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SIMPLE OPEN ECONOMY MACRO WITH
COMPREHENSIVE ACCOUNTING:
A TWO COUNTRY MODEL

Wynne Godley & Marc Lavoie

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e-mail: wynnegodley@aol.com

**SIMPLE OPEN ECONOMY MACRO WITH COMPREHENSIVE ACCOUNTING:
A TWO COUNTRY MODEL**

Wynne Godley

CERF – University of Cambridge

Marc Lavoie

Dept. of Economics, University of Ottawa

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ABSTRACT

This paper presents a stock flow model of two economies (together comprising the whole world) which trade goods and financial assets with one another. The accounting framework, though comprehensive in its own terms, is very much simplified so as to reach the main conclusions as simply and easily as possible. 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 which display the basic constraints and forces at work. 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. In all models interest rates are exogenous and the money supply is (found to be) endogenous.

KEYWORDS: OPEN ECONOMY MACROECONOMICS, STOCKS AND FLOWS, TWO COUNTRY MODELS, EXCHANGE RATE DETERMINATION IN ASSET MARKETS

JEL CLASSIFICATION: F41 F42 F47

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SIMPLE OPEN ECONOMY MACRO WITH COMPREHENSIVE ACCOUNTING

This paper presents a Keynesian model of two economies which together comprise the whole world. The exchange rate is assumed to continuously clear the market for (the stocks of) internationally traded assets and thence to determine a sequence of trade, income, expenditure and output flows. Tobin and De Macedo (1980), Allen and Kenen (1980) and also Branson and Henderson (1985) presented models in which the exchange rate is determined by mutual trading of assets between two countries, but while these were path breaking studies, none of them did more than establish timeless equilibria without characterising all the temporal processes which brought those equilibria about. Rather complicated simulation models have been proposed by Godley (1999) and Godley and Lavoie (2004) which extended these earlier models to include a description of the whole dynamic process with embedded Post Keynesian assumptions. There remains a place for a statement of this alternative view simple enough to be taught at 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 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 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 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

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. Investment is set aside because its inclusion in our framework requires a complete if 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 since 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. Finally, the accounting is only *nearly* comprehensive because interest payments 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.

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 (2004, p. 2), 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’.

A SINGLE OPEN ECONOMY WITH A FIXED RATE OF EXCHANGE

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 following matrices which will be useful points of reference in the text which follows.

³ While the method that we use is highly similar to the one used by Taylor (2004, ch. 10; 2004b) 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
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	- ΔB_p		- ΔB_{cb}	+ ΔB	0
Cash	- ΔH		+ ΔH		0
Foreign exchange reserves			- ΔR		+ ΔR 0
0					
Sum	0	0	0	0	0 0
Changes in					
total wealth/debt	+ ΔV	0	0	- ΔB	- ΔR 0

BALANCE SHEETS (STOCKS) AT END OF PERIOD

T-Bills	+ B_p		+ B_{cb}	-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 column 2 of the flow matrix, is:

$$1) \quad Y = C + G + X - IM,$$

where Y is GDP, C is consumption, G is government expenditure, X is exports and IM is imports.

Personal saving, the change in wealth, shown in column 1, is given by:

$$2) \quad \Delta V = Y - T - C$$

where V is total wealth and T is taxes.

Taxes are determined by the tax rate, τ , and income

$$3) \quad T = \tau Y$$

Imports are determined by the import propensity, α , and income

$$4) \quad IM = \alpha Y$$

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

$$5) \quad C = \beta_1 Y(1 - \tau) + \beta_2 V_{-1} \quad 0 < \beta_1, \beta_2 < 1$$

The lagged stock variable supplies the essential dynamic component which will generate sequences in real time. Note that by virtue of 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:

$$6a) \quad \Delta V = \beta_2 (\beta_3 Y(1 - \tau) - V_{-1})$$

where $\beta_3 = (1 - \beta_1)/\beta_2$ and where the β_3 suffix in the equation number means that this equation is not part of the computer model.

The partial adjustment coefficient is the β_2 parameter while target wealth is $\beta_3 Y(1 - \tau)$, thus implying that β_3 is the wealth to disposable income target ratio.

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 1), 3), 4) and 5):

$$7a) \quad Y = (G + X + \beta_2 V_{-1}) [1 - \beta_1((1 - \tau) + \alpha)]^{-1}$$

thus yielding a nearly standard expression for the short-term equilibrium level of income, with the multiplicand being the term in brackets, and one over the term in square brackets being the multiplier.

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 $\dot{V} = 0$, can be derived directly from 6), which means that the target wealth to disposable income ratio \forall_3 has been achieved.

$$8a) \quad V^* = \forall_3 Y^* (1 - 2)$$

where the star denotes stationary state values.

Steady state income, of a kind⁵, can thus be obtained from equations 7) and 8), recalling that $\forall_3 = (1 - \forall_1)/\forall_2$. After some manipulations, we get:

$$9a) \quad Y^* = (G + X)/(2 + \cdot)$$

Flow of funds and financial stocks

How does the rest of the system fit together? We may 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:

$$10a) \quad H_d = (8_0 - 8_1 \cdot r) \cdot V$$

$$11) \quad Bp_d = [(1 - 8_0) + 8_1 \cdot r] \cdot V$$

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.⁶

The coefficients in this array are constrained according to Tobinesque principles so that the sum of constants is equal to one and the sum of the other column is zero. As 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 over-determination.

$$10) \quad H_d = V - Bp_d$$

⁵ 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.

⁶ Asset functions are linearized, as they usually are.

In other words, by having a certain demand for bills, as in 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:

$$12) \quad B_s = G - T$$

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

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.⁷ 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.

$$13) \quad B_{p_s} = B_{p_d}$$

And this carries (by virtue of the central bank's balance sheet identity in column 4 of Table 1) the logical implication that cash is also supplied passively in response to demand. In other words, the money supply H has to be endogenous.

$$14) \quad H_s = H_d$$

We can now infer how much the government has to 'borrow' from the central bank. The Bank will have to hold any amount of Treasury bills that the private sector is unwilling to hold at the target rate of interest.⁸ This is given by residual:

$$15) \quad B_{cb_s} = B_s - B_{p_s}$$

where B_{cb} is the central bank's holdings of Treasury bills.

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

$$16) \quad R = X - IM$$

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

As the central bank acquires or loses foreign reserves there is a counterpart change (in the contrary direction) in its acquisition of government bills which is revealed by changes in the bank's balance sheet, as shown in the flow-of-funds part of Table 1.

⁷ See Fontana (2002) and Lavoie and Seccareccia (2004).

⁸ 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 we shall see with equation 17), once the target rate of interest has been set by the central bank.

$$17) \quad B_{cb_d} = H_s - R$$

As long as the central bank wishes to keep interest rates fixed, it has no choice but to reduce its demand for Treasury bills holdings whenever foreign reserves are rising while the demand for money stays put.⁹ This is because with constant interest rates it has to be the case that the Bank must be assumed to sell or purchase bills, as already noted in equations 13) and 15) on any scale whatever in response to demand, which implies (equation 14) that cash is also supplied passively in response to demand. Unless the wealth of households changes when reserves are changing (or interest rates or liquidity preference change), there will be no increase in the demand for money. In sum, there will be no increase in the supply of money, even though foreign reserves increase. This is in line with the claim made by Arestis and Eichner (1988, p. 1015) 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'. Interest rates can be set by the central bank and money is demand-determined in this fixed exchange rate regime.

Note that we have equations both in the demand for Treasury bills by the central bank (equation 17) and in the supply of Treasury bills to the central bank (equation 15). Note also that demand and supply for central bank holdings of Treasury bills are generated by two quite separate routes – the demand because the Bank needs an asset to back its liability (H), the supply because this is the residual between the total Treasury bill supply and the Treasury bill supply to the household sector. But there is neither need nor place for a separate equation to make the supply and demand for Treasury bills by the central bank equal to one another. Thus equation 18a) is the 'redundant' equation:

$$18a) \quad B_{cb_s} = B_{cb_d}$$

This equality, the 'redundant' equation, is guaranteed by the coherence of the accounting system as a whole which, since every row and column sum to zero, implies that once every equation save one is satisfied, that last equation ($B_{cb_s} = B_{cb_d}$ in this case) must be satisfied as well.

Implications of the model

We have now described a complete stock-flow model (there is an equation for every endogenous variable) which, conditional on initial conditions and, depending on the values taken by the exogenous variables – the fiscal variables Z and G , the trade variables X and Y , the monetary policy variable r , as well as the behavioural portfolio parameters θ – will generate all stock and all flow variables period by period on their way towards a stationary state. This is illustrated in

⁹ This was recognized by earlier Keynesian authors, such as Meade. As Allen and Kenen (1980, p. 8), 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'.

the appendix 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, since some stocks will still be changing, namely the central bank stock of foreign reserves, and the stock of government debt. 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.

In the usual textbook models with fixed exchange rates, trade deficits or surpluses get corrected through endogenous changes in the supply-led stock of money. With trade deficits, in these textbook models, the stock of money gets gradually depleted, thus leading to higher interest rates and/or lower domestic prices, which help net exports to recover through absorption and substitution effects. Similarly, with trade surpluses, the stock of money rises, inducing lower interest rates and/or higher domestic prices, until the trade balance is finally back to equilibrium.

There is no such mechanism here, since ‘sterilization’ is endogenous, 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.¹⁰ This is the ‘compensation’ thesis underlined by French central bankers.¹¹ The so-called *rules of the game*, the purpose of which is to mimic the effects of the old *price-specie flow* mechanism, just do not apply.¹²

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

$$19a) \quad +\Delta V - \Delta B - \Delta R = 0$$

And hence:

$$20a) \quad +\Delta V - (G - T) - (X - IM) = 0$$

¹⁰ In one of its background papers, the Bank of Canada (2004) 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’. 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.

¹¹ 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.

¹² It must be pointed out that Mundell (1961), 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 behaviour 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’ (1961, 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!

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

$$21a) \quad (IM - X) = (G - T)$$

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 do 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.¹³

$$22a) \quad Y^{**} = X/\lambda = G/2$$

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 $G/2$ ratio becomes endogenous, and responds to the constraint imposed by the X/λ 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 US dollar and its huge balance of payments surplus. The country is accumulating 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. The Chinese economy can continue to run balance of payments surpluses for ever, if its government leaders are happy to accumulate US financial assets. There is no mechanism, neither a price mechanism nor a quantity mechanism, that will force the surplus countries to converge towards a balanced current account; as a result there is a world-wide 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.

¹³ As suggested by Godley and Cripps (1983, pp. 295-6).

We start off with an extended matrix which includes two economies which together make up the whole world. On the left we have a \$ country with all transactions measured in the \$ currency; on the right 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 exchange rate.

Table 2: Transactions matrix in a two-country economy with capital flows

	COUNTRY \$				XR	COUNTRY #				Sum
	1.HH\$	2.Frm\$	3.CB\$	4.Gvt\$		5.HH#	6.Frm#	7.CB#	8.Gvt#	
1. Consumption	-C\$	+C\$				-C#	+C#			0
2. Gov. 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	-ΔH\$		+ΔH\$			-ΔH#		+ΔH#		0
8. Δ T-Bills \$	-ΔB\$\$		-ΔBcb\$	+ΔB\$.xr	-ΔB#\$		-ΔBcb#\$		0
9. Δ T-Bills #	-ΔB\$#				.xr	-ΔB##		-ΔBcb#	+ΔB#	0
Sum	0	0	0	0		0	0	0	0	0

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. Since transactions by agents in the \$ country are all measured in \$ currency, while 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 dollar 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 which are not needed to solve the model.

$$1A) \quad 2A) \quad [GDP \text{ identity}] \quad Y\$ = C\$ + G\$ + X\$ - IM\$ \quad Y\# = C\# + G\# + X\# - IM\#$$

$$3A) \quad 4A) \quad [Wealth \text{ identity}] \quad)V\$ = Y\$ - T\$ - C\$ + CG\$ \quad)V\# = Y\# - T\# - C\# + CG\#$$

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

$$5A) \quad 6A) \quad [Tax \text{ take}] \quad T\$ = 2\$Y\$ \quad T\# = 2\#Y\#$$

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.

$$7A) \quad 8A) \quad [\text{Exports}] \quad X\$ = IM\#/xr \quad X\# = IM\$.xr$$

Imports are determined in each country by the relevant income and price elasticities

$$9A) \quad 10A) \quad [\text{Imports}] \quad \mathbf{im\$} = :_{0\$} + :_{1\$}.y\$ - :_{2\$}.xr \quad \mathbf{im\#} = :_{0\#} + :_{1\#}.y\# - :_{2\#}.xrr$$

where lower case bold letters denote logs.

The variable xrr is the converse of xr , as we shall see in equation 35A), that 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, 2004).

$$11A) \quad 12A) \quad [\text{Consumption}] \quad C\$ = \nabla_{1\$}.Y\$(1 - 2\$) + \nabla_{2\$}.V\$._{-1} \quad C\# = \nabla_{1\#}.Y\#(1 - 2\$) + \nabla_{2\#}.V\#_{-1}$$

$$13A) \quad 14A) \quad [\text{Treasury Bill supply}] \quad)B\$_s = G\$ - T\$ \quad)B\#_s = G\# - T\#$$

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. The array of asset demands for $\$$ residents is

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

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

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

where all asset demands are valued in $\$$ currency.

For $\#$ residents the array is

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

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

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

where all asset demands are valued in $\#$ currency.

Expectations about future spot exchange rates have not been explicitly introduced as part of the expected rate of return on assets. Since 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.¹⁴

Tobinesque constraints apply once again.¹⁵ To obtain solutions to the whole model, equations 17B) and 20B) are dropped, and the demand for cash is written as:

$$17A) \quad 20A) \quad H\$_d = V\$ - B\$\$_d - B\$_d \quad H\#_d = V\# - B\#\$_s - B\#\$_d$$

Note that, if both interest rates are exogenous and fixed, *every one of the ratios in 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 both cash and bills endogenous.

$$21A) \quad 22A) \quad H\$_s = H\$_d \quad H\#_s = H\#_d$$

$$23B) \quad 24A) \quad B\$\$_s = B\$\$_d \quad B\#\$_s = B\#\$_d$$

Hence, (see the balance sheet matrix, columns 3 and 7), the supply of domestic T-bills to their respective central banks is endogenous as well.

$$25A) \quad 26A) \quad Bcb\$_s = Bcb\$_d \quad Bcb\#_s = Bcb\#_d$$

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.¹⁶

$$27A) \quad 28A) \quad \Delta Bcb\$_d = \Delta H\$_s \quad \Delta Bcb\#_d = \Delta H\#_s$$

All bill supplies must go somewhere, as can be seen from the balance sheet identity (lines 8 and 9 of Table 2). Treasury bills ($B\$_s$) issued by the US government can be held by # foreign residents ($B\#\$_s$), US 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 which meet domestic demand.

$$29B) \quad B\#\$_s = B\$_s - B\$\$_s - Bcb\#\$_s - Bcb\$_s$$

¹⁴ We thus rule out UIP (uncovered interest parity), and make no use of CIP (covered interest parity), since its causality must be reversed (Lavoie 2000).

¹⁵ Once again the sum of the constants δi_0 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.

¹⁶ In the case of the # central bank, we must use the first difference operator, since, because of 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.

$$30A) \quad B\$_s = B\$_s - B\$_d - Bcb\$_s$$

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 which must be sold abroad, denominated in the currency of the country where they have been issued, have been determined in equations 29B) and 30A) above. *The exchange rate must be such that it equalises the demand and supply for internationally traded assets which now confront one another in each country.* That is, it must simultaneously be the case that:

$$31B) \quad xr = B\$_d/B\$_s$$

and also that

$$32A) \quad xr = B\$_s/B\$_d$$

For these conditions both 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.

$$33A) \quad 34A) \quad CG\$ =)xrr.B\$_{s-1} \quad CG\# =)xr.B\$_{s-1}$$

To check out that we have enough equations to determine a single exchange rate which 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, since we cannot let the exchange rate, xr , appear on the left-hand side of two equations. We shall retain 32A) and write 31B) as:

$$31A) \quad B\$_s = B\$_d.xr$$

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

$$29A) \quad B\$_s = B\$_s - B\$_s - Bcb\$_s - Bcb\$_s$$

and close the model by recalling that:

$$35A) \quad xrr = 1/xr$$

We now have an equation in every endogenous variable, save the two interest rates which remain exogenous.¹⁷ 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 Bcb 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 off. The two terms of this equation are equivalent without the need for any equation to make that happen – so long as every other equation is satisfied.¹⁸

The model is now complete and we are happy to report that it solved very sweetly using the numbers listed in Appendix 2. Besides the stock of foreign reserves, $BCB\#\$,$ held by the # central bank, the exogenous variables are $G, 2,$ 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 thence output in each country – and thence (all still within one period) the budget deficit/surplus and changed supplies of assets, thence back to the exchange rate, etc. And having reached a kind of temporary equilibrium in each short period, the imaginary economies evolve further in sequences through time on their way towards a full steady state.

It hardly seems possible that there exists an analytic solution to this model – at least one which is transparent enough to have any useful meaning. There is however no difficulty about 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’ which is easy to visualise and with which a new solution can be unambiguously compared.

¹⁷ While the method that we use is similar to the one used by Taylor (2004, ch. 10; 2004b) 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 (2004, p. 333) 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’. This forces Taylor to introduce UIP (uncovered interest parity) 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)!

¹⁸ Thus the model contains 34 equations, since equation 23B) needs to be dropped off. Each country has 16 endogenous variables, plus their exchange rate.

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

ALL FIGURES AT THE END OF THE PAPER

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 2.¹⁹ 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 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 which are supplied abroad. But a similar situation is occurring in the $\#$ country. Because interest rates are fixed, $B^{\#}_d/V^{\#}$ and $B^{\#}_s/V^{\#}$ 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 be seen also 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 which 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). In addition, the changed exchange rate generates capital gains for residents in the $\#$ country where the value of the opening stock of bills issued abroad increases, and capital losses 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. While 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 which 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.

¹⁹ There is a small increase the output of the $\#$ country because its exports have increased, as can be seen in Chart 1. Its budget position improves, but only by a very small amount.

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 impacts 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 succeed 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 a higher propensity to import and higher imports, the \$ economy will run into a trade account deficit. The latter, along with the capital losses of \$ households on their holdings of foreign Treasury bills due to the fall of the depreciation of the # currency, will slow down the \$ economy and propel the \$ government budget position into a deficit. As a result of this, \$ Treasury bills will have to be newly issued. The outstanding stock of B\$, will rise gradually, and thus respond to the higher demand for this security. As a result, the value of the dollar will revert towards 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 reduction in the outstanding stock of # Treasury bills, B#\$, 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 a temporary one. 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 favour of \$ Treasury bills would lead to the very 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 δ_{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 want.

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:

$$32F) \quad B\$_s = B\$_d.xr$$

But the inclusion of this particular equation would over-determine 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 neutralise an *ex ante* excess supply of bills flowing into the market (in which case it must be endogenised); *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 to be 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)

$$30A) \quad B\$_s = B\# - B\#\#_s - Bcb\#_s$$

and replace it with equation 30F):

$$30F) \quad Bcb\#_s = B\# - B\#\#_s - B\$_s$$

But $B_{cb\#_s}$ was already on the left-hand side of equation 26A). We decide to define equation 26A) as the ‘redundant’ equation, which will insure that the amount of domestic bills supplied to the # central bank will be the amount demanded, and hence rewrite it as 26FB):

$$26FB) \quad B_{cb\#_s} = B_{cb\#_d}$$

This means that equation 23B) cannot be the redundant equation, and must be part of the new model, becoming 23F):

$$23F) \quad B_{\$\$}_s = B_{\$\$}_d$$

But now equation 29A) must get bumped, since $B_{\$\$}_s$ is also on its left-hand side. We thus rewrite it as:

$$(29F) \quad B_{cb\#\$}_s = B_{\$}_s - B_{\#\$}_s - B_{\$\$}_s - B_{cb\$}_s$$

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:

$$28F) \quad)B_{cb\#_d} =)H_{\#_s} -)B_{cb\#\$}_s.xr$$

with the addition of:

$$28FF) \quad)B_{cb\#\$}_d =)B_{cb\#\$}_s.xr$$

The two-country fixed exchange regime model is now complete. The reader may wish to verify that equations 15), 16), 17) and 18a) of the one-country fixed exchange regime model are the equivalent of equations 30F), 29F), 28F) and 26FB) of the two-country version.

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 (US 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 US 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 so-called *sterilisation* 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.²⁰

²⁰ If the stock of # Treasury bills ever gets entirely depleted, as it nearly does in Figure 7, then the central bank can issue and sell its own central bank bills to the private sector, as the People’s Bank of China is actually doing. These central bank bills will appear on the liability side of the balance sheet of the central bank.

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.

CONCLUSION

We have presented a small model which 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 interest rates. Within the flexible exchange regime closure, 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). 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.

Appendix 1

This numerical example shows how the simple open economy described in the first part of the paper moves from one quasi steady state towards 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 the exogenous rise in government expenditure can easily be reproduced with a calculator and are written out line by line.

Period		-1	0	1	2	3 etc.
Government expenditure	G		20	22	22	22.....
Exports	X		25	25	25	25.....
Wealth $V_{-1} + Y - T - C$	V	100	100	100.5	101	101.4 ...
The multiplier $1/(1 - \forall_1(1 - 2) + :)$	M = 1.8393 (constant)					
Total output $(G + X + \forall_2 V_{-1}) \cdot M$	Y		100	103.3	103.4	103.5 ...
The tax yield $2Y$	T		20	20.7	20.7	20.7....
Consumption $\forall_1(Y - T) + \forall_2 V_{-1}$	C		80	82.1	82.3	82.4....
Imports $:Y$	IM		25	25.8	25.9	25.9 ...
Household demand for bills $V[(1 - \delta_0) + \delta_1 r]$	B _{p_d}		80	80.4	80.8	81.1....
Demand for cash $V - B_{p_d}$	H _d		20	20.1	20.2	20.3....
Supply of bills and cash to households equals demand						
Total supply of bills $B_{s-1} + G - T$	B _s	80	80	81.3	82.7	84.....
Supply of bills to central bank $B_s - B_{p_s}$	B _{cb_s}		0	0.9	1.9	2.8.....
Demand for bills by central bank						
$B_{cb_{d-1}} + H_s - B_{p_s}$	B _{cb_d}	As above				
Reserves $R + (X - M)$	R	20	20	19.2	18.3	17.4.....
Parameters $\forall_1, \forall_2, 2, :, \delta_0, \delta_1$ are, respectively,		0.8, 0.16, 0.2, 0.25, 0.28, 2.0				

A full steady state is never reached because the balance of payments never recovers and reserves fall until they are exhausted.

Appendix 2

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.

$$Y = 100$$

$$C = 80$$

$$G = 20$$

$$T = 20$$

$$X = 25$$

$$IM = 25$$

$$V = 100$$

$$B = 100$$

$$H = 20$$

$$Bcb = 20$$

$$\text{All other } B's = 40$$

$$xr = 1$$

$$r = .04$$

$$\delta_{10} = 0.396 ; \delta_{11} = 2.1 ; \delta_{12} = 2.0.$$

$$\delta_{20} = 0.396 ; \delta_{21} = 2.0 ; \delta_{22} = 2.1$$

$$\delta_{30} = 0.208 ; \delta_{31} = 0.1 ; \delta_{32} = 0.1$$

The other parameters, $\forall_1, \forall_2, \beta, \alpha_0, \alpha_1, \alpha_2$ are, respectively, 0.8, 0.16, 0.2, -1.39, 1.0, 0.2
Foreign exchange reserves of the # central bank (Bcb#)\$ start off at zero.

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

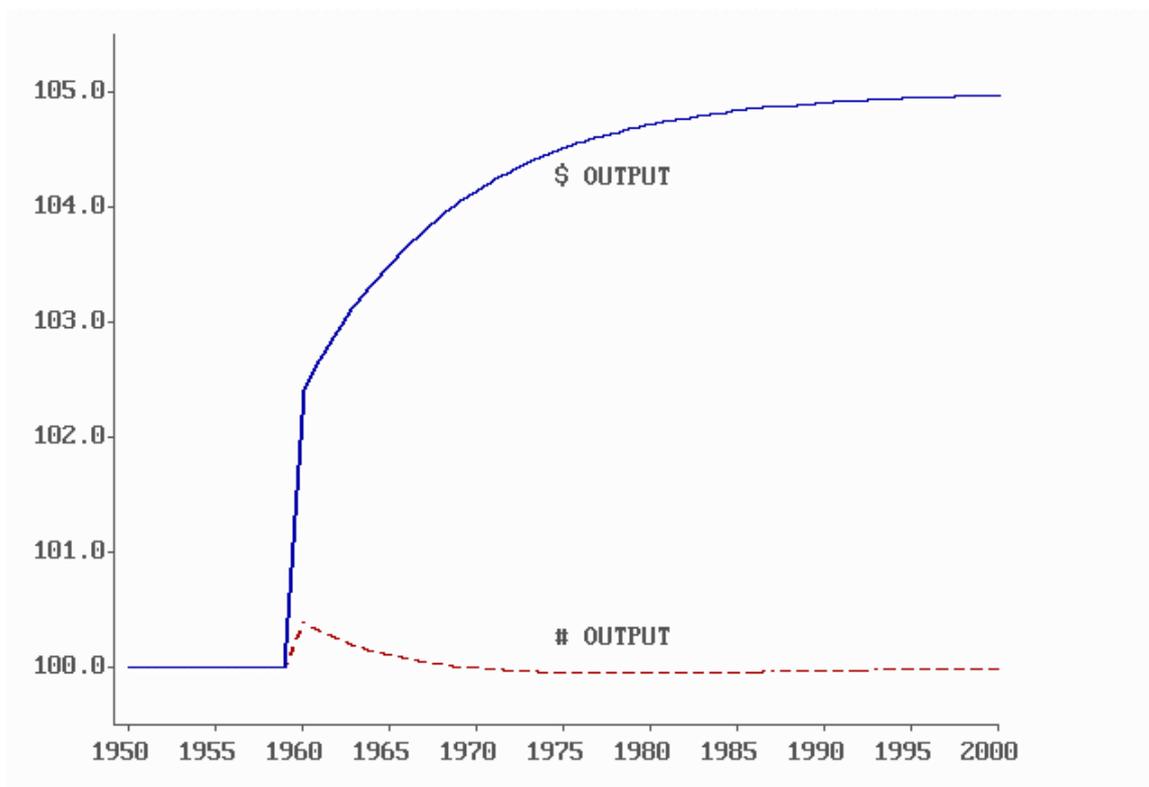


Figure 2: Effect of a permanent increase in \$ government expenditures on the \$ balance of trade and the dollar exchange rate (xr)

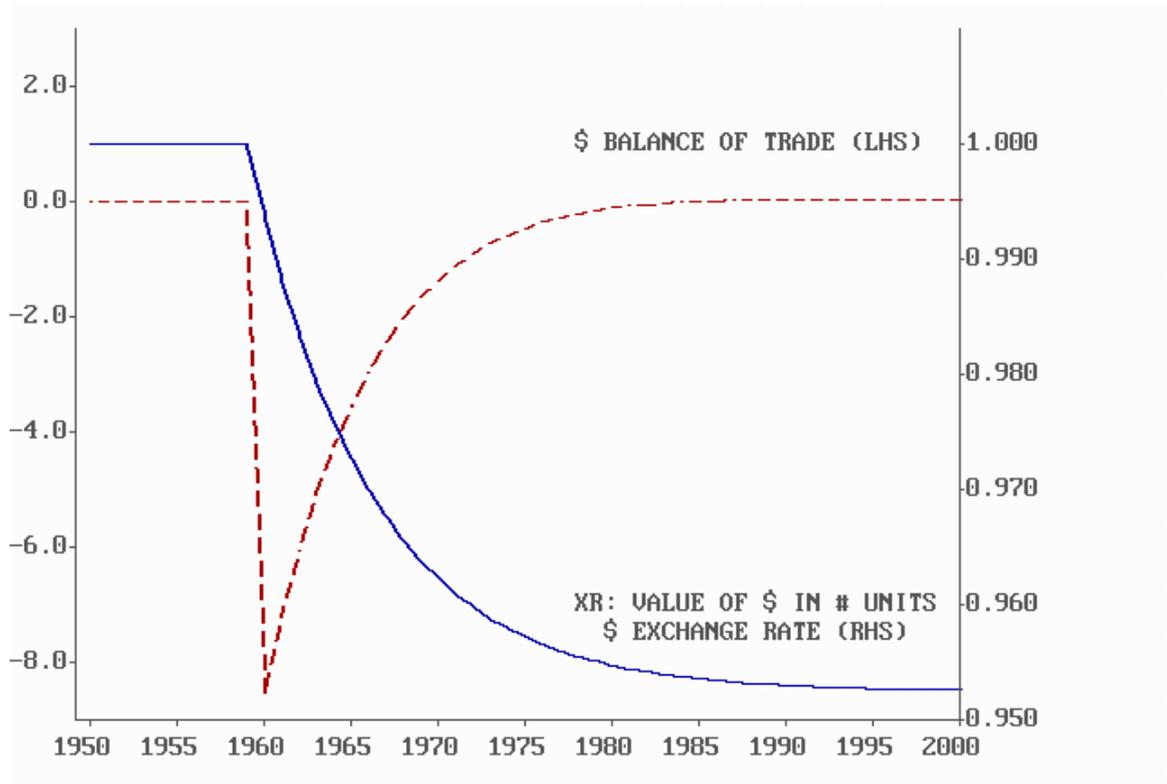


Figure 3: Effect of a permanent increase in \$ government expenditures on the proportions of assets held in # household portfolios, flexible exchange regime

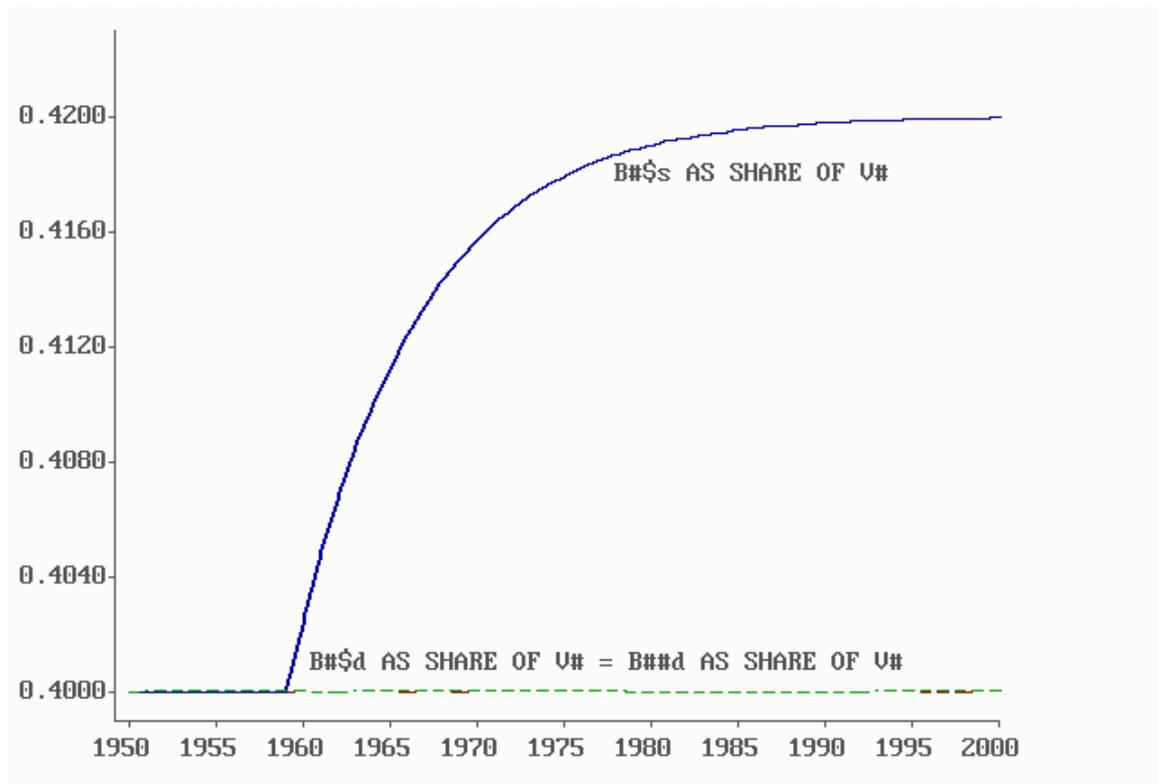


Figure 4: Effect of a permanent increase in the \$ rate of interest on the dollar exchange rate (xr)

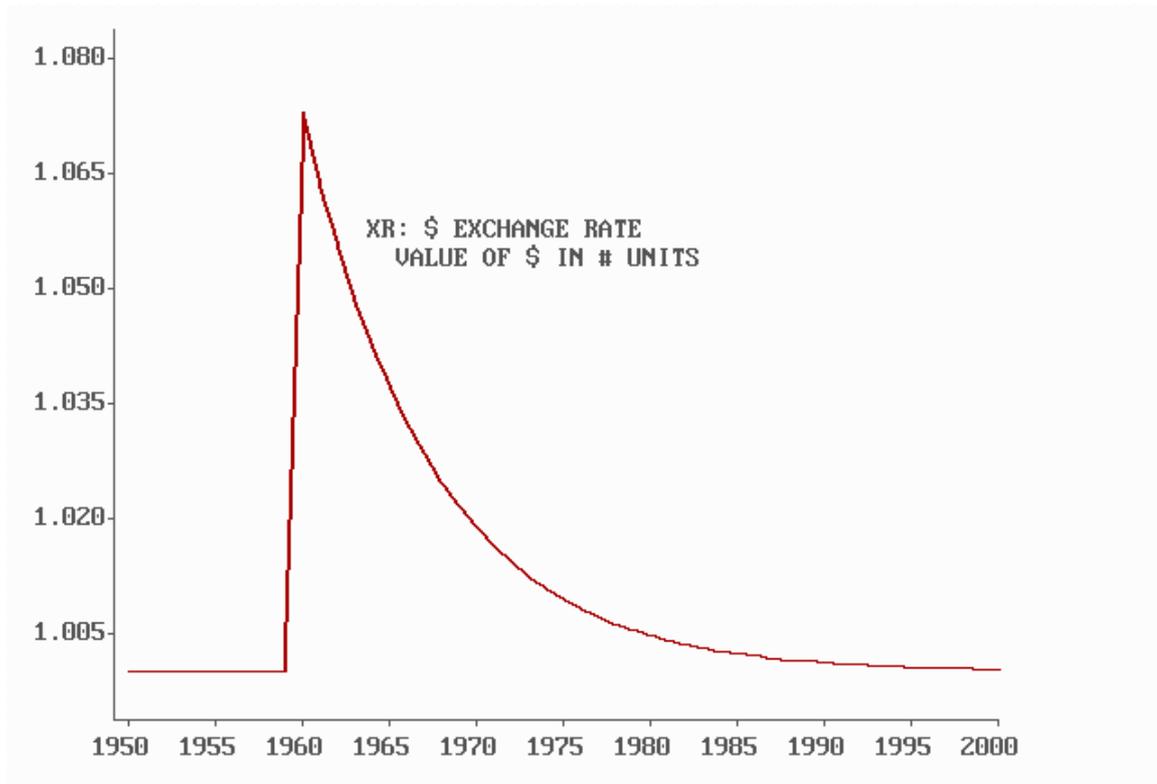


Figure 5: Effect of a permanent increase in the \$ rate of interest on the proportions of assets held in # household portfolios, flexible exchange regime

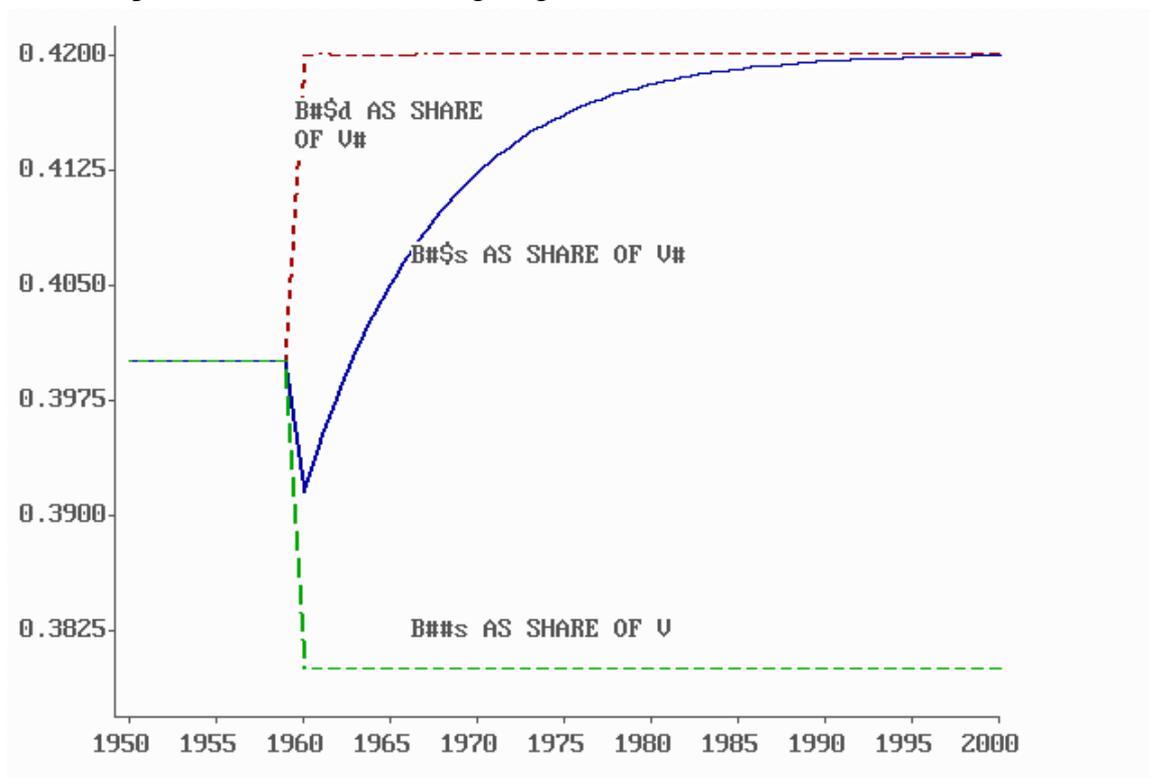


Figure 6: Effect of a permanent increase in the \$ rate of interest on \$ output and # output, flexible exchange regime

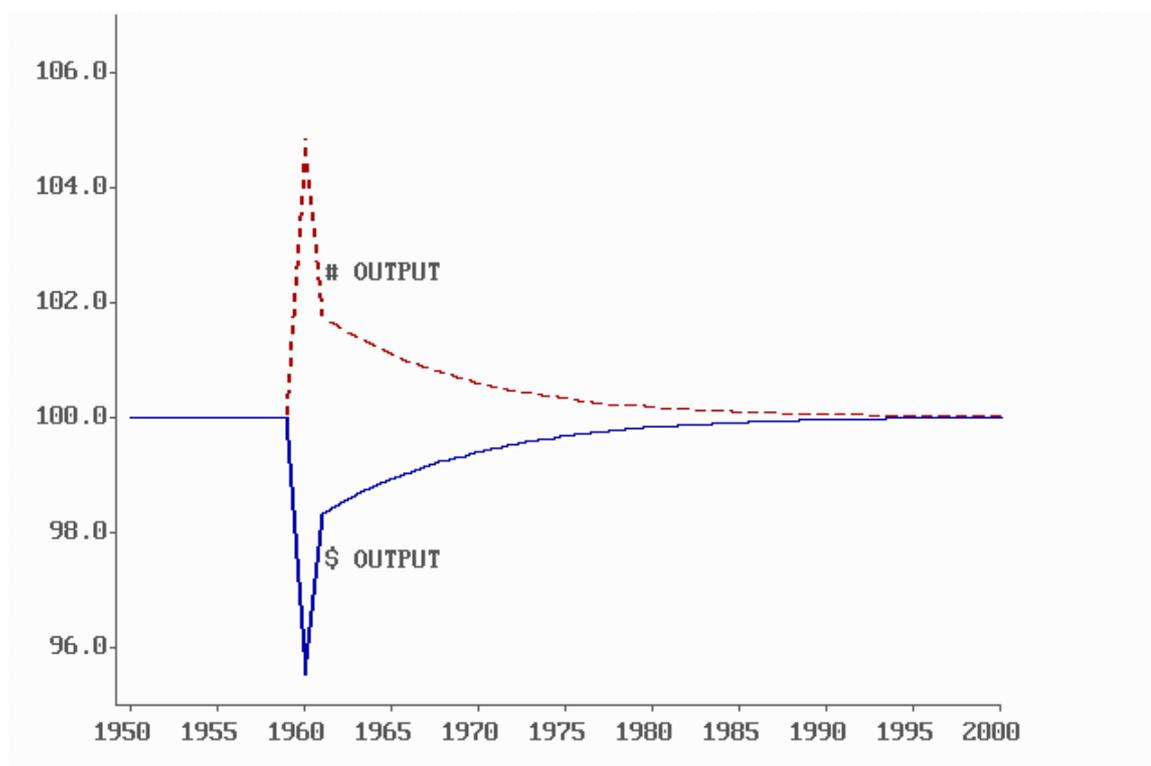
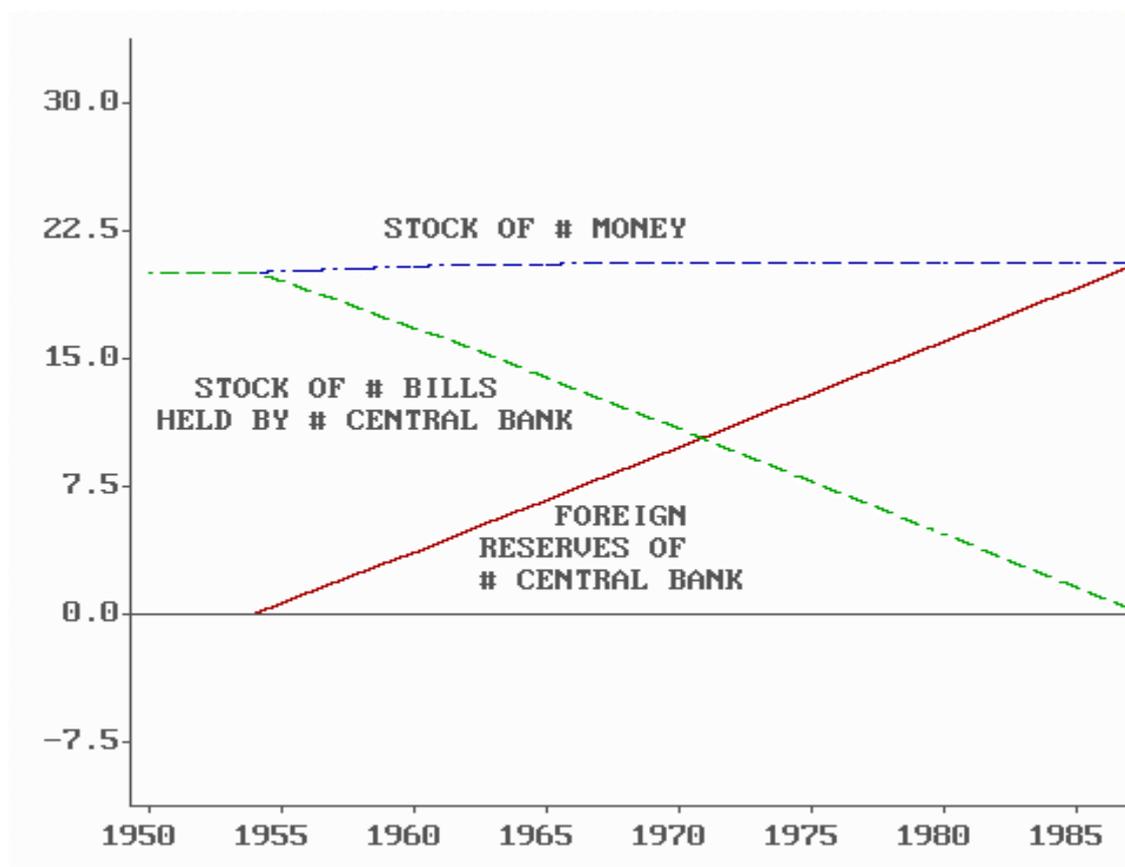


Figure 7: Effect of an increase in the \$ propensity to import on the components of the balance sheet of the # central bank (of the 'Chinese' country), fixed exchange regime.





Working Papers

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Please address enquiries about the series to:

*The Administrator, Cambridge Endowment for Research in Finance, Judge Business School,
Trumpington Street, Cambridge CB2 1AG, UK, Tel: +44(0) 1223 764 115, E-Mail: admin@cerf.cam.ac.uk, <http://www.cerf.cam.ac.uk>*