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EXCHANGE RATE FLEXIBILITY AND THE TRANSMISSION OF BUSINESS CYCLES

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ABSTRACT

This paper presents a very simple model of the effects of flexible exchange rates in the transmission of business cycles. The starting point is the traditional "locomotive" effect, through exports and imports. Aside from this horizontal transmission, the intertemporal exchange rate model presented here allows for the effect of future internal shocks on home income (horizontal transmission) as well as for the effect of future external shocks on home income (diagonal transmission). These channels highlight the role of flexible rates and follow from an intertemporal constraint on the trade balance.

In the presence of foreign-held debt, furthermore, the locomotive effect can be reversed, so that a foreign boom can cause a recession at home. The determinants of the debt ceiling are derived.

The model is simulated in the case of two symmetric countries with constant values for the policy variables and the interest rates at home and abroad.

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Introduction

As economies of similar size become increasingly open to international trade in goods and assets, business cycles in one country are transmitted to the others and vice-versa. Throughout the prosperous sixties, it was well understood that the then prevailing international economic order was generating structural as well as policy interdependence among industrial countries. But it was also thought that moving to a system of exchange rate flexibility could decrease interdependence.

Instead, over the last ten years, interdependence among industrial countries has increased and it has also spread to middle-income countries. Few national economies have been insulated from external shocks. No doubt, the global supply shocks of the 1970s, especially the oil shocks, played an important role in the transmission process. However, the focus of this paper is on the role of flexible exchange rates. We analyze it first by means of a theoretical model. In the second part of the paper, we simulate the transmission of demand shocks across countries in a world with floating rates.

In order to focus on the international transmission of business cycles, we develop a model different from the standard monetary and asset market approaches, reviewed, for example, in Jones and Kenen (1984). While fully consistent with the emphasis on stock equilibria that characterizes both approaches, the model presented below allows us to study the transmission of business cycle across countries more directly. As in Meerschwam (1982), a requirement of intertemporal balance of the balance of trade is used to determine the exchange rate. Having determined the exchange rate, comparative static results can then show the effects of, for instance, a current or expected foreign cyclical upturn on the home economy. Hence, it will be possible to see in an intertemporal set-up under what conditions the foreign country acts as a "locomotive" to pull the home economy along.

1. The Model

The interaction of goods and asset markets in the determination of a floating exchange rate appears, in different ways, in the two popular models of exchange rate determination. In the monetary model, perfect goods arbitrage ensured purchasing power parity. In the portfolio model, trade in goods determined the long-run equilibrium level of the exchange rate. In our presentation asset accumulation is tied to the basic insight of the so-called absorption approach.[1]

To obtain an explicit solution for the level of the exchange rate, we assume unitary trade elasticities. We also identify throughout real and nominal magnitudes. All the results can be interpretated in real terms when prices vary. This is particularly useful when the nominal rates happen to be fixed.

1.1 Income determination under fixed exchange rates

The current account balance is defined as net exports plus the interest account:

$$C = e\overset{*}{B} + e\overset{*}{r}F \tag{1}$$

$$\overset{*}{B} = \overset{*}{M} - M/e \tag{1'}$$

where $\overset{*}{B}$ is the trade balance in foreign currency

$\overset{*}{r}$ is the foreign interest rate

F is the stock of foreign assets at the beginning of the period

e is the exchange rate (units of home per foreign currency)

C is the current account balance in domestic currency

$\overset{*}{M}$ exports of the home country in foreign currency

and M imports of the home country in domestic currency

Note that (1') implies that $\overset{*}{B}_e > 0$ (unitary trade elasticities). The effect of an exchange rate change on the current account is, given by $\overset{*}{M} + \overset{*}{r}F$ rather than by $\overset{*}{M}$, so that it will be dampened by the existence of foreign held debt and magnified by claims on foreigners.

The absorption approach uses the open-economy identity to note that the current account equals the difference between income and expenditure at home and abroad:

$$C = Y - A = -e(\overset{*}{Y} - \overset{*}{A}) \tag{2}$$

where $Y(\overset{*}{Y})$ is disposable income at home (abroad)

$A(\overset{*}{A})$ is absorption at home (abroad)

We specify imports and non-autonomous absorption as a proportion of income (m and 1 - s respectively), and allow the government to fix the current government budget deficit or surplus. In fact, we assume for simplicity that it will move the budget in such a way as to offset the interest account.[2]

$$A = E + T + (1 - s)Y \tag{3}$$

$$\overset{*}{A} = \overset{*}{E} - T/e + (1 - \overset{*}{s})\overset{*}{Y} \tag{3'}$$

$$M = mY \tag{4}$$

$$\overset{*}{M} = \overset{*}{m}\overset{*}{Y} \tag{4'}$$

where $T = -e\overset{*}{r}F \lessgtr 0$

and $E(\overset{*}{E})$ is autonomous expenditure at home (abroad)

Using (1), (1'), (2), (3) and (4) (respectively (3') and (4')) in the open economy income identity, collecting terms, and substituting, we obtain the equilibrium level of income in both countries and the trade balance:

$$Y = \frac{1}{\Delta}\,[(\overset{*}{s} + \overset{*}{m})E + \overset{*}{m}\,e\,\overset{*}{E}] \tag{5}$$

$$\overset{*}{Y} = \frac{1}{\Delta}\,[(s + m)\overset{*}{E} + m\,\frac{E}{e}] \tag{5'}$$

$$\overset{*}{B} = \frac{1}{\Delta}\,(s\overset{*}{m}\overset{*}{E} - \overset{*}{s}m\,\frac{E}{e}) \tag{6}$$

where $\Delta = s\overset{*}{s} + s\overset{*}{m} + \overset{*}{s}m$ is the open economy multiplier with repercussion.

Equation (5) shows that higher foreign income (autonomous expenditure) leads to higher domestic income through greater import demand. Hence the foreign country can easily transmit cyclical behavior and serve as a locomotive or brake for the home economy. The transmission mechanism is quite straightforward, provided the exchange rate is exogenous. Consider, though, the effects of a flexible exchange rate in this process. Is it possible that higher foreign income leads to such an appreciation of the exchange rate that domestic income actually falls? To answer this question, we develop a model of exchange rate determination that recognizes the existence of an intertemporal budget constraint.[3]

1.2 The intertemporal budget constraint

Since the interest account is explicit in this model, the equality of the current and capital accounts, in the absence of central bank intervention, can be stated as:

$$\overset{*}{B} + \overset{*}{r}F = F_1 - F \qquad (7)$$

Equation (7) shows that the flow of foreign exchange, i.e., the current account, is reflected in the change in the stocks of foreign assets, i.e., the capital account. Note that this identity is expected to hold in each future period i:

$$\overset{*}{B}_i + \overset{*}{r}F_i = F_{i+1} - F_i \qquad (7')$$

In (7'), the interest rates are assumed to be fixed. Substituting sequentially backward into (7) and using a term structure equation for interest rates we find that, given suitable transversality conditions:[4]

$$\sum_{i=0}^{\infty} \left(\frac{1}{1+\overset{*}{r}}\right)^{i} \overset{*}{B}_{i} = -(1 + \overset{*}{r})F \tag{8}$$

Equation (8) shows the intertemporal budget constraint. The discounted value of present and expected future trade surpluses and deficits must exactly offset the current stock of foreign assets. The intuition behind this result is that foreign asset holdings represent purchasing power over foreign goods: their ultimate use lies in consumption. The balance of trade is a vehicle for intertemporal saving and consumption. Current output claims on the future consumption of foreign goods are thus accumulated through savings.

Suppose that initially no foreign assets are held (F = 0). A country will then only be able to run a balance of trade deficit if it is expected that future net surpluses will, after discounting, allow for "repayment" of the debt incurred in the interim. For example, it is expected (with certainty) that after 2 periods onward balances will be in equilibrium but the country is currently running a deficit of size $\overset{*}{B}$. Given an interest rate, $\overset{*}{r}$, a surplus of $\overset{*}{B}(1 + \overset{*}{r})$ has to be expected for period 1 in order to observe the intertemporal balance constraint.

Because of the intertemporal balance constraint, it is the role of the exchange rate in this model to force the current and expected trade balances into line. We can therefore find an equilibrium exchange rate path that allows for intertemporal balance. Since (6) is expected to hold for each period i, we write:

$$\overset{*}{\dot{B}}_i = \frac{s\overset{*}{m}}{\Delta} \overset{*}{\dot{E}}_i - \frac{\overset{*}{s}m}{\Delta} \frac{E_i}{e_i} \qquad (6')$$

Under conditions of speculative efficiency, the exchange rate expected in period i is linked to the current rate by the given i-period interest rate differential:

$$e_i = \left(\frac{1 + r}{1 + \overset{*}{r}}\right)^i e \qquad (9)$$

Substituting (9) into (6'), and using (8), we get the current exchange rate, denoted by $\overset{\infty}{e}$, which would only obtain if the present discounted value of future trade inbalances were zero, that is to say if F = 0. This depends on the expected path of expenditures at home and abroad:[5]

$$\overset{\infty}{e} = \frac{s\overset{*}{m}E_\infty}{\overset{*}{s}m\overset{*}{\dot{E}}_\infty} \qquad (10)$$

where $E_\infty = \sum_{i=0}^{\infty} \frac{E_i}{(1+r)^i}$

and $\overset{*}{\dot{E}}_\infty = \sum_{i=0}^{\infty} \frac{\overset{*}{\dot{E}}_i}{(1+\overset{*}{r})^i}$

We now allow F to differ from zero. Using the intertemporal budget constraint (8), we obtain a relationship between the current exchange rate and the initial stock of foreign assets as a proportion of exports.

$$e = \frac{\overset{\infty}{e}}{1+\phi} \tag{11}$$

where $$\phi = \Delta(1 + \overset{*}{r})F/s\overset{*}{m}\overset{*}{E}_\infty \tag{11'}$$

Equation (11) gives the outcome for the exchange rate in this model. It shows how expected future levels of expenditure determine the current exchange rate both via the ratio of their discounted expected paths, i.e. via $\overset{\infty}{e}$ and via ϕ.

It is seen from (11) that in order to have a well-behaved exchange rate ϕ has to exceed -1. This implies a ceiling on initial debt, $\bar{F}$, so that we can write:

$$e = \frac{\overset{\infty}{e}}{1 - F/\bar{F}} \tag{12}$$

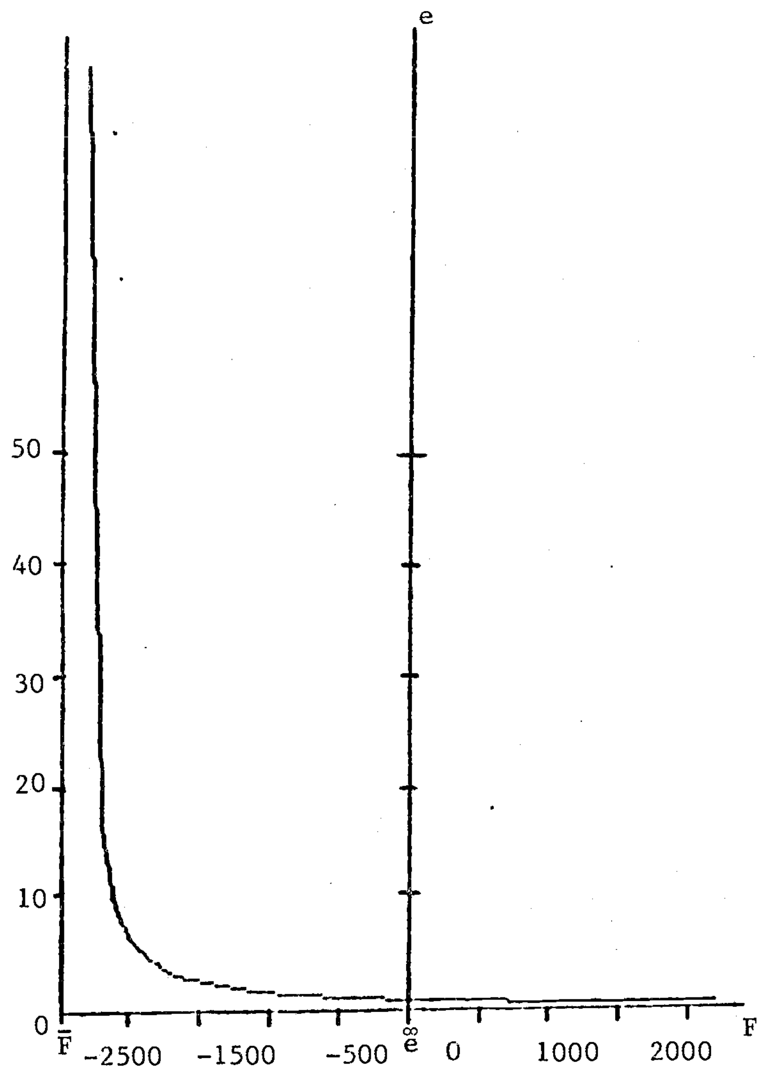
where $$\bar{F} = -\frac{s\overset{*}{m}}{\Delta}\overset{*}{E}_\infty$$

Because of the infinite horizon, the extra interest rate term is subsumed in $\overset{*}{E}_\infty$. According to equation (12), the largest stock of initial foreign debt allowed in the model equals the discounted value of the largest potential intertemporal accumulation of trade surpluses.

We can draw (12) as an hyperbola in e and F (see Figure 1). It is clear that an increase in $\overset{*}{E}_\infty$ will shift the hyperbola as $\bar{F}$, its asymptote, shifts to the left. As a result, given constant F, e will fall as will $\overset{\infty}{e}$. Instead, an increase in E_∞ will only affect the

Figure 1

The Exchange Rate and the Stock of Foreign Assets



Note: Values obtained from the base case in section 2 below.

($\overset{\infty}{e}$ = 1 and $\bar{F}$ = -2130) curvature of the hyperbola without changing the asymptote, leading to a rise in e and $\overset{\infty}{e}$.

Thus the role of exchange rate in this setup is to influence the balances of trade, current and expected, so that the sum of the discounted values equals the initial stock of foreign assets. As a result, a change in foreign income which causes one of the balances to change, will cause an exchange rate adjustment so as to retain intertemporal balance. It is therefore possible to analyze the effects of higher foreign income on domestic income while allowing the exchange rate to fluctuate.

1.3 Comparative statics

Suppose that the exchange rate is such that the balance of trade is in intertemporal equilibrium, but that the foreign country is expected to experience a cyclical upturn, in period j, relative to what was expected before ($\overset{*}{\bar{E}}_j$ increases). With an unchanged exchange rate, the simple effect discussed below equation (6) obtains: higher foreign income improves the expected balance of trade for period j and is transmitted to the home economy through higher exports for that period. Hence, if we expect future foreign income to rise, we can also expect future domestic income to increase.

This "locomotive" story is not complete because, had the exchange rate remained unchanged, the improved balance in period j would, in combination with the unchanged other balances, violate the intertemporal budget constraint. This implies that, in order to retain intertemporal balance, the balances expected for periods other than j have to worsen.

Since the exchange rates for different periods are linked together by (9), the whole path of current and expected exchange rates has to fall (all rates must appreciate). Thus, because of the exchange rate effect, current domestic income will fall as future foreign income is expected to rise.

The balance for period j is the only balance that is affected both by the exchange rate effect (that tends to worsen it) and by the foreign income effect (that tends to improve it). The foreign income effect dominates in this period because, if it did not, all balances would worsen, which would be inconsistent with intertemporal balance. The simple locomotive story therefore provides the direction of change.

To show the effect of expenditure changes on the exchange rate differentiate (1) totally, to yield:

$$\frac{de}{e} = \sum_{j=0}^{\infty} \left[\varepsilon_j \frac{dE_j}{E_j} - \frac{\overset{*}{\varepsilon}_j}{1+\phi} \frac{d\overset{*}{E}_j}{\overset{*}{E}_j}\right] = \frac{1}{E_\infty} \sum_{j=0}^{\infty} \left[\frac{dE_j}{(1+r)^j} - \frac{\overset{*}{sme}}{\overset{*}{sm}} \frac{d\overset{*}{E}_j}{(1+\overset{*}{r})^j}\right]$$

$$= \frac{1}{\overset{*}{E}_\infty(1+\phi)} \sum_{j=0}^{\infty} \left[\frac{\overset{*}{sm}}{\overset{*}{sme}} \frac{dE_j}{(1+r)^j} - \frac{d\overset{*}{E}_j}{(1+\overset{*}{r})^i}\right] \qquad (13)$$

where $\varepsilon_j = \dfrac{E_j/(1+r)^j}{\sum_i [E_i/(1+r)^i]}$

and $\overset{*}{\varepsilon}_j = \dfrac{\overset{*}{E}_j/(1+\overset{*}{r})^j}{\sum_i [\overset{*}{E}_i/(1+\overset{*}{r})^i]}$

A proportional increase in foreign expenditure has an unambiguous effect on the exchange rate which is dampened or magnified depending on whether the initial shock of foreign assets is positive or negative (i.e. $\phi \lessgtr 0$). The reason for this can be seen from (6) or (6'). The increase in $\overset{*}{E}_j$, the income effect, improves $\overset{*}{B}_j$ by a certain amount, irrespective of the level of e, which is the only endogenous variable affected by F. The newly generated surplus has to be offset by the effects of the induced exchange rate change in order to retain intertemporal balance. This exchange rate effect operates only through the foreign currency value of home imports. The level of the exchange rate itself enters there, so that, for a certain improvement of the balance in period i, a larger proportional (and absolute) appreciation is needed, the lower the initial level of e. Since this level varies inversely with the stock of foreign assets, debtor nations will experience larger absolute and proportionate appreciations than do creditor nations (similarly the larger the stock of the smaller the appreciation). It is easily seen from (13) that the discounted income and exchange rate effects offset each other when $d\overset{*}{E}_i = 0$, $i \neq j$ and $dE_i = 0$, all i:[6]

$$\frac{de}{e} = - \frac{\overset{*}{\varepsilon}_j}{1+\phi} \frac{d\overset{*}{E}_j}{\overset{*}{E}_j} \tag{13'}$$

Equation (13) also shows that the further in the future the disturbance occurs the lesser its impact on the current exchange rate. Furthermore, global demand expansion ($dE_j = e_j d\overset{*}{E}_j$) leaves the current exchange rate unchanged if the two countries are symmetric (in the sense that $s/m = \overset{*}{s}/\overset{*}{m}$). Given (9), the increases in expenditure have to be equal in present discounted value terms: $dE_j/(1 + r)^j = ed\overset{*}{E}_j/(1 + \overset{*}{r})^j$ (Table 1, first column, 3rd row).

To show the effects on the balance of trade, differentiate (6) totally for period j and substituting for the exchange rate by using (13), to obtain:

$$d\overset{*}{B}_j = \frac{(1-\varepsilon_j)}{\Delta} [\overset{*}{s}\overset{*}{m}d\overset{*}{E}_j - \overset{*}{s}m \frac{dE_j}{e_j}]$$

$$- \frac{\varepsilon_j}{\Delta} (1 + \overset{*}{r})^j \sum_{i \neq j}^{\infty} \frac{1}{(1+\overset{*}{r})^i} [\overset{*}{s}\overset{*}{m}d\overset{*}{E}_i - sm \frac{dE_i}{e_i}] \qquad (14)$$

If $\varepsilon_j < 1$, the combined contemporaneous income and exchange rate effect of an increase in domestic (foreign) autonomous expenditure is negative (positive). When $\varepsilon_j = 1$, the two exactly offset each other and there is no net effect. An increase in $E_i(\overset{*}{E}_i)$ only causes an exchange rate effect, improving (worsening) $\overset{*}{B}_j$. Since the sum of the discounted values of all changes in the trade balances is zero and $\Sigma\varepsilon_j = 1$, we see that:

$$\sum_{i \neq j} \frac{1}{(1+\overset{*}{r})^i} (\overset{*}{s}\overset{*}{m}d\overset{*}{E}_i - \overset{*}{s}m \frac{dE_i}{e}) = \sum_{j=0}^{\infty} \frac{1-\varepsilon_j}{(1+\overset{*}{r})^j} (\overset{*}{s}\overset{*}{m}d\overset{*}{E}_j - \overset{*}{s}m \frac{dE_j}{e_j}) \quad (25)$$

The effect of a global increase in expenditure of the same magnitude is ambiguous, as shown in Table 1 (2nd column, 3rd and 7th row), if the two countries have different marginal propensities. If the home economy is more open or has a higher propensity to spend, the contemporaneous

Table 1

Effect of Various Disturbances

Effect on:	(1) e	(2) $e_j\overset{*}{B}_j$	(3) Y_j	(4) $e_j\overset{*}{Y}_j$
of				
E_j	+	-	+	+
$e_j\overset{*}{E}_j$	-	+	?	+
$E_j=e_j\overset{*}{E}_j{}^*$	? (0)	? (0)	? (+)	? (+)
$E_j=-e_j\overset{*}{E}_j{}^*$	+	-	+	-
E_i	+	+	+	-
$e_i\overset{*}{E}_i$	-	-	-	+
$E_i=e_i\overset{*}{E}_i{}^*$	? (0)	? (0)	? (0)	? (0)
$E_i=-e_i\overset{*}{E}_i{}^*$	+	+	+	-

$d\overset{*}{E}_k > 0,\ k = i,j$

Symmetric case ($s/m = \overset{*}{s}/\overset{*}{m}$) in parentheses when different from non-symmetric case.

trade balance will deteriorate and the others will improve. If the two countries are symmetric all trade balances remain unchanged.

1.5 Three types of transmission

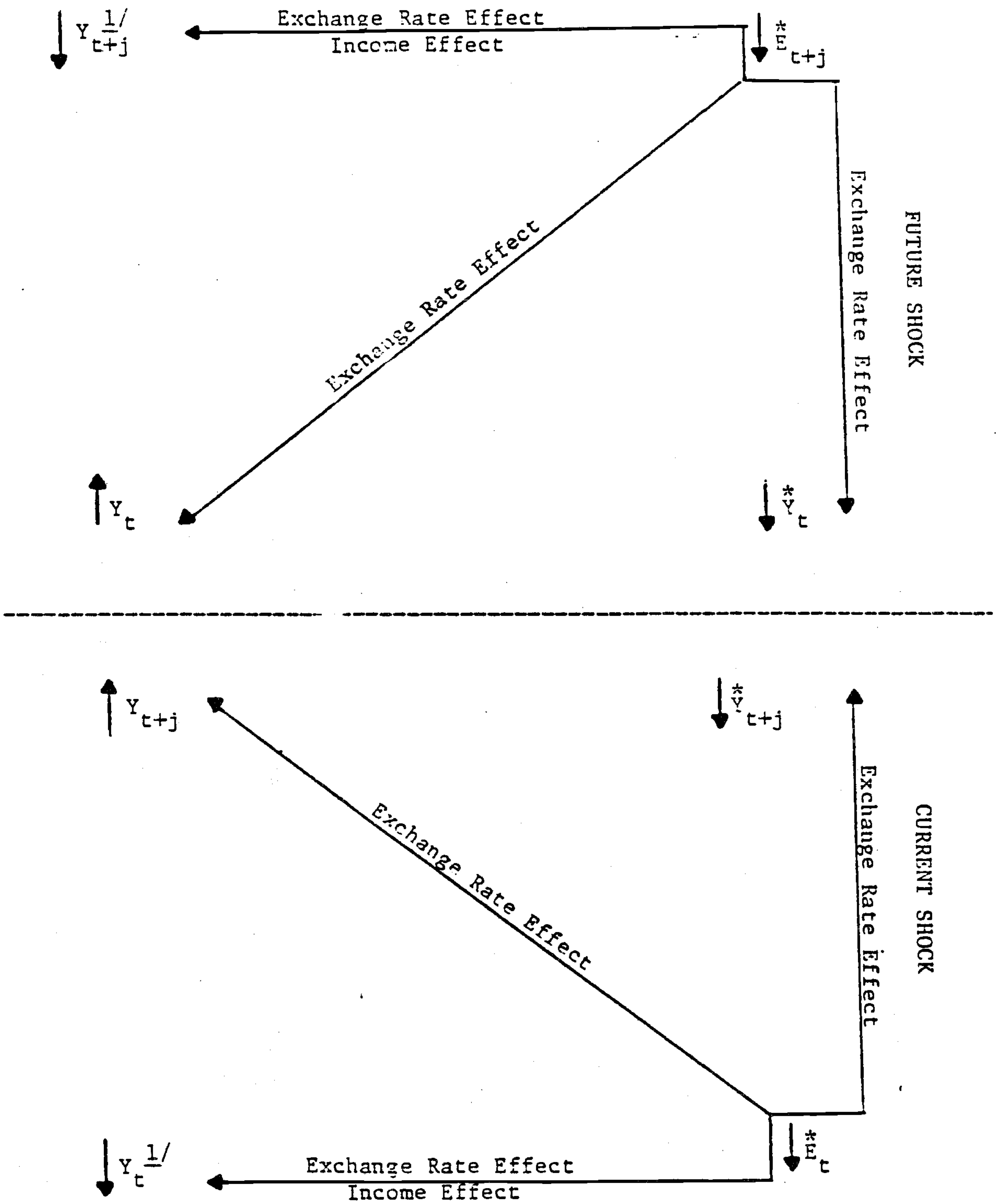
The analysis indicates that in the transmission of cycles across countries in a two-country setting, where both countries fully interact, the exchange rate establishes intertemporal equilibrium and, in so doing, transmits to the present shocks expected in the future. As a result, expected future cyclical upswings and downturns abroad will affect current domestic income. Aside from the "own" effect of a contemporaneous upturn, three kinds of cyclical transmission can be identified in this framework. The first is the effect of an upswing abroad in period i on home income in the same period i. In this horizontal transmission, home income will typically rise too; the standard locomotive pulls ahead but not as fast as usual, due to the exchange rate effect. The exchange rate effect will not dominate unless initial foreign debt is very large.

The second is the effect of an expected internal shock in period i on home income in period j. Since in this case it is only the exchange rate that matters, a future upswing will be transmitted vertically to a current upswing. This intertemporal effect is also responsible for the third type of transmission: expected foreign shocks in period i to home income in period j, or diagonal transmission. This is illustrated in Figure 2.

To look formally at the transmission effect of foreign income variation on the home economy, differentiate (5) totally and substitute

Figure 2

Three Types of Transmission



[1]It is assumed that the income effect dominates. If the initial stock of foreign debt is large enough a reverse locomotive effect occurs and the exchange rate effect dominates.

for the exchange rate using (9) and (3). The types of transmission are identified below:

$$dY_j = \frac{1}{\Delta}\{[\overset{*}{s} + \overset{*}{m}(1 + \frac{\overset{*}{s}m}{s\overset{*}{m}}\frac{\overset{*}{\varepsilon}_j}{1+\phi})]dE_j + \overset{*}{m}(1 - \frac{\overset{*}{\varepsilon}_j}{1+\phi})e_j d\overset{*}{E}_j\}$$

own horizontal

$$+ \frac{\overset{*}{m}}{\Delta}\frac{\overset{*}{\varepsilon}_j}{1+\phi}(1 + r)^j \sum_{i \neq j}[\frac{1}{(1+r)^i}(\frac{\overset{*}{s}m}{s\overset{*}{m}} dE_i - e_i d\overset{*}{E}_i)] \qquad (16)$$

vertical diagonal

$$d\overset{*}{Y}_j = \frac{1}{\Delta}\{[s + m(1 + \frac{s\overset{*}{m}}{\overset{*}{s}m}\varepsilon_j)]d\overset{*}{E}_j + m(1 - \varepsilon_j)\frac{dE_j}{e_j}\} +$$

own horizontal

$$+ \frac{m}{\Delta}\varepsilon_j(1 + \overset{*}{r})^j \sum_{i \neq j}\frac{1}{(1+\overset{*}{r})^i}[\frac{s\overset{*}{m}}{\overset{*}{s}m} d\overset{*}{E}_i - \frac{dE_i}{e_i}] \qquad (17)$$

vertical diagonal

1.6. The reverse locomotive

The contemporaneous effect of a foreign boom - horizontal transmission - is only ambiguous when the domestic economy is a sufficiently large debtor initially. The condition for the reverse locomotive effect to obtain is $\phi > \overset{*}{\varepsilon}_j - 1$. In that case the exchange rate effect exceeds the income effect. Using (12), we see that the reverse locomotive effect will occur if and only if:

$$\bar{F} + \frac{s\overset{*}{m}}{\Delta} \frac{\overset{*}{\bar{E}}_i}{(1+\overset{*}{r})^{j+1}} > F \qquad (18)$$

As argued before, in this case the ex-ante exchange rate is at such a high level that the relative required appreciation gives an exchange rate effect that more than offsets the income effect. It is also seen in (18) that, given a certain stock of initial debt, it is more likely that the reverse locomotive operates the larger the foreign autonomous expenditures during that period.[7]

The intertemporal balance model can be used to study various unanticipated shocks, for example, the consequences on export competitiveness of a natural resource boom in the home country. Suppose it finds a marketable resource (whose world price is fixed) that can only be exported in period i and exports are maintained at the new level forever after. At a given exchange rate, the higher future autonomous exports of the home country cause an intertemporal imbalance. In order to offset the expected surpluses, the currency appreciates. In other words: the expectation of future revenues causes the current exchange rate to appreciate. Since for the current period nothing else has changed, the domestic economy will experience a drop in income. This is seen by setting j = 0 in equation (18) and interpreting i as all periods at the new export level. The appreciating exchange rate affects export competitiveness and lowers current income through the export sector of the economy. This is sometimes referred to as the "Dutch disease".

Before we turn to the simulation results, it should be stressed that other, especially intertemporal, transmission channels can be found using different models. What we showed was the simplest flexible exchange rate model that would bring out the transmission mechanism.

2. Simulation Results

2.1. The Base Case

We now show simulation results, which bring to the fore the central aspects of the theoretical model. Recall that one of the strong assumptions made in the model is that expectations about future levels of autonomous expenditures, both at home and abroad, are held with certainty. Even though this assumption does not affect the structure of the model, it allows us to characterize the solutions in the particular form we do.

We also assume that the exogenous variables are expected (with certainty) to be constant over time.[8] While the model could still be simulated, with particular paths for autonomous expenditures or interest rates, the results presented below are sufficient for our purposes.

In the base case, domestic and foreign interest rates are set equal to 10%, savings propensities are 5% and import propensities are 15%. The countries are assumed to be perfectly symmetric except for the fact that only the foreign country can issue international assets. Given the initial specification, the open economy income multiplier, $1/\Delta$, is equal to 57.Autonomous expenditure - denoted by E and E* - is set at 500 units for a time horizon of 50 periods.[9]

Due to symmetry, the spot equilibrium exchange rate which, given the present discounted values of autonomous expenditure, intertemporally equilibrates the trade balance when $F = 0$ is unity. This is clear from equation (11) above. Because there is no interest differential, the exchange rate, and therefore the trade balance, are expected to remain constant, see equations (9) and (6').

In order to determine the largest stock of debt acceptable, $\bar{F}$, recall the condition set in equation (12). Since ϕ is proportional to F, ϕ/F is independent of the initial stock, so that the maximum debt capacity of the home country ($\bar{F}$ such that $\phi = -1$) is simply the absolute value of the inverse of ϕ/F. In the base case $\phi/F = .00047$ and $\bar{F} = -2130$. The initial stock of foreign assets runs from 2000 to the debt ceiling.

Figure 1 above showed clearly that as the stock of foreign assets falls, the exchange rate depreciates. The country has to "save" more on its international accounts to make good its lost international wealth. Recall also the asymptotic behavior of the exchange rate as the stock of foreign debt reaches the implied maximum.

The depreciation of the exchange rate induces a less than proportional rise in domestic income as foreign assets are reduced. Since the exchange rate effect is the only one operating, domestic income measured in foreign currency falls. Similarly foreign income is seen to fall. Domestic absorption also rises as F falls, because Y rises and T becomes a smaller negative number. This can be seen from equation (3).

The sign of the current account is equal to that of the trade balance: interest flows do not offset the trade adjustments needed to maintain intertemporal balance. Fewer foreign assets thus imply smaller trade deficits while larger foreign debts call for larger trade surpluses.

2.2. Sensitivity analysis

The sensitivity of the model to changes in exogenous variables and parameters is reported in Table 2, which presents the results for the initial period and when F=2000 units.[10] The base case is in the first row. In the second row, the domestic rate rises to 15%. Column (2) in that row shows that the debt capacity of the home country, as measured by $\bar{F}$, is unaffected. According to equation (11'), the upper bound of debt is determined by the largest intertemporal international accumulation of the home country. But the value of $\overset{\infty}{e}$ changes and this affects the determination of the spot rate. As shown in column (3), it lowers $\overset{\infty}{e}$ and, given the unchanged value of $\bar{F}$, the spot exchange rate falls (fourth column). Higher domestic interest rates will therefore lead to an appreciating exchange rate. It should be stressed here that this effect is not the standard capital account adjustment effect often discussed. Even though it seems that the capital account for the first period does indeed go into significant surplus as the domestic interest rate rises (the current account deficit goes from 1 to 64 units as shown in the fifth column), this effect is obtained without specifying asset demand functions. The cause of the capital account adjustment is the stock adjustment that takes place on the asset side of the model, in order to assure that there is zero intertemporal accumulation of foreign assets.

The lower level of the exchange rate causes domestic income to fall, as shown in column (6) and in equation (5). Similarly, foreign income rises in column (7) and a large increase is seen in the foreign currency value of home income, column (8). The effects on B are a direct result of the exchange rate change. The domestic currency value of the trade deficit becomes 104, column (10) the service account is in surplus at 72, column (5), and the current account shows an initial deficit of 64 units.

The effects of an increase in the foreign interest rate are shown in the third row of Table 2. Now, in contrast to a change in the domestic interest rate, the debt capacity of the home country is affected. As shown in column (2), it falls to -1430 units. This result has direct implications for the current debate about the so-called "debt crisis" since it indicates that a rise in the interest rate charged to a debtor nation can result in a situation in which no level of domestic restraint (i.e., maximum possible international surpluses) allows the country to pay off its debt. Indeed, as foreign interest rates rise, it becomes more likely that the "reverse locomotive" operates.

Columns (2) and (3) show opposite effects on the exchange rates. In the absence of foreign assets, the exchange rate depreciates because the present discounted value of foreign expenditures has fallen. This is offset, however, by the larger interest account, so that the exchange rate appreciates slightly. As a consequence, the ratio of the two rates falls from 51.5% (base case and rise in the domestic interest rate) to 34.6%, the lowest value in the various experiments of Table 2.

The effects on income and the balance of trade are straightforward: column (6) shows that the higher exchange rate raises domestic income through the higher value of home exports. Foreign income falls and the same is true for the domestic currency value of home income, see columns (7) and (8) respectively. The increased interest income brings the current account into surplus, column (2).

In row (4) we increase the domestic marginal propensity to save by 20%. The debt capacity increases by 7.5%, column (2). As the export

Table 2

Sensitivity Results

column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
row	$1/\Delta$	$-\bar{F}$	$\overset{\infty}{e}$	e	$er\overset{*}{F}$	Y	$\overset{**}{Y}$	Y/e	$-\overset{**}{B}$	$-B$	A	$-C$
base	57.1	2130	1.000	0.515	103	7922	14034	15379	201	104	7923	1
$r = .15$	57.1	2130	0.703	0.362	72	7265	17561	20081	378	137	7329	64
$r^* = .15$	57.1	1430	1.423	0.493	178	8256	12942	13923	147	87	8165	-91
$s = .06$	51.3	2290	0.833	0.445	89	6838	14034	15379	201	90	6839	1
$s^* = .06$	51.3	1910	1.200	0.586	171	7637	11695	13040	201	118	7638	1
$m = .2$	50.0	1860	1.333	0.642	129	7409	14034	11534	201	130	7410	1
$m^* = .2$	50.0	2480	0.750	0.415	83	8325	14034	20057	201	84	8326	1

side in equation (6') rises, i.e., at unchanged e, B^* in (6') would go to surplus. To offset this, $\overset{\infty}{e}$ appreciates, as does e, see columns (3) and (4). The rise in $\bar{F}$ induces a counterforce, which does not however offset the tendency for e to fall. Changes in m and m^* also affect the debt capacity of the home country less than proportionally but the elasticities are slightly higher than with respect to s and $\overset{*}{s}$. The difference is due to the larger size of import propensities in the base case.

Table 3 reports some implied elasticities from the experiments of Table 2. It is evident that they are generally smaller than one. The exceptions are the more than proportional increase in the trade deficit due to the rise in the domestic interest rate and the proportional effect of $\overset{*}{s}$ and m on $\overset{\infty}{e}$. The response of the debt ceiling is highest in connection with the foreign interest rate. The elasticities with respect to the trade balance are zero unless interest rates change.

With an infinite horizon, the constant exchange rate and trade balance in the base case imply that there is no asset accumulation or decumulation, so that the terminal stock of foreign assets would be 2000 units. In a 50 period horizon, however, a small accumulation (less than 1%) takes place.[11] At the long-run equilibrium foreign asset level the current account is in balance. Interest payments from abroad precisely offset the trade balance, again due to the infinite horizon property of the model. Had we specified a finite model with zero foreign asset holdings at the end point, the current account would be non-zero.

Even when the terminal stock of foreign assets is the same as initially, there is substantial accumulation and decumulation when interest rates change. Basically, when the foreign interest rate rises, the exchange rate appreciates, so that a creditor country experiences a

Table 3

Elasticities

	$-\bar{F}$	$\overset{\infty}{e}$	e	Y/e	$\overset{*}{Y}$	$-\overset{*}{B}$
r	0	-.6	-.6	.6	.5	1.8
$\overset{*}{r}$	-.7	.8	-.1	.2	-.2	-.5
s	.4	-.9	-.7	0	0	0
$\overset{*}{s}$	-.5	1.0	.7	-.7	-.9	0
m	-.4	1.0	.8	-.9	0	0
$\overset{*}{m}$	.5	-.8	-.6	.9	0	0

greater trade deficit, more than offset by the larger interest inflow. Over time, the exchange rate effect becomes stronger and decumulation of foreign assets takes place. A debtor country starts with a larger surplus than in the base case, pays its debt, and even accumulates assets before it returns to its initial debt. This pattern is required by the appreciating exchange rate and would be exacerbated if the terminal debt were smaller than initially. When the domestic interest rate increases, there is a depreciation of the exchange rate and the reverse pattern obtains. Assets are decumulated initially and accumulated later. Therefore the pattern of asset accumulation is strongly influenced by the expected path of the exchange rate.

2.3 Transmission of business cycles

To analyze the transmission process, we raise domestic and foreign expenditure by 50% both currently (period 0) and in the future (period 10). Table 4 summarizes the results for three levels of the stock of foreign assets: 2000 units, 0 and a value close to the debt ceiling (-2000).[12] An increase in E depreciates the exchange rate independently of the stock of foreign assets. The further away the increase is expected, the less of a depreciation is seen. It falls from 1% when E_o rises to about .4% when E_{10} rises. Domestic income rises, by 8% at F = 2000, 6% at F = 0 and 2% at F = -2000. Again the asymptotic behavior of e is responsible for this lower response. Foreign income rises in response to the income effect (horizontal transmission), but falls due to the exchange rate effect (diagonal transmission). Domestic absorption always rises but the current account deficit deteriorates with the current expansion and improves slightly with the future expansion.

Table 4

Transmission Results

	F	e	Y	$\overset{*}{Y}$	Y/e	$\overset{*}{B}$	B	eF	A	C
1. Base Case										
	2000	0.515	7922	14034	15379	-201.7	-103.9	1030	7923	-0.89
	0	1.000	10000	10000	10000	.0	.0	0	10000	0.00
	-2000	17.051	78790	5966	4621	201.7	3439.5	-34102	78761	29.30
2. E_0 = 550 (own transmission)										
	2000	0.520	8514	14783	16378	-239.2	-124.3	1040	8534	-20.36
	0	1.009	10611	10386	10514	-19.3	-19.5	0	10630	-19.46
	-2000	17.207	80031	5988	4651	200.6	3451.6	-34415	80021	10.10
3. E_{10} = 550 (vertical transmission)										
	2000	0.517	7930	14002	15336	-200.1	-103.5	1034	7931	-0.06
	0	1.004	10017	9983	9978	0.8	0.8	0	10016	0.83
	-2000	17.117	79074	5965	4620	201.8	3453.7	-34235	79044	30.45
4. $\overset{*}{E}_0$ = 550 (horizontal transmission)										
	2000	0.513	8131	14645	15860	-182.3	-93.4	1025	8122	9.10
	0	0.991	10386	10611	10481	19.5	19.3	0	10366	19.29
	-2000	14.746	75229	6576	5102	221.2	3261.5	-29491	74917	312.34
5. $\overset{*}{E}_{10}$ = 550 (diagonal transmission)										
	2000	0.514	7917	14051	15401	-202.6	-104.1	1028	7919	-1.31
	0	0.996	9983	10017	10022	-0.8	-0.8	0	9984	-0.83
	-2000	15.991	74246	5982	4643	200.9	3212.3	-31981	74232	14.15

Suppose now E^* is raised to 10%. If the home country's initial debt is larger than 1930 units, the present or future increase in foreign lowers home income; the exchange rate effect exceeds the income effect. Specifically, with an initial debt of 1920 units, the elasticity of home income with respect to foreign expenditure is 4, with a debt of 1930 units it becomes -.1. Nearer the debt limit, the reverse locomotive effect explodes. If F = -2120, the elasticity becomes -8, that is home income falls by 80%! The large value of home income is of course due to the very high valuation of home exports implied by the asymptotic behavior of the exchange rate as F approaches $\bar{F}$.

Foreign income rises by more than the increase in E^* itself due to the exchange rate effect. The absolute amount of the improvement in Y^* due to the "own" transmission is independent of the stock of debt but it increases from 4% to 6% to 10% as the debt increases. For domestic income measured at foreign prices, we see that the transmission of business cycles is not disturbed. There is no reverse locomotive effect but a smaller improvement than in the foreign country, respectively by 3%, 5% and 10%. The balance of trade in foreign currency goes into higher surplus for at the initial period. The intertemporal accumulation, as governed by F, has not changed and thus other balances will move towards deficits.

We saw above that the domestic currency value of home income may fall depending on F but that the foreign currency value will rise, i.e, there is no problem with the transmission of business cycles measured in foreign currency. The reverse locomotive effect leads domestic absorption to fall as the stock of debt exceeds 1920 units. In other words, a debtor nation may see home absorption fall as foreign countries move through a cyclical upturn.

Note also that the current account measured in home currency of these countries improves; as foreign income rises and e falls (the appreciation discussed before) the interest payments measured in home currency are significantly reduced.

In the case of an expected future cyclical upturn abroad, the exchange rate appreciates once again to insure intertemporal balance. At 2000 units of debt, domestic income falls by 4% if $\overset{*}{E}_0$ rises and by 6% if $\overset{*}{E}_{10}$ rises. The foreign currency value rises by 10% and 0, respectively.

When the stock of foreign assets is positive, a current cyclical upturn abroad is transmitted to the home country as a current home upturn, while an expected foreign upturn will have current downturn (but possibly future upturn) effects. When $\overset{*}{E}_{10}$ rises, domestic absorption falls at all levels of F but the current account remains in surplus when F is negative. When $\overset{*}{E}_0$ rises, absorption only falls in that latter case.

Conclusion

The model presented here was designed to show, in the simplest framework, how the traditional view of cyclical transmission via the "locomotive" is changed if a flexible exchange rate model is used. The model has its roots in the flow-equilibrium models of the old international finance literature but, in contrast to those, it fully accounts for stock accumulation and decumulation through intertemporal constraints. A change in the present or expected trade balance has to be offset by an exchange rate change that retains intertemporal balance in the sense that the sum of the discounted values of the expected future surpluses equals the current holdings of foreign assets. It is the exchange rate effect that can put a counterveiling influence on the standard locomotive effect.

Three types of transmission are identified, aside from the "own" effect of domestic demand expansion on domestic output. The second is the vertical transmission of future domestic demand expansion to current domestic output. The third, which is negative, associates future foreign demand expansion to current domestic recession.

The analytical results were simulated, with an emphasis on the condition for existence of a reverse locomotive effect. Thus, when the interest account is in surplus and 1.3% of domestic income, the elasticity of horizontal transmission is 2.6%. Conversely, when the interest account is in deficit and accounts for 4.3% of domestic income, the elasticity becomes negative and equal to 4.5%.

NOTES

1. Models sharing some of the features of the present one are in Kouri and Macedo (1978), Krugman (1981) and Kouri (1983). On the absorption approach, see Macedo (1972).

2. This allows us to ignore the interest payments on the absorption side and simplifies both the model and intuition, without altering the results.

3. Note from (6) and (1'), that a zero trade balance in the current period would imply an exchange rate $\bar{e}$, such that:

$$\bar{e} = \frac{s m \overset{*}{E}}{\overset{*}{s} \overset{*}{m} E}$$

Higher expenditure at home relative to abroad depreciates the one-period exchange rate. The same is true for an increase in the home country's openness--as measured by the marginal propensity to import--or a decrease in the home country's marginal propensity not to spend. By specifying a Cambridge money demand function $H = kY$ ($\overset{*}{H} = \overset{*}{k}\overset{*}{Y}$), this effect is seen as an increase in domestic velocity (decrease in k). Indeed, substituting for M and $\overset{*}{M}$ in (1') from (4) and (4'), a "monetary looking" equation is obtained:

$$\bar{e} = \frac{H m \overset{*}{k}}{\overset{*}{H} \overset{*}{m} k}$$

4. The present discounted value of the stock of foreign assets in the last period is of course zero when we have an infinite horizon:

$$\lim_{i \to \infty} \left(\frac{1}{1+\overset{*}{r}}\right)^i F_{i+1} = 0$$

In a finite horizon, the terminal value must be given to solve for the initial exchange rate.

5. Suppose that autonomous expenditures at home and abroad are expected to grow over time at a constant rate, respectively g and $\overset{*}{g}$. In order for E_∞ and $\overset{*}{E}_\infty$ to be finite, these rates have to be less than the respective rates of discount. In this special case, the zero-intertemporal-trade-balance exchange rate, $\overset{\infty}{e}$, depreciates relative to the zero-current-trade-balance exchange rate, $\bar{e}$, if the expected rate of growth of domestic expenditure increases:

$$\overset{\infty}{e} = \bar{e}\,\overset{*}{\rho}/\rho$$

where $\rho = (r-g)/(1+r)$

and $\overset{*}{\rho} = (\overset{*}{r}-\overset{*}{g})/(1+\overset{*}{r})$

6. For an increase in domestic income we find that, if the income and exchange rate effect offset each other, the level of e drops out. The reason is that in this case the initial improvement of the balance is itself affected by the level of e.

7. It is easy to show that the foreign currency value of domestic income always increase as foreign expenditures rise.

8. While it avoids the complications associated with the infinite horizon, the constant growth rate case cannot be used for the analysis of temporary shocks. Even when the initial value is allowed to change, and therefore the whole path of autonomous expenditures also changes, it is easy to show that an increase in domestic expenditure will have no effect on foreign income. See Appendix 1 to Macedo and Meerschwam (1984).

9. Note that at a 10% interest rate the terminal value of expenditure is 4.7, so that the 50 period horizon reduces the sums of the discounted values of E and E^* to 5453 instead of the infinite horizon level of 5500. The 1% error implied by the finite horizon does not affect the exchange rate, which is within 2.7% of the infinite horizon one after 10 periods and within .07% after 20 periods (assuming the terminal stock is the same as the initial stock).

10. The complete results are in Macedo and Meerschwam (1984) as follows: Row 1 in Table 2, Rows 2 through 7 in Tables A1 through A6.

11. Since $\dot{B}^*$ is constant in the base case, it follows from equation (8) that

$$\dot{B}^* \sum_{i=0}^{\infty} \left[\frac{1}{1+r^*}\right]^i = \dot{B}^* \left[\frac{1+r^*}{r^*}\right] = -(1+r^*)F$$

Therefore $\dot{B}^* = -r^*F$ and this is true for all periods as shown in Appendix 2 to Macedo and Meerschwam (1984). In a 50 period horizon, however, we find $\dot{B}^* = -201.7$, so that the long run value of F is 2017 when the foreign interest rate is 10%.

12 The complete results are in Macedo and Meerschwam (1984) as follows: Row 1 in Table 4; Row 2 in Table A7; Row 3 in Table A8; Row 4 in Table 5 and Row 5 in Table 6.

REFERENCES

Jones, R.W. and P.B. Kenen, eds., 1984, Handbook of International Economics, Vol. 2, North Holland.

Kouri, P.J.K., 1983, "Intertemporal Balance of Payments Equilibrium and Exchange Rate Determination," Discussion Papers on International Economics and Finance, Banca d'Italia.

Kouri, P.J.K. and J.B. de Macedo, 1978, "Exchange Rates and the International Adjustment Process," Brookings Papers on Economic Activity, 1978 (1).

Krugman, P.R., 1981, "Real Financial Determinants of the Real Exchange Rate," unpublished manuscript, National Bureau of Economic Research (Summer Institute).

Macedo, J.B. de, 1972, "The Absorption Approach to Devaluation: A Survey Twenty Years After," unpublished manuscript, Yale University.

Macedo, J.B. de and D.M. Meerschwam, 1984, "Exchange Rate Flexibility and the Transmission of Business Cycles," unpublished manuscript, Princeton University.

Meerschwam, D.M., 1982, "Exchange Rate Determination: The Balance of Trade in Intertemporal Balance," Working Papers in International Economics, Princeton University.