

**WORKING PAPER NO 10
TWO-COUNTRY
STOCK-FLOW-CONSISTENT
MACROECONOMICS USING
A CLOSED MODEL WITHIN A
DOLLAR EXCHANGE REGIME**

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TWO-COUNTRY STOCK-FLOW-CONSISTENT MACROECONOMICS USING A CLOSED MODEL WITHIN A DOLLAR EXCHANGE REGIME

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1. INTRODUCTION

This paper presents a dynamic model of a world comprising two economies, each with its own currency, which enjoy free trade with one another in both merchandise and financial assets. The various domestic and foreign assets are however imperfect substitutes. The path-breaking paper, which introduced the *genre*, is Tobin and Macedo (1980). A similar construction was proposed by Branson and Henderson (1985), and recapitulated in a review of exchange rate theory by Isard (1995). These studies took supplies of bonds on the open market as exogenous and concentrated entirely on the way in which a timeless equilibrium exchange rate could be determined via resolution of a confrontation between demands and supplies of internationally tradeable assets. *A fortiori*, they ignored the way in which exchange rates, once determined in asset markets, feed back so as to change relative prices, and therefore trade flows – and thence the demand for and supply of assets, income flows and so back to exchange rates themselves. Nor did they consider alternative “closures” in which the exchange rate is taken as exogenous and some other mechanism handles imbalances. The purpose of this paper is to amplify the Tobin-Macedo insights by characterising some of the relevant dynamic adjustment processes.

It will be one of our central contentions that any characterization of a whole macroeconomic system should be grounded in a double entry accounting framework which combines income/expenditure with flow-of-funds concepts (Godley 1999b). Such a framework will make it essential to analyse the behaviour of all parties to any international transaction; it also means that the model is complete in the sense that the financial balances of every sector have counterpart transactions in stock variables which have, in turn, explicit

¹ This work is part of a much larger enterprise that we are carrying out. A textbook/monograph on stock-flow-consistent monetary macroeconomics is in preparation. We are grateful for the comments received from various readers, in particular Lance Taylor, Alex Izurieta, Jan Kregel and Bill Martin. All simulations were carried out using MODLER software.

implications for end-of-period stocks.² The model presented here, like those mentioned above, subsists in an entirely different paradigm from Mundell-Fleming-type models which largely ignore the concept of stock equilibrium and attempt to explore the “openness” of a single economy without taking explicit account of responses from the rest of the world. Stock equilibrium is central to the following analysis, which generates results qualitatively different from those based on the Mundell-Fleming model, which is itself based, ultimately, on the IS-LM model. Our model also generates results qualitatively different from other models, for instance the so-called monetary approach to the balance of payments, the inter-temporal optimisation models proposed by Obstfeld and Rogoff (1995), and standard post-Keynesian models as can be found in McCombie and Thirlwall (1994).

The model presented here is a heavily revised version of Godley (1999a) and has benefited greatly from related work by Mathieu Lequain (2003). Other open-economy models based on the same method can be found in Izurieta (2003) and Lavoie (2003a, 2003b). The results are also broadly coherent with those obtained by Lance Taylor (2002), who has based his work on our accounting framework but used alternative analytical methods and closures to explore its implications. We believe that the post-Keynesian closure adopted in most variants of our model, i.e., the assumption that central banks set interest rates rather than attempting to target money supplies or the supply of securities, is more realistic and better describes the actual behaviour of central banks (Godley 1999b). Indeed, this is also the main assumption of the so-called *New consensus* models, as they can be found among central bank practitioners (Meyer 2001) and some New Keynesians (Romer 2000).

2. OVERVIEW

Having set forth the conceptual framework in the form of two matrix tables, the paper first summarises the identities describing each economy’s arterial flows. We next present a conventional sub-model of real and nominal trade flows in which real exports and imports are determined by relative prices and by real output at home and abroad, while trade prices are determined by the general level of domestic and foreign prices together with the nominal exchange rate. The following section of the paper describes a sub-model of income/expenditure transactions which contains a consumption function with the lagged stock of real wealth as an argument. This implies, given that the exogenous variables do not change, that a *quasi* stationary steady state (of a kind noted by Godley and Cripps, 1983:294), which will be defined below) will be reached in which the change in real wealth is zero.

As the prices of exports, imports and domestic sales vary relative to one another, the income/expenditure section perforce includes a rather large number of steps, most of which

² See also Gray and Gray (1988-89: 241) for the advantages of adopting a flow-of-funds matrix for the world, thus identifying the “constraints and interdependencies which must characterize the international financial system” and transforming “balance-of-payments analysis from a partial to a general framework”.

are no more than simple but tedious accounting relationships. The paper then confronts asset demands, which are determined by wealth stocks accumulated by the private sector, allocated between individual assets according to Tobinesque principles, with asset supplies which are generated by the governments' fiscal transactions. The penultimate section describes (with the aid of numerical simulation) how the model as a whole solves and responds to shocks. For instance, we can precisely trace through how, if fiscal and monetary policy are given and the exchange rate is fixed, a shock to the exports of one country will result in an equivalent shock to imports of the other and a change in both countries' foreign exchange reserves. We shall then be in a position to explore the nature of any effect this might have on each country's monetary system. In the final section we shall also explore alternative "closures" to the model by assuming alternative policy responses – in particular floating the currency or changing fiscal or monetary policy.

The simplifying assumptions which have been made are enormous. There is (for instance) no domestic or foreign investment in fixed or working capital, no holdings of financial assets by firms, no wage inflation and, crucially, neither commercial banking nor "hot money". The government does not follow any solvency rule, nor do the households care about the government debt ratio. The treatment of expectations, which are crucially important in any real world of floating or managed exchange rates, is rudimentary. These simplifying assumptions mean that many of the results of the model must be very heavily qualified.

Yet the model already contains ninety-odd equations and each additional realistic feature would require several more. At least in the present model there exist (as there exist in the real world) at least two parties to each transaction while every financial balance has a counterpart change in balance sheets, making the model complete in the vitally important sense that the n th equation is logically implied by the other $n-1$. This completeness even provides some ostensive justification for the model by comparison with others which do not use a comprehensive accounting framework. Indeed the logical structure of the model and the need to find an equation for each of its ninety-odd variables brings a degree of inevitability to its overall properties, which might survive alternative specifications of key behavioural relationships, for instance the equations describing international trade or the consumption function.

3. AN ACCOUNTING SYSTEM WITH NO BLACK HOLES

Table 1: BALANCE SHEETS

	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
	Households	Firms	Govt.	Central Bank		Households	Firms	Govt.	Central Bank	
	"Japan" or "U.K" (#)				Exch. Rte.	"U.S." (\$)				Sum
BALANCE SHEETS										
B1	Cash	+H#		-H#		+H\$			-H\$	0
B2	# Bills	+B##		+Bcb#	.xr#	+B\$#.xr#				0
B3	\$ Bills	+B#\$.xr\$		+Bcb#\$.xr\$.xr#	+B\$\$		-B\$	+Bcb\$	0
B4	Gold			+or#.pg#	.xr#				+or\$.pg\$	Sum or.pg\$
B5	Balance	-V#		NWg#+=+B#	NWcb#	.xr#		-V\$	NWg\$+=+B\$	0
B6	Sum	0		0	0	.xr#		0	0	0

Table 2: TRANSACTIONS

	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	
INCOME - EXPENDITURE TRANSACTIONS										Sum	
T1	Consumption	-C#	+C#				-C\$	+C\$		0	
T2	Govt.Exp.		+G#	-G#				+G\$	-G\$	0	
T3	Trade		-IM#			.xr#		+X\$		0	
T4			+X#			.xr#		-IM\$		0	
T5	GDP	+Y#	-Y#				+Y\$	-Y\$		0	
T6	Taxes	-T#		+T#			-T\$		+T\$	0	
T7	Interest	+r#(-1).B##(-1)		-r#(-1).B#(-1)	+r#(-1).Bcb#(-1)	.xr#	+r#(-1).B\$#(-1).xr#			0	
T8	Payments	+r\$(-1).B#\$(-1).xr\$			+r\$(-1).Bcb#\$(-1).xr\$.xr#	+r\$(-1).B\$\$(-1)		-r\$(-1).B\$(-1)	+r\$(-1).Bcb\$(-1)	0
T9	CB profits			+Fb#	-Fb#				+Fb\$	-Fb\$	0
Changes in FLOW OF FUNDS TRANSACTIONS											
T10	Cash	-ΔH#			+ΔH#		-ΔH\$			+ΔH\$	0
T11	# Bills	-ΔB##		+ΔB#	-ΔBcb#	.xr#	-ΔB\$#.xr#				0
T12	\$ Bills	-ΔB#\$.xr\$			-ΔBcb#\$.xr\$.xr\$	-ΔB\$\$		+ΔB\$	-ΔBcb\$	0
T13	Gold				-Δor#.pg#	.xr#				-Δor\$.pg\$	0
T14	Sum	0		0	0		0	0	0	0	

These two tables will provide useful reference points which will assist the exposition which follows. Table 1 sets out the balance sheets of our two economies, which will initially be called “Japan” and “the US”. As no physical capital exists apart from foreign exchange reserves held in the form of gold, every private asset is a financial asset which has a counterpart liability. Household wealth has three components, cash (in the domestic currency only), bills issued at home and bills issued abroad. Where an asset is issued by one country and held in another, the first term in the suffix refers to the country where the asset is held, the second to the country where it was issued; thus (for instance) $B_{\#\$}$ describes a bill owned by a Japanese household but issued in the US.

Table 1 also shows that the model assumes that firms hold neither assets nor liabilities and that the government sectors (deprived of their central bank) only issue bills, denominated in their own currency. Central banks issue cash money. Their assets are made up of bill holdings and of gold (noted “*or*”, as in the French word for gold). On the assumption that the price of gold in US dollars remains constant, the net worth of the US central bank has to be zero. By contrast, the net worth of the # central bank (Japan or the UK) may become positive (negative) when exchange rates vary, because the # central bank can achieve capital gains (losses) when the # currency appreciates (depreciates), that is when the number of yen per dollar ($xr\$$) goes up (down). This occurs because the price of gold is set in dollars, and because the # central bank holds bills denominated in dollars.

The flow matrix in Table 2 uses a double entry format to describe all transactions within and between the two economies and defines all of the nominal variables which will be used. All rows and all columns must sum to zero by accounting identity. The left half of Table 2 describes all Japanese transactions measured in #s, the right half describes US transactions measured in \$s. There are seven entries common to both countries, those in rows 3, 4, 7, 8, 11, 12 and 13, and in each case (accounting) equivalence is brought about by the exchange rate, shown in the central column. The top section of the table gives, for each country, simplified components of the national income accounts. The middle section of Table 2 describes flows of interest payments. The lower third of the table describes transactions in assets – the flow of funds accounts.

The assumption that there are no private holdings of foreign cash implies that any payments or receipts of foreign currency from trade in goods or assets are exactly and simultaneously exchanged by the central bank into its own currency. How the central bank and the government then respond to the implied *ex ante* change in its reserves will have profound consequences for the overall outcome.

4. EQUATIONS DEFINING THE MODEL

4.1 Identities describing arterial flows

The accumulation of private wealth in nominal terms is equal to personal income defined (in line with Haig and Simons) to include any capital gains on foreign bills as a result of exchange rate changes, less taxes and consumption.

$$(1) \quad \Delta V\# \equiv Y\# + r\#_{-1}.B\#\#_{-1} + r\$_{-1}.B\#\$_{-1}.xr\$\$ + \Delta xr\$.B\#\$_{-1} - T\# - C\#$$

$$(2) \quad \equiv YD\# - C\#$$

where V is wealth, Y is total factor income, T is taxes, r is the bill rate of interest³, C is consumption and B is Treasury bills where, recall, the first suffix denotes the country where the bill is held and the second denotes the country of origin, while xr is the exchange rate⁴. Equation (2) abbreviates (1) and gives the definition of disposable personal income, YD , which we shall use. Equation (1) describes Japanese wealth accumulation denominated in “yen”, hence interest payments on US bills (the third term on the RHS) is being converted from dollars into yen using the exchange rate. Capital gains (the fourth term on the RHS) describe the change in the yen value of previously issued US bills measured in dollars; note that capital gains are not transactions and therefore have no place in the matrix’s columns 1 and 6.

Equations (3) and (4) give exactly comparable identities for the US.

$$(3) \quad \Delta V\$ \equiv Y\$ + r\$_{-1}.B\#\$_{-1} + r\#_{-1}.B\#\#_{-1}.xr\#\# + \Delta xr\#\#.B\#\#_{-1} - T\$ - C\$$$

$$(4) \quad \equiv YD\$ - C\$$$

The identities describing the national income at current prices (columns 2 and 6) are:

$$(5): (6) \quad Y\# \equiv C\# + G\# + X\# - IM\# : \quad Y\$ \equiv C\$ + G\$ + X\$ - IM\$$$

where G is government expenditure, X is exports and IM is imports.

As central banks have no interest-paying liabilities, their profits (Fb) are equal to total interest receipts from any domestically issued bills, Bcb , plus, as is the case for the Japanese or the UK central bank, any foreign Treasury bills, $Bcb\#\$, which they hold, as shown in columns 4 and 9 of the matrix.$

$$(7): (8) \quad Fb\# \equiv r\#_{-1}.Bcb\#_{-1} + r\$_{-1}.Bcb\#\$_{-1}.xr\#\# : \quad Fb\$ \equiv r\$_{-1}.Bbc\$_{-1}$$

Given that central bank profits are all paid back to the government, we can write the (government) budget constraints (columns 3 and 8) as:

$$(9): (10) \quad \Delta B\# \equiv G\# - T\# + r\#_{-1}.B\#\#_{-1} - Fb\# : \quad \Delta B\$ \equiv G\$ - T\$ + r\$_{-1}.B\#\$_{-1} - Fb\$$$

where, recall, B is bills – the sole liability of the government, as distinct from the whole public sector including the central bank.

³ The rate of interest is lagged by one period because the interest payments on the bills that were acquired in the previous period are only made in the next period, at time t . But the rate of interest on these bills was set at the end of the previous period, at time $t-1$ when the bills were bought. See Turnovsky (1977: 74) and Flaschel, Gong and Semmler (2001: 111).

⁴ The dollar rate of exchange is the reciprocal of the $\#$ rate of exchange. Both rates of exchange are used so that the accuracy of the arrays can be more easily checked out.

It is important to note that payments by the US government on US Treasury bills held by the Japanese central bank are comprised within total interest payments by the US, $r_{\$-J}.B_{\$-1}$, the third term on the RHS of (10), as is clear from line 8 of the transactions matrix. Hence interest payments on US Treasury bills appear as a credit to the Japanese central bank but not as a debit to the US central bank.

It is a feature of Table 2 which may have seemed surprising that neither country has a column describing its balance of payments. However the coherence enforced by double entry accounting ensures that total flows into each country always exactly equal total outflows, *whether measured as current (trade etc.) flows or as capital account transactions*. Thus trade flows (lines 3 and 4 of the transactions matrix) plus net flows of interest payments (lines 7 and 8) make up the balance of payments on current account which is, in turn, exactly equal to the sum of each country's transactions in capital assets shown in lines 11-13. To link the transactions described in Table 2 to the balance sheets in Table 1, it will be necessary to take any capital gains into account. The balance of payments identities, which are not directly shown in the matrix, are:

$$(11) \quad CAB_{\$} \equiv X_{\$} - IM_{\$} + r_{\$-1}.B_{\$-1}.xr_{\$} - r_{\$-1}.B_{\$-1} + r_{\$-1}.Bcb_{\$-1}.xr_{\$}$$

$$(12) \quad CAB_{\$} \equiv -KAB_{\$} \equiv \Delta B_{\$s}.xr_{\$} - \Delta B_{\$s} + \Delta Bcb_{\$s}.xr_{\$} + \Delta or_{\$}.pg_{\$}$$

$$(13) \quad CAB_{\$} \equiv X_{\$} - IM_{\$} + r_{\$-1}.B_{\$-1}.xr_{\$} - r_{\$}.B_{\$-1} - r_{\$-1}.Bcb_{\$-1}.xr_{\$}$$

$$(14) \quad CAB_{\$} \equiv -KAB_{\$} \equiv \Delta B_{\$s}.xr_{\$} - \Delta B_{\$s} - \Delta Bcb_{\$s} + \Delta or_{\$}.pg_{\$}$$

where CAB is the current account balance, while KAB is the capital account balance, defined such that $CAB + KAB \equiv 0$. In other words, KAB includes the value of the changes in official reserves. The current account balance, by the normal NIPA conventions, only records transactions and takes no account of capital gains.

4.2 Trade

Trade prices are assumed to be determined in the following way:

$$(15) \quad \ln pm_{\$} = \mu_0 - \mu_1 \ln xr_{\$} + (1 - \mu_1) \ln py_{\$} + \mu_1 \ln py_{\$} \quad 0 < \mu_1 < 1$$

$$(16) \quad \ln px_{\$} = \nu_0 - \nu_1 \ln xr_{\$} + (1 - \nu_1) \ln py_{\$} + \nu_1 \ln py_{\$} \quad 0 < \nu_1 < 1$$

where pm is import prices, px is export prices, py is the GDP deflator, while bold characters denote natural logs of these variables.

The justification for the constraints derives from the following propositions which are stylised facts, either self evident or well established empirically.

1) If there were a simultaneous addition of some given amount to domestic inflation in both countries with no change in the exchange rate, then there would be an equivalent addition to export and (therefore) import prices in each country – hence the constraint that the coefficients on domestic and foreign inflation sum to unity.

2) If depreciation were exactly paralleled by a simultaneous and equal addition to domestic inflation, it is reasonable to expect that import prices would rise by the full amount of the depreciation – hence the sum of the coefficients on the exchange rate and domestic inflation must also sum to unity. It is well established empirically that, following depreciation, and given no immediate effect on domestic inflation, export and import prices denominated in home currency rise, but there will normally be some deterioration in the terms of trade (*i.e.*, $\mu_1 > <_1$) and vice versa for appreciation. Presumably exporters in both countries adjust prices in order to maintain or achieve some desired market share when exchange rates change (as shown by Bloch and Olive 1995).

Import and export prices for the US now follow by symmetry:

$$(17) \quad px\$ = pm\#.xr\#$$

$$(18) \quad pm\$ = px\#.xr\#$$

Trade flows, measured at constant prices, are determined, very conventionally, by relative price and income elasticities, with bold variables again representing logs.

$$(19) \quad x\# = \varepsilon_0 - \varepsilon_1(\mathbf{pm}\$._{-1} - \mathbf{py}\$._{-1}) + \varepsilon_2.y\$\$$

$$(20) \quad \mathbf{im}\# = \eta_0 - \eta_1(\mathbf{pm}\#_{-1} - \mathbf{py}\#_{-1}) + \eta_2.y\#\$$

Equation (19) says that the volume of Japanese exports ($x\#$) responds with an elasticity of ε_1 with respect to the price of \$ imports relative to that of \$ domestic prices and ε_2 with respect to domestic output ($y\#$). Equation (20) says that Japanese imports ($\mathbf{im}\#$) respond with elasticities η_1 with respect to import prices ($\mathbf{pm}\#$) relative to domestic prices ($\mathbf{py}\#$) and η_2 with respect to domestic output ($y\#$).

As with prices, these equations imply, logically, what dollar export and import volumes must be since, at constant prices and base year exchange rates (assumed equal to 1), the exports of one country are the imports of the other:

$$(21): (22) \quad x\$ \equiv \mathbf{im}\# : \mathbf{im}\$ \equiv x\#\$$

Finally the four identities generating the values of trade flows in own currency are:

$$(23): (24) \quad X\# \equiv x\#.px\# \quad : \quad X\$ \equiv x\$.pm\$\$$

$$(25): (26) \quad \mathbf{IM}\# \equiv \mathbf{im}\#.pm\# \quad : \quad \mathbf{IM}\$ \equiv \mathbf{im}\$.pm\$\$$

It is worth pointing out, since it is so often assumed that the sum of the elasticities with respect to relative prices must sum to at least one if the trade balance is to improve following devaluation (the Marshall-Lerner condition), that in verity the sum of these elasticities need be no greater than the elasticity of terms of trade with regard to devaluation. For instance, if the deterioration in the terms of trade were 20% of the devaluation, then the sum of the price

elasticities need be no more than 0.2. If there were no change at all in the terms of trade following devaluation – not an impossible outcome – the sum of the elasticities need be no greater than *positive* for the balance of trade to improve.

4.3 Income and expenditures

The consumption function, with the wealth acquisition function that this implies, is central to the way in which the system is driven towards a steady state. We already have the definition of disposable income (YD) from (2) and (4):

$$(2): (4) \quad YD\# \equiv C\# + \Delta V\# : \quad YD\$ \equiv C\$ + \Delta V\$$$

The change in the real stock of wealth, v , is defined as: $\Delta v \equiv V/pds - V_{-1}/pds_{-1}$, where pds is the price of domestic sales.

Real (inflation accounted) disposable income (yd), once again in line with the Haig-Simons definition of disposable income, is therefore given by:

$$(27) : (28) \quad yd\# \equiv YD/pds\# - v\#_{-1} \cdot \Delta pds\#/pds\# : \quad yd\$ \equiv YD\$/pds\$ - v\$_{-1} \cdot \Delta pds\$/pds\$\$$

It follows, by definition, that the change in the real stock of wealth is equal to real disposable income less real consumption

$$(29) : (30) \quad \Delta v\# \equiv yd\# - c\# : \quad \Delta v\$ \equiv yd\$ - c\$$$

Real consumption is assumed to be determined by expected real disposable income and the opening stock of (real) wealth. As we shall see in more detail later, we have a two-stage decision, where households first decide on an overall flow of saving, and then choose how they will allocate their wealth or rather their expected wealth (Keynes 1936: 166).

$$(31) : (32) \quad c\# = \alpha_1\# \cdot yd\#_e + \alpha_2\# \cdot v\#_{-1} : \quad c\$ = \alpha_1\$ \cdot yd\$_e + \alpha_2\$ \cdot v\$_{-1}$$

where the subscript e denotes an expected value.

The formation of expectations about income (and therefore wealth) is no big deal in a well wrought stock flow model. Any way of forming expectations that is not downright perverse (such as would be the case if expectations were to move in a way that ignores or compounds previous errors) will eventually lead to the same result. This is because errors lead inevitably to unwanted changes in stocks of wealth which lead, in turn, to self-correcting adjustments in subsequent periods.

This becomes more obvious when one notices that, by virtue of equations (29 - 32), the consumption function may alternatively be written as a wealth adjustment function,

$$\Delta v_e = \alpha_2(\alpha_3 \cdot yd_e - v_{-1}),$$

where $\alpha_3 = (1 - \alpha_1)/\alpha_2$. The system will come to rest (of a kind) when the changes in the real

stock of wealth are zero, implying that wealth targets, v^* , have been met, *i.e.*, when $v = \alpha_3.yd$.

We shall assume in this model that the implicit targeted wealth to disposable income ratio is a positive function of the domestic rate of interest. The purpose of this assumption is to make sure that higher interest rates do have negative effects on aggregate demand, at least in the short run. This assumption will be useful in one variant of the model, where interest rates will be made endogenous. Since there are no investment expenditures by the producing sector, the only way for higher interest rates to reduce domestic demand is for higher interest rates to raise the propensity to save and reduce consumption expenditures. We thus assume that $\alpha_3 = \alpha_{30} + \alpha_{34}.r$, which, from what has been said above, thus implies:

$$(33) : (34) \quad \alpha_{2\#} = (1 - \alpha_{1\#}) / (\alpha_{30\#} + \alpha_{4\#}.r\#) : \quad \alpha_{2\$} = (1 - \alpha_{1\$}) / (\alpha_{30\$} + \alpha_{4\$}.r\$)$$

For the rest of this section we have a raft of equations, most of them identities, which set out how real wealth accumulation and real consumption are inter-related with all the current price variables.

The total volume of sales, s , is equal to the sum of its components:

$$(35) : (36) \quad s\# \equiv c\# + g\# + x\# : \quad s\$ \equiv c\$ + g\$ + x\$$$

The value of sales is:

$$(37) : (38) \quad S\# \equiv s\#.ps\# \quad : \quad S\$ \equiv s\$.ps\$$$

where ps is the average price of all sales.

The price level of sales, ps , is determined as a mark-up, ρ , on unit costs:

$$(39) : (40) \quad ps\# = (1 + \rho).(W\#.N\# + IM\#)/s\# \quad : \quad ps\$ = (1 + \rho).(W\$.N\$ + IM\$)/s\$$$

where W is the nominal wage rate and N is employment. All profits earned as a result of the mark-up are assumed to be distributed instantaneously to the household sector.

The price of domestic sales is

$$(41) : (42) \quad pds\# \equiv (S\# - X\#)/(s\# - x\#) \quad : \quad pds\$ \equiv (S\$ - X\$)/(s\$ - x\$)$$

The remaining relationships in this section are those necessary to complete the income/expenditure flow system. They describe, in turn, domestic sales value, DS ; domestic sales volume, ds ; nominal GDP, Y ; real GDP, y ; the GDP deflator, py ; the value of consumption, C ; the value of government expenditure, G ; the tax yield, T , and employment, N .

$$(43) : (44) \quad DS\# \equiv S\# - X\# : \quad DS\$ \equiv S\$ - X\$$$

$$(45) : (46) \quad ds\# \equiv c\# + g\# : \quad ds\$ \equiv c\$ + g\$$$

$$(47) : (48) \quad Y\# \equiv S\# - IM\# : \quad Y\$ \equiv S\$ - IM\$$$

$$(49) : (50) \quad y\# \equiv s\# - im\# : \quad y\$ \equiv s\$ - im\$$$

$$\begin{aligned}
(51) : (52) \quad & py\# \equiv Y\#/y\# : \quad py\$ \equiv Y\$/y\$ \\
(53) : (54) \quad & C\# \equiv c\#.pds\# : \quad C\$ \equiv c\$.pds\$ \\
(55) : (56) \quad & G\# \equiv g\#.pds\# : \quad G\$ \equiv g\$.pds\$ \\
(57) : (58) \quad & T\# = \theta\#(Y\# + r\#_{-1}.B\#\#_{-1} + r\$_{-1}.B\#\$_{-1}.xr\$) : \quad T\$ = \theta\$(Y\$ + r\$_{-1}.B\#\$_{-1} + r\#_{-1}.B\#\#_{-1}.xr\#) \\
(59) : (60) \quad & N\# \equiv y\#/pr\# : \quad N\$ \equiv y\$/pr\$
\end{aligned}$$

where pr is productivity.

4.4 Asset demands

Up to this point, thanks mainly to the simplifying assumption that there is no inventory investment, we have been able to assume that supply (including the supply of labour) is instantaneously equal to demand. How about asset demands and supplies? Outside a stationary steady state all stocks and flows will be changing. Demands for assets will be originating from the private sectors' wealth accumulation and desired asset allocation. Supplies of assets originate from the balance of both governments' transactions. The way in which demands are brought into equivalence with supplies will determine how the system as a whole behaves. The manner of this reconciliation, which can take many forms, comprises the core of what this paper has to say.

The equations summarising how nominal wealth is created for the private sectors were given right at the beginning, in equations (2) and (4). The private sector's *ex ante* allocation of wealth between the (only) three categories of financial asset available is determined according to Tobinesque principles:

$$\begin{aligned}
(61) \quad & B\#\#_d = V\#_e.(\lambda_{10} + \lambda_{11}.r\# - \lambda_{12}.(r\$ + dxr\$_e) - \lambda_{13}.YD\#_e/V\#_e) \\
(62) \quad & B\#\$_d = V\#_e.(\lambda_{20} - \lambda_{21}.r\# + \lambda_{22}.(r\$ + dxr\$_e) - \lambda_{23}.YD\#_e/V\#_e) \\
(63) \quad & H\#_d = V\#_e.(\lambda_{30} - \lambda_{31}.r\# - \lambda_{32}.(r\$ + dxr\$_e) + \lambda_{33}.YD\#_e/V\#_e) \\
(64) \quad & B\#\$_d = V\$_e.(\lambda_{40} + \lambda_{41}.r\$ - \lambda_{42}.(r\# + dxr\#_e) - \lambda_{43}.YD\$_e/V\$_e) \\
(65) \quad & B\#\#_d = V\$_e.(\lambda_{50} - \lambda_{51}.r\$ + \lambda_{52}.(r\# + dxr\#_e) - \lambda_{53}.YD\$_e/V\$_e) \\
(66) \quad & H\$_d = V\$_e.(\lambda_{60} - \lambda_{61}.r\$ - \lambda_{62}.(r\# + dxr\#_e) + \lambda_{63}.YD\$_e/V\$_e)
\end{aligned}$$

where, for each country, the sum of the constants is equal to one and the sum of the coefficients in each remaining column is equal to zero.

For bills the assumption is that the coefficient on its own interest rate will be positive and that on other interest rates will be negative. The subscript d denotes demand and readers must take note that where the asset is issued abroad this subscript signifies that the asset is denominated in *domestic* currency (see equations (74), (77) and (80) below). The subscript e denotes an expected value, while the prefix d denotes a proportional rate of change – thus the expected rate of return on bills issued abroad equals the foreign rate of interest plus the change in the exchange rate which is expected to occur by the next period.

$$(67) : (68) \quad dxr\$_e = \Delta xr\$_e/xr\$ \quad : \quad dxr\#_e = \Delta xr\#_e/xr\#$$

We could make the conventional neoclassical assumption that the expected rate of exchange is equal to the difference between domestic and foreign rates of interest, thereby establishing equivalence between expected total rates of return on the two assets. We would have:

$$xr\$_e = xr\$ + (rb\# - rb\$).xr\$_{-1}$$

$$xr\#_e = xr\# + (rb\$ - rb\#).xr\#_{-1}$$

These equations imply that uncovered interest parity holds. But according to the views held by traders, the above equations define the forward rate, not the expected future spot rate (Isard 1995: 78). Banks and traders set the forward rate for their customers precisely on the basis of the above equations. The forward rate, relative to the spot rate, gives no indication of how the spot rate will move in the future.⁵ In other words, the forward rate relative to the spot rate does not help to predict the future spot rate. The forward rate cannot be the expected future spot rate, and hence the conventional neoclassical assumption is not helpful (Lavoie 2000; 2002-3).

Instead, we revert back to assuming that the expected exchange rate is a given, which might correspond to some fundamental exchange rate that investors believe will be realized sooner or later. When exchange rates become endogenous, the changes in realized exchange rates would have an impact on the expected change in exchange rates (the difference between the “fundamental” and the realized spot rates), and hence on the expected rates of return.⁶

If we really want the expected and the realized exchange rates to be equal in the very long run, we can introduce a further equation, which endogenizes the “fundamental” exchange rate, by making it slowly adjusting to the realized exchange rate.

$$(69) : (70) \quad xr\$_e = xr\$_{e-1} + \beta(xr\$ - xr\$_{e-1}) : \quad xr\#_e = xr\#_{e-1} + \beta(xr\# - xr\#_{e-1})$$

The demand for bills in each country is assumed to be made effective (carried through) on the basis of expected values for wealth, disposable income and the two expected rates of return. As expected values will not in general be realised, the amount of cash which *ex post* people actually find themselves holding at the end of each period is a residual between realised wealth and the demand for foreign and domestic bills (Lavoie and Godley 2001-2).

$$(71) : (72) \quad H\#_h = V\# - B\#\#_d - B\#\$_d : \quad H\$_h = V\$ - B\#\$_d - B\#\#_d$$

⁵ Isard (1995: 81-2) says that it is “widely acknowledged that interest differentials explain only a small proportion of subsequent changes in exchange rates” and “often mispredict the direction of change”. Tobin (1982: 124) himself provided some anecdotal evidence against the view that the forward rate is a predictor of future spot rates.

⁶ Another, often used, possibility is to introduce some risk premium. Here it could be postulated that expected future rates depend on the foreign debt to GDP ratio (Smithin 2002-3). For instance, if the US were to accumulate too large a foreign debt, investors would start expecting a depreciation of the US dollar.

where the subscript h denotes that the cash is what people find themselves *holding* as opposed to what they plan to hold. It goes without saying that actual cash holdings are residual quantities which make it possible for people to transact under conditions of uncertainty. Cash is a buffer.

4.5 Asset supplies

What of asset supplies? The government, having taken decisions about tax rates and public expenditure authorisations, has no control over its surplus/deficit nor over the issue of bills to which this gives rise; nor has it any control over where the bills go to. Central banks (interest rates and exchange rates being treated as exogenous in the main model) will always exchange cash for bills and vice versa. This is equivalent to saying that the supply of all assets to the private sector of each country passively matches demand. This is the post-Keynesian closure, which corresponds to the assertion that the money supply is endogenous and demand-led, as claimed by various post-Keynesian authors in the past (Robinson 1956, ch. 23; Kaldor 1982; Godley and Cripps 1983; Moore 1988). The present model formalizes this insight within an open-economy stock-flow consistent model.

In the case of assets issued by US institutions, government and central bank, and acquired by the private sector, domestic or foreign, we may write the following issuing requirements:

$$(73) \quad H\$_s = H\$_h$$

$$(74) \quad B\#\$_s = B\#\$_d.xr\#$$

$$(75) \quad B\$\$_s = B\$\$_d$$

where the subscript s denotes supply.

In the case of assets issued by Japanese (or British) institutions, and acquired by the private sector, domestic or foreign, we may write, symmetrically:

$$(76) \quad H\#_s = H\#_h$$

$$(77) \quad B\#\#_s = B\#\#_d.xr\#$$

$$(78) \quad B\#\#_s = B\#\#_d$$

Monetarists and most mainstream economists, however, would object that the supply of high-powered money – the supply of cash – is determined by the asset side of the balance sheet identity of central banks (net of capital gains). The balance sheet identity does indeed apply, but since all of its elements are endogenous, it does not imply that cash is supply-led. In the case of the US central bank, column 9 of the balance sheet yields the following identity:

$$(79) \quad H\$_s \equiv Bcb\$_d + or\$.pg\$$$

Noting that the Japanese central bank is always free to buy US Treasury bills in the open market, so we can equate supply with demand,

$$(80) \quad Bcb\$_s = Bcb\$_{d,xr\#}$$

the value of US bills supplied to the US central bank is pinned down to:

$$(81) \quad Bcb\$_s = B\$_s - B\#\$_s - B\$\$_s - Bcb\#\$_s$$

since each of the terms on the RHS of (81) has already been accounted for – in equations (10), (74), (75) and (80) respectively.

Since we assume that central banks wish to keep interest rates at the level which they have set, it must be that the US central bank is ready to take on any amount of domestic US bills that is being left-over residually. Hence we have:

$$(82) \quad Bcb\$_d = Bcb\$_s$$

But now, for an instant, the model looks over-determined. Equation (79) defines the supply of US cash to US residents; it is said to depend on gold holdings (which are either given or depend on balance of payments surpluses) and on the value of bills held by the central bank, which is pinned down by equations (81) and (82). So how can it also be the case that this same supply of cash is demand determined as in (73) above? The answer is that there is no room, but also no need, for an equation lying down this equality. It is guaranteed by the accounting coherence of the system as a whole. As every column and every other row are in equivalence, it must be, under our version of Walras' law, that this last equivalence holds as well. Accordingly equation (73) can (indeed for simulation purposes must) be “dropped” without altering the hypothesis that, at given interest rates, the supply of cash to dollar residents passively matches residual demand. And this equivalence is confirmed by all the numerical simulations we have carried out. Whatever is assumed about the exogenous variables of the model, it will always be found that the supply of cash to US residents which is being provided by the US central bank as a result of the evolution of its assets is exactly equal to the amount of cash that US residents are found to holding willingly, although there is no equation which makes this happen.⁷

We now look at the accounting of the # central bank. Reading across line 11 of the transactions matrix, we see that the value of Japanese government bills that is being supplied to the Japanese central bank is given, as a residual, by:

$$(83) \quad Bcb\#_s = B\#_s - B\#\#_s - B\#\$_s$$

Once again, we assume that the central bank, this time the # central bank, takes on any amount of domestic # bills which is left on the bill market, at the rate of interest that it sets. As a result we have:

⁷ Of course, the model could be constructed in such a way that some other equation would need to be “dropped”. But equation (73) seems an obvious candidate.

$$(84) \quad Bcb\#_d = Bcb\#_s$$

We have now written down equations describing demands for and supplies of all financial assets to the private sectors of both countries. But there is no reason, within the assumptions of the model, why *total* supplies of assets should be equal the sum of supplies to the private sectors. We need a safety valve.

And we have one at hand – for there is still one variable for which there is no equation. Reading vertically, column 4 of the transactions matrix implies that the value of US Treasury bills, measured in Japanese currency, which the Japanese central bank acquires, is:

$$(85) \quad \Delta Bcb\#\$_d = \Delta H\#_s - \Delta Bcb\#_d - \Delta or\#.pg\# + \Delta xr\$.Bcb\#\$_{s-1}$$

The final term on the RHS of (85) above measures the capital gain (or loss) on existing holdings of US Treasury bills if the exchange rate should change (and it is to allow for this that the equation is written in first difference form). Equation (85) is saying that unless the Japanese bank buys gold, it must settle any residual discrepancy between the country's current account balance and net private purchases of foreign issued assets by accumulating reserves in the form of US Treasury bills. Alternatively expressed, (85) describes the purchases of US Treasury bills which the Japanese central bank must make in order to prevent its exchange rate from floating up.

The model is nearly complete. There are two equations that still need to be defined. Under the assumption that the exchange rate variable is a given, it implies that the number of yen per dollar is the reciprocal of $xr\#$. The very last equation of the model illustrates the application of the law of one price to gold, assuming that the price of gold in dollars, $pg\$_$, is a given. Hence we have the following two equations:

$$(86) \quad xr\$_ = 1/xr\#$$

$$(87) \quad pg\# = pg\$.xr\$_$$

5. SOLUTIONS TO THE MAIN MODEL

5.1 Practical implications

Our simulation procedure is to start from a full stationary steady state, introduce a disturbance, and then inspect a sequence of solutions which will lead either to a new full steady state or to a hopefully intelligible form of instability. In the first exhibit we assume that "Japan" achieves an uncovenanted addition to exports in a step which is maintained indefinitely. Assuming that fiscal policy (the parameters 2 and G for each country), monetary policy (the rates of interest in both countries), the exchange rate and gold reserves are all fixed, the consequences for the trade account balance and the current account balance (CAB), as well as for domestic output and the government's deficit of Japan are shown in Chart 1.

CHART 1 CLOSURE 1: Fixed exchange regime
Effects on "Japanese" variables of a positive shock to "Japanese" exports

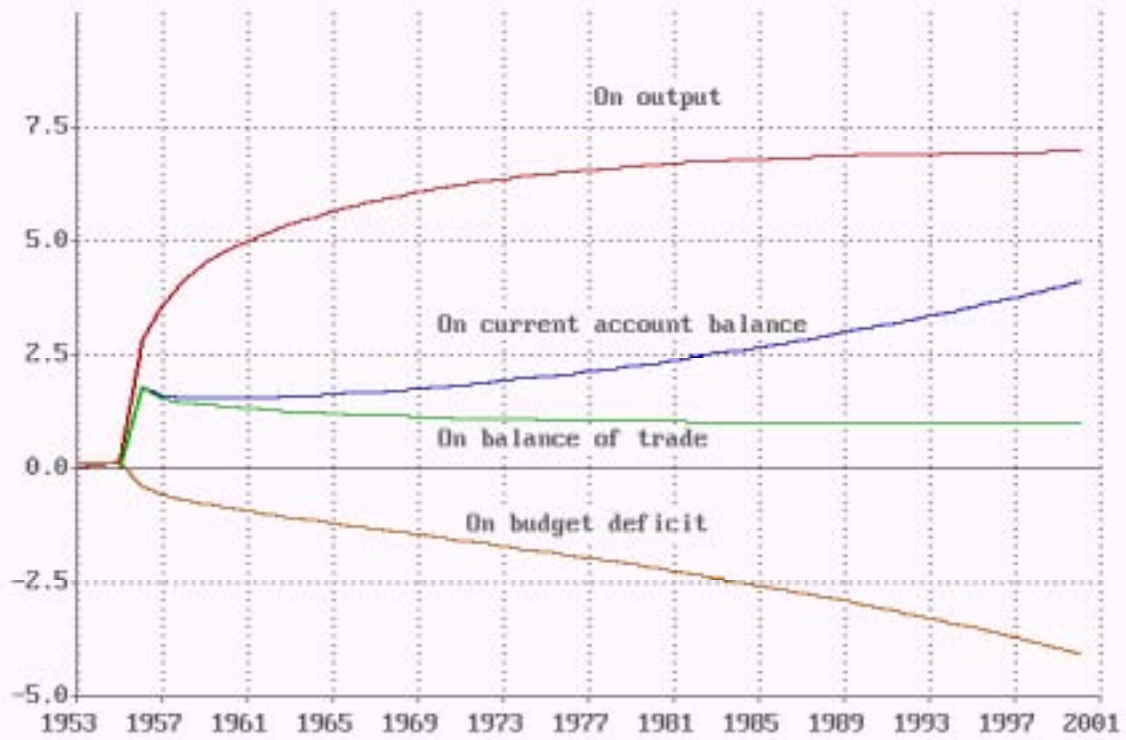


CHART 2 CLOSURE 1: Fixed exchange regime:Chart 1 continued
Effects on "Japanese" variables of a positive shock to "Japanese" exports

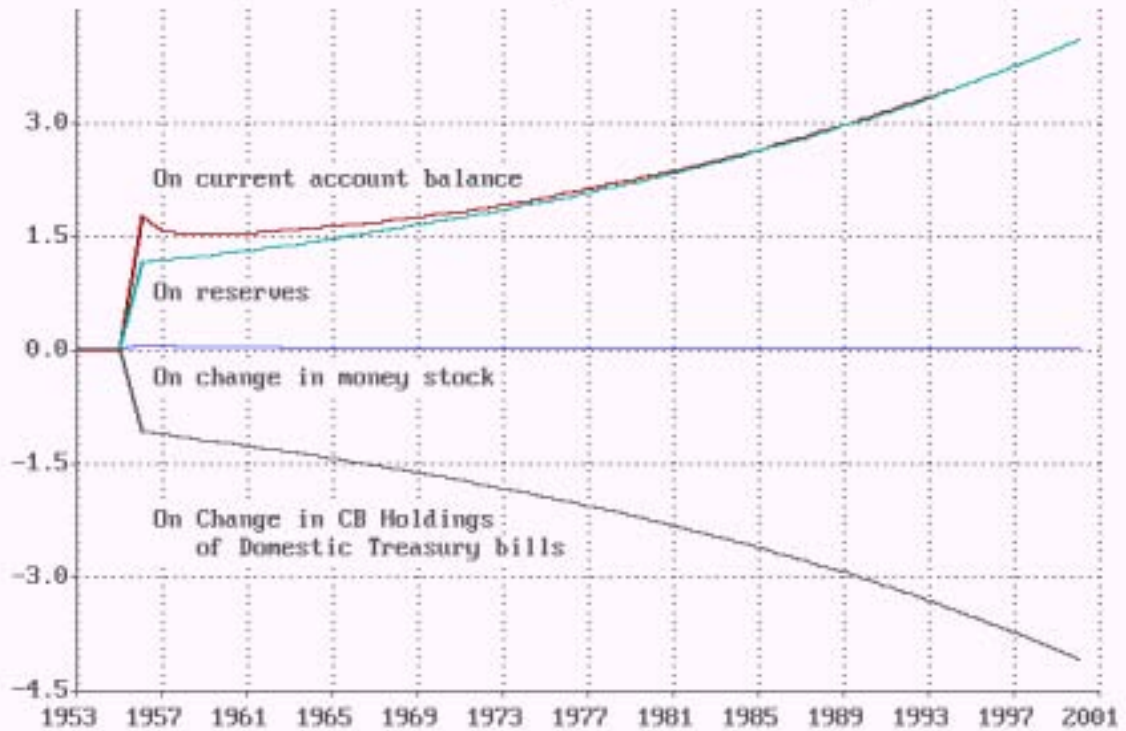


Chart 1 shows how the level of total demand and output rises and then stabilises at a higher level in Japan, while the same things are happening in reverse in the US though this is not shown. The Japanese balance of trade and also output improves, but as monetary and fiscal policy, as defined above, and also the exchange rate are all fixed, there is no corrective mechanism in operation, so they continue indefinitely at their new higher level. But the current account balance, which includes interest flows on foreign assets or liabilities, while initially improving by the same amount as the balance of trade, proceeds thereafter to increase by ever larger – and accelerating – amounts as the Japanese central bank's holdings of US Treasury bills increase, generating ever larger flows of interest payments. As to the Japanese government deficit, after a few wobbles, it is the exact mirror image of the current account surplus, i.e., the Japanese government surplus is increasing along with the Japanese current account surplus. These two variables are increasing exponentially.⁸ Exactly the same thing is happening in reverse in the US. The US government deficit and the US current account deficit are both increasing without limit.

Chart 2 shows the current account balance and the change in the value of US Treasury bills held by the Japanese central bank. Initially the two series differ because there is a change in the private income flows in both countries which leads to a counterpart adjustment in stocks of US assets held privately in Japan and vice versa. In particular, since Japanese households earn higher revenues, they purchase additional bills, among which bills issued in the US. As a result, the negative capital account balance (net of the acquisition of official foreign reserves), partly compensates for the current account surplus for a while. Eventually, however, the income flow settles down at a new constant level and the changes in private wealth revert to zero. But the Japanese current account balance remains in surplus, while the overall government sector (including the central bank) keeps accumulating foreign assets on an equivalent scale, so the Japanese central bank's acquisition of US bills comes to exactly match the current account surplus.

There is no intrinsic limit to these processes. The Japanese central bank does not lose control of its own monetary policy as it buys US Treasury bills, and there is no flooding of their economy with liquidity. This again can be seen on Chart 2, by checking the line illustrating changes in cash newly issued by the Japanese central bank, which quickly reverts to zero. This roughly constant stock of money occurs despite the enormous and exponential increase in foreign reserve assets. This is because the increase in holdings of US Treasury bills is being *compensated* by the decrease in the Japanese central bank holdings of domestic bills, as can also be seen in Chart 2. The increases in private disposable income, consumption, output and the pressure of demand in Japan are no more than can be accounted for by the increase in exports

⁸ This result is also achieved by Lequain (2003). This is the main difference from previous models where gold stocks, carrying no interest, were the only means to hold foreign reserves, as in Godley (1999a) and Lavoie (2003b). In those models, the current account surplus remained constant, so that foreign reserves rose linearly.

and the multiplier effects of this. The increase in private wealth, and its allocation between cash and bills of each kind, is in no way different from what would have taken place had the increase in income originated in a quite different way, for instance as a result of a relaxation of fiscal policy.

All the same things are happening in reverse to the US economy. Initially, there is a slight reduction in the stock of cash and the stock of US bills held by the Fed, as a result of a decrease in GDP, but afterwards all these remain constant, despite the current account deficit. Because the US dollar is the international currency, there is no need to “sterilize” anything on the part of the Fed. There is no fall in the foreign reserves of the US central bank; the financial assets that have to be provided, as a counterpart to the current account deficit, are being provided by the US Treasury. The accumulation of US Treasury bills by the Japanese central bank, and the payment of interest on these bills to it by the US government, is an entirely self-contained process which at no point affects private stocks and flows in either country. That this is the case can actually be observed in the introductory system describing arterial flows, in equations (7)-(10) together with the text which immediately follows, where it is shown that receipts by the Japanese government derived from bills issued by the US government ($r\$_{.1}BCB\#\$._{.1}xr\$$) are components of both governments’ budget balance and also of both countries’ current account balance – but they do not enter the flows of private disposable income which are comprehensively given by the sum of the first four terms on the RHS of equations (1) and (3).

To judge from its recent behaviour (in 2003), it is not implausible to suppose that under such circumstances the US government would, in practise, relax fiscal policy enough to keep the level of GDP where it would otherwise have been, thereby generating an even larger trade deficit and an even larger public sector deficit. Under these circumstances the “real” thing that would be happening is that US residents would be producing the same amount as before but absorbing more goods and services than they are producing. Japanese residents would be producing more but absorbing less than they produce.⁹ There may be solid political or strategic reasons why both countries are happy to let the whole thing go on indefinitely.¹⁰

5.2 Theoretical implications

Is it right to call such accumulation of reserves by the Japanese central bank “intervention”; and is it right to describe the process as one in which the US is “*having to attract \$x billion per day*” to finance its deficit”? Not really. What is happening, surely, is that Japanese exporters receive, for their increased sales abroad, an additional flow of dollars which they exchange with their

⁹ We are grateful to Randy Wray for pointing this out.

¹⁰ It could be argued, as we did in a previous footnote, that at some point domestic and foreign investors will be scared by the rising debt to GDP ratio of the US government, or by the large foreign debt to GDP ratio of the US economy, and hence will reduce their demand for US bills. But as long as the Japanese central bank is willing to hold its foreign reserves in the form of US bills, this portfolio reshuffle can be handled within the described system, *i.e.*, with fixed exchange rates and unchanged interest rates.

central bank for their own currency. The Japanese central bank finds itself with an equivalently rising stock of dollar balances which it exchanges for US Treasury bills. Beyond these two exchanges the Japanese central bank neither needs nor wants to do anything at all.

These “findings” are profoundly at odds with much conventional wisdom and with the received view that arises from the standard Mundell-Fleming model. Alan Greenspan has been saying that Chinese accumulation of US Treasury bills is making it difficult for them to manage their monetary policy; but the above analysis strongly suggests that he is mistaken. Peter Kenen (1985: 669) writes, as many others: “... Reserve flows alter the money stock, undermining the influence of monetary policy.... The monetary approach to the balance of payments is built on this basic proposition”. But the monetary approach does not have a fully articulated monetary system in which the private sector allocates its wealth between money and other assets. In both countries, the private sector’s accumulation of wealth and its allocation between available assets are not in any way affected by these central bank operations beyond what is implied by the step change in disposable income.

Mainstream authors would say that the Japanese central bank of our model is “sterilizing” foreign reserves, by selling Japanese Treasury bills on the open market. In a way, it is true. While the Japanese central bank’s foreign reserves are sky-rocketing, its holdings of domestic bills are dwindling, as already pointed out. But this is not the result of any intentional policy, where central bankers are actively intervening in financial markets. The Japanese central bank, just like the US one, is simply attempting to keep interest rates constant. Bills are provided to those who demand them at the set rate of interest. The central bank provides cash on demand to its citizens. The reduction in domestic bills holdings by the Japanese central bank is essentially the consequence of the reduction in the amount of outstanding debt of the Japanese government. This can clearly go on indefinitely without any negative implication for the Japanese economy.

Chart 2 clearly illustrates the so-called *compensation thesis* that had been put forth by researchers at the Banque de France, and which was sometimes called the Banque de France view (Berger 1972; Lavoie 2001). The compensation thesis is the open-economy variant of the reflux mechanism, which asserts that there can never be any excess money. When the central bank’s foreign reserves increase, claims on the domestic economy decrease. The compensation thesis denies the validity of the Mundell-Fleming IS/LM/BP mechanism, which is a modern incarnation of the *Rules of the game* set by the “price-specie flow” mechanism”, that were said to function in the days of the gold standard. These rules, and variants of the IS/LM/BP model, both claimed that any surplus in the balance of payments would generate increases in the money supply, and hence rising prices, which would tend to bring back the balance of payments towards equilibrium. Our main model is a formalized proof of the *compensation* phenomenon, which had been observed by Nurkse (1944) and Bloomfield (1959) to operate even during the gold standard period.

The compensation thesis was first set out as a mechanism operating within *overdraft* financial systems. As defined by Hicks (1974: 51), overdraft financial systems are characterized

by firms that must borrow from commercial banks, and by banks that must borrow from the central bank. Most economies in the world are of the overdraft type. Japan and China clearly run overdraft financial systems since a substantial proportion of their central bank claims are advances to the commercial banking sector. We would need a much more complicated model to properly reflect the institutional details of these two economies, since commercial banks and their advances from the central bank would need to be introduced. In reality, when these two countries experience balance of payments surpluses, compensation operates through the “advances to private banks” component of their central bank balance sheet. When Japanese or Chinese banks get loaded with foreign currency, they sell it to their respective central bank, acquiring domestic high-powered money with the proceeds. This cash is then used to reduce their outstanding debt vis-à-vis the central bank. Thus, on the asset side of the books of these overdraft economy central banks, the increase in foreign reserves (US Treasury bills) is compensated by a reduction in the advances granted to the domestic private banking sector. As in our main model, balance of payments surpluses do not generate any unwanted liquidity in an overdraft economy.

6. ALTERNATIVE CLOSURES

Let us now assume that the # country (which we now call “the UK”) is assumed to find itself in balance of payments deficit, but wants to maintain a fixed exchange rate and also to maintain full employment (that is, to not use deflationary fiscal policy). This is a simple and familiar story. Instead of being in a position to buy foreign Treasury bills on any scale whatever, the UK is obliged to *spend* reserves on whatever scale is necessary to keep its exchange rate fixed. To understand what is going on, we only need to take the case of Japan and its balance of payments surplus, and turn it upside down. Now, the UK central bank is selling its foreign exchange reserves – its US Treasury bills – at an exponentially growing pace. This, once more, can go on for quite a long time without any need for alarm. As a result of the negative export shock, domestic UK income will fall to a new steady state level, as will UK wealth, while the UK domestic interest rate and the exchange rate can be kept constant.

But this, in contrast to the US case, cannot go on forever. At some point, the UK central bank will run out of US bills, and it will have to sell gold to the US central bank (on the assumption that the latter will always be prepared to take it in settlement). But the UK central bank can only do this so long as it has gold reserves to spend. As the stock of gold approaches zero, the government is forced to act in order to bring exports into equivalence with imports. It has an awkward range of options, some of which will be discussed right at the end of this paper. In brief, it can raise interest rates, it can operate a restrictive fiscal policy, and it can float its currency.¹¹ Alternatively it can try to borrow from the IMF, which is likely to impose the

¹¹ There are yet other options if a country cannot borrow when its reserves are exhausted – e.g., it can impose import restrictions.

condition that one or more of these options is followed.

Such possible responses are very familiar. What needs to be added is that, as with Japanese purchases of Treasury bills, the spending of gold reserves has no effect whatever on the private flow of income and wealth to the private sector beyond the generalised losses arising from the fact imports have gone up or exports have fallen plus multiplier effects – the price specie mechanism has no counterpart whatever in modern monetary systems (Godley 1999a).

6.1 Flexible exchange rates

We next assume that the UK central bank, faced with a step-up in imports, makes no reserve transactions, so changes in its domestic bill holdings are exactly equal to changes in the supply of cash, which is demand determined. Switching round equation (85) we have:

$$(85F) \quad \Delta Bcb\#_d = \Delta H\#_s - \Delta or\#.pg\# - \Delta Bcb\#\$_d - \Delta xrr\$.Bcb\#\$_{s-1}$$

and hence under the assumption that reserves are not being modified ($\Delta or\# = 0$, and $\Delta Bcb\#\$_s = 0$), this means that: $\Delta Bcb\#_d = \Delta H\#_s$.

But now, once again, we must face two equations with $Bcb\#_d$ on the left-hand side: the new equation (85F) and equation (84), given by:

$$(84) \quad Bcb\#_d = Bcb\#_s$$

We cannot drop equation (84), because we have already dropped one equation, equation (73). So the only option left is to invert equation (84), obtaining:

$$(84F) \quad Bcb\#_s = Bcb\#_d$$

The amount of domestic bills demanded by the central bank will determine the amount of bills supplied by the UK Treasury to its central bank. But we are not yet out of trouble, for it is now the $Bcb\#_s$ variable that makes its appearance on the left-hand side of two equations – equations (84F) and (83):

$$(83) \quad Bcb\#_s = B\#_s - B\#\#_s - B\#\$_s$$

So the bumping process must continue. Switching round (83), we obtain:

$$(83F) \quad B\#\$_s = B\#_s - B\#\#_s - Bcb\#_s$$

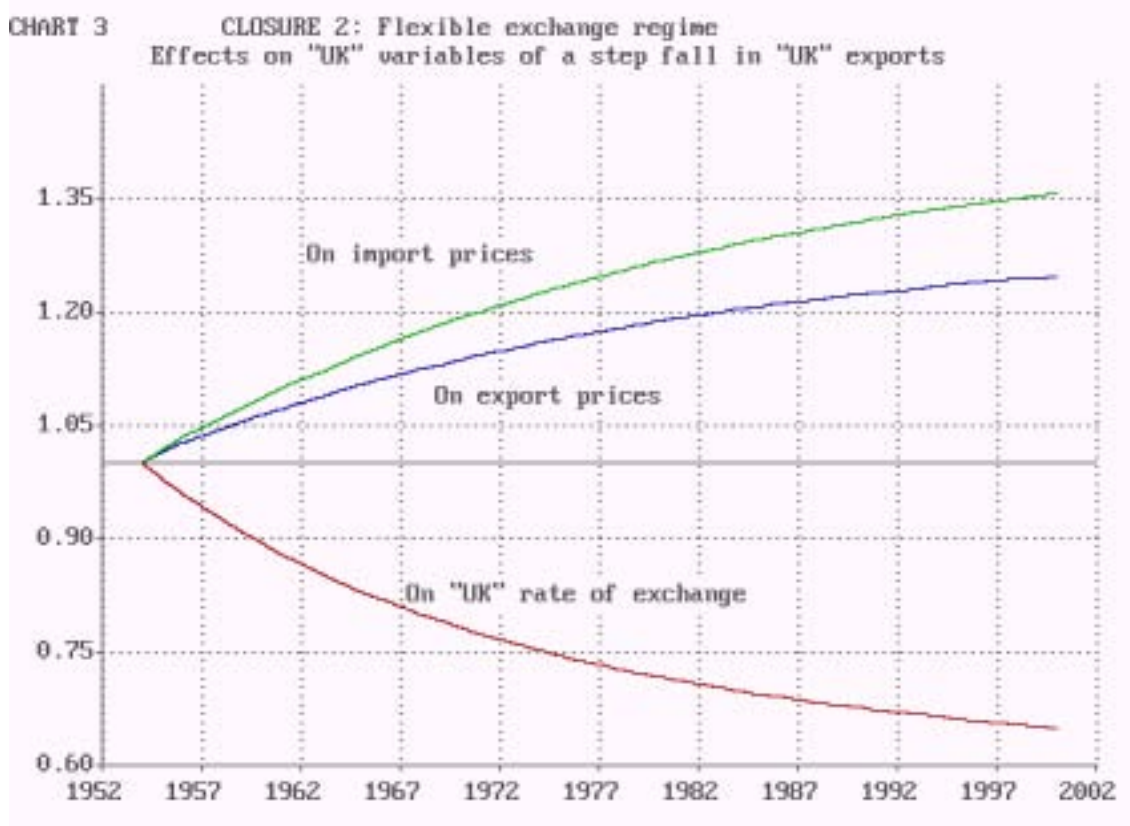
The bumping is nearly over. There are once again two equations that have the $B\#\$_s$ variable on their left-hand side. Equation (77) is that other equation. But now we can rewrite equation (77) under the form:

$$(77F) \quad xr\$_ = B\#\#_d/B\#\$_s$$

making the exchange rate $xr\$$ endogenous and the alternative model with flexible exchange rates complete (with equations 77F, 83F, 84F and 85F replacing equations 77, 83, 84, 85).

The endogeneity of the exchange rate only finds itself (only can find itself) expressed in one single equation. But when the whole model is solved as a completely interdependent system, the effect works its way round so that the supply and demand for all assets are all brought into equivalence at (and by) the new exchange rate. What is happening (supposing there has been a spontaneous rise in UK imports) is that the private income and budget flows are immediately affected. The UK has a higher budget deficit; the US has a lower deficit, the UK has a current account deficit, the US has a balance of payments surplus. The net change in the supply of foreign assets causes sterling to fall in order to clear the market in all assets simultaneously.

But the dynamic response of the system as a whole is only just beginning. For as long as the balance of payments is non-zero this must be generating a change in the net supply of foreign denominated assets in each country causing a further change in the exchange rate. When exchange rates change, the absolute and relative prices of exports and imports all change; so trade volumes and values, income flows and accumulations of wealth all change. A train of sequences ensues – and continues until the balance of payments and all changes in stock variables revert to zero. Some of these processes are illustrated in Chart 3 and 4



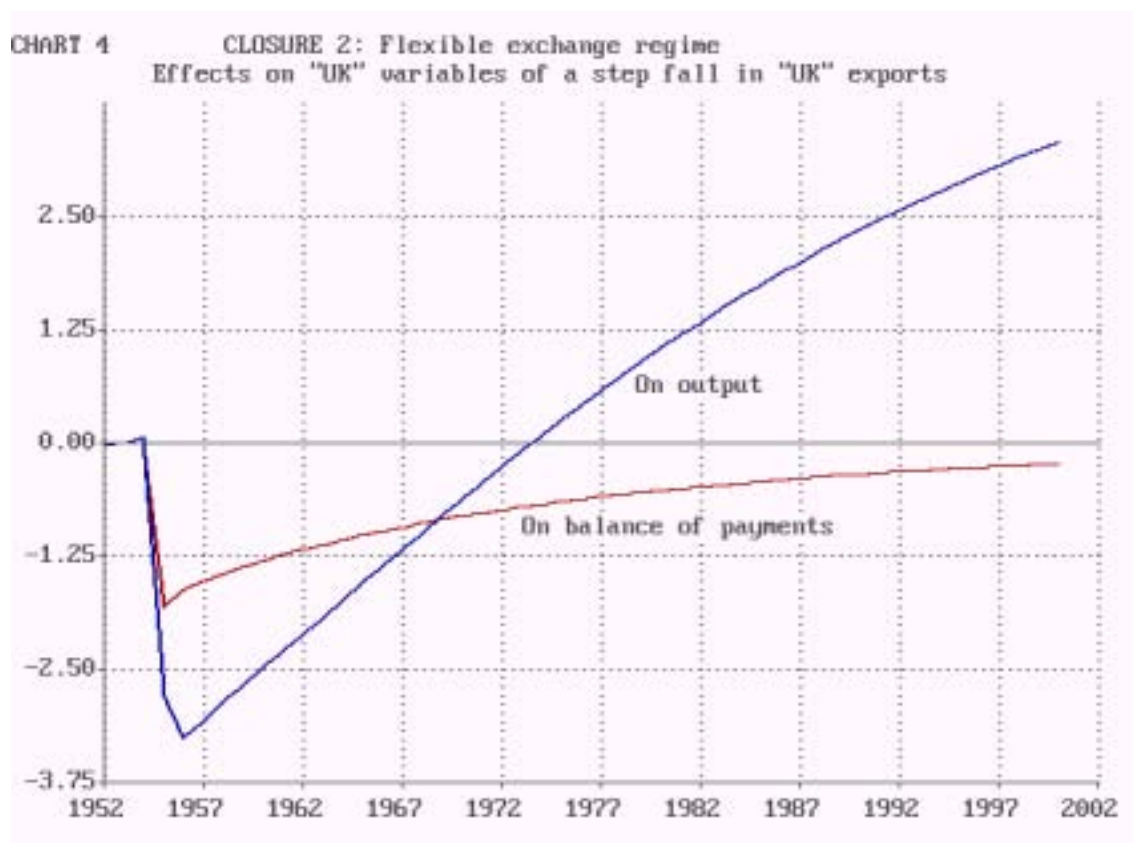


Chart 3 shows what would happen, according to the model, following a spontaneous step upwards in UK imports, on the assumption that reserves, fiscal policy and interest rates are not only exogenous but fixed. It shows how sterling depreciates at a decelerating rate until a new equilibrium is restored. It also shows how export and import prices both rise measured in sterling, accompanied by a deterioration in the terms of trade.

Chart 4 shows how the current account balance deteriorates initially but then reverts to zero. It also shows how the level of domestic output falls as a result of the direct and indirect (multiplier) effect of the fall in net export demand. However the fall in output, under flexible rates, is temporary. The deterioration in the terms of trade and the rise in import prices act so as to make real exports exceed real imports in the new steady state. As the current account balance reverts towards zero, the total demand for domestic product rises above what it was in the first place.

This outcome contrasts strongly with one in which the shock takes the form of a step fall in government expenditures (not shown here). In the latter case, there is an *upward* movement in the exchange rate. The relative price of imports falls and real imports rise relative to real exports. As in the previous case, the current account balance at current prices reverts to zero but the level of output is lower than at the outset.

6.2 Other possible closures

We end by briefly describing two further closures. The first of these is very simple. It is relatively easy to rearrange the equations, following the procedure outlined in the previous subsection, so as to show how fiscal policy could be adjusted to preserve a fixed rate of exchange in the face of a deteriorated trade balance. The new fiscal stance has to be such that after allowing for all lags and feedbacks, the level of domestic output is reduced to such an extent that the value of imports exactly equals that of exports.

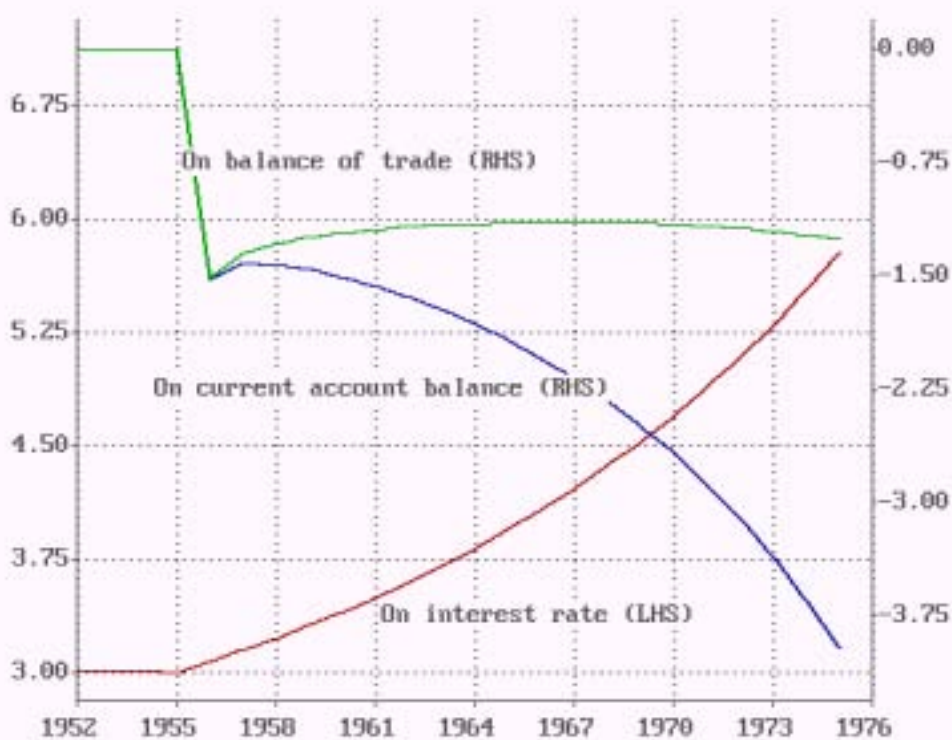
An alternative way of facing off devaluation, in theory, is to raise the interest rate. Once again, it is easy to adapt the equations of the model to show how this would have to happen. Essentially we start from the flexible exchange rate model, but impose upon it that the exchange rate must remain constant. Hence another variable, which was previously assumed to be constant, now needs to be made endogenous and that will be the rate of interest on UK bills $r^\#$. To achieve this we need to make two modifications to the flexible exchange rate variant. First we need to invert equation (77F), by saying that the demand for UK bills by US residents, $B^{\$}_d$ is determined by the supply of such bills. But then we would have two equations determining the foreign demand for UK bills, since the portfolio demand equations already have the $B^{\$}_d$ variable on the LHS. So we also need to invert equation (65) to make it determine the rate of interest $r^\#$; for by the assumptions of the model, there will always be some pair of interest rates which will make all assets willingly held. We thus have the following two modifications:

$$(77R) \quad B^{\$}_d = B^{\$}_s \cdot x r^\#$$

$$(65R) \quad r^\# = - dx r^\#_e + \{ \delta_{51} \cdot r^\$ - \delta_{50} + \delta_{53} \cdot YD^{\$}_e / V^{\$}_e + B^{\$}_d / V^{\$}_e \} / \delta_{52}$$

But a single adjustment to interest rates of this kind will only keep the asset market in equilibrium for a single period. If the “UK” goes on having an external deficit, there will have to be a further rise in the UK interest rate, to induce foreign inflows of capital and a positive capital account. As there is no mechanism in play to correct the deficit, we end up with an unstable situation – the interest rate has to go on rising for ever. Meanwhile, the balance of trade remains negative, while the current account balance keeps getting worse, due to the rising burden of interest payments that need to be made abroad, as shown in Chart 5.

CHART 5 CLOSURE 3: Endogenous "UK" interest rate with pegged exchange rate
Effect on "UK" variables of a negative shock to "UK" exports



7. CONCLUSIONS

We have presented a model of a two-country economy that makes up a whole world. The model is set up with one country, the "US", which provides Treasury bills which are accepted as a reserve asset by the central bank of the other country. Goods are freely traded, and financial assets, although they are not perfect substitutes, are freely exchanged between countries. The main model and its alternative closures are all based on a rigorous and watertight system of stock and flow accounts. Income, consumption, government deficits, exports and imports of both countries are all endogenous variables in these models, as are the various price indices. In addition, wealth, the stock of money and the stock of bills held by households, or the stock of bills held by the central banks are all endogenous variables. Depending on the chosen closure, foreign reserves, the exchange rate or one rate of interest can be made endogenous. The model evolves through time, solving dynamically from one period to the next.

In the main model with fixed exchange rates, we have shown that it is perfectly feasible for a country like the United States to run a trade deficit, as well as a current account deficit, while setting the rate of interest of its choice and without losing any control over the supply of high-powered money. Reciprocally, when other countries are running current account surpluses or balance of payments surpluses, their central banks can also peg interest rates at the level of their choice while still keeping the supply of money in line with the demand for it arising from private agents. Despite the fact that growing interest payments will enlarge the US current

account deficit at an exponential rate, GDP and the stock of high-powered money will converge to constant levels in both countries. On the other hand, when countries other than the US run balance of payments deficits, pressures to modify fiscal or monetary policy, or to move onto a floating exchange regime will be mounting, as official reserves gradually vanish and approach some minimal level.

Our view of the impact of balance of payments surpluses or deficits on the money stock can be contrasted with the standard view, which is conveyed by the authors of most textbooks and in the usual Mundell-Fleming IS/LM/BP model. Of course it could be objected to us that the Mundell-Fleming model is not anymore the model in use in top-tiered journals, but Isard (1995: 116) in his recent survey points out that “the Mundell-Fleming model remains the ‘workhorse’ in academic discussions of stabilization policy for the open economy”.

The standard view is generally justified on the basis of a partial analysis of equations (79) or (85) – the balance sheet of the central bank, where its assets, among them foreign reserves, are said to supply-determine the stock of money. One of these authors for instance says: “Let us conclude this section by reiterating its central and fundamental message: in order to maintain a fixed exchange rate, a central bank must engage in foreign exchange transactions that prevent it from managing the monetary base so as to achieve other macroeconomic objectives” (McCallum 1996: 139).¹² Our complete stock-flow model shows that such a statement is far from the truth. When the US is running a deficit and the rest of the world a surplus, central banks can clearly set interest rates at the level they feel is most appropriate. In our view, there is no “price-specie flow” mechanism of any kind at work.

It is of course recognized by textbook authors that “central bank interventions in the foreign exchange market may not affect the home-country money stock if they are sterilized” (McCallum 1996: 138). But such sterilization is then said to be “weak and short-lived”, or it is claimed that such “sterilization” will lead to modified holdings by the private sector of claims on the US government or on foreign governments (Isard 1995: 140-3). We have argued in contrast that the so-called “sterilization” process is entirely self-contained and affects neither the flows nor the stocks of the private economy. In addition, we object to such a process being called sterilization, and believe that the word “compensation” process is much more appropriate. As long as the central bank wishes to peg the exchange rate and its main interest rate, a compensation mechanism will operate quite automatically, as part of the defensive operations conducted daily to maintain settlement balances at their required level. The central bank will neutralize the net impact of any public flow between its balance sheet and that of the financial

¹² McCallum (1996: 137) claims that “each exchange by the central bank of dollars for foreign currency has the effect of changing the home country’s stock of ‘high-powered money’ (alternatively referred to as ‘base money’ or the ‘monetary base’, with purchases of foreign exchange increasing (and sales decreasing) the stock of base money”. He presents the balance sheet of five central banks, not realizing that in two of them, France and Germany, the claims on domestic banks are more than five times greater than the claims on central government – both being overdraft economies!

system (through repos or any other means at its disposal) in order to keep the overnight rate (the federal funds rate) at or near its target rate (Eichner 1985, ch. 5; Howard 1998).

In the rest of the paper, we have shown that the main model could be quickly adopted to yield alternative closures, using the same method, with no black holes. Flexible exchange rates and flexible fiscal policy yielded a stable model; endogenous interest rates generated instability.

It must be emphasised that the use of the different closures, as presented here, does not correspond in any straightforward way to different policy regimes. The closures are not in any general sense alternatives to one another. It would, for instance, be perfectly possible for a country which had a depreciating currency to switch course and use fiscal policy or put up interest rates. Government expenditures would be gradually reduced, or interest rates would be pushed up, as long as the depreciation goes on. One could also assume a fixed exchange regime, where government expenditures and interest rates are gradually modified by the fiscal and the monetary authorities in an attempt to reduce the balance of payments deficit (Lavoie 2003a). Our experience with various closures is that, whatever the institutional background, some results are being systematically achieved when a particular closure is being adopted.

The important thing to bring out is that, there is not, in general, as Lance Taylor (2002) has forcefully argued, an equilibrium towards which economies and exchange rates are moving. Any attempt to model econometrically the behaviour of exchange rates on the assumption that they are moving towards some underlying rate which conforms with “fundamentals” is doomed to failure.

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