Comprehensive Accounting in Simple Open Economy Macroeconomics with Endogenous Sterilization or Flexible Exchange Rates

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Abstract: *This paper presents a stock-flow model of two economies (together comprising the whole world) that trade goods and financial assets with one another. The first part of the paper describes a single economy on a fixed exchange rate, with no private capital flows, in order to obtain simple analytic solutions that display the basic constraints and forces at work—notably, endogenous "sterilization." The second part describes a flexible exchange rate model, with two economies trading financial assets as well as merchandise. A final section adapts the two-country model to describe a fixed exchange rate regime. Our findings challenge established results, such as those of the Mundell–Fleming model.*

Key words: *exchange rate determination, open economy macroeconomics, portfolio analysis, sterilization, stocks and flows, two-country models.*

This paper presents a Keynesian model of two economies that together comprise the whole world. The exchange rate is assumed to continuously clear the market for (the stocks of) internationally traded assets and, hence, to determine a sequence of trade, income, expenditure, and

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output flows. Tobin and De Macedo (1980), Allen and Kenen (1980), and Branson and Henderson (1985) presented models in which the exchange rate is determined by mutual trading of assets between two countries, but, although these were path-breaking studies, none did more than establish timeless equilibria without characterizing all the temporal processes that brought those equilibria about. Rather complicated simulation models have been proposed by Godley (1999) and Godley and Lavoie (2003) that extended these earlier models to include a description of the whole dynamic process with embedded Post Keynesian assumptions, most notably a monetary policy defined by interest rates administered by central banks. There remains a place for a statement of this alternative view simple enough to be taught at the advanced undergraduate level, and this is the object of the present paper, at least with respect to its first part.[1]

The paper is divided into two parts. First we present a model of an open economy under a regime of fixed exchange rates, with no private international capital flows. It can be interpreted as a small open economy, perhaps a less-developed country, the economic situation of which has no impact on the rest of the world, and in which financial liberalization has not yet occurred. The assumption that exchange rates are fixed makes it possible to obtain a recursive model with sequential analytic solutions for all stocks and flows in that single country.[2] In addition, this model will show that reductions or increases in foreign exchange reserves, as a result of foreign exchange interventions by the central bank to keep the exchange rate fixed, have no effect on the money supply, in direct contradiction to a claim found in many textbooks. In other words, foreign exchange interventions by central banks are "automatically" sterilized, and we shall claim that this is the norm rather than the exception.

The way in which this model works will prepare the ground for a more complex model, presented in the second part of the paper, in which the exchange rate is determined by demand and supply for internationally tradable financial assets and in which changes in the exchange rate feed

[1] The main simplifications are that there are no supply constraints, no fixed investment, no banks (other than the central bank), and no price changes, while everyone enjoys perfect foresight. Finally, the accounting is only *nearly* comprehensive, because interest payment flows arising from Treasury bills have been omitted to cut down on the number of equations.

[2] The assumption that households hold no foreign financial assets, and that foreigners hold none of the debt issued by the domestic government, simplifies the financial constraints of the model.

back to help determine trade and all other flows as sequences in real time. We shall show that it is impossible to model this flexible exchange regime in one country without taking explicit account of the full range of responses in the rest of the world.[3] It will also be shown how this more complex model can be extended to a fixed exchange regime.

Our models are grounded in a double entry system of accounts in which all flows "come from somewhere and go somewhere," sometimes called SAM, the social accounting matrix. The approach advocated here relies on accounting relationships as they can be found in the national income and product accounts and in the "flows of funds" accounts in accordance with the principles of "stock-flow consistent" (SFC) accounting, where all stocks are the result of cumulated flows plus capital appreciation.[4] We believe, as does Taylor, that this approach helps to "remove many degrees of freedom from possible configurations of patterns of payments at the macro level, making tractable the task of constructing theories to 'close' the accounts into complete models" (2004b, p. 2).

It may be tempting to compare the present analysis to the standard Mundell–Fleming models (the IS-LM-BP models). But comparisons are hard to come by. Mundell (1963) assumes perfect capital mobility and perfect asset substitutability, whereas we assume only the former so that capital flows generated by differing rates of return cannot go on forever. Mundell (ibid.) and Fleming (1962), along with their textbook representations, assume that monetary policy is best represented by purchases and sales of securities on the open market, whereas we assume that interest rate targeting best represents monetary policy. Finally, we make explicit the interdependence of all variables within a stock-flow approach, whereas the standard textbook approach does not.

A single open economy with a fixed exchange rate

The economy is assumed to comprise firms, households, a foreign sector, and a government with a separate central bank. The accounting framework is displayed in the matrices shown in Table 1, which will be useful points of reference in the text that follows.

[3] While the method that we use is highly similar to the one used by Taylor (2004a; 2004b, ch. 10) in his open economy models, there is a crucial difference: Taylor still assumes endogenously determined interest rates.

[4] SFC is the expression coined by Dos Santos (2002).

Table 1
Transaction and balance sheet matrices of a simplified economy with capital controls

Flows per period

Sectors	Households	Firms	Central Bank	Government	Foreign	Sum
National accounts						
Consumption	$-C$	$+C$				0
Government		$+G$		$-G$		0
Exports		$+X$			$-X$	0
Imports		$-IM$			$+IM$	0
Total income/output	$+Y$	$-Y$				0
Taxes	$-T$			$+T$		0
Flow of funds						
Changes in						
T-bills	$-\Delta Bp$		$-\Delta Bcb$	$+\Delta B$		0
Cash	$-\Delta H$		$+\Delta H$			0
Foreign exchange reserves			$-\Delta R$		$+\Delta R$	0
Sum	0	0	0	0	0	0
Changes in						
Total wealth/debt	$+\Delta V$	0	0	$-\Delta B$	$-\Delta R$	0
Balance sheets (stocks) at end of period						
T-bills	$+Bp$		$+Bcb$	$-B$		0
Cash	$+H$		$-H$			0
Foreign exchange reserves			$+R$		$-R$	0
Sum = Total wealth/debt	$+V$	0	0	$-B$	$-R$	0

National income and product accounts

The national income identity, shown in the "firms" column of the flow matrix (see Table 1), is

$$Y = C + G + X - IM, \tag{1}$$

where Y is gross domestic product (GDP), C is consumption, G is government expenditure, X is exports, and IM is imports.[5]

Personal saving, the change in wealth, shown in the "households" column of Table 1, is given by

$$\Delta V = Y - T - C, \tag{2}$$

where V is total wealth, and T is taxes.

Taxes are determined by the tax rate, θ, and income:

$$T = \theta.Y \quad 0 < \theta < 1, \tag{3}$$

so that $Y(1-\theta)$ represents disposable income.

Imports are determined by the import propensity, μ, and income:

$$IM = \mu.Y \quad 0 < \mu < 1. \tag{4}$$

Consumption each period is determined by disposable income and the stock of wealth inherited from the previous period:

$$C = \alpha_1.Y(1-\theta) + \alpha_2.V_{-1} \quad 0 < \alpha_2 < \alpha_1 < 1. \tag{5}$$

The lagged stock variable supplies the essential dynamic component that will generate sequences in real time. Note that, by virtue of Equations (2) and (5), the consumption function can alternatively be written as a saving function (the increase in wealth ΔV is the saving of the current period), which turns out to be a wealth adjustment function:

$$\Delta V = \alpha_2 \left\{ \alpha_3.Y(1-\theta) - V_{-1} \right\}, \tag{6a}$$

[5] Investment is set aside because its inclusion in our framework requires a complete yet simplified representation of the way in which investment is financed and a large number of additional equations. Its inclusion would not change our essential conclusions because net investment would need to be equal to zero once a long-run equilibrium has been reached, unless we moved the analysis to growth models. A referee has suggested that we set a fixed level of investment, but this would imply an ever-falling rate of accumulation through time, and hence we do not feel that this would be an appropriate assumption to make.

where $\alpha_3 = (1 - \alpha_1)/\alpha_2$, and hence, where $\alpha_3.Y(1 - \theta)$ represents the current target stock of wealth, thus implying that α_3 is the implicit wealth to disposable income target ratio, while α_2 is the partial adjustment coefficient.

The "a" suffix in the equation number means that this equation is not part of the computer model. (It is not independent of the other equations of the model and, hence, is not required for the dynamic solution of the model.)

Under the assumption that government expenditure and exports to foreign markets (G and X) are exogenous, we already have enough equations to solve the model for GDP, consumption, wealth, tax payments, and the balance of payments, given the opening stock of wealth, the tax rate, and other parameters. By Equations (1), (3), (4), and (5), we obtain:

$$Y = m\left(G + X + \alpha_2 V_{-1}\right), \tag{7a}$$

thus yielding a nearly standard expression for the short-term equilibrium level of income, with the multiplicand being the term in parentheses, while the Keynesian income multiplier is

$$m = 1/\left\{1 - \alpha_1 (1 - \theta) + \mu\right\}.$$

This expression, however, can only remain constant provided the V_{-1} term remains constant, which will happen only in a (stationary) steady state. The steady-state stock of wealth, when $\Delta V = 0$, can be derived directly from Equation (6), which means that the target wealth to disposable income ratio α_3 has been achieved.

$$V^* = \alpha_3 Y^* (1 - \theta), \tag{8a}$$

where the asterisk denotes stationary state values.

Steady-state income, of a kind,[6] can thus be obtained from Equations (7a) and (8a), recalling that $\alpha_3 = (1 - \alpha_1)/\alpha_2$. After some manipulations, we get:

$$Y^* = (G + X)/(\theta + \mu). \tag{9a}$$

[6] This will not, in general, be a full stationary state as we shall soon see, because exports will not, in general, be equal to imports.

Flow of funds and financial stocks

Our simple model is recursive, with national account flows being determined without considering flows of funds and portfolio choices. How does the rest of the system fit together? We now move on to the financial side of the model.

Saving each period, together with the opening stock of wealth, creates a new end-period stock of wealth (given by Equation (2)), which the personal sector allocates between cash and Treasury bills in a proportion determined by the exogenous interest rate. The array of asset demands (assuming for simplicity no transactions demand for cash) is

$$H_d = (\lambda_0 - \lambda_1.r).V \tag{10a}$$

$$Bp_d = [(1-\lambda_0)+\lambda_1.r].V, \tag{11}$$

where H is cash, Bp is Treasury bills held by the personal sector, the subscript d denotes demand, and r is the exogenous rate of interest on Treasury bills.[7]

The coefficients in this array are constrained according to Tobinesque adding-up principles so that the sum of constants is equal to one, and the sum of the other column is zero. As Equation (10a) is logically implied by the stock of wealth and the demand for bills by the personal sector, to obtain a solution for the whole model, the demand for cash must be entered (as Tobin laid down) as follows to avoid overdetermination.

$$H_d = V - Bp_d. \tag{10}$$

In other words, by having a certain demand for bills, as in Equation (11), the personal sector is thereby implying a unique demand for cash, as a result of the "wealth constraint." There is one decision, not two, to be made.

Looking now at the supply side, the government sells (issues) additional Treasury bills to cover any deficit:

$$\Delta B_s = G - T, \tag{12}$$

where B is the stock of Treasury bills outstanding, and the subscript s means supply.

[7] Asset functions are linearized, as they usually are.

We assume, in line with standard Post Keynesian theories, and in line with the new "consensus view" espoused by some New Keynesians, that the interest rate is set and administered by the central bank.[8] With constant interest rates, it has to be the case that the central bank will exchange Treasury bills for cash on any scale whatever in response to demand.

$$Bp_s = Bp_d. \tag{13}$$

Equations (12) and (13) imply, by virtue of the identity in the first of the flow-of-funds lines of the transactions matrix, that the supply of Treasury bills to the central bank is

$$Bcb_s = B_s - Bp_s, \tag{14}$$

where *Bcb* is the central bank's holdings of Treasury bills.

This is the amount that the government has to "borrow" from the central bank. We assume that the Bank will hold any amount of Treasury bills that the private sector is unwilling to hold at the target rate of interest.[9]

$$Bcb_d = Bcb_s. \tag{15}$$

The central bank holds two kinds of assets, namely, domestic and foreign Treasury bills, the latter being the foreign reserves of the domestic economy. Any imbalance in trade (because there are no capital flows) implies an equivalent change in the stock of foreign reserves:

$$\Delta R = X - IM, \tag{16}$$

where reserves, R, are defined as balances held by the central bank with the central banks of foreign countries.

The supply of cash is now implied by the Bank's balance sheet:

$$H_s = R + Bcb_d. \tag{17}$$

[8] See Fontana (2002) and Lavoie and Seccareccia (2004) for Post Keynesian assessments of this "new consensus."

[9] Thus, the Treasury and the monetary authorities do not decide what proportion of the public debt ought to be "monetized," if we dare use the wording of mainstream authors. This proportion is determined endogenously by the portfolio decisions of the private sector and the evolution of the external balance (as Equation (17) will show), once the target rate of interest has been set by the central bank.

We now have equations both in the demand for money (Equation (10)) and in the supply of money (Equation (17)). But the equivalence between the two, that is,

$$H_s = H_d, \tag{18a}$$

is guaranteed by the comprehensive accounting in which the model is grounded. As there is an equation in every other endogenous variable, it must, under quasi-Walrasian principles, be the case that this final equation is satisfied as well. There is neither a need nor a place for an equation (the "redundant" equation) to make the demand for money equal to the supply. The money stock is thus comprehensively endogenous; it is what the central bank finds itself supplying, given the demand for money.

This finding is in line with the claim made by Arestis and Eichner that "so long as it is recognized that money supply is credit-driven and demand-determined, the exchange rate regime is of absolutely no consequence in the determination of money and credit" (1988, p. 1015). Interest rates can be set by the central bank and money is demand-determined in this fixed exchange rate regime.[10]

Implications of the simple fixed exchange rate model

We have now described a complete stock-flow model (there is an equation for every endogenous variable) that, conditional on initial conditions and, depending on the values taken by the exogenous variables—the fiscal variables θ and G, the trade variables X and μ, the monetary policy variable r, as well as the behavioral portfolio parameters λ—will generate all stock and all flow variables period by period on their way toward a stationary state.[11] This is illustrated in Appendix

[10] This was recognized by earlier Keynesian authors, such as James Meade. As Allen and Kenen point out, "Meade instructs the central bank to maintain a constant interest rate; the bank's open market operations offset changes in the supply of money caused by movements of reserves and offset changes in the demand for money caused by the movements in domestic income" (1980, p. 8). As a matter of fact, Fleming, who is associated with Mundell as being the founder of the standard IS-LM-BP model, recognizes that "the only clear-cut alternative would appear to be that of defining constancy of monetary policy as the maintenance of a constant rate of interest" (1962, p. 370), giving Mundell (1961a) as an example of this choice.

[11] It turns out that the model is stable whatever the values taken by the parameters, so that we know that the economy is moving toward a stationary state. This can be verified by checking the recurrence equation describing the evolution of the stock of wealth. Current wealth is past wealth plus saving out of income minus consumption out of wealth:

A with a simple arithmetical example, which can be worked out with no aid other than a pocket calculator.

A major feature of this model is that there is nothing in it, no self-correcting mechanism, to make exports equal to imports. In general, once the steady-state level of income has been reached, trade will still be unbalanced, which implies that this solution is instead a *quasi* steady state, because some stocks will still be changing, namely, the central bank stock of foreign reserves and the stock of government debt (Godley and Cripps, 1983, p. 294). Meanwhile, the private sector is receiving no signal that anything is wrong, apart from the fact that it may be suffering from a loss in income and output when there is a trade deficit.

This result brings into focus the crucial importance, central to the methodology we are advocating, of always deploying a fully articulated SFC model. The mainstream deployment at this stage of the argument presents a central bank balance sheet—identical to our own in Table 2—with government bills and foreign exchange reserves as assets and cash ("money") as the sole liability. But this balance sheet is presented in total isolation from everything else that is going on. If the country develops a balance-of-payments surplus, there has to be an equivalent rise in foreign exchange reserves that (inspection of the balance sheet seems to suggest) generates an equivalent change in the "supply of money," because it is being assumed that the stock of domestic securities being held by the central bank remains constant. This quasi exogenous increase in "the money supply" is commonly fed into an IS-LM (or an AS-AD) structure with the increase in the money balances typically leading to lower interest rates and rising economic activity (or higher prices in a model with flexible prices), thereby generating a self-correcting process. With trade deficits, in these models, the stock of "money" gets gradually depleted, thus leading to higher interest rates or lower domestic prices, which help net exports to recover through absorption and substitution effects.

There is no such mechanism here, because the balance of trade and the central bank's balance sheet are both integrated into a fully interlocking system of income/expenditure flows and private sector and government

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$$V = V_{-1} + (1 - \alpha_1)(1 - \theta)Y - \alpha_2 . V_{-1}.$$

Making use of Equation (7a), this can be rewritten in the form $V = \mathrm{A} + \mathrm{B}.V_{-1}$ where the absolute value of B must be smaller than unity to ensure stability. Because

$$\mathrm{B} = \{1 - \alpha_1(1 - \theta) - \alpha_2\theta + (1 - \alpha_2)\mu\}/\{1 - \alpha_1(1 - \theta) + \mu\}^{-1},$$

this condition is always fulfilled.

Table 2
Effect of a jump in exports on the balance sheet of the central bank

Change in foreign reserves	+3.0	Change in cash	+0.4
Change in T-bills	−2.6		

balance sheets. In Appendix A, we give a numerical example of what would happen, according to our simple model, if exports were to jump by $5. In the first period, the balance of trade would improve by $3, and the budget balance by $1.6. The central bank's balance sheet would change as shown in Table 2.

Our SFC model shows how "sterilization" would occur automatically and endogenously, being the consequence of the central bank decision to keep interest rates at a given level, which is how central banks function in the real world.[12] The reduction in the holdings of Treasury bills by the central bank compensates for the increase in foreign reserves that is not accompanied by an increase in money demand. This is the "compensation" thesis underlined by French central bankers.[13] The *rules of the game,* the purpose of which is to mimic the effects of the old *price-specie flow* mechanism, eventually through an *income-specie-flow* mechanism as Mundell (1961b, p. 159) calls it, just do not apply.[14]

In the case of a trade deficit, it is for the government to worry about the losses of foreign exchange reserves and the associated rising debt.

[12] In one of its background papers, the Bank of Canada explains that when it conducts exchange rate operations, moderating a decline in the Canadian dollar for instance, it must sterilize its purchases of Canadian dollars by "redepositing the same amount of Canadian-dollar balances in the financial system," in order "to make sure that the Bank's purchases do not take money out of circulation and create a shortage of Canadian dollars, which could put upward pressures on Canadian interest rates" (2004). Thus sterilization is not a matter of choice, it is a necessity as long as the central bank wants to keep the interest rate at its target level.

[13] See Lavoie (2001) for several references to and a historical review of this concept, and Godley (1999) for the first demonstration of its validity within the context of a stock-flow coherent model.

[14] It must be pointed out that Mundell (1961b), whose other works are often invoked to justify the relevance of the rules of the game in textbooks and the IS-LM-BP model, was himself aware that the automaticity of the *rules of the game* relied on a particular behavior of the central bank. Indeed, he lamented over the fact that modern central banks were following the *banking principle* instead of the *bullionist principle,* and hence adjusting "the domestic supply of notes to accord with the needs of trade" (ibid., p. 153), which is another way to say that the money supply was endogenous and that central banks were concerned with maintaining the targeted interest rates. This was in 1961!

This is an instance of the well-known *twin deficit* situation.[15] The possible existence of twin deficits can be recovered from the last row of the flow-of-funds section of Table 1. We have:

$$+\Delta V - \Delta B - \Delta R = 0. \tag{19a}$$

And hence:

$$+\Delta V - (G - T) - (X - IM) = 0. \tag{20a}$$

When the (quasi) steady state has been reached, there are no changes in flows and in private wealth, so that $\Delta V = 0$, and

$$(IM - X) = (G - T). \tag{21a}$$

This equation shows that, in a (quasi) steady state, a trade deficit will be accompanied by an equivalent budget deficit, and, conversely, that a trade surplus will be associated with a budget surplus. In the case of a trade deficit, as long as private capital flows are not allowed, there are no means to finance a trade deficit after the reserves of the central bank have become exhausted. A possible response, when reserves run out, will be to restrict demand, using fiscal policy, to the point where exports equal imports, $IM - X = 0$. In this case, using Equation (21a) and recalling Equations (3) and (4), we end up with the *super* steady state where all stocks as well as all flows are constant.[16]

$$Y^{**} = X / \mu = G / \theta. \tag{22a}$$

Under a fixed exchange regime, the level of output is thus ultimately restricted to a value set by exports relative to the import propensity. The G/θ ratio becomes endogenous, and responds to the constraint imposed by the X/μ ratio. The first part of Equation (22a) is simply Roy Harrod's static foreign trade multiplier equation, which, in its dynamic form (in growth terms), has been resuscitated as Thirlwall's Law (McCombie and Thirlwall, 1999).

The situation is, however, different when countries are running trade surpluses. Take the case of China with its exchange rate fixed to the U.S. dollar and its huge balance-of-payments surplus. The country is accu-

[15] Note that the twin deficit proposition *stricto sensu* holds neither during the transition to a stationary state nor when the economy is growing with private investment.

[16] As suggested by Godley and Cripps (1983, pp. 295–296).

mulating enormous additions to its foreign reserves. The People's Bank of China—the Chinese central bank—is still able to control interest rates, the economy is not being flooded with liquidity, and hence there is no inherent corrective mechanism, save continued expansion, that would bring about a balanced trade account.[17] The Chinese economy can continue to run balance-of-payments surpluses forever, if its government leaders are happy to accumulate U.S. financial assets.[18] There is no mechanism, neither a price mechanism nor a quantity mechanism, that will force the surplus countries to converge toward a balanced current account.[19] As a result, there is a worldwide asymmetry here, with only austerity policies being forced upon countries, while no expansionary policies ever seem to be needed for external reasons—a point previously made by several Keynesian and Post Keynesian authors, including Keynes himself.

The open economy with mutual trading in financial assets

We are now well prepared for the more complex situation when the residents of all countries are able to buy and sell foreign financial assets—namely, Treasury bills issued by foreign governments. If central banks do not buy or spend reserves—if, that is, there is "clean" floating—a solution to the model will require a change in the exchange rate. It will also become apparent that it is impossible to solve the model for one country without incorporating the full range of responses from the rest of the world.

We start off with an extended matrix—shown in Table 3—that includes two economies that together make up the whole world. On the left, we

[17] The Chinese financial system being an "overdraft" system, commercial banks are indebted to the central bank. When the country is running a balance-of-payments surplus, commercial banks can use their foreign currency holdings to reduce their indebtedness vis-à-vis the central bank. Sterilization thus occurs in large part at the initiative of the commercial bank sector—sterilization is endogenous. See Lavoie (2001) for further discussion on this issue.

[18] When we made this claim, the response of some central bankers was that China could not, or at least would not, sterilize forever, because of its opportunity cost. When asked more about this cost, we were told that, when sterilizing, the central bank of China would be accumulating assets (U.S. Treasury bills) that would pay a lesser interest rate than the rate obtained on the domestic assets that the Chinese central bank would be unloading. We see no reason why rates of interest in China (or in any other surplus country) ought to be higher than those in the United States.

[19] Surplus countries may be running at high rates of utilization, but this does not imply rising inflation rates, unless one believes in the vertical Phillips curve.

Table 3
Transactions matrix in a two-country economy with capital flows

	Country $					Country #				
	1. HH$	2. Frm$	3. CB$	4. Gvt$	*xr$*	5. HH#	6. Frm#	7. CB#	8. Gvt#	Sum
1. Consumption	$-C\$$	$+C\$$				$-C\#$	$+C\#$			0
2. Government expenditure		$+G\$$		$-G\$$			$+G\#$		$-G\#$	0
3. Exports/imports		$+X\$$			$.xr\$$		$-IM\#$			0
4. Imports/exports		$-IM\$$			$.xr\$$		$+X\#$			0
5. Output/income	$+Y\$$	$-Y\$$				$+Y\#$	$-Y\#$			0
6. Taxes	$-T\$$			$+T\$$		$-T\#$			$+T\#$	0
7. Δ Money	$-\Delta H\$$		$+\Delta H\$$			$-\Delta H\#$		$+\Delta H\#$		0
8. Δ T-bills $	$-\Delta B\$\$$		$-\Delta Bcb\$$	$+\Delta B\$$	$.xr\$$	$-\Delta B\#\$$		$-\Delta Bcb\#\$$		0
9. Δ T-bills #	$-\Delta B\$\#$				$.xr\$$	$-\Delta B\#\#$		$-\Delta Bcb\#$	$+\Delta B\#$	0
Sum	0	0	0	0		0	0	0	0	0

have a \$ country with all transactions measured in the \$ currency; on the right, we have a # country with all transactions measured in the # currency. These definitions will be repeated in the text. Each country has four sectors, households (HH), firms (Frm), the central bank (CB), and the government (Gvt). All entries common to both countries must be converted to a common currency, multiplying through by the exchange rate.

Imports into one country are exports from the other and vice versa. Treasury bills issued by each government may be purchased by the residents of either country. Because transactions by agents in the \$ country are all measured in \$ currency, and transactions in the # country are measured in the # currency, all cross-border transactions must be converted from one currency to the other—in the matrix, by multiplying the relevant \$-denominated entries in the \$ section by the exchange rate ($xr\$$) in the central column or vice versa. Hence, $xr\$$ is the number of # per \$ (the value of a \$ in # currency). Where bills have two suffixes, the first refers to the country where the Treasury bill is owned, the second refers to the country where the Treasury bill was issued. For instance, $B\$\#$ are Treasury bills held in the \$ country that were issued by the # Treasury.

Equations

At the risk of being repetitious, we shall next run through the whole sequence of equations describing these two economies. There will be no explanation except when the equation in question differs from that in the fixed exchange rate model. All equation numbers with a B suffix are auxiliaries that are not needed to solve the model.

The GDP identity:

$$Y\$ = C\$ + G\$ + X\$ - IM\$ \tag{1A}$$

$$Y\# = C\# + G\# + X\# - IM\#. \tag{2A}$$

The wealth identity:

$$\Delta V\$ = Y\$ - T\$ - C\$ + CG\$ \tag{3A}$$

$$\Delta V\# = Y\# - T\# - C\# + CG\#. \tag{4A}$$

Equations (3A) and (4A) have a new term, CG, which describes capital gains, to be discussed below.

The tax take:

$$T\$ = \theta\$.Y\$ \tag{5A}$$

$$T\# = \theta\#.Y\#. \tag{6A}$$

With the two countries forming a single system, exports now become endogenous. Exports by each country are thus equal to imports by the other, converted to a common rate of exchange.

Exports and imports:

$$X\$ = IM\# / xr\$ \tag{7A}$$

$$X\# = IM\$.xr\$ \tag{8A}$$

$$\mathbf{im\$} = \mu_{0\$} + \mu_{1\$}.\mathbf{y\$} + \mu_{2\$}.\mathbf{xr\$} \tag{9A}$$

$$\mathbf{im\#} = \mu_{0\#} + \mu_{1\#}.\mathbf{y\#} + \mu_{2\#}.\mathbf{xr\#}. \tag{10A}$$

Imports are determined in each country by the relevant income and price elasticities, with lowercase boldface letters denoting logs.

The variable $xr\#$ is the converse of $xr\$$, as we shall see in Equation (35A), which is the number of dollars per unit of the # currency. It is, of course, a drastic simplification simply to write, for the relative price elasticity, a coefficient times the exchange rate. The full alternative would be to postulate a relationship between the exchange rate and import prices and add a relationship describing the price elasticity of demand for import volumes (as in Godley and Lavoie, 2003). Of course, the volume of imports goes down if there is a devaluation. The price of imports goes up, but the volume falls by more given normal assumptions about the price elasticity of demand. Strictly the favorable volume responses of exports and imports combined are larger than the terms of trade deterioration that characteristically take place with devaluation.

The consumption of households:

$$C\$ = \alpha_{1\$}.Y\$(1-\theta\$) + \alpha_{2\$}.V\$_{-1} \tag{11A}$$

$$C\# = \alpha_{1\#}.Y\#(1-\theta\#) + \alpha_{2\#}.V\#_{-1}. \tag{12A}$$

The supply of Treasury bills:

$$\Delta B\$_s = G\$ - T\$ \tag{13A}$$

$$\Delta B\#_s = G\# - T\#. \tag{14A}$$

The next new feature is that the residents of each country can now purchase bills issued by the government of the other country, so the arrays of asset demands must be augmented. Recall the convention that the suffixes are such that when two currencies are involved, the first is the currency of residents owning the asset, the second is the currency of the government issuing the asset. Still omitting the transaction demand for money, we have the following.

The array of asset demands for \$ residents, where all asset demands are valued in \$ currency:

$$B\$\$_d / V\$ = \lambda_{10\$} + \lambda_{11\$}.r\$ - \lambda_{12\$}.r\# \quad (15A)$$

$$B\$\#_d / V\$ = \lambda_{20\$} - \lambda_{21\$}.r\$ + \lambda_{22\$}.r\# \quad (16A)$$

$$H\$_d / V\$ = \lambda_{30\$} - \lambda_{31\$}.r\$ - \lambda_{32\$}.r\#. \quad (17B)$$

The array of asset demands for # residents, where all asset demands are valued in # currency:

$$B\#\#_d / V\# = \lambda_{10\#} - \lambda_{11\#}.r\$ + \lambda_{12\#}.r\# \quad (18A)$$

$$B\#\$_d / V\# = \lambda_{20\#} + \lambda_{21\#}.r\$ - \lambda_{22\#}.r\# \quad (19A)$$

$$H\#_d / V\# = \lambda_{30\#} - \lambda_{31\#}.r\$ - \lambda_{32\#}.r\#. \quad (20B)$$

Expectations about future spot exchange rates have not been explicitly introduced as part of the expected rate of return on assets. Because technical rules rather than fundamentals seem to explain the evolution of exchange rate expectations (Harvey, 2002), we implicitly assume the simplest of these rules, that the current exchange rate is expected to continue to rule in the next period.[20]

Tobinesque adding-up constraints apply once again.[21] To obtain solutions to the whole model, Equations (17B) and (20B) are dropped, and the demand for cash is written as:

$$H\$_d = V\$ - B\$\$_d - B\$\#_d \quad (17A)$$

$$H\#_d = V\# - B\#\#_d - B\#\$_d. \quad (20A)$$

[20] We thus rule out uncovered interest parity (UIP) and make no use of covered interest parity (CIP), because its causality must be reversed (Lavoie, 2000).

[21] Once again, the sum of the constants λ_{i0} must equal unity, while the sum of the coefficients in the other columns must equal zero. See Karacaoglu (1984) for an application within a Post Keynesian model.

Note that, since the transaction demand for cash and exchange rate expectations have been omitted, as long as both interest rates are exogenous and fixed, each of the ratios in Equations (15A)–(20B) is also fixed and predetermined, whatever else happens.

In order to keep interest rates fixed, the central bank must exchange bills for cash, and vice versa, on demand, making the supply of both cash and bills endogenous.

$$H\$_s = H\$_d \tag{21A}$$

$$H\#_s = H\#_d \tag{22A}$$

$$B\$\$_s = B\$\$_d \tag{23B}$$

$$B\#\#_s = B\#\#_d. \tag{24A}$$

Hence, the supply of domestic T-bills to their respective central banks is endogenous as well.

$$Bcb\$_s = Bcb\$_d \tag{25A}$$

$$Bcb\#_s = Bcb\#_d. \tag{26A}$$

We further recall that the \$ currency is the international currency, so that the \$ central bank does not hold any foreign reserves, while the # country is on a pure flexible exchange rate regime and does not intervene in exchange markets, which implies that the # central bank does not acquire new reserves ($\Delta Bcb\#\$_s = 0$, so that $Bcb\#\$_s$ is a historically given constant). This implies that changes in central banks' stocks of domestic Treasury bills are equal to changes in the liabilities of each central bank.[22]

$$\Delta Bcb\$_d = \Delta H\$_s \tag{27A}$$

$$\Delta Bcb\#_d = \Delta H\#_s. \tag{28A}$$

All bill supplies must go somewhere, as can be seen from the balance sheet identity (lines 8 and 9 of Table 3). Treasury bills ($B\$_s$) issued by

[22] In the case of the # central bank, we must use the first-difference operator, because, due to reserves and possible capital gains (or losses) on foreign exchange reserves, the stock of cash is not equal to the stock of domestic Treasury bills.

the U.S. government can be held by # foreign residents ($B\#\$_s$), U.S. residents ($B\$\$_s$), the \$ central bank ($Bcb\$_s$), and the # central bank ($Bcb\#\$_s$). Similarly, Treasury bills issued by the # government can be held by foreign \$ residents, # domestic residents, or the # central bank.

As all supplies of assets to domestic residents have been demand-determined in Equations (21A)–(26A), the supply of assets abroad must, in each case, equal the gap between total supplies and supplies that meet domestic demand.

$$B\#\$_s = B\$_s - B\$\$_s - Bcb\#\$_s - Bcb\$_s \tag{29B}$$

$$B\$\#_s = B\#_s - B\#\#_s - Bcb\#s. \tag{30A}$$

But now we have a sharp confrontation. Demand in each country for assets issued abroad, denominated in the currency of the country where they are held, has been determined in Equations (16A) and (19A). At the same time, supplies of assets that must be sold abroad, denominated in the currency of the country where they have been issued, have been determined in Equations (29B) and (30A). The exchange rate must be such that it equalizes the demand and supply for internationally traded assets that now confront one another in each country. That is, it must simultaneously be the case that

$$xr\$ = B\#\$_d \,/\, B\#\$_s, \tag{31B}$$

and also that

$$xr\$ = B\$\#_s \,/\, B\$\#_d, \tag{32A}$$

For both of these conditions to be met, rather more has to happen than is immediately obvious. When the model comes to be solved, the exchange rate, in a raft of interdependent processes, must satisfy, and be satisfied by, not only the asset demand/supply equivalences but every other equation in which it (the exchange rate) appears. The whole process is further complicated because the response of the trade variables (Equations (9A) and (10A)) to changes in the exchange rate will normally be completely different as between the two countries. The two countries will also exhibit different responses of consumption as a result of capital gains, which may now be identified as the change in the value of the opening stock of foreign issued bills due to a change in the exchange rate within the period.

$$CG\$ = \Delta xr\#.B\$\#_{s-1} \tag{33A}$$

$$CG\# = \Delta xr\#.B\#\$_{s-1}. \tag{34A}$$

To check that we have enough equations to determine a single exchange rate that is capable of doing all the work that is required of it, we must write out the model with each variable appearing not more than once on the left-hand side of an equation. We are faced with a bit of a Chinese puzzle. The solution is simple enough, though it may take a long time to find.

First note that one of the two Equations (31B) and (32A) must be modified, because we cannot let the exchange rate, $xr\$$, appear on the left-hand side of two equations. We shall retain Equation (32A) and write Equation (31B) as

$$B\#\$_s = B\#\$_d \,/\, xr\$. \tag{31A}$$

But now we have two equations with $B\#\$_s$ on the left-hand side, Equations (31A) and (29B). Hence, we rewrite Equation (29B) as

$$B\$\$_s = B\$_s - B\#\$_s - Bcb\#\$_s - Bcb\$_s \tag{29A}$$

and close the model by recalling that

$$xr\# = 1 \,/\, xr\$. \tag{35A}$$

We now have an equation in every endogenous variable, save the two interest rates that remain exogenous.[23] A careful reader may note that we still have two equations with $B\$\$_s$ on the left-hand side (Equations (23B) and (29A)), so we shall drop Equation (23B). It would then seem that $B\$\$_s$ (Equation (29A)) and $B\$\$_d$ (Equation (15A)) are independent of each other. However, as was the case with H in the fixed exchange rate model, since the accounting of the whole system is comprehensive, the system guarantees that $B\$\$_s = B\$\$_d$, which is Equation (23B). This is the "redundant" equation, which must be dropped. The two terms of

[23] While the method that we use is similar to the one used by Taylor (2004a; 2004b, ch. 10) in his open economy models, there is a crucial difference: Taylor still assumes endogenously determined interest rates, while ours are set exogenously by central banks. Thus these target rates of interest act as an anchor. This difference may help explain why Taylor believes that, in contrast to what we claim, "the exchange rate is not set by temporary macro equilibrium conditions. It must evolve over time subject to rules based on expectations about its future values in the future" (2004b, p. 333). This forces Taylor to introduce UIP to close his model, on the basis that UIP relies on "arbitrage arguments that 'should be true'" (ibid., p. 333), while acknowledging earlier that UIP "does not fit the data" (ibid., p. 315).

this equation are equivalent without the need for any equation to make that happen—so long as every other equation is satisfied.[24]

The model is now complete and it is solved using the numbers listed in Appendix B. Besides the stock of foreign reserves, $BCB\#\$_s$, held by the # central bank, the exogenous variables are G, θ, and r (for each country). Output in each country together with consumption, imports, exports, wealth, and its allocation between the available assets and the exchange rate are all endogenously determined. When the exchange rate changes, this changes the import propensity, disposable income, and hence output in each country—and hence (all still within one period) the budget deficit/surplus and changed supplies of assets, hence back to the exchange rate, and so on. And having reached a kind of temporary equilibrium in each short period, the imaginary economies evolve further in sequences through time on their way toward a full steady state.

It hardly seems possible that there exists an analytic solution to this model—at least one that is transparent enough to have any useful meaning. There is, however, no difficulty in obtaining model solutions by simulation, which are qualitatively quite easy to understand.

First experiment: increasing government expenditure in one country

We are now in a position to give a narrative account of how the whole model works. Imagine that the whole system is in a full stationary steady state with no change taking place in any stock or any flow. Imagine this not because such a state ever exists, but because it is a convenient "alternative position" that is easy to visualize and with which a new solution can be unambiguously compared.

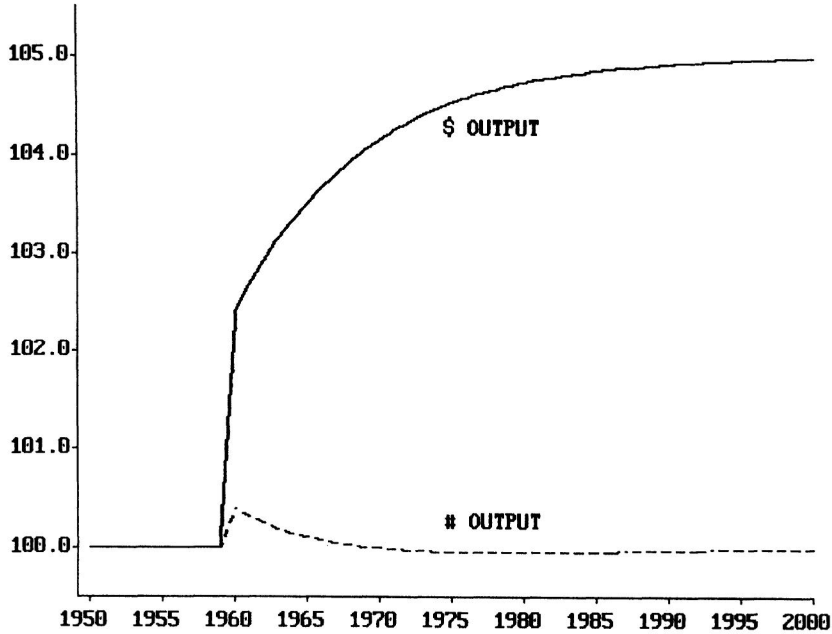
First assume that there is a step up, which persists, in $G\$$, government expenditure in the \$ country, and next trace through the consequences.

Output by the \$ country rises, as can be seen in Figure 1. As a result, imports $IM\$$ by the \$ country rise, and the \$ balance of trade becomes briskly negative, as shown in Figure 2.[25] In addition, taxes $T\$$ rises (because of the rise in $Y\$$) but less than $G\$$, so the \$ government budget goes into deficit. This means that there has to be an increase in the

[24] Thus the model contains 34 equations, because Equation (23B) needs to be dropped. Each country has 16 endogenous variables, plus its exchange rate.

[25] There is a small increase in the output of the # country because its exports have increased, as can be seen in Figure 1. Its budget position improves, but only by a small amount.

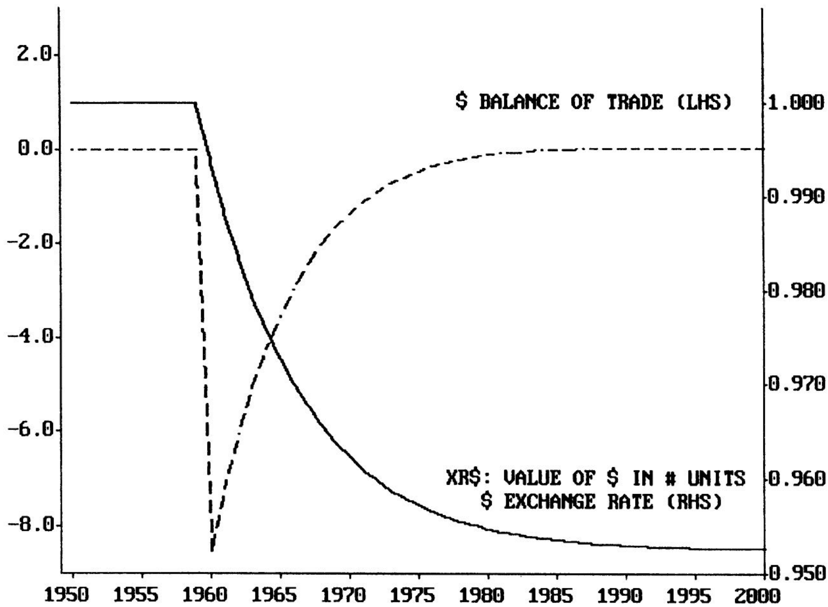
Figure 1 Effect of a permanent increase in \$ government expenditures on \$ output and # output, flexible exchange regime



outstanding stock of bills $B\$_s$ issued by the \$ Treasury. Because $B\$\$_d/V\$$ and $H\$_d/V\$$ are fixed (there being no change in interest rates by assumption), and because the one-period change in $V\$$ is small, there has to be an increase in $B\#\$_s$, the amount of \$ Treasury bills that are supplied abroad. But a similar situation is occurring in the # country. Because interest rates are fixed, $B\#\$_d/V\#$ and $B\#\#_d/V\#$ are also both fixed, as shown in Figure 3. In addition, because the one-period change in V# is small, the demand by # households for Treasury bills issued by the \$ government, $B\#\$_d$, hardly changes. The increase in the supply of these Treasury bills to # households, as can also be seen in Figure 3, must thus be absorbed through a change in the exchange rate. The exchange rate, *xr\$*, as shown in Equation (31B), must change in a way that makes the supply of \$ Treasury bills abroad equal to the overseas demand for them, when expressed in the same currency. In other words, *xr\$*—the dollar exchange rate (the value of the dollar in # currency)—depreciates as shown in Figure 2.

Next, the change in the exchange rate feeds into both import functions, reducing the import propensity in the \$ country and raising it in the # country, thus eventually generating balanced trade in the \$ country

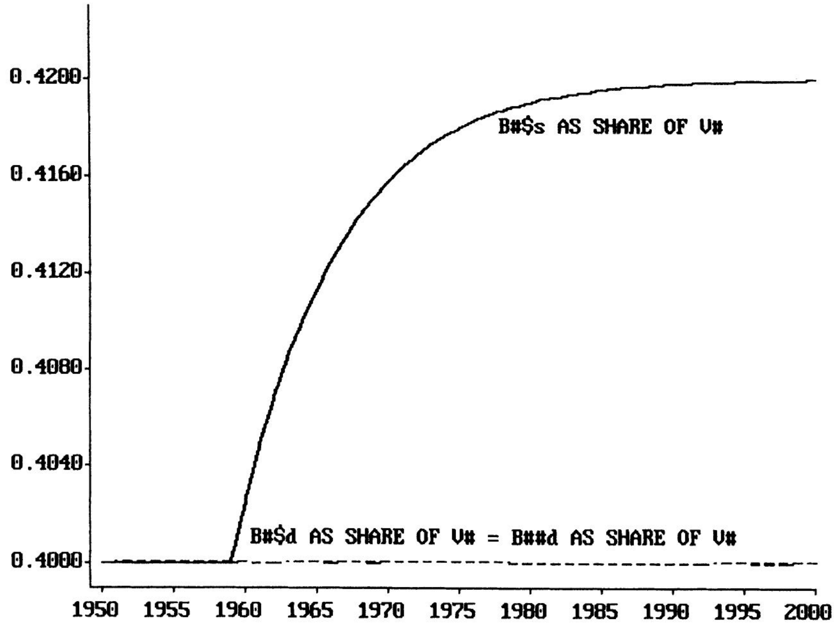
Figure 2 Effect of a permanent increase in $ government expenditures on the $ balance of trade and the dollar exchange rate (*xr$*)



(Figure 2). In addition, the falling dollar generates capital losses for residents in the # country where the value of the opening stock of bills issued abroad increases, and capital gains in the $ country, which confronts a reduced value of bills issued in the # country. These revaluations of wealth stocks will feed into the asset demands in both countries in the same period, and affect consumption expenditures in the succeeding period, through a wealth effect. Although the responses in the two countries are symmetrical, they will not, in general, be identical. The coefficients in the asset demand functions will, in general, be entirely different as between the two countries, yet there has to be only a single exchange rate to satisfy all the relevant responses.

The one-period solution that this model generates when shocked does not, in general, simultaneously generate a new overall steady state in which the balance-of-payments imbalance is eliminated. Rather, a new balance-of-payments deficit/surplus will occur, which will, in turn, generate a new, and similar, set of responses. So long as the exogenous variables do not change, the exchange rate will go on falling at a reducing rate until a new full steady state is achieved. Fiscal policy and also monetary policy in the form of interest rates are both under the full control of each government.

Figure 3 Effect of a permanent increase in $ government expenditures on the proportions of assets held in # household portfolios, flexible exchange rate

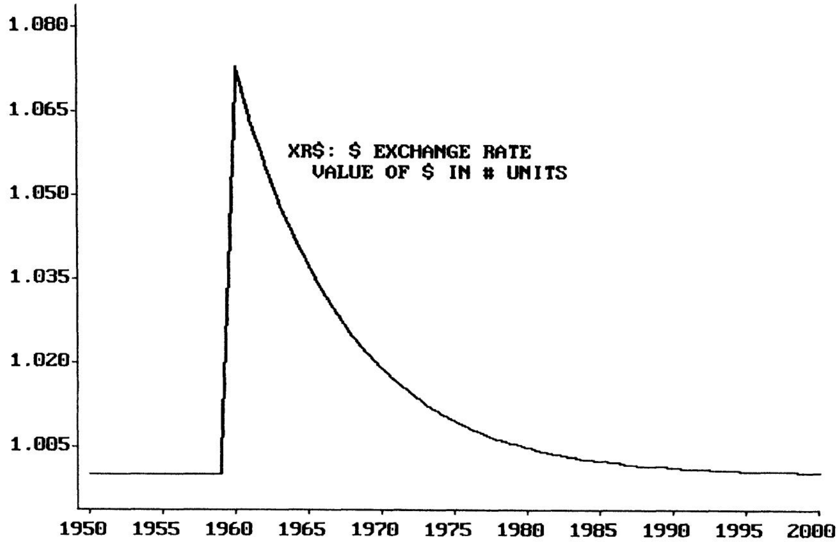


Second experiment: increasing interest rates in one country

We may now proceed to a second experiment, describing how a change in one of the interest rates affects the system under a floating exchange regime. This may help understand Figure 3.

The rise in the $ rate of interest immediately leads to a brisk hike in the $ exchange rate, the value of the dollar in # units. In other words, there is a sudden appreciation of the dollar, as can be seen in Figure 4. There is nothing surprising about this, as the higher $ rate of interest attracts net foreign capital, with all households now wanting to hold a larger proportion of $ Treasury bills and a smaller proportion of # Treasury bills. As Figure 5 shows, and as is clearly implied by Equations (18A) and (19A), the share of $ bills in # portfolios immediately rises and that of # bills in # portfolios falls by an equivalent amount so long as both shares are measured in # currency. However, this conceals the fact that, because the exchange rate has changed, the share of $ bills measured in $ currency initially falls, rising only at a later stage. The initial fall is due to the fact that, since there is an approximately constant supply of $ Treasury bills in the entire world, not all households will suc-

Figure 4 Effect of a permanent increase in the \$ rate of interest on the dollar exchange rate (*xr\$*)



ceed in increasing their share of wealth held in the form of \$ Treasury bills, when measured in dollars. Households from the # country will thus initially hold less \$ Treasury bills, when measured in dollars, but they will succeed in holding more of them, when measured in their local currency. This will be achieved through an appreciated dollar.

The stronger dollar will disturb the whole system by generating fiscal and trade imbalances. Because the stronger dollar will induce higher imports, the \$ economy will run a trade account deficit. The latter, along with the capital losses of \$ households on their holdings of foreign Treasury bills due to the depreciation of the # currency, will slow the \$ economy and propel the \$ government budget position into a deficit. Because of this, \$ Treasury bills will have to be newly issued. The outstanding stock of $B\$_s$ will rise gradually, and thus respond to the higher demand for this security. As a result, the value of the dollar will revert toward its original value (Figure 4), and so will the output of the \$ country (Figure 6).

A symmetric process will occur in the # country. The appreciation of the dollar will lead to an increase in exports and capital gains for households holding dollar-denominated securities. Both of these effects will induce an initial boost in the output of the # country, as shown in Figure 6, as well as a trade surplus and a budget surplus. There will thus be a

Figure 5 Effect of a permanent increase in the $ rate of interest on the proportions of assets held in # household portfolios, flexible exchange regime

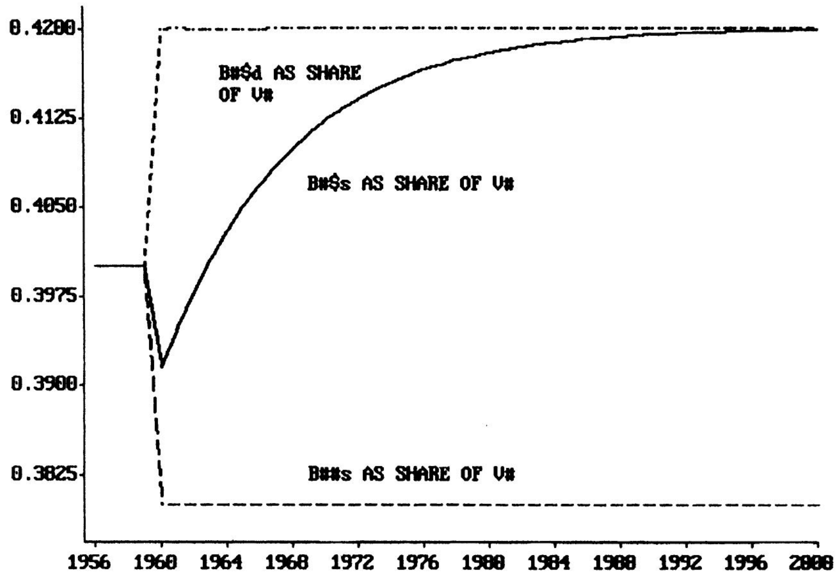
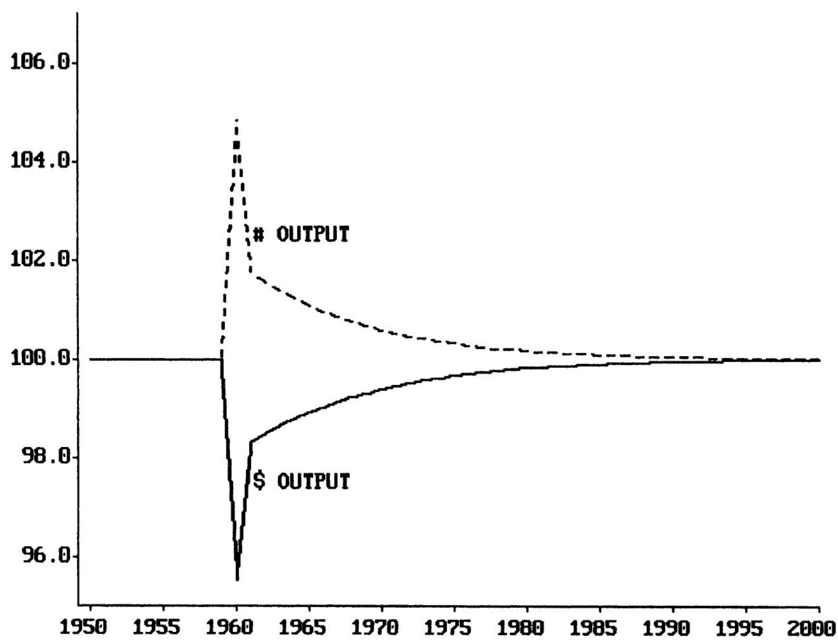


Figure 6 Effect of a permanent increase in the $ rate of interest on $ output and # output, flexible exchange regime



reduction in the outstanding stock of # Treasury bills, $B\#_s$, which will correspond to the reduced demand for this security caused by the higher \$ interest rate. This will contribute to bringing back the value of the dollar to its original value.

Thus, in this model, an increase in the interest rate leads to a slowdown of the economy through the exchange rate channel, but this negative impact is only temporary. In the new steady state, both economies are back to their initial flow levels, except that the \$ country, which imposed the higher interest rate, is now stuck with more substantial public debt and foreign debt.

Changes in liquidity preference or speculative activity could be represented within the framework outlined above. An increase in the liquidity preference of asset holders in favor of \$ Treasury bills would lead to the same dynamics. This is because such a change in liquidity preference, just as an increase in the \$ interest rate, leads to an attempt by households to increase the share of \$ securities in their portfolios (through the constants λ_{i0}). Thus, such a change in liquidity preference would impose fluctuations in the exchange rate, and it would induce transitory changes in output and consumption. In the current case, it would lead to a momentary slowdown of the \$ economy, through the exchange rate channel. The system, by inducing a \$ government deficit, would create the \$ government assets that the investors desire.

To sum up about the flexible exchange rate regime, we see that monetary policy, defined as administered interest rates, is relatively less effective than fiscal policy, because its effect on output is only temporary, whereas fiscal policy has a permanent effect. This reverses the standard results achieved with the Mundell–Fleming model, where fiscal policy is relatively ineffective with flexible exchange rates. In addition, higher government expenditures here lead to a depreciation of the domestic currency, because of the induced trade deficit. By contrast (provided the BP curve is flat, when securities are perfect substitutes, or at least flatter than the LM curve), the Mundell–Fleming model concludes that higher government expenditures lead to an appreciation of the domestic currency, arising from a capital account surplus. This surplus is generated by higher interest rates, caused by crowding out, which result from the unrealistic assumption that central banks hold constant the money supply despite an increased demand for money.[26]

[26] The result that we achieved with fiscal policy could be derived from the standard IS-LM-BP graph of a modified Mundell–Fleming model. Assume that the LM curve is flat, while the other two curves have their usual shapes. An increase in government

A fixed exchange regime closure

The model can be adapted to describe a fixed exchange rate world. First, of course, we must delete Equation (32A) and make the exchange rate exogenous and constant. If governments are to hold exchange rates fixed, they must, given any given configuration of interest rates, be willing to buy or sell bills on any scale whatever at the chosen exchange rate. That is, among the other demand-determined asset supply functions, we must now have:

$$B\$\#_s = B\$\#_d . xr\$, \tag{32F}$$

where the "F" suffix in the equation number means that this is the relevant equation for the fixed exchange rate model.

But the inclusion of this particular equation would overdetermine the model, since $B\$\#_s$ is already given by Equation (30A). There are three obvious possibilities if we imagine this system out of kilter. *Either* fiscal policy of the deficit country must adjust to neutralize an ex ante excess supply of bills flowing into the market (in which case it must be endogenized); *or* the (endogenous) interest rate in the deficit country must rise indefinitely so that (in theory) a continuing increase in the relative supply of bills by the deficit country is always willingly held. The remaining possibility is that the central bank of the surplus country acquires (while the deficit country disposes of) reserve assets on a limitless scale, as was discussed in the first section of this paper in the case of the single economy.

We proceed to explore the last of these three possibilities, noting in advance that, under this assumption, both governments still retain full control over both fiscal and monetary policy.

Besides adopting Equation (32F), all we need to do to construct a fixed exchange rate version of our two-country model is invert a series of equations. As we "bump" one equation, because its left-hand side variable is already found in a previous equation, we must be prepared to bump a series of other equations until all variables appear only once on the left-hand side. Thus, as already said, we first bump out Equation (30A):

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expenditures shifts the IS curve to the right, thus leading to a new internal equilibrium that is situated below the BP curve, inducing a depreciation of the domestic currency and hence inducing further rightward shifts of the IS and BP curves. By contrast, the IS-LM-BP graph would not be able to show that the positive effects of an interest rate reduction would mainly be temporary.

$$B\$\#_s = B\# - B\#\#_s - Bcb\#_s, \tag{30A}$$

and replace it with Equation (30F):

$$Bcb\#_s = B\# - B\#\#_s - B\$\#_s. \tag{30F}$$

But $Bcb\#_s$ was already on the left-hand side of Equation (26A). We decide to define Equation (26A) as the "redundant" equation (which ensures that the amount of domestic bills supplied to the # central bank is the amount demanded). This means that Equation (23B) cannot be the redundant equation any more and must be part of the new model, becoming (23F):

$$B\$\$_s = B\$\$_d. \tag{23F}$$

But now Equation (29A) must get bumped, since $B\$\$_s$ is also on its left-hand side. We thus rewrite it as

$$Bcb\#\$_s = B\$_s - B\#\$_s - B\$\$_s - Bcb\$_s, \tag{29F}$$

which defines the supply of foreign reserves to the # central bank.

And we modify Equation (28A), the balance sheet constraint of the # central bank, to take into account possible changes in these foreign reserves:

$$\Delta Bcb\#_d = \Delta H\#_s - \Delta Bcb\#\$_s.xr\$, \tag{28F}$$

knowing that the change in the value of these foreign reserves measured in # currency depends both on the addition to foreign reserves measured in dollars and to a possible revaluation of the dollar, so that the value of the foreign reserves of the # country measured in domestic currency is

$$Bcb\#\$_d = Bcb\#\$_s.xr\$. \tag{36F}$$

The two-country fixed exchange regime model is now complete. The case we want to illustrate is where a surplus country (call it "China") wishes to maintain its surplus and, in so doing, purchases reserve assets (U.S. Treasury bills) on whatever scale is necessary to keep the exchange rate where it is.

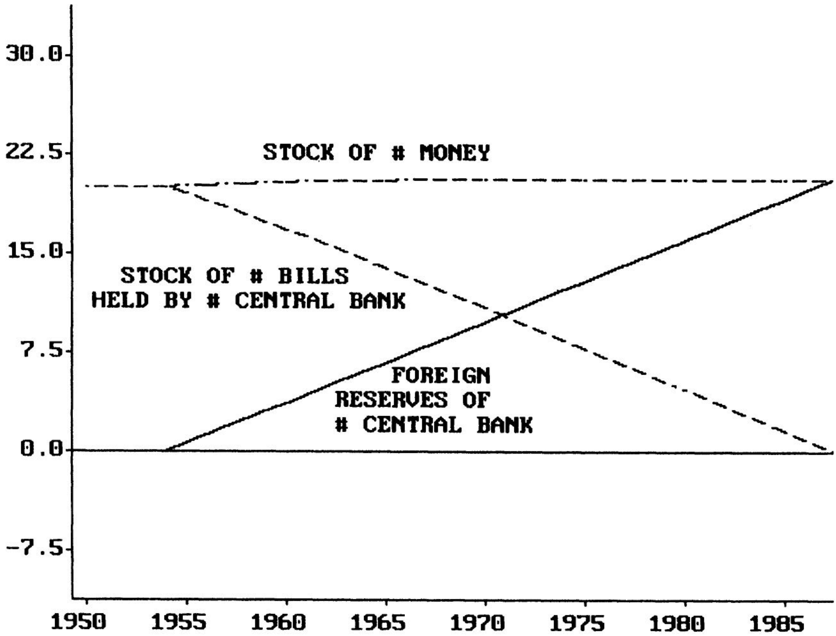
The model says that there is no limit to this process. We start from a full stationary state (with no external imbalance) and assume that the \$ propensity to import rises permanently in a step. The Chinese economy (the # country) reaches a new quasi stationary state with a constant surplus in the trade account (and in the overall balance of payments). All flows and all privately held stocks, *including the stock of money,* do not change at all. Checking now the balance sheet of the # central bank (the Chinese central bank), as shown in Figure 7, we see that this is accompanied by an ever-rising stock of holdings of U.S. Treasury bills by the People's Bank of China (its foreign reserves, measured in the # currency), while the stock of domestic Treasury bills also held by the Chinese central bank gets gradually depleted—this is the *sterilization* effect, which occurs endogenously as long as the # central bank acts to keep the interest rate constant. This phenomenon can occur without any forces leading to its reversal.[27] The surplus in the # balance of payments is unaccompanied by the "increase in the money supply," which is often postulated in such circumstances. We have thus recovered the result that was discussed earlier within our fixed exchange single economy. As to the dollar economy, it can face a balance-of-payments deficit as long as foreigners are willing to hold increasing amounts of $ securities.

Further experiments could be conducted, but they are left to the reader to conceptualize. In the fixed exchange rate regime, fiscal expansion leads to a permanently increased output but is accompanied by a twin deficit. It would seem that fiscal and monetary policies are relatively more effective in the context of flexible exchange rate regimes.[28] Indeed, lower interest rates, unsurprisingly, have only one effect—a temporary capital account deficit. If we further assume that consumption depends negatively on interest rates, a reduction in interest rates leads to a sharp capital account deficit that quickly turns into a temporary surplus, a temporary increase in consumption and income, and a temporary budget surplus and trade deficit. This is shown in Figure 8, and it clearly

[27] If the stock of # Treasury bills held by the # central bank ever gets entirely depleted (assuming we cannot have a negative amount of Treasury bills), as it nearly does in Figure 7, then either the # government starts acquiring deposits at the central bank or the central bank can start exchanging its own central bank bills for Treasury bills held by the private sector. These new central bank bills, which appear on the liability side of the balance sheet of the central bank, will then compensate for the dwindling supply of # Treasury bills (arising from the budget surplus) relative to the constant demand for # Treasury bills arising from household portfolios. In China, endogenous sterilization occurs mainly through a mechanism of this sort and through the reduction in the advances taken by commercial banks at the People's Bank of China.

[28] Mundell (1961a, p. 516) arrives at the same conclusions in a simple model where interest rates at home and abroad "are parameters determined by monetary policy" (ibid., p. 510), in line with what was assumed in Mundell (1961b), but, of course, in contrast to what was assumed in the so-called Mundell–Fleming literature that followed Mundell (1963).

Figure 7 Effect of an increase in the $ propensity to import on the components of the balance sheet of the # central bank (of the "Chinese" country), fixed exchange regime



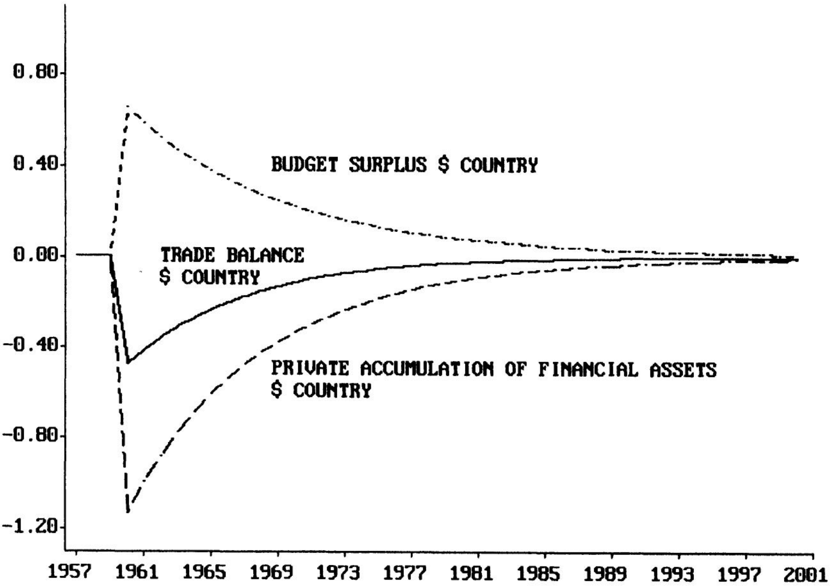
illustrates the fact that the twin deficit proposition holds in the steady state, but not necessarily during the transition, when households accumulate or get rid of financial assets.[29]

Conclusion

We have presented a small model that tracks the two-country dynamics of imports, exports, GDP, disposable income, consumption, money, government securities, wealth, and portfolio choices, as well as the exchange rate in the flexible exchange rate closure, and the amount of foreign reserves in the fixed exchange rate closure. In the latter closure of the model, as well as its one-country version, we show why sterilization becomes endogenous when central banks fix interest rates, as they always used to do, but as they do transparently now through explicit target

[29] Figure 8, in fact, illustrates Equation (20a), which can be derived under more general conditions. We get the well-known accounting identity: private financial surplus + public budget surplus = current account surplus (here, the trade surplus).

Figure 8 Effect of a decrease in the \$ rate of interest ($r\$$) on the budget account ($T\$ - G\$$), the trade account ($X\$ - IM\$$), and the private sector net accumulation of financial assets ($\Delta V\$$)



interest rates. Within the flexible exchange regime closure, still with monetary policy being represented by administered interest rates, we show that governments can achieve higher levels of activity by an appropriate choice of fiscal policy, at least within the limits imposed by the inflationary consequences of high activity levels (which have not been dealt with here). This clearly contradicts the usual assertion, found in the Mundell–Fleming model, that fiscal policy has a weak or no effect in a flexible exchange regime. We have also shown that changes in liquidity preference or interest rates, though they may have large and immediate consequences on the exchange rate and hence on levels of activity, seem to have effects that are self-reversing, thus inclining us to believe that the feedbacks tied to trade may still play a major role in the medium and long run.

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Appendix A

This numerical example shows how the simple open economy described in the first part of the paper moves from one quasi steady state toward another. The example defines every variable and gives, in period zero, numbers corresponding to a full steady state in which there is no change in any stock or any flow. The steps following an exogenous step up of $5 in exports can easily be reproduced with a calculator and are written out line by line, as shown in Table A1.

A full steady state is never reached, because the balance of payments never reverts to zero, so reserves go on rising forever, while the stock of private wealth remains constant in the *quasi* steady state.

Table A1
Numerical example of the evolution from a full steady state, following an increase in exports

Period		−1	0	1	2	3	4
Government expenditure	G		20	20	20	20	20
Exports	X		25	30	30	30	30
Wealth $V_{-1} + Y - T - C$	V	100	100	101.3	102.5	103.5	104.4
The multiplier $1/(1 - \alpha_1(1 - \theta) + \mu)$	m = 1.6393 (constant)						
Total output $(G + X + \alpha_2 V_{-1}).m$	Y		100	108.2	108.5	108.8	109.4
The tax yield θY	T		20.0	21.6	21.7	21.8	21.8
Consumption $\alpha_1(Y - T) + \alpha_2.V_{-1}$	C		80.0	85.2	85.7	86.1	86.4
Imports $\mu.Y$	IM		25	27.0	27.1	27.2	27.3
Household demand for bills $V[(1 - \lambda_0) + \lambda_1.r]$	Bp_d	70	70	70.9	71.7	72.4	73.1
Demand for cash $V - Bp_d$	H_d	30	30	30.4	30.7	31.0	31.3
Supply of bills and cash to households equals demand							
Total supply of bills $B_{s-1} + G - T$	B_s	90	90.0	88.4	86.7	84.9	83.1
Supply of bills to central bank $B_s - Bp_s$	Bcb_s	20	20.0	17.4	14.9	12.4	10.0
Demand for bills by central bank $Bcb_{d-1} + \Delta H_s - \Delta R$	Bcb_d	As above					
Reserves $R_{-1} + (X - IM)$	R	10	10.0	13.0	15.8	18.6	21.3

Parameters $\alpha_1, \alpha_2, \theta, \mu, \lambda_0, \lambda_1, r$ are, respectively, 0.8, 0.16, 0.2, 0.25, 0.40, 5, 2 percent.

Appendix B

The numbers corresponding to the initial steady state are shown below. The solutions are not qualitatively different if the numbers differ as between the two countries. The model was solved using MODLER software.

$Y = 100$
$C = 80$
$G = 20$
$T = 20$
$X = 25$
$IM = 25$
$V = 100$
$B = 100$
$H = 20$
$Bcb = 20$
All other Bs = 40
$xr\$ = 1$
$r = 0.04$
$\lambda_{10} = 0.396; \lambda_{11} = 2.1; \lambda_{12} = 2.0$
$\lambda_{20} = 0.396; \lambda_{21} = 2.0; \lambda_{22} = 2.1$
$\lambda_{30} = 0.208; \lambda_{31} = 0.1; \lambda_{32} = 0.1$

The other parameters, α_1, α_2, θ, μ_0, μ_1, μ_2 are, respectively, 0.8, 0.16, 0.2, −1.3863, 1.0, and 0.2. Foreign exchange reserves of the # central bank (*Bcb#$*) start at zero.