Seminar Paper No. 28

A MACROECONOMIC MODEL WITH ASSET
EQUILIBRIUM FOR AN OPEN ECONOMY

by

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December, 1973

There are four markets in this model: the output market, the credit market, the money market and a market for real capital assets (eliminated). There are three prices: the credit market interest rate, the general price level and the price of real capital assets. The latter is defined as the market value of a unit of real capital.

The output market is described by the following equation (see next page for notations).

$$(1) \quad F^D(i, P/p, \frac{W}{p}) + \frac{G}{p} - Tr(p) - F^S(K) = 0$$

The real private demand for output is a function of the interest rate, the asset price in real terms and total real wealth. Government demand for output is assumed to be exogenously determined in nominal terms. Exports are also exogenous and imports are a function of the price of domestic output relative to the price of foreign output.

The supply of output is a function of the real capital stock, which is defined as the sum of human and non-human capital.

The credit market is an aggregation of the bank loan market and the government bond market. It can be regarded as a market where the public exchanges an asset, which is a government bond and/or an IOU, against money from the banks.¹

The excess demand for credit is then

$$(2) \quad E^D(i, P/p, W/p, S) + E_X^D(i, P/p) - E_I^S(i, P/p, \frac{W}{p}) - E^S(i, B) = 0$$

The first part of this equation is the domestic demand for credit (or the public's supply of assets to the banking sector). The second part, E_X^D , is the foreign demand for domestic credit. It

1. For a more detailed description of this aggregation, see Brunner and Meltzer [1968].

is also a function of the foreign wealth position, but that is assumed to be constant. The third part is the domestic demand for foreign credit, and E^S , finally, is the supply of credit from the banking system, or the banks' demand for earning assets.

Equation (2) is the general form of the credit market equation in analogy with the output market equation. The normal procedure in all one-sector models is to have one good which is produced both at home and abroad but with different prices. Theoretically, at the microlevel, if two goods are aggregated to one good their relative prices should be constant. In the aggregate for a whole economy, however, it might be a valid approximation for many problems to assume that the commodity bundle in one country is the same as the commodity bundle in the rest of the world (or as in the countries of its trading partners), but that the relation between the general price levels in the two economic regions are variable.

The reason for the possibility of a variable relative price of this type must of course be the existence of adjustment costs and/or government interference in the form of import quotas or the like. The problem then becomes a question of how long it will take for all adjustments to be made. We will comment on this later.

In the model in this paper the equation describing the credit market is constructed in a similar way as for the output market. Therefore, the same problem of aggregation and substitutability exists in principle, although it seems reasonable to assume a much shorter adjustment period for the credit market than for the output market.

To avoid unnecessary complications the credit market will be treated in the following way. First, the model is solved with a credit market with only one domestic asset which means that there is zero substitutability with foreign credit. This version of the model can also be interpreted as having *some* substitutability since this will not affect the qualitative results. It will only affect

the size of the effects, not the direction. Finally the model is analyzed with the assumption of perfect substitutability, which is the same as what is called perfect capital mobility. In this case there is only one asset on the credit market, the international asset.

The money market equation is

$$(3) \quad M^D(i, P/p, \frac{W}{p}) - M^S(i, B) = 0$$

The model also contains an equation describing the budget restriction for the government sector:

$$(4) \quad \Delta B = G - p \cdot T - \Delta S \frac{1}{i} - p \cdot Tr + \Delta E_X^D - \Delta E_I^S$$

This equation shows that an increase in the monetary base can come from the government budget deficit minus the amount that is financed by bond issues and/or from an increase in foreign reserves. This formulation also says that, since taxes and foreign trade are endogenous, the government sector cannot set G , ΔB and ΔS independently. In this paper the government determines G and ΔS while B is an endogenous entity. The government can make changes in B , but it cannot determine the total change in B independent of its choices for G and ΔS .

Equations (5) and (6), finally, define taxes and real wealth.

$$(5) \quad T = teK$$

$$(6) \quad \frac{W}{p} = \frac{P}{p}K + \frac{S}{ip} + \frac{B}{p}$$

The model, as it now stands, is undetermined. This is due to the fact that the long-run equilibrium conditions have not yet been specified. For a stationary state solution all stocks must be constant in equilibrium. Therefore we impose that

$$\Delta E_X^D = \Delta E_I^S = \Delta B = \Delta S = 0$$

But even the capital stock has to be stationary. One way to introduce this condition is to observe that

$$\Delta K = 0 \rightarrow p = P$$

in this type of model where there is only one output good. Therefore we have the long-run equilibrium condition of

$$p = P$$

Substituting equations (5) and (6) into the rest of the equations and using the equilibrium conditions, the model written as excess demand functions is

$$(7) \quad F(i, p, \frac{W}{p}, K) + \frac{G}{p} = 0$$

$$(8) \quad E(i, \frac{W}{p}, S, B) = 0$$

$$(9) \quad M(i, \frac{W}{p}, B) = 0$$

$$(10) \quad Tr(p) = \frac{G}{p} - T$$

This is now a model with four equations and four unknowns: i , p , B and K .

III. Effects of Economic Policy

To investigate the effects of monetary and fiscal policy the model has to be differentiated and solved for the effects of changes in policy parameters. For this purpose an extra assumption is made, namely that there are no wealth effects on the credit market. The reason for this assumption is that it is difficult even in theory to derive the direction of this effect.² All other assumptions concerning signs of partial derivatives are in the Appendix.

2. See the discussion in Brunner and Meltzer [1972a].

First, the entire model is solved for some parameter changes. Then the model is changed so as to represent different special cases, and is solved again. In this way, with this method of analysis, the importance of different model specifications can be analyzed.

Let us first look at the effects of a government budget deficit. It is assumed that the government increases its expenditures and that it finances this by an increase in either base money or government securities. This statement is unambiguous in the one-period case. However, in the many-period case, or in the stationary state, further specification is necessary. If the budget is not automatically balanced from period two and on by the reaction of the economy, an assumption has to be made as to how the deficit is financed in all the following periods. It will be assumed here that the government increases its expenditures, financing this with a bond issue, and keeps G and S constant period after period. The alternative would have been to assume that every positive difference between G and T in every period is financed by issuing more bonds. Consider, e.g., an open market operation. If the central bank sells government securities and if the result is deflationary so that the government budget is in deficit would it not then seem to be more natural to assume that base money increases rather than that the stock of securities will continuously increase? Of course, if there is a pegged interest policy, then the change in government securities becomes an endogenous variable.

In solving a model of this type it is not easy to get determinate signs. One possible shortcut is to compute the effects of a bond-financed budget deficit and a base-financed deficit and then deduct the second from the first to get the effect of an open market sale of bonds.

$$dG + dS/i - (dG + dB) = dS/i - dB$$

Since the main interest is on the effects of pure monetary policy, as was illustrated by the quotations in the introduction, this is what will be done in the first place.

The effects of an open market sale are then: a decrease in the price level, an increase in the interest rate and an increase in the capital stock.³ This is contrary to Swoboda's statement about zero effects of monetary policy in the long run. It is therefore important to understand under what circumstances this result will appear.

A close inspection of the model shows that this result depends on the existence of the term $\epsilon(E, S) \frac{dS}{S}$, which is the elasticity of the excess demand for credit with respect to an increase in the supply of government securities. The economic interpretation of this phenomenon is that an increase in the amount of government bonds outstanding has a direct effect on the equilibrium in the credit market with repercussions on the rest of the system.⁴

It is interesting to compare this result with an ordinary IS-LM model. In that model the credit market is the eliminated market and therefore an increase in the amount of government bonds is often not recognized. This may not make much difference in the very short run, but in the long run it must be recognized that there are more bonds to be held by asset owners and that this will generally not take place at unchanged asset prices.

One important problem must be treated at this moment of the exposition. This is the problem regarding the length of the long run. It is not just a matter of whether or not stocks are allowed to adjust. It influences the way the model is constructed, as will be shown later on.

Imperfect capital mobility, imperfect goods mobility and a government budget restriction were included in the model that has just been solved. Is their existence consistent with a long-run horizon? If the long run is a couple of hundred years the answer is clearly

3. This is shown in the Appendix.

4. Note that this is not dependent on whether bonds are perfectly discounted or not, since it is not the wealth effect we talk about.

no. Suppose, however, that the horizon is 10-20 years. In that case, the assumption of imperfect capital mobility is clearly totally unrealistic. There is, though, one case in which this assumption may be used; namely, when there is efficient government control of capital movements.

In the case of mobility of goods it is not so obvious which might be the better assumption. On the one hand there are all the goods called non-tradeables. On the other hand, the development in the world in recent years has been toward more and more tradeable goods.

Finally, there is the problem of the government budget deficit. In the new equilibrium there could be a balance-of-payments deficit, which seems to contradict the idea of equilibrium. This is true in the sense that there is one price movement missing, the exchange rate, to help the economy to reach a full equilibrium. It is possible, however, to have a balance-of-payments deficit in the new equilibrium if it is exactly balanced by a government budget deficit. The increase in base money through the budget deficit is exactly balanced by the decrease in base money due to the balance-of-payments deficit. In this case all the other markets remain in equilibrium. This is what Mundell has called "quasi-equilibrium" [Mundell 1968, p. 124], because it can only continue as long as the central bank is willing to lose (or accumulate) reserves.⁵

Let us try to illustrate the discussion in some figures. In figure 1 an ordinary IS-IM model is extended to include a foreign sector in the way that is done in Swoboda [1973] or Branson [1972].

5. It is interesting to consider an alternative. If the surplus countries are willing to substitute the reserves they gain from the deficit countries for government bonds from the deficit countries, these may not necessarily lose any reserves. They only have to issue government securities with an interest rate high enough to attract the surplus countries. Another suggestive idea has been proposed by Allan H. Meltzer: if the surplus countries wish to maintain the surplus, they can buy equities in the deficit countries.

Figure 1

i is equal to the interest rate and Y to real income since the price level is assumed to be fixed. The BP-curve shows all combinations of i and Y that give equilibrium in the balance of payments. Now consider an open market sale of bonds. This will initially shift the LM-curve to $L'M'$. The increase in i and the reduction of Y will lead to a balance of payments surplus, reserve increases and consequently to an increase in the money supply. This means that the LM-curve shifts back again until it reaches the first position, since only at this point will there be an intersection of all three curves at the same time.

Let us now present the model of this paper in an analogous way. In Figure 2 the FF-curve represents the combinations of i and p that gives equilibrium in the output market. In the same way the MM-curve and the EE-curve illustrate equilibrium in the money and credit markets. It should be observed that these curves, as well as those in Figure 1, are drawn for given stocks of assets. An open market sale of bonds will tend to shift both the EE- and the MM-curve upwards. However, in the new equilibrium the capital stock will be larger and the larger capital stock will shift the FF-curve to the left. The new equilibrium is at $i_1 p_1$.

Figure 2

In this case monetary policy had an effect, while it did not in Figure 1. What is the reason for the different results? One important reason is that there is no balance of payments curve in Figure 2. In Figure 1 the BP curve cuts the IS curve in one point and this determines the equilibrium level of i and Y and the money market has to adjust to this equilibrium in the absence of wealth effects in the output market. In Figure 2, on the other hand, there is no balance of payments equilibrium condition. Therefore, the economy is free to move to any new equilibrium situation. Instead of the balance of payments condition there is the government budget constraint. This is illustrated in Figure 3, where the BB-curve is the combination of p and K that satisfies the government budget constraint. To every value of p there is a value of K to ensure this equilibrium. This condition can be interpreted as a stock equilibrium condition. It is important to understand the crucial role of this constraint. In the beginning, its use was more of a consistency check to ensure that the government expenditures, the government securities and the monetary base cannot be determined independent of each other. In this model it is an important equilibrium condition for full asset equilibrium. Therefore, it acts as an important constraint on the working of the rest of the model.⁶

6. The government budget constraint is having the same importance in the Brunner-Meltzer model. See Brunner-Meltzer [1972a].

Figure 3

Let us now impose the condition that the balance of payments has to be in equilibrium. This means that the equilibrium price level becomes determined by the trade balance since there is only one price level that gives this result. At the same time this implies that the equilibrium capital stock is determined since given the price level there is only one level of the capital stock that gives a balanced budget. In Figure 3 the pp line is the equivalent of the BP -curve in Figure 1 (it is a vertical line in the absence of capital mobility), and the KK -line shows the equilibrium capital stock. The BB -curve is reduced to a point.

The BB -curve represents the government budget constraint. For a closed economy this curve would be the straight KK -line if the government fixed its expenditures in real terms. If instead the expenditures would be fixed in nominal terms, then the curve would be a hyperbola with the elasticity approximately equal to -1 . Now, with also the trade balance included the slope of the curve is

$$\frac{-\epsilon(T, K)}{\epsilon(Tr, p) \frac{Tr}{T} + \frac{G}{p \cdot T}}$$

In the case of a closed economy this expression would change into

$$\frac{-\epsilon(T, K)}{\frac{G}{B \cdot T}}$$

which is approximately equal to -1.

However, a country cannot go on like this forever. Therefore, if the horizon for the problem to be studied is longer than the period during which the balance of payments can be allowed to show a continuous surplus or deficit, then the government budget restraint has to be broken up and the extra equilibrium condition (that the demand for foreign exchange is equal to the supply) has to be introduced. In the next section we will study these problems as special cases of our model.

IV. Effects of Economic Policy in Special Cases

Let us first take the case of perfect capital mobility. This means that there is a world market interest rate at which everybody in a small country can borrow and lend freely. Therefore, there is no credit market equation in the model to determine any interest rate.

Solving this version of the model for the effects of an open market sale gives the result that both the price level and the capital stock are unchanged. Perfect capital mobility is obviously a sufficient condition for zero effects of monetary policy in the long run. However, it is not a necessary condition.

Next, to be consequent, the output of goods is assumed to be a perfect substitute for foreign goods. Here the effects of an open market sale are that the interest rate goes up and the capital stock is unchanged and, by assumption, the price level as well. Perfect output substitutability is thus also a sufficient, but not a necessary, condition for zero effects of monetary policy.

Finally, let us break up the government budget constraint. This is the same as introducing the equilibrium condition that supply and demand of foreign exchange have to be equal. At the same time, in the long run this also implies that government expenditures and taxes have to be equal in equilibrium.

Solving the model with the new equilibrium conditions substituted for the government budget constraint and asking the same question about the effects of an open market sale of bonds, we find no effects on the price level or on the capital stock. This is yet another sufficient, but not necessary, condition.

V. Economic Interpretation of the Results

The results which have been produced in several places in this paper are different enough from many of the more well-known statements in the literature to warrant a little more consideration in order to bring out the differences clearly.

Professor Mundell has stated that "...monetary policy under fixed exchange rates has no sustainable effect on the level of income" [Mundell 1968, p. 255]. This statement has been generalized by Alexander Swoboda to hold irrespective of the degree of capital mobility [Swoboda 1973, p. 138]. It seems clear, however, that both statements are derived from the Keynesian income-expenditure model without explicit treatment of asset equilibrium. Ronald McKinnon has tried to consider asset equilibrium and draws the conclusion that in this case the degree of capital mobility makes a difference for "inside" monetary policy (open market operation) but that it makes no difference for "outside" monetary policy [McKinnon 1969, p. 229]. The latter is a change in the money stock (or base money) brought about without a simultaneous change in the public's holdings of government securities. This can only be accomplished by a government budget deficit. When McKinnon draws this conclusion he has not introduced any government in his model.

All of these statements can be evaluated in our model and its special cases. First of all, it is perfectly clear that monetary

policy can have effects on the economy even in the long run. However, this is not to say that it must have effects, but under certain circumstances, such as imperfect goods and capital (credit) mobility and when the reserves of foreign exchange are allowed to change, then monetary policy has effects even in an open economy under fixed exchange rates. The question then is whether these circumstances will ever occur. Imperfect capital (credit) mobility in the long run seems utterly unrealistic, but let us assume efficient government control of capital movements. Some goods immobility is easier to imagine.

We are then left with the problem of reserve accumulation (or decumulation). Brunner and Meltzer [1972a] as well as Bent Hansen [1973] and many others have stressed the importance of the government budget constraint. In this paper it turns out that in the very long run the government budget constraint for an open economy must be broken up and partly replaced by an equilibrium condition for foreign exchange. However, as pointed out in footnote 5 above, we may very well imagine situations in which a country can have deficits and, more likely, surpluses for many years.

In fact, as Assar Lindbeck has pointed out several times, there is no reason why a deficit country could not issue bonds that are exchanged against the increased reserves in the surplus country. Why should a country be allowed to borrow freely without any charge, or not borrow at all and take the costly adjustment-of-the-economy-medicine instead of borrowing on the lender's conditions?

We are now in a position to explain the divergent results cited earlier. It should be clear from our exposition that Swoboda's result in a crucial way depends on two assumptions, namely that government bonds are perfectly discounted and that there is an equilibrium condition for the foreign exchange market. The Bretton Woods system has made it possible for countries to avoid this for a considerable time. By not introducing this equilibrium condition McKinnon reaches his conclusion that open market operations have an effect on the economy in the absence of perfect capital mobility, but otherwise not. However, his conclusion about what he calls out-

side monetary policy is not correct because the money supply can only increase in this way through a budget deficit and then the effect will once more depend on the degree of capital mobility in the absence of an equilibrium condition for foreign exchange.

Finally, to check the importance for the results of having interest payments on the government debt explicitly in the government budget constraint the model has been solved after this modification. The result is now less unambiguous but it seems to be that all the effects go in the same direction as before, although they are smaller.

VI. Conclusions

In this paper the problem that has been treated is whether monetary policy has any effects in the long run in an open economy under fixed exchange rates. First, some care was taken in formulating the proper model specification for this purpose. This was necessary, since many earlier conclusions about long run effects were drawn from short-run models.

The main conclusions are that monetary policy may have effects under certain circumstances, but that there are also sufficient conditions for no effects. These are perfect capital (credit) mobility, perfect goods mobility and equilibrium in the market for foreign exchange. Each one in itself is a sufficient condition. In other words, if there is a government budget restriction explicitly introduced in the model, then the degree of capital mobility makes a difference, otherwise not.

Appendix

The model in the text is here differentiated, converted into elasticities and written in matrix form. We then have

$$\begin{bmatrix} -\epsilon(F,W)b - \epsilon(F,W)c + \epsilon(F,p) - \frac{G}{p \cdot F} & \epsilon(F,i) - \epsilon(F,W)c & \epsilon(F,W)a + \epsilon(F,K) & 0 \\ 0 & \epsilon(E,i) & 0 & \epsilon(E,B) \\ -\epsilon(M,W)b - \epsilon(M,W)c & \epsilon(M,i) - \epsilon(M,W)c & \epsilon(M,W)a & \epsilon(M,B) \\ \epsilon(Tr,p)\frac{Tr}{T} + \frac{G}{p \cdot T} & 0 & \epsilon(T,K) & 0 \end{bmatrix}$$

$$\begin{bmatrix} \frac{dp}{p} \\ \frac{di}{i} \\ \frac{dK}{K} \\ \frac{dB}{B} \end{bmatrix} = \begin{bmatrix} -\epsilon(F,W)b \frac{d\alpha}{B} - \epsilon(F,W)c \frac{d\alpha}{S/i} - \frac{dG}{G} \frac{G}{p \cdot F} \\ -\epsilon(E,B) \frac{d\alpha}{B} - \epsilon(E,S) \frac{d\alpha}{S/i} \\ -\epsilon(M,W)b \frac{d\alpha}{B} - \epsilon(M,B) \frac{d\alpha}{B} - \epsilon(M,W)c \frac{d\alpha}{S/i} \\ \frac{dG}{G} \frac{G}{p \cdot T} \end{bmatrix}$$

$\epsilon(y,x)$ is the elasticity of y with respect to x .

$$\begin{aligned} \text{where} \quad a &= \frac{K}{W/p} & d\alpha &= dB = dS/i = dG \\ b &= \frac{B/p}{W/p} \\ c &= \frac{S/i \cdot p}{W/p} \end{aligned}$$

The following signs are assumed:

$$\epsilon(E,S), \epsilon(F,W), \epsilon(M,W), \epsilon(Tr,p) > 0$$

$$\epsilon(E,B), \epsilon(M,B) = -1, \epsilon(T,K) = 1$$

$$\epsilon(F,i), \epsilon(F,K), \epsilon(E,i), \epsilon(M,i) < 0$$