S_g = SAVG$, $BO = BORR$, and $BR = BR$. See also the definition of $\Delta SECR$ in footnote 8.

effects due to the contractions in output. Because of the price lags in the import equations, a change in prices in quarter t has no direct effect on the real value of imports in quarter t. The real value of imports decreased in both countries in quarter t because of the contractions in output. P increased more than did p and x^* decreased more than did X^*, which, as can be seen from eq. (61), means an increase in the saving (S) of country 1. In the (0,0) regime, all the variables in eq. (62), country 1's budget constraint, are exogenous except S and Q, and so the increase in S in this case resulted in an equal increase in country 1's reserves. The saving of country 1's government increased by 0.13 in quarter t, and this increase plus the 1.25 decrease in B_g was offset by a 0.67 increase in bank borrowing, a 0.60 decrease in bank reserves, and a 0.11 increase in country 1's reserves. The saving of country 2's government increased by 0.01, which took the form of a 0.07 increase in bank borrowing, a 0.04 decrease in bank reserves, and the 0.11 decrease in country 2's reserves. (The increase in bank borrowing plus the decrease in bank reserves less the decrease in reserves is 0.00 rather than 0.01 because of rounding.)

The economic contraction continued in both countries in quarters $t+1$ and $t+2$. The contraction continued to be more severe in country 1 than in country 2. This led to a continued fall in country 1's imports relative to country 2's imports and thus to a continued positive level of saving of country 1. The positive values of country 1's saving led to a continued accumulation by it of reserves.

4.2. *Regime* $(\infty, 0)$

In column 2 the decrease in B_g had almost identical effects in the two countries. A decrease in B_g has no other direct effects than to take funds out of the system. With perfect capital mobility and a fixed exchange rate, it makes no difference which country the funds are initially taken out of. Therefore, since the two countries are virtually the same, taking funds out of the system results in virtually identical effects in the two countries.

In this regime there is only one (world) interest rate, and the increase in quarter t in this rate was smaller than the increase in country 1's interest rate in column 1 and larger than the increase in country 2's interest rate in column 1. This led to a somewhat smaller contraction in country 1 and a somewhat larger contraction in country 2 in column 2 relative to column 1. The figure for b^* is negative in column 2, which means that there was a capital inflow into country 1. This inflow led to a larger accumulation of reserves by country 1 in column 2 than in column 1. The reason for the capital inflow is fairly clear. In the case of zero capital mobility in column 1, country 1's interest rate increased more than did country 2's interest rate. Therefore, to have the interest rate increases be the same in column 2, capital

Table 1

Results of eight experiments for model A.[a]
(Sustained 1.25 decrease in B_g (monetary-policy contraction in country 1))

Change in:	Quarter	Price lags in import equations Regime				No price lags in import equations Regime			
		(0,0) (1)	(∞,0) (2)	(0,∞) (3)	(∞,∞) (4)	(0,0) (5)	(∞,0) (6)	(0,∞) (7)	(∞,∞) (8)
X_f (Output in country 1)	t	−0.62	−0.37	−0.78	0.26	−0.71	−0.37	−0.70	−0.78
	$t+1$	−1.28	−0.76	−1.71	0.58	−1.27	−0.77	−1.20	−0.70
	$t+2$	−0.94	−0.62	−1.39	0.41	−0.86	−0.63	−0.63	−0.51
x_f (Output in country 2)	t	−0.15	−0.36	0.04	−1.03	−0.05	−0.36	−0.03	0.01
	$t+1$	−0.24	−0.75	0.12	−2.19	−0.23	−0.75	−0.18	−0.88
	$t+2$	−0.20	−0.59	0.18	−1.68	−0.25	−0.59	−0.41	−0.74
R (Interest rate in country 1)	t	1.90	1.12	2.23	1.18	1.98	1.13	2.02	1.16
	$t+1$	−0.25	−0.08	−0.36	−0.08	−0.29	−0.08	−0.22	−0.09
	$t+2$	−1.13	−0.69	−1.47	−0.73	−1.13	−0.69	−0.83	−0.71
r (Interest rate in country 2)	t	0.19	1.12	−0.17	1.18	0.13	1.13	0.17	1.16
	$t+1$	−0.01	−0.08	−0.03	−0.08	0.05	−0.08	0.29	−0.09
	$t+2$	−0.18	−0.69	−0.12	−0.73	−0.14	−0.69	−0.10	−0.71
$100 \cdot P$ (domestic price level in country 1)	t	0.478	0.260	0.631	−0.368	0.481	0.261	0.428	0.005
	$t+1$	0.160	0.131	0.339	−0.742	0.146	0.133	−0.057	−0.036
	$t+2$	0.001	0.015	0.159	−0.867	−0.016	0.015	−0.117	−0.158
$100 \cdot p$ (domestic price level in country 2)	t	0.070	0.256	−0.078	0.907	0.060	0.257	0.091	0.527
	$t+1$	0.055	0.129	−0.089	1.014	0.067	0.131	0.214	0.300
	$t+2$	0.016	0.014	−0.173	0.904	0.026	0.014	0.165	0.185
$100 \cdot e \cdot p$ (price of imports of country 1)	t	0.070	0.256	1.154	−8.292	0.060	0.257	−0.215	−3.156
	$t+1$	0.055	0.129	0.515	−4.847	0.067	0.131	−1.038	0.605
	$t+2$	0.016	0.014	1.056	−2.530	0.026	0.014	−0.154	−0.434
$100 \cdot P/e$ (price of imports of country 2)	t	0.478	0.260	−0.611	8.572	0.481	0.261	0.726	3.642
	$t+1$	0.160	0.131	−0.235	5.403	0.146	0.133	1.348	−0.351
	$t+2$	0.001	0.015	−1.015	2.634	−0.016	0.015	0.208	0.457
x^* (imports of country 1)	t	−0.06	−0.03	−0.07	0.02	−0.02	−0.03	0.00	0.24
	$t+1$	−0.03	−0.02	−0.04	−0.01	−0.09	−0.06	0.01	−0.11
	$t+2$	−0.04	−0.03	−0.10	0.27	−0.06	−0.04	−0.03	−0.01

X^* (imports of country 2)	t	−0.01	−0.04	0.00	−0.10	−0.05	−0.03	−0.07	−0.32
	$t+1$	−0.01	−0.02	−0.00	−0.03	−0.03	−0.06	−0.11	−0.01
	$t+2$	−0.03	−0.03	0.03	−0.35	−0.01	−0.04	−0.03	−0.08
S (saving of country 1)	t	0.11	0.00	0.03	0.87	0.02	0.00	−0.01	−0.31
	$t+1$	0.04	0.00	0.03	0.51	0.09	0.00	−0.03	0.04
	$t+2$	0.02	0.00	0.04	0.56	0.05	0.00	−0.00	−0.05
e (exchange rate, price of	t								
country 2's currency in	$t+1$	0.0	0.0	0.0100	−0.0750	0.0	0.0	−0.0025	−0.0300
terms of country 1's	$t+2$	0.0	0.0	0.0050	−0.0475	0.0	0.0	−0.0100	0.0025
currency)		0.0	0.0	0.0100	−0.0275	0.0	0.0	−0.0025	−0.0050
Q (country 1's holdings of the international reserve)	t	0.11	0.61	0.0	0.0	0.02	0.61	0.0	0.0
	$t+1$	0.15	0.61	0.0	0.0	0.11	0.60	0.0	0.0
	$t+2$	0.16	0.60	0.0	0.0	0.16	0.59	0.0	0.0
b^* (country 1's holdings of country 2's securities)	t	0.0	−0.61	0.0	0.97	0.0	−0.61	0.0	−0.23
	$t+1$	0.0	−0.61	0.0	1.67	0.0	−0.60	0.0	−0.19
	$t+2$	0.0	−0.60	0.0	1.23	0.0	−0.59	0.0	−0.18
S_g (saving of country 1's government)	t	0.13	0.06	0.22	−0.48	0.08	0.06	0.03	−0.51
	$t+1$	−0.99	−0.53	−1.15	−0.56	−1.01	−0.53	−1.16	−0.54
	$t+2$	−0.65	−0.43	−0.84	−0.45	−0.62	−0.44	−0.46	−0.48
s_g (saving of country 2's government)	t	0.01	0.09	−0.11	0.75	0.06	0.09	0.11	0.72
	$t+1$	−0.12	−0.52	0.02	−0.51	−0.09	−0.51	0.10	−0.54
	$t+2$	−0.12	−0.41	−0.05	−0.42	−0.15	−0.42	−0.18	−0.39
BO (bank borrowing from the government in country 1)	t	0.67	0.39	0.79	0.42	0.70	0.40	0.71	0.41
	$t+1$	−0.08	−0.03	−0.13	−0.03	−0.10	−0.02	−0.08	−0.03
	$t+2$	−0.41	−0.25	−0.52	−0.26	−0.41	−0.25	−0.30	−0.26
bo (bank borrowing from the government in country 2)	t	0.07	0.39	−0.06	0.42	0.04	0.40	0.06	0.41
	$t+1$	−0.00	−0.03	−0.01	−0.02	0.02	−0.02	0.10	−0.03
	$t+2$	−0.07	−0.25	−0.04	−0.26	−0.05	−0.25	−0.04	−0.26
BR (level of bank reserves in country 1)	t	−0.60	−0.30	−0.68	−0.31	−0.61	−0.30	−0.57	−0.33
	$t+1$	−0.33	−0.20	−0.44	−0.17	−0.31	−0.21	−0.19	−0.23
	$t+2$	0.02	−0.00	−0.00	0.06	0.04	−0.00	0.06	−0.02
br (level of bank reserves in country 2)	t	−0.05	−0.31	0.04	−0.33	−0.03	−0.30	−0.05	−0.30
	$t+1$	−0.04	−0.20	0.06	−0.26	−0.05	−0.20	−0.10	−0.19
	$t+2$	0.00	−0.00	0.07	−0.07	−0.02	0.00	−0.06	0.01

[a]*Notes:* (1) Flow variables are at quarterly rates.
(2) Interest rates are in units of percentage points.
(3) Initial price levels are approximately 1.3.
(4) Initial value of e is 1.0.

must flow into country 1. To put this another way, the decrease in B_g takes funds out of country 1's economy, and in order to prevent the interest rate from rising more in country 1 than in country 2, capital must flow into country 1.

In both this regime and the (0,0) regime, the results are not sensitive to whether or not there are price lags in the import equations. In these two regimes the changes in prices are not very large, and so the results are not very sensitive to what one assumes about the price responsiveness of imports.

4.3. *Regime* $(0, \infty)$

This is an old regime, in particular in combination with a model with static exchange rate expectations ($e' = e$) and price lags in the import equations. It is clearly not likely to be realistic. For what they are worth, however, the results are as follows. In the price-lag case (column 3), the contractionary monetary policy in country 1 actually led to an expansion in country 2's output. The reason for this is as follows. In the $(0, \infty)$ regime the saving of each country cannot change, since there are no capital movements and no international reserve changes [eq. (62)]. In other words, the solution value of S when B_g is changed must be roughly[13] the same as the solution value for S in the base simulation. This is in fact the case in table 1, where the changes in S are small in the two $(0, \infty)$ columns. Given this, if imports do not respond to current price changes, then the adjustment to the contractionary monetary policy must take place through a terms-of-trade effect. Country 1's currency must depreciate to turn the terms of trade against it to offset the increase in its saving that would otherwise have taken place as a result of its contractionary policy [eq. (61)]. The appreciation of country 2's currency leads to a decrease in its price level [country 2's version of eq. (ii)], which is, other things being equal, expansionary. This expansionary effect was strong enough in the present experiment so as to lead to a net expansion in country 2's output. This is, of course, a bizarre result, and it is hard to think of any market forces that would bring it about: the fact that the Gauss–Seidel algorithm that was used to solve the model found the solution is no guarantee that this solution would be found in practice.

[13]Because of the way in which the experiments were performed, the solution values for S after the change in the $(0, \infty)$ regime does not have to be exactly equal to the solution value before the change. This can be seen from eq. (62). In the $(0, \infty)$ regime, the other endogenous variable in eq. (62), aside from S, is e, where e multiplies the change in two exogenous variables (b^* and m^*). Treating b^* and m^* as exogenous means that the actual (historic) values of Δb^* and Δm^* were used in all the experiments for this regime. These values are not in general zero, and so e in general multiplies two nonzero variables in eq. (62) in the $(0, \infty)$ regime. Therefore, with e endogenous, the solution value for S after the change can differ from the solution value before the change. This possible difference is, however, not important, and it is ignored in the discussion in the text.

In the no-price-lag case (column 7) the situation is not so odd. In this case real output in country 2 contracts rather than expands and country 1's currency appreciates rather than depreciates. The offset to the increase in country 1's saving that would otherwise have taken place as a result of its contractionary monetary policy occurs in the no-price-lag case through a change in imports and exports rather than through a change in the terms of trade.

4.4. *Regime* (∞, ∞)

There is also a somewhat unusual result in this regime in the price-lag case (column 4) in that the contractionary monetary policy in country 1 had a positive effect on its real output. The reason for this is as follows. First, country 1's currency appreciated as a result of the contractionary policy, which led to a lower domestic price level [eq. (ii)]. A lower price level is, other things being equal, expansionary, and in this experiment the positive effect on output from the lower price level in country 1 was large enough to offset the negative effects induced by the policy contraction. In the no-price-lag case, on the other hand, the appreciation of country 1's currency has a direct negative effect on country 2's demand for country 1's exports, which is contractionary for country 1. There is, in other words, an extra contractionary channel in the no-price-lag case, and in this case (column 8) there is no longer an expansion in country 1's output.

The reason for the appreciation of country 1's currency in this regime is, speaking loosely, as follows. The decrease in B_g takes funds out of the system. For the $(0, \infty)$ regime in column 3, this resulted in an increase in country 1's interest rate and a decrease in country 2's interest rate. This cannot happen for the (∞, ∞) regime in column 4, however, since in this regime there is only one world interest rate. For the $(\infty, 0)$ regime in column 2, the interest rates in the two countries were kept equal by having a capital inflow into country 1, which resulted in an accumulation of reserves by country 1. For the (∞, ∞) regime, however, reserves are exogenous, and so any attempted capital inflow into country 1 to keep the interest rates the same results instead in an appreciation of country 1's currency.

5. Conclusion

Although the results in section 4 are not to be taken too seriously because of the limitations of model A, in particular with respect to its treatment of the forward rate, it does seem clear from the sensitivity of the results to the choice of regime that it is important to account for capital flows in the construction of multicountry models. These results indicate, in other words, that the treatment of capital flows and exchange rates as exogenous in a model like LINK [Ball (1973)] is a serious restriction. The results also indicate that there may be important price linkages among countries in the case of flexible exchange rates, something which has generally been ignored or treated very lightly in previous theoretical work. In the future I hope that the model outlined in sections 2 and 3 can serve as a basis for the construction of actual multicountry econometric models, so that model A can be replaced with more realistic versions.

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