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MONETARY AND EXCHANGE RATE POLICIES IN
AN OPEN MACROECONOMIC MODEL WITH
UNEMPLOYMENT AND RATIONAL EXPECTATIONS

by

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Abstract

A two period, two good open economy macroeconomic model is constructed. There is excess supply of labour in both periods and agents have rational expectations about future variables. Money is also introduced explicitly into the analysis. A number of exchange rate regimes are possible, and in each of these the effects of monetary and exchange rate policies are analyzed.

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MONETARY AND EXCHANGE RATE POLICIES IN AN OPEN MACROECONOMIC
MODEL WITH UNEMPLOYMENT AND RATIONAL EXPECTATIONS

For a long time, certainly since Keynes's 'General Theory', the importance of expectations for macroeconomics has been widely recognised. However, there have been changes in the assumptions made about how expectations are formed. Keynes, it may be argued, assumed exogenous expectations; since then, expectation formation has been endogenised in a number of ways. Initially, the tendency was to assume that expectations were formed adaptively; nowadays an assumption of rational expectations seems more or less universal.

There have also been some advances since Keynes in the modeling of underemployed economies; the work of Barro and Grossman (see, for example, Barro/Grossman (1976)) has provided a more rigorous basis for the analysis of economies characterised by non-market clearing, and this framework has been extended in several directions. In particular, a number of authors have sought to build open economy models of this type (see, for example, Dixit (1978), Neary (1980), Cuddington et al. (1984)). However, in spite of the widely recognised importance of expectations, particularly in open economies, they have received only rudimentary treatment in this literature. An important exception is Neary/Stiglitz (1983), who introduce rational expectations into a temporary equilibrium with rationing framework. In models characterised by market clearing, it is usually sufficient for agents to formulate expectations about future prices; however,

in a model where some markets may fail to clear, it will usually be necessary for agents to form expectations over quantities as well. In the Neary/Stiglitz paper, the concept of rational constraint expectations is introduced, and it is shown that, in general, the effectiveness of stabilization policy is enhanced, rather than diminished, when expectations are rational (compared with the situation when they are static).

The main aim of this paper is to analyse the behaviour of an open economy, characterized by unemployment, under the influence of rational expectations about future economic variables. For this purpose, it is necessary to use an intertemporal analysis; accordingly, a two-period framework is developed. Some recent papers have analysed open economy models based on such an approach; examples are Aizenman (1983), Greenwood (1983), Persson and Svensson (1983) and Cuddington and Vinals (1984). There now seems to be widespread agreement that a number of issues in macroeconomics are most appropriately tackled in such a framework. However, both Aizenman and Greenwood develop models with market-clearing in both periods; the Cuddington/Vinals paper has non-market clearing in just the first period and whilst the Persson/Svensson paper considers non-market clearing in both periods and develops a model which is similar in some respects to that presented here, the authors are concerned with rather different questions.

So our analysis will concern an economy in which two periods (the present and the future, or periods one and two) are distinguished. We follow Neary (1980), Cuddington/Vinals (1984), Persson/Svensson (1983) and others in distinguishing between

two domestically produced goods, a tradeable and a non-tradeable. The tradeable can be bought and sold on world markets at a given world currency price (this will be normalized to unity in what follows). Output of the non-tradeable is assumed to be demand determined and its price in both periods is fixed. There is unemployment in both periods (we are hence concerned with what is often described as a situation of Keynesian unemployment). Employment is determined through the production technology from the output of the two goods. A constant money wage in each period is assumed; by appropriate choice of units this is equated to unity in both periods. We also introduce money into the model; as well, agents can borrow and lend on the world market at a given real interest rate (defined in terms of the tradeable). Consumption behaviour is derived through the maximisation of an intertemporal utility function subject to the appropriate budget constraint. The exchange rate may be fixed or flexible in each period; hence, there are four combinations of exchange rate regimes to be considered. In each of these, the effects of monetary policy (actual and anticipated) and, where appropriate, exchange rate policy (actual and anticipated) will be analysed. We shall be primarily concerned with the effects on current period variables.

In the first main section of the paper, the model will be described in more detail; in the following section it is used to analyse monetary and exchange rate policies, and there is a concluding section.

It will be assumed that the representative consumer maximizes a utility function of the form:

$$U = \alpha \log c_1 + \beta \log n_1 + \gamma \log(L_1/P_1) \quad (1)$$

$$+ \Delta[\alpha \log c_2 + \beta \log n_2 + \gamma \log(L_2/P_2)]$$

where c_i is consumption of the tradeable in period i
 n_i is consumption (and output) of the non-tradeable
in period i
 L_i is money holdings in period i
 P_i is the appropriate price index for evaluating
money balances.

The incorporation of real money balances into the utility function may not be fully satisfactory; however, it seems that there is no entirely appropriate way of introducing the demand for money into macroeconomic models based on a maximizing approach; the procedure adopted here does have the advantage of generating some interest sensitivity in the demand for money, something not done by the main alternative, the 'cash in advance' approach. The utility function is maximized subject to the following budget constraint:

$$\Omega = L_1 + e_1 c_1 + q_1 n_1 + \frac{e_1 \{L_2 - L_1 + q_2 n_2 + e_2 c_2\}}{e_2(1+r^*)} \quad (2)$$

where
$$\Omega \equiv \bar{L}_1 + Y_1 + \frac{e_1}{e_2(1+r^*)} (\bar{L}_2 + Y_2) .$$

$$Y_i \equiv e_i t^s(e_i) + q_i n_i \quad i = 1, 2$$

e_i is the domestic currency price of the tradeable in period i (and also, given the normalization assumption, the exchange rate in the relevant period)

q_i is the price of the non-tradeable in period i .

r^* is the world rate of interest.

$\bar{L}_i$ is the money transferred to the consumer at the beginning of period i .

Y_i is (nominal) income received during period i .

$t^s(\cdot)$ is the domestic supply function of tradeables.

The budget constraint can be explained as follows: in each period the consumer receives a certain transfer of money from the government and receives income generated from the sale of tradeables and non-tradeables (it is assumed that all income so generated accrues to the consumer). The present value of these receipts is designated ' Ω ' and will sometimes be referred to as 'wealth'. Nominal income is defined to be the sum of the values of tradeable and non-tradeable output. Tradeable output depends solely on the domestic currency price of tradeables (this is as might be expected on the basis of profit maximizing, price-taking behaviour by producers with one variable factor of production, labour, the price of which is normalised to unity).

The discount term can be explained in the following way: one unit of domestic currency will buy $(1/e_1)$ units of foreign currency this period. Invested at the foreign interest rate,

this will produce $(1/e_1)(1+r^*)$ units of foreign currency in the next period, which can be exchanged to produce $(e_2/e_1)(1 + r^*)$ units of domestic currency. The discount factor is hence the reciprocal of this.

The income generated in the first period plus the money transferred to the consumer is allocated either to consumption goods, or to money holdings, or to foreign assets. In the next period, the consumer realises his foreign assets, receives another money transfer $(\bar{L}_2)$ and income of Y_2 . He also brings forward money holdings from the first period. He allocates these resources either to consumption expenditure or to increasing his money holdings.

By maximizing (1) subject to (2), using standard techniques, we can derive the following equations:

$$c_1 e_1 = X\Omega \quad (3)$$

$$n_1 q_1 = \left(\frac{\beta}{\alpha}\right) X\Omega \quad (4)$$

$$c_2 e_1 = (1 + r^*) \Delta X\Omega \quad (5)$$

$$n_2 q_2 = \frac{\beta}{\alpha} (1 + r^*) \frac{e_2}{e_1} X\Omega \quad (6)$$

$$\alpha L_1 = \frac{\gamma X\Omega}{\{1 - e_1/e_2(1 + r^*)\}} \quad (7)$$

$$\alpha L_2 = \frac{e_2}{e_1} \gamma (1 + r^*) X\Omega \quad (8)$$

$$\text{where } X \equiv [(1 + \beta/\alpha)(1 + \Delta) + 2\gamma/\alpha]^{-1}$$

Current expenditure on both goods is proportional to wealth; this is as expected, given the logarithmic utility function. Equation (7) shows that the (current) demand for nominal money balances depends both on wealth and the nominal interest rate. In fact, the interest rate affects current money demand in two ways, since wealth depends on the interest rate as well, through the discount factor.

The above equations generate the consumer's demands for goods and money as functions of prices and wealth, which he treats as parametric.

Since wealth depends on non-tradeable output, n_1 appears on both sides of equation (4) and n_2 on both sides of equation (6). This represents a type of multiplier process: anything which leads to increased spending on the non-tradeable raises income and this leads to further spending on the non-tradeable, and so on. It would be desirable to eliminate n_1 and n_2 from the right hand sides of equations (3) to (8); we do this by substituting equations (4) and (6) into the expression for Ω . Doing this, and solving, we derive

$$X\Omega = K\phi \quad (9)$$

$$\text{where } K = (1 + \Delta + (2\gamma/\alpha))^{-1}$$

$$\text{and } \phi = \bar{L}_1 + e_1 t^s(e_1) + \frac{e_1 \{\bar{L}_2 + e_2 t^s(e_2)\}}{e_2(1 + r^*)}$$

Equation (9) can hence be substituted into equations (3) to (8) to give demand for goods and money in both periods as functions of e_1 , e_2 , $\bar{L}_1$ and $\bar{L}_2$ (since changes in q_1 , q_2 and r^* are not

considered in this paper, we treat these variables as parameters).

We can also calculate the partial derivatives of the functions with respect to the relevant arguments. This gives

$$c_1 = c_1(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (11)$$

$$c_{11} \geq 0 \quad c_{12}, c_{13}, c_{14} > 0$$

$$n_1 = n_1(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (12)$$

$$n_{11}, n_{12}, n_{13}, n_{14} > 0.$$

$$c_2 = c_2(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (13)$$

$$c_{21} \geq 0, c_{22}, c_{23}, c_{24} > 0$$

$$n_2 = n_2(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (14)$$

$$n_{21} \geq 0, n_{22}, n_{23}, n_{24} > 0 \quad (15)$$

$$L_1 = L_1(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (16)$$

$$L_{11} > 0, L_{12} \geq 0, L_{13}, L_{14} > 0$$

$$L_2 = L_2(e_1, e_2, \bar{L}_1, \bar{L}_2) \quad (17)$$

$$L_{21} \leq 0 \quad L_{22}, L_{23}, L_{24} > 0$$

where L_{ij} represents the partial derivative of L_i with respect to its j th argument, and similar notation is used for the other functions. Some of the calculations used in signing the partial

derivatives are given in Appendix I.

It is apparent from equations (3), (4) and (9) that the value of current expenditure on the two goods is proportional to ϕ . It follows that since a current depreciation of the exchange rate (a rise in e_1) raises ϕ , it must raise the value of current expenditure on both tradeables and non-tradeables; it therefore also raises the volume of non-tradeable consumption, although the effect on tradeable consumption is ambiguous (because there is a price effect going in the opposite direction). The effect of a future depreciation on current expenditure depends, again, entirely on its effect on ϕ ; we assume here that the effect is positive (a condition for this is given in the Appendix). A depreciation of the current exchange rate unambiguously increases the current demand for money, since it both raises ϕ and reduces the nominal interest rate. A future depreciation, however, is ambiguous in its effect; by raising the current interest rate, it tends to reduce the current demand for money, whereas by raising ϕ , it tends to raise it. A criterion for positivity is given in the Appendix. The effect is more likely to be positive, the higher the supply elasticity of tradeables. It can be noted also that increases in $\bar{L}_1$ and $\bar{L}_2$, for given e_1 and e_2 raise ϕ and hence increase demand for both goods and for money in both periods.

So far, we have characterised the demands of the representative consumer (whose demands hence represent those of the economy) as functions of the exchange rate and monetary transfer in each period. The next task is to characterise the nature of the equilibrium for the whole economy and to consider the effects of changes in some of the exogenous variables.

II

It is necessary first of all to specify the exchange rate regime in each period; it is assumed that each period's rate can either be freely floating or fixed, and it hence follows that there are four combinations of exchange rate regimes to analyse. Each will be examined in turn, and the effects of monetary and exchange rate policies in each combination of regimes will be discussed.

1. Exchange Rates Flexible in Each Period

This is characterised by the following equations:

$$L_1(e_1, e_2, \bar{L}_1, \bar{L}_2) = \bar{L}_1 \quad (18)$$

$$L_2(e_1, e_2, \bar{L}_1, \bar{L}_2) = \bar{L}_1 + \bar{L}_2 \quad (19)$$

Here, the exchange rates adjust in order to ensure that the demand for money in each period is equated to the exogenously given supply ($\bar{L}_1$ in period 1, $\bar{L}_1 + \bar{L}_2$ in period 2). With e_1 and e_2 determined, the output and consumption of each good can be calculated in a straightforward manner. Tradeable output, for example, follows from the relevant exchange rate in each period through the tradeable supply function. We are interested here in the effects of changes in $\bar{L}_1$ and $\bar{L}_2$. Accordingly, we totally differentiate the above system of equations and solve for changes in the exchange rate in terms of changes in the money supplies; details are given in the Appendix.

The most surprising result here seems to be the strong possibility (a sufficient condition for which is that $L_{12} > 0$)

that a future monetary expansion results in an appreciation of the current exchange rate. This is in sharp contrast to virtually all other models which have looked at this link : 'The fact that an increase in the expected future money supply should lead to a depreciation of the current exchange rate ... is a ubiquitous conclusion of simple monetary approach models' (Greenwood (1983) p. 551). The explanation is quite straightforward, though. The increase in the future money supply may result in a depreciation of the future exchange rate. This raises the current interest rate, reduces the demand for money and hence tends to depreciate the current exchange rate - this is the channel stressed by conventional models. However, in the current model, there are forces going in the opposite direction. The increase in the future money supply raises wealth, and hence the current demand for money. Also, any future depreciation of the exchange rate will tend to raise future economic activity, hence future income and wealth, and so raise the current demand for money. This results in an appreciation of the current exchange rate. This is more likely to happen, the higher the supply elasticity of tradeables, as is apparent from the condition for positivity of L_{12} (as already noted, the magnitude of this elasticity is crucial in determining the sign and magnitude of $\partial\phi/\partial e_2$).

If, indeed, the current exchange rate does appreciate in response to a future monetary expansion, then, current output of tradeables falls. However, since wealth rises, consumption of both the tradeable and the non-tradeable rises. The balance of trade hence deteriorates whereas the effect on overall employment is ambiguous; employment in tradeable production rises whereas employment in non-tradeable production falls.

If, on the other hand, the current exchange rate does depreciate in response to the anticipated monetary expansion, then tradeable output must rise. Non-tradeable output rises as well, provided that wealth rises, as will consumption of tradeables.

The effects of an increase in $\bar{L}_1$, the current money supply, seem more straightforward. It seems reasonable to suppose that it will result in a depreciation of the current exchange rate; in these circumstances both tradeable and nontradeable output (and consumption) rise, although it seems difficult to sign the overall effect on the balance of trade.

We can also compare the effects of a permanent monetary expansion with those of a temporary one. Analytically, this is equivalent to an increase in $\bar{L}_1$ accompanied by an equal and opposite change in $\bar{L}_2$. On the assumption that $\partial e_1 / \partial \bar{L}_2 < 0$, it is apparent that a temporary monetary expansion has a greater effect on the current exchange rate, and hence results in a greater increase in tradeable output. However, the increase in both tradeable and non-tradeable consumption is less with a temporary increase (as the increase in wealth is lower), so the balance of trade is more likely to improve; the (differential) effect on employment is unclear, though.

2. Fixed Exchange Rates in Each Period

With fixed exchange rates in each period, the levels of output of the tradeable can be inferred from the relevant exchange rate, whereas consumption of (and output of) the non-tradeable can be deduced from knowledge of both periods' exchange rates and monetary transfers.

The actual money supplies in each period will be determined endogenously via the balance of payments:

$$L_1(\bar{e}_1, \bar{e}_2, \bar{L}_1, \bar{L}_2) = L_1 \quad (20)$$

$$L_2(\bar{e}_1, \bar{e}_2, \bar{L}_1, \bar{L}_2) = L_2 \quad (21)$$

Effects on the money supplies in each period can be derived quite simply by differentiating the appropriate equation with respect to the relevant argument.

Increases in current and future monetary transfers (which can be described as monetary policy) have predictable effects.

By increasing Ω , they increase current demand for tradeables and non-tradeables without affecting tradeable output. Monetary policy is hence expansionary, and leads to a deterioration in the current balance of trade. The effect it has on the current balance of payments depends very much on the period in which the monetary expansion occurs. With a current monetary expansion, a deterioration in the overall balance of payments is to be expected ($\partial L / \partial \bar{L}_1 < 1$); the increase in the monetary transfer is less than the increase in the demand for money, and economic agents dispose of the excess through the balance of payments, either by buying foreign goods or foreign assets. A future increase in the money supply will, however, improve the balance of payments; the current demand for money rises, but the domestic component of the current money supply is unchanged. It follows that the increase in the amount of money demanded must be generated through the balance of payments. Since the balance of trade deteriorates, there must be an improvement in the capital account which more than offsets this.

Turning now to the effects of a future devaluation, we see that, on the assumption that it raises wealth, it will raise consumption of both goods, and therefore be expansionary and worsen the balance of trade. Whether the balance of payments improves depends on whether the demand for money increases, and this, in turn, depends on the sign of L_{12} . The anticipated devaluation raises the interest rate; this reduces the demand for money (and thus tends to worsen the balance of payments); however, it also raises future income and this, through its effect on wealth, tends to raise the demand for money and hence improve the balance of payments. A net improvement in the balance of payments is hence more likely, the higher the supply elasticity of tradeables.

A current devaluation must, however, be expansionary; this follows since it raises ϕ (see equation A-1) and so the demand for non-tradeables rises. Since it also raises the demand for money, the balance of payments must improve, although the effect on the balance of trade is unclear. These results are not surprising; however, the result that devaluation cannot be contractionary does run counter to some recent literature (e.g. Krugman/Taylor (1978)), which has suggested that devaluation may, under certain circumstances, be contractionary. It is true that some of the conditions under which this might happen are excluded by assumption (there are no income redistributional effects, for example), but some are not. It is possible for the value of imports to exceed the value of exports in the first period, and the real value of monetary transfers is certainly reduced by the devaluation. Nevertheless, devaluation cannot have a contractionary effect in this model. There would seem

to be two possible explanations: one is that a contractionary effect is ruled out because of something in the specific functional forms used here; the other is that the possibility disappears when an explicit maximizing intertemporal approach is adopted.

It may be noted that the devaluation discussed here might be described as a temporary devaluation, in that the future exchange rate is unaffected. It would be straightforward to analyse the effects of a permanent devaluation (i.e. one in which the future exchange rate is devalued as well).

3. Current Exchange Rate Flexible, Future Exchange Rate Fixed

This regime can be characterised by the following equations:

$$L_1(e_1, \bar{e}_2, \bar{L}_1, \bar{L}_2) = \bar{L}_1 \quad (22)$$

$$L_2(e_1, \bar{e}_2, \bar{L}_1, \bar{L}_2) = L_2 \quad (23)$$

In the first period the exchange rate is endogenous and adjusts to ensure money market equilibrium. In the second period, with a fixed exchange rate, the money supply adjusts endogenously through the balance of payments to ensure money market equilibrium. The regime may be of relevance in a situation where a government has allowed the currency to float but has announced a return to a fixed parity. The above pair of equations is solved in the Appendix for changes in the endogenous variables in terms of the exogenous variables. The effects of a current monetary expansion are, as might be expected, a depreciation in the current exchange rate and an increase in the future money stock. The effects of a future monetary expansion are perhaps of greater interest. The consequence

is an unambiguous appreciation of the current exchange rate. The explanation is that the future monetary expansion increases wealth both directly and through the associated effects on spending on the non-tradeable in both periods, and this, in turn, increases the current demand for money. With a flexible exchange rate, this must result in an appreciation of the currency. Tradeable output falls, but consumption of both goods rises; the balance of trade hence deteriorates. There is no ambiguity here, as there was in the first regime, because the future exchange rate is fixed and hence there is no possibility that the demand for money, at the initial exchange rate, can fall because of an increase in the interest rate.

The effect of a future devaluation of the exchange rate is ambiguous, though. It does tend to raise future economic activity and hence wealth, so tending to appreciate the current exchange rate. But the anticipated devaluation means an increase in the interest rate, tending to reduce the demand for money and therefore tending to depreciate the exchange rate. The overall effect depends upon which of these factors dominates. If the exchange rate does depreciate, then current tradeable output rises. Non-tradeable output rises if and only if $d\phi/d\bar{e}_2 > 0$. If the exchange rate appreciates, then current tradeable output falls. But both tradeable and non-tradeable consumption rise (since wealth must rise in this case), so that the balance of trade unambiguously deteriorates.

4. Current Exchange Rate Fixed, Future Exchange Rate Flexible

This regime is characterized by the following equations:

$$L_1(\bar{e}_1, e_2, \bar{L}_1, \bar{L}_2) = L_1 \quad (24)$$

$$L_2(\bar{e}_1, e_2, \bar{L}_1, \bar{L}_2) = L_1 + \bar{L}_2 \quad (25)$$

The money stock is determined endogenously in the first period. In the second period, the money stock equals that inherited from the previous period, plus any monetary transfer; the exchange rate adjusts in order to ensure money market equilibrium in this period. In the Appendix, the above system is solved for changes in the endogenous variables in terms of the exogenous ones. We shall, as before, concentrate on first period effects.

A current devaluation of the exchange rate increases the current demand for (and hence supply of) money and also results in a future depreciation of the exchange rate. The latter effect is not surprising; the increase in the money stock created by the devaluation is permanent and the future exchange rate adjusts in order to ensure future money market clearing. Since a devaluation increases the current money supply, the current balance of payments must improve. The effect on the balance of trade is not so clear cut; tradeable output increases but so does tradeable consumption. Non-tradeable output also increases, so the devaluation is, as before, expansionary.

Both a current and a future monetary expansion raise the current demand for money, but whereas an increase in $\bar{L}_2$ results in a depreciation of the future exchange rate, the effect of an increase in $\bar{L}_1$ on the future exchange rate is ambiguous.

An increase in $\bar{L}_1$ might be expected to be expansionary, raising non-tradeable output and hence employment. However, tradeable

consumption also rises, so the balance of trade deteriorates. Since the increase in the demand for money is less than the increase in the supply, the overall balance of payments worsens - the economy 'exports' money. Here we have a case where the balance of trade and the balance of payments move in the same direction. However, an increase in $\bar{L}_2$, if it is expansionary in its effect on current output and employment raises tradeable consumption as well as the current demand for money. It follows that the balance of payments must improve, in order to increase the current money stock, whereas the balance of trade worsens.

CONCLUDING COMMENTS

Our main purpose in writing this paper was to develop an intertemporal open macroeconomic model, where agents form rational expectations about future non-market clearing states. In the context of such a model, a number of conclusions about the effects of monetary and exchange rate policies have been drawn. Some of these conclusions confirm results derived using more conventional models; others do not. Perhaps the following conclusions should be emphasised:

1. A future monetary expansion may well result in an appreciation of the current exchange rate. This effect is more likely, the higher the supply elasticity of tradeables. This possibility is due to the assumption that future unemployment may occur; inasmuch as the future monetary expansion is expected to raise future output, income and employment, it will increase the current demand for money, and this, with a given current money stock, results in an appreciation of the current exchange rate.

2. In a fixed exchange rate world, a future devaluation can be either expansionary or contractionary as far as current output and employment are concerned. A criterion for an expansionary effect can be given; expansion is more likely, the higher the supply elasticity of tradeables.

3. A current devaluation will be expansionary, and improve the balance of payments, although the effect on the balance of trade is unclear.

4. A deterioration in the balance of trade may be associated with either an improvement or a deterioration in the balance of payments; the direction of the relationship may well depend upon the nature of the 'shock' responsible. In a fixed rate world, an increase in the current money supply results in a deterioration in both the current balance of trade and the balance of payments, whereas a future monetary expansion creates a worsened balance of trade yet an improved balance of payments.

5. A number of measures will benefit one sector at the expense of the other. For example, a future monetary expansion in Regime 3 will result in an increase in current non-tradeable output whereas current tradeable output will fall (because of an exchange rate appreciation).

6. A number of conclusions can be drawn about the effects of permanent, as opposed to temporary, changes. For example, a permanent devaluation will be more expansionary than a temporary devaluation if and only if the effects of a future devaluation are expansionary.

The model does contain certain features which might attract criticism, in particular the assumption of nominal wage rigidity, the way in which the demand for money is incorporated into the model and the two period nature of the analysis. However, taking the points in reverse order, the two period structure is used so that the influence of the future on the present can be analysed in a fairly tractable way; it is not meant to be descriptive of reality. The assumption that real money balances enter the utility function may not be particularly palatable, but it does generate demand for money functions with reasonable properties, and there seems to be no fully satisfactory theory of the demand for money which can be incorporated into a macroeconomic model. The assumption of money wage rigidity (and the associated rigidity in non-tradeable prices) is used as an analytical device to enable unemployment (excess supply of labour) to be analysed; it is not to be supposed that wages are literally rigid. Inasmuch as prices are not perfectly flexible, it will almost certainly be the case that periods of disequilibrium will occur, and in such circumstances a non-market clearing approach should generate some insight. A more satisfactory theory would explain both price and quantity adjustments in a satisfactory manner. However, we are a considerable way from such a theory at the moment.

It is possible to think of a number of ways in which the present model could be extended. One extension, which it is hoped to pursue in further work, would be to incorporate government expenditure, taxation and the appropriate governmental budget constraint into the analysis.

APPENDIX

Differentiation of ϕ gives:

$$\frac{\partial \phi}{\partial e_1} = t^s(e_1)[1 + \epsilon_{st}] + \frac{\{\bar{L}_2 + e_2 t^s(e_2)\}}{e_2(1 + r^*)} > 0 \quad (A-1)$$

$$\epsilon_{st} \equiv \frac{e_i}{t^s} \cdot \frac{\partial t^s}{\partial e_i} \quad i = 1, 2.$$

ϵ_{st} is hence the supply elasticity of tradeables, and is assumed constant.

$$\begin{aligned} \frac{\partial \phi}{\partial e_2} &= \frac{e_2(1+r^*)[e_1 t^s(e_2)(1 + \epsilon_{st})] - e_1(1 + r^*)(\bar{L}_2 + e_2 t^s(e_2))}{e_2^2(1 + r^*)^2} \\ &= \frac{e_1}{e_2(1 + r^*)} \left[t^s(e_2) \epsilon_{st} - \frac{\bar{L}_2}{e_2} \right] \quad (A-2) \\ &\geq 0 \quad \text{as} \quad \epsilon_{st} \geq \frac{\bar{L}_2}{e_2 t^s(e_2)}. \end{aligned}$$

In the text it is assumed that $\partial \phi / \partial e_2 > 0$, so that $c_{12} > 0$ and $n_{12} > 0$.

Properties of L_1 and L_2

L_1 and L_2 can be written:

$$L_1 = \frac{(1 + r)}{r} K^1 \phi$$

$$L_2 = K^1 \frac{e_2}{e_1} (1 + r^*) \phi$$

where $K^1 \equiv (\gamma/\alpha)K$

and $r \equiv \left\{ \frac{e_2}{e_1} (1 + r^*) - 1 \right\}$

Differentiation and manipulation yield:

$$L_{11} = \frac{K^1(1+r)}{r} \left[\frac{\phi}{e_1 r} + \frac{\partial \phi}{\partial e_1} \right] > 0$$

$$L_{12} = \frac{K^1(1+r)}{r} \left[\frac{\partial \phi}{\partial e_2} - \frac{\phi}{e_2 r} \right] \geq 0$$

$$L_{21} = \frac{K^1(1+r)}{r} \left[\frac{\partial \phi}{\partial e_1} - \frac{\phi}{e_1 r} \right] \geq 0$$

$$L_{22} = \frac{K^1(1+r)}{r} \left[\frac{\partial \phi}{\partial e_2} + \frac{\phi}{e_2 r} \right] > 0$$

$$L_{13} = \frac{K^1(1+r)}{r} \quad L_{14} = K^1 r$$

$$L_{23} = K^1(1+r) \quad L_{24} = K^1 .$$

It will be assumed in what follows that the four last terms are all < 1 .

Regime 1

Totally differentiating the system of equations (18) and (19), and writing the result as a matrix equation, we obtain:

$$\begin{pmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{pmatrix} \begin{pmatrix} de_1 \\ de_2 \end{pmatrix} = \begin{pmatrix} (1 - L_{13})d\bar{L}_1 - L_{14}d\bar{L}_2 \\ (1 - L_{23})d\bar{L}_1 + (1 - L_{24})d\bar{L}_2 \end{pmatrix}$$

Using Cramer's rule, we obtain:

$$\frac{de_1}{d\bar{L}_1} = \frac{(1 - L_{13})L_{22} - (1 - L_{23})L_{12}}{\Delta} \quad (> 0) \quad (A-3)$$

$$\frac{de_1}{d\bar{L}_2} = - \frac{L_{14} L_{22} - L_{12} (1 - L_{24})}{\Delta} \quad (A-4)$$

A sufficient condition for negativity is $L_{12} > 0$.

$$\frac{de_2}{d\bar{L}_1} = \frac{L_{11}(1 - L_{23}) - L_{21}(1 - L_{13})}{\Delta} \quad (> 0)$$

$$\frac{de_2}{d\bar{L}_2} = \frac{L_{11}(1 - L_{24}) + L_{21} L_{14}}{\Delta} > 0$$

$\Delta = L_{11} L_{22} - L_{12} L_{21}$. This can be shown to be positive.

Where a sign appears in brackets it represents the sign which we consider most plausible, although the effect is not unambiguous.

-

Regime 3

Totally differentiating the system of equations (22) and (23), we obtain

$$\begin{pmatrix} L_{11} & 0 \\ L_{21} & -1 \end{pmatrix} \begin{pmatrix} de_1 \\ dL_2 \end{pmatrix} = \begin{pmatrix} (1 - L_{13})d\bar{L}_1 - L_{14}d\bar{L}_2 \\ - L_{12}d\bar{e}_2 \\ - L_{22}d\bar{e}_2 - L_{23}d\bar{L}_1 - L_{24}d\bar{L}_2 \end{pmatrix}$$

Solving, we obtain

$$\frac{de_1}{d\bar{L}_1} = \frac{(1 - L_{13})}{-L_{11}} > 0$$

$$\frac{de_1}{d\bar{L}_2} = \frac{L_{14}}{-L_{11}} < 0$$

$$\frac{de_1}{d\bar{e}_2} = \frac{L_{12}}{-L_{11}} \gtrless 0$$

$$\frac{dL_2}{d\bar{L}_1} = \frac{-L_{11} L_{23} - L_{21}(1 - L_{13})}{-L_{11}} > 0$$

$$\frac{dL_2}{d\bar{L}_2} = \frac{-L_{11} L_{24} + L_{14} L_{21}}{-L_{11}} \quad (> 0)$$

$$\frac{dL_2}{d\bar{e}_2} = \frac{-L_{11} L_{22} + L_{12} L_{21}}{-L_{11}} > 0$$

Regime 4

Total differentiation of the system of equations (24) and (25) yields the following matrix equation:

$$\begin{pmatrix} 1 & -L_{12} \\ 1 & -L_{22} \end{pmatrix} \begin{pmatrix} dL_1 \\ de_2 \end{pmatrix} = \begin{pmatrix} L_{11}d\bar{e}_1 + L_{13}d\bar{L}_1 \\ + L_{14}d\bar{L}_2 \\ L_{21}d\bar{e}_1 + L_{23}d\bar{L}_1 \\ + (L_{24} - 1)d\bar{L}_2 \end{pmatrix}$$

$$\frac{dL_1}{d\bar{e}_1} = \frac{-L_{11}L_{22} + L_{12}L_{21}}{L_{12} - L_{22}} \quad > 0$$

$$\frac{dL_1}{d\bar{L}_1} = \frac{-L_{13}L_{22} + L_{23}L_{12}}{L_{12} - L_{22}} \quad (> 0)$$

$$\frac{dL_1}{d\bar{L}_2} = \frac{-L_{14}L_{22} + (L_{24} - 1)L_{12}}{L_{12} - L_{22}} \quad (> 0)$$

$$\frac{de_2}{d\bar{e}_1} = \frac{L_{21} - L_{11}}{L_{12} - L_{22}} \quad (> 0)$$

$$\frac{de_2}{d\bar{L}_1} = \frac{L_{23} - L_{12}}{L_{12} - L_{22}} \quad (> 0)$$

$$\frac{de_2}{d\bar{L}_2} = \frac{(L_{24} - 1) - L_{14}}{L_{12} - L_{22}} \quad (> 0)$$

We assume $L_{12} - L_{22} < 0$ (the precise criterion for this can be deduced from the formulae given earlier). In most of the above cases, the sign is the one which is considered most plausible.

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