Inflation Targeting Monetary and Fiscal Policies in a Two-Country Stock-Flow Consistent Model: Technical Annex

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1 The Structure of the Model

The model developed here is an extension of Godley and Lavoie's (2007b) advanced open economy model. Inflationary forces are introduced through a wage-led cost-push mechanism and the marginal propensities to consume out of disposable income and wealth are endogenised as negative functions of the real interest rate in order to generate the cyclicality that motivates stabilisation policy (see also Godley and Lavoie, 2007a). Using this framework, simple procyclical IT and leader-follower interest rate rules are investigated both in isolation and in conjunction with countercyclical fiscal policy.

1.1 Notational Conventions

The model represents two sovereign states denoted 'A' and 'B'. In the majority of cases, a superscript will identify the country to which a variable relates. Government bills are the exception to this rule as they may be traded internationally. In this case, a superscript 'A' or 'B' will denote the issuing country, while a subscript 'A' or 'B' will denote the holding country. Furthermore, in relation to financial assets, subscripts 's' and 'd' will denote supply and demand. To maintain the consistency of the accounting framework, demand will be denominated in the currency of the demanding country and supply in the currency of the issuing country. A subscript 'e' will denote an expected value. Capital letters will denote nominal values, while lower case and Greek letters will denote real quantities and parameters, respectively. 'xr^A' will refer to the value of currency A in units of currency B and $xr^B = 1/xr^A$. 'Δ' is the backward difference operator and a 'd' prefix will indicate a proportional rate of change (i.e. $dxr_e^A = \Delta xr_e^A / xr^A$). The remaining terminology is largely self-explanatory and will be introduced as necessary. Finally, as many of the equations that follow will be common to both countries, indexation by $i = s$ where $s \in \{A, B\}$ and $j = i^c$ where i^c is the complement of i will be used to avoid repetition where possible.

Note that since a complete equation listing is provided here the equation numbers do not match those in the paper which only shows selected equations. However, it should be straightforward to relate one to the other.

1.2 The Balance Sheet and Transactions-Flow Matrices

Tables 1 and 2 are reproduced directly from the paper for reference. They present the balance sheet and transactions-flow matrices, respectively (see Godley and Lavoie, 2007b, ch. 2, for a detailed discussion of the properties of these matrices). The notation in the tables will become clear over the following pages. The model consists of two distinct economies each composed of four sectors: households, firms, government and the CB.

Four classes of financial assets are modelled: high powered money, bills issued by both governments and gold. Cash usage is limited to the domestic economy by assumption. Bills are internationally traded and make up part of the household's asset portfolio in both countries. Furthermore, bills issued in country A are held by CB B for settlement purposes and the price of gold is assumed to be fixed in terms of the currency of country A[1]. Together, these assumptions open the possibility of capital gains/losses accruing to CB B due to fluctuations in the exchange rate. These do not, however, represent transactions as there is no counterparty in the traditional sense and they do not, therefore, appear in Table 2. By contrast, CB A must, at all times, have precisely zero net worth in this model. Finally, it should be stressed that uses of funds appear with a negative sign in the transactions-flow matrix even though the agent may be accumulating assets.

1.3 Firms' Equations

The equations defining the the firm sector are listed below. Equation 1 defines nominal output with recourse to the national accounts identity, while equation 2 notes that real output is equal to real sales less real imports. Equation 3 defines the level of employment, N^i, as the ratio of real output to labour productivity, pr^i. The nominal wage bill, WB^i, is defined by equation 4 as the product of the nominal wage and employment. Similarly, equation 5 defines firms' unit costs, UC^i, as the sum of the wage bill and nominal imports divided by real sales. The sales price, p_s^i, is a simple mark-up (ϕ^i) over unit costs (equation 6). Equations 7 and 8 express real and nominal sales once again using the national accounts identity.

[1]Gold appears on the CBs' balance sheets as a remnant of the Bretton Woods era in the Godley and Lavoie model. Although it is assumed that no gold changes hands in the present paper, its inclusion in the model provides a simple means to modify the code to represent a situation in which the international asset held by the CBs is not a liability of either government. Experimentation with such alternative closures of the model may yield interesting insights into the nature of the monetary transmission mechanism under various settlement systems and provides an interesting avenue for continuing research.

	Economy B					Economy A				Σ
	H/holds	Firms	Govt	CB		H/holds	Firms	Govt	CB	
Base money	$+H^B$			$-H^B$		$+H^A$			$-H^A$	0
B bills	$+B^B_B$		$-B^B$	$+B^B_{cbB}$	$\cdot xr^B$	$+B^B_A \cdot xr^B$				0
A bills	$+B^A_B \cdot xr^A$			$+B^A_{cbB} \cdot xr^A$	$\cdot xr^B$	$+B^A_A$		$-B^A$	$+B^A_{cbA}$	0
Gold				$+au^B \cdot p^B_g$	$\cdot xr^B$				$+au^A \cdot p^A_g$	$+\sum au \cdot p^A_g$
Balance	$-V^B$		$-V^B_g$	$-V^B_{cb}$	$\cdot xr^B$	$-V^A$		$-V^A_g$	0	$-\sum au \cdot p^A_g$
Σ	0	0	0	0	$\cdot xr^B$	0	0	0	0	0

NOTES: 'A' and 'B' subscripts and superscripts are interpreted following the rules in Section 1.1. The variable names are interpreted as follows: H – high powered money; B – bills; V – net worth; au – gold holdings; and p_g – gold price in units of currency A. Subscripts 'g' and 'cb' associated with bill holdings and net worth denote the government and central bank, respectively. The exchange rates xr^A and xr^B are defined in Section 1.1.

Table 1: Balance Sheet Matrix

	Economy B					Economy A				Σ
	H/holds	Firms	Govt	CB		H/holds	Firms	Govt	CB	
Cons.	$-C^B$	$+C^B$				$-C^A$	$+C^A$			0
Gov. purch.		$+G^B$	$-G^B$				$+G^A$	$-G^A$		0
Trade		$-IM^B$			$\cdot xr^B$		$+X^A$			0
		$+X^B$			$\cdot xr^B$		$-IM^A$			0
GDP	$+Y^B$	$-Y^B$				$+Y^A$	$-Y^A$			0
Tax	$-T^B$		$+T^B$			$-T^A$		$+T^A$		0
CB profits			$+F^B_{cb}$	$-F^B_{cb}$				$+F^A_{cb}$	$-F^A_{cb}$	0
Interest on:										
B bills	$+r^B_{b-1} \cdot B^B_{B-1}$		$-r^B_{b-1} \cdot B^B_{-1}$	$+r^B_{b-1} \cdot B^B_{cbB-1}$	$\cdot xr^B$	$+r^B_{b-1} \cdot B^B_{A-1} \cdot xr^B$				0
A bills	$+r^A_{b-1} \cdot B^A_{B-1} \cdot xr^A$			$+r^A_{b-1} \cdot B^A_{cbB-1} \cdot xr^A$	$\cdot xr^B$	$+r^A_{b-1} \cdot B^A_{A-1}$		$-r^A_{b-1} \cdot B^A_{-1}$	$+r^A_{b-1} \cdot B^A_{cbA-1}$	0
Δ stock of:										
Cash	$-\Delta H^B$			$+\Delta H^B$		$-\Delta H^A$			$+\Delta H^A$	0
B bills	$-\Delta B^B_B$		$+\Delta B^B$	$-\Delta B^B_{cbB}$	$\cdot xr^B$	$-\Delta B^B_A \cdot xr^B$		$+\Delta B^A$		0
A bills	$-\Delta B^A_B \cdot xr^A$			$-\Delta B^A_{cbB} \cdot xr^A$	$\cdot xr^B$	$-\Delta B^A_A$			$-\Delta B^A_{cbA}$	0
Gold				$-\Delta au^B \cdot p^B_g$	$\cdot xr^B$				$-\Delta au^A \cdot p^A_g$	0
Σ	0	0	0	0		0	0	0	0	0

NOTES: 'A' and 'B' subscripts and superscripts are interpreted following the rules in Section 1.1. The variable names are interpreted as follows: C – nominal consumption; Y – nominal GDP; T – nominal tax; r – bill interest rate; B – bills; H – high powered money; G – nominal government spending; IM – nominal imports; X – nominal exports; F_{cb} – central bank profits; au – gold holdings; and p_g – gold price in units of currency A. The exchange rates xr^A and xr^B are defined in Section 1.1. A subscript '-1' indicates a lagged value.

Table 2: Transactions-Flow Matrix

$$
\begin{aligned}
Y^i &= C^i + G^i + X^i - IM^i && (1)\\
y^i &= s^i - im^i && (2)\\
N^i &= y^i/pr^i && (3)\\
WB^i &= N^i \cdot W^i && (4)\\
UC^i &= \frac{WB^i + IM^i}{s^i} && (5)\\
p_s^i &= \left(1+\phi^i\right) \cdot UC^i && (6)\\
s^i &= c^i + g^i + x^i && (7)\\
S^i &= p_s^i \cdot s^i && (8)
\end{aligned}
$$

1.4 Household Equations

The following equations define household income, wealth and the consumption decision:

$$
\begin{aligned}
YD_r^i &= Y^i + r_{-1}^i \cdot B_{is-1}^i + r_{-1}^j \cdot B_{is-1}^j \cdot xr^j - T^i && (9)\\
YD_{hs}^i &= YD_r^i + \Delta xr^j \cdot B_{is-1}^j && (10)\\
V^i &= V_{-1}^i + YD_{hs}^i - C^i &&\\
&= V_{-1}^i + YD_r^i - C^i + \Delta xr^j \cdot B_{is-1}^j &&\\
&= V_{-1}^i + NAFA^i + CG^i && (11)\\
yd_{hs}^i &= \frac{YD_{hs}^i}{p_{ds}^i} - v_{-1}^i \cdot \frac{\Delta p_{ds}^i}{p_{ds}^i} && (12)\\
v^i &= V^i/p_{ds}^i && (13)\\
c^i &= \alpha_1^i \cdot yd_{hse}^i + \alpha_2^i \cdot v_{-1}^i && (14)\\
yd_{hse}^i &= \frac{1}{2} \cdot \left(yd_{hs}^i + yd_{hs-1}^i\right) && (15)\\
C^i &= c^i \cdot p_{ds}^i && (16)
\end{aligned}
$$

Equation 9 defines the regular disposable household income, YD_r^i, as GDP, less income tax, plus interest income derived from holdings of domestic and foreign bills, B_i^i and B_i^j, respectively. The Haig-Simons (Haig, 1921; Simons, 1938, hereafter HS) definition of disposable income adjusts regular disposable income to take account of capital gains arising through exchange rate fluctuations (equation 10). Equation 11 notes that nominal wealth, V^i, accumulates when nominal HS disposable income exceeds nominal consumption. A simple re-arrangement reveals that the change in nominal wealth is equal to the sum of the net accumulation of financial assets, $NAFA^i$, and capital gains, CG^i.

Real HS disposable income is defined by equation 12, while equation 13 defines real wealth in the usual manner (the domestic price level, p_{ds}^i, is defined in Section 1.7).

Equation 14 states that the household consumption decision is based on real magnitudes as opposed to nominal magnitudes (i.e. they suffer no money-illusion). Real consumption, c^i, depends on expected real HS disposable income, yd^i_{hse}, where equation 15 notes that expectations are formed adaptively.

Godley and Lavoie (2007b) treat the marginal propensities to consume out of disposable income and wealth (i.e. α^i_1 and α^i_2) as exogenous. In a separate paper (2007a) addressing stabilisation policies, they endogenise α^i_1 as a simple negative function of the real interest rate. In this way, an interest rate hike may reduce consumption and thereby aggregate activity. The present paper adopts a slightly different approach in which both α^i_1 and α^i_2 are endogenous magnitudes, the values of which are bounded in order to ensure that they remain within tractable limits.

Equation 17 offers the standard definition of the real interest rate which then feeds into equations 18 to 20 which define the behaviour of the marginal propensity to consume out of income. $\mu^i_{\alpha_1}$ measures the strength of the response to changes in the real interest rate while equations 19 and 20 define dummy variables which ensure that the parameter remains within an acceptable band, i.e. $\alpha^i_{1L} \leq \alpha^i_1 \leq \alpha^i_{1U}$. Equations 21 to 23 model the marginal propensity to consume out of wealth similarly. A tilde denotes the value taken by a variable in the initial steady state. The specification of these equations relates to the assumption that stabilisation policies attempt to maintain or regain this initial equilibrium (this will be revisited in Section 2).

$$
\begin{aligned}
rr^i &= \frac{1+r^i}{1+\pi^i_{ds}} - 1 && (17)\\
\alpha^i_1 &= \widetilde{\alpha^i_1} - \mu^i_{\alpha_1}\left(rr^i - \widetilde{rr^i}\right)\left(1 - z1^i\right)\left(1 - z2^i\right) + z1^i \cdot \alpha^i_{1L} + z2^i \cdot \alpha^i_{1U} && (18)\\
z1^i &= 1 \quad \text{iff} \quad \alpha^i_1 < \alpha^i_{1L} && (19)\\
z2^i &= 1 \quad \text{iff} \quad \alpha^i_1 > \alpha^i_{1U} && (20)\\
\alpha^i_2 &= \widetilde{\alpha^i_2} - \mu^i_{\alpha_2}\left(rr^i - \widetilde{rr^i}\right)\left(1 - z3^i\right)\left(1 - z4^i\right) + z3^i \cdot \alpha^i_{2L} + z4^i \cdot \alpha^i_{2U} && (21)\\
z3^i &= 1 \quad \text{iff} \quad \alpha^i_2 < \alpha^i_{2L} && (22)\\
z4^i &= 1 \quad \text{iff} \quad \alpha^i_2 > \alpha^i_{2U} && (23)
\end{aligned}
$$

1.5 Household Portfolio Equations

Household portfolio decisions are modelled following the principles laid out by Brainard and Tobin (1968) and Tobin (1969). They formalised the notion that a household cannot increase the proportion of its wealth held in any one asset class without reducing its relative holdings of other asset classes. Equations 24, 25 and 26A represent household demand for domestic bills, foreign bills and high powered money, respectively (i.e. the portfolio decision)[2].

[2]Note that the portfolio equations could be constructed using either nominal or real rates of return; the results will be equivalent in this simple model. Note also that the transactions demand for money

$$
\begin{aligned}
B^i_{id} &= V^i \cdot \left\{\lambda^i_{10} + \lambda^i_{11} \cdot r^i + \lambda^i_{12} \cdot \left(r^j + dxr^j_e\right)\right\} && (24)\\
B^j_{id} &= V^i \cdot \left\{\lambda^i_{20} + \lambda^i_{21} \cdot r^i + \lambda^i_{22} \cdot \left(r^j + dxr^j_e\right)\right\} && (25)\\
H^i_d &= V^i - B^i_{id} - B^j_{id} && (26)
\end{aligned}
$$

However, where expectations are prone to frustration, there must be a buffer asset to absorb the resulting fluctuations without violating the accounting framework. Following Godley and Lavoie, it is assumed that cash holdings perform this role and so equation 26 replaces equation 26A. The 'A' suffix indicates that this equation is omitted from the simulated model.

$$H^i_d = V^i \cdot \left\{\lambda^i_{30} + \lambda^i_{31} \cdot r^i + \lambda^i_{32} \cdot \left(r^j + dxr^j_e\right)\right\} \tag{26A}$$

Equations 24, 25 and 26A may be re-written in matrix form as follows to facilitate the discussion of the Brainard-Tobin constraints:

$$
\begin{bmatrix} B^i_{id} \\ B^j_{id} \\ H^i_d \end{bmatrix} = \begin{bmatrix} \lambda^i_{10} \\ \lambda^i_{20} \\ \lambda^i_{30} \end{bmatrix} \cdot V^i + \begin{bmatrix} \lambda^i_{11} & \lambda^i_{12} & \lambda^i_{13} \\ \lambda^i_{21} & \lambda^i_{22} & \lambda^i_{23} \\ \lambda^i_{31} & \lambda^i_{32} & \lambda^i_{33} \end{bmatrix} \cdot \begin{bmatrix} r^i \\ r^j + dxr^j_e \\ 0 \end{bmatrix} \cdot V^i
$$

The vertical adding up constraints imply that $\sum_m \lambda^i_{m0} = 1$ and $\sum_m \lambda^i_{mn} = 0$ for $m, n = 1, 2, 3$. The symmetry constraints associated with Friedman (1978) imply that $\lambda^i_{12} = \lambda^i_{21}$, $\lambda^i_{13} = \lambda^i_{31}$ and $\lambda^i_{23} = \lambda^i_{32}$. However, because the nominal rate of return on cash holdings is zero, the last two are obsolete. The coefficient on the own rate of return in each equation is positive, while those on the rates of return associated with other assets are negative. Hence, in the 3×3 matrix of λ^i's, only the prime diagonal values are positive.

The nominal rate of return on foreign bills is equal to the nominal foreign interest rate plus the expected proportional change of the exchange rate, dxr^j_e. Following Godley and Lavoie (pp. 459-60), it is assumed that $dxr^A_e = dxr^B_e = 0$, implying that investors expect exchange rate constancy. Alternatively, one could impose UIP, although its aforementioned unsatisfactory empirical performance, coupled with various theoretical concerns, cautions against this (c.f. Godley and Lavoie, pp. 459-60)[3].

1.6 Government Equations

Equation 27 defines nominal tax revenues, T^i, as a proportion, θ^i, of regular household income. Nominal government spending, G^i, is the product of the domestic price level and real government spending, which is determined exogenously in this simple closure of the

has been omitted here in the interests of simplicity.

[3]Note that although exchange rate constancy is assumed here, the computer programme can easily accommodate alternative assumptions.

model (equations 28 and 29, where the bar denotes exogeneity). The public sector borrowing requirement, $PSBR^i$, is defined by equation 30 as the sum of nominal government expenditure and the cost of servicing existing public debt. Equation 31 states that bills are issued in the amount required to cover the $PSBR$ after accounting for government revenues derived from tax receipts and the profits of the CB, F^i_{cb}.

$$
\begin{aligned}
T^i &= \theta^i \cdot \left(Y^i + r^i_{-1} \cdot B^i_{is-1} + r^j_{-1} \cdot B^j_{is-1} \cdot xr^j\right) && (27)\\
g^i &= \overline{g^i} && (28)\\
G^i &= p^i_{ds} \cdot g^i && (29)\\
PSBR^i &= G^i + r^i_{-1} \cdot B^i_{s-1} - \left(T^i + F^i_{cb}\right) && (30)\\
B^i_s &= B^i_{s-1} + G^i - T^i + r^i_{-1} \cdot B^i_{s-1} - F^i_{cb} && (31)
\end{aligned}
$$

1.7 Inflationary Forces

Inflationary pressure arises through a conflicting claims process in which workers enter nominal wage negotiations with a target real wage in mind. The target real wage, ω^{Ti}, is defined by equation 32 as a function of labour productivity (which takes a constant exogenous value at present) and the employment rate, where N^i_{fe} is the full employment level (i.e. N^i/N^i_{fe} is a measure of the 'reserve army' of unemployed labour). The nominal wage, W^i, then adjusts toward the targeted real wage at the rate Ω^i_3 (equation 33). Equation 34 offers the standard definition of the rate of sales price inflation, although this includes the price of exported goods. In order to define an appropriate domestic price index, it is necessary to remove exports. Equations 35 and 36 define the nominal value and real quantity of domestic sales, DS^i and ds^i, while equation 37 defines the domestic sales deflator, p^i_{ds}. It is then a simple matter to define the rate of inflation of domestic sales prices, π^i_{ds}. Godley and Lavoie argue that the price of domestic sales is approximately equivalent to CPI (2007b, p. 455). This is particularly important in the current application, as it suggests that it is π^i_{ds} rather than π^i_s that should be the target of monetary policy.

$$
\begin{aligned}
\omega^{Ti} &= \Omega^i_0 + \Omega^i_1 \cdot pr^i + \Omega^i_2 \cdot \left(N^i/N^i_{fe}\right) && (32)\\
W^i &= W^i_{-1} \cdot \left(1 + \Omega^i_3 \cdot \left(\omega^{Ti}_{-1} - W^i_{-1}/p^i_{-1}\right)\right) && (33)\\
\pi^i_s &= \frac{p^i_s}{p^i_{s-1}} - 1 && (34)\\
DS^i &= S^i - X^i && (35)\\
ds^i &= c^i + g^i && (36)\\
p^i_{ds} &= \frac{DS^i}{ds^i} && (37)\\
\pi^i_{ds} &= \frac{p^i_{ds}}{p^i_{ds-1}} - 1 && (38)
\end{aligned}
$$

1.8 Trade and the Balance of Payments (BOP)

The treatment of trade follows directly from that of Godley and Lavoie (2007b, pp. 453-5). For clarity, the system of indexation of country-specific equations that has been adopted thus far is abandoned for equations 39 to 46. Godley and Lavoie carefully formulate equations 39 and 40 defining the price of imports and exports in country B, p_m^B and p_x^B. Real exports and imports of economy B, x^B and im^B, are defined by equations 41 and 42, which stress the role of relative prices and income. These four equations are log-linearised for convenience. Equations 43 to 48 follow trivially and equation 49 expresses the GDP deflator, p_y^i, as the ratio of nominal to real output.

$$
\begin{aligned}
ln\left(p_m^B\right) &= \nu_0 + \nu_1 \cdot ln\left(xr^B\right) + (1-\nu_1) \cdot ln\left(p_y^B\right) - \nu_1 \cdot ln\left(p_y^A\right) && (39)\\
ln\left(p_x^B\right) &= \upsilon_0 + \upsilon_1 \cdot ln\left(xr^B\right) + (1-\upsilon_1) \cdot ln\left(p_y^B\right) - \upsilon_1 \cdot ln\left(p_y^A\right) && (40)\\
ln\left(x^B\right) &= \epsilon_0 - \epsilon_1 \cdot \left\{ln\left(p_m^A\right) - ln\left(p_y^A\right)\right\} + \epsilon_2 \cdot ln\left(y^A\right) && (41)\\
ln\left(im^B\right) &= \mu_0 - \mu_1 \cdot \left\{ln\left(p_{m-1}^B\right) - ln\left(p_{y-1}^B\right)\right\} + \mu_2 \cdot ln\left(y^B\right) && (42)\\
p_x^A &= p_m^B \cdot xr^B && (43)\\
p_m^A &= p_x^B \cdot xr^B && (44)\\
x^A &= im^B && (45)\\
im^A &= x^B && (46)\\
X^i &= x^i \cdot p_x^i && (47)\\
IM^i &= im^i \cdot p_m^i && (48)\\
p_y^i &= Y^i / y^i && (49)
\end{aligned}
$$

Moving on to the BOP equations, it is once again necessary to abandon indexation due to the differences in the behaviour of each CB. Equation 50 depicts the current account balance of country B, CA^B, including net exports and net interest income but omitting capital gains arising from exchange rate fluctuations. Equation 51 is the capital account balance including the official settlement accounts, KA^B, and is, by definition, equal in magnitude to the current account balance but of opposite sign (au^i denotes gold holdings). Finally, equation 52 defines the capital account balance of country B excluding the official settlement accounts, KAX^B. The equivalent definitions for country A are presented in equations 53 to 55.

$$
\begin{aligned}
CA^B &= X^B - IM^B + r_{-1}^A \cdot B_{Bs-1}^A \cdot xr^A - r_{-1}^B \cdot B_{As-1}^B + r_{-1}^A \cdot B_{cbBs-1}^A \cdot xr^A && (50)\\
KA^B &= \Delta B_{As}^B - \Delta B_{Bs}^A \cdot xr^A - \left\{\Delta B_{cbBs}^A \cdot xr^A + \Delta au^B \cdot p_g^B\right\} && (51)\\
KAX^B &= \Delta B_{As}^B - \Delta B_{Bs}^A \cdot xr^A && (52)
\end{aligned}
$$

$$CA^A = X^A - IM^A + r^B_{-1} \cdot B^B_{As-1} \cdot xr^B - r^A_{-1} \cdot B^A_{Bs-1} - r^A_{-1} \cdot B^A_{cbBs-1} \quad (53)$$
$$KA^A = \Delta B^A_{Bs} + \Delta B^A_{cbBs} - \Delta B^B_{As} \cdot xr^B - \left\{\Delta au^A \cdot p^A_g\right\} \quad (54)$$
$$KAX^A = \Delta B^A_{Bs} - \Delta B^B_{As} \cdot xr^B \quad (55)$$

1.9 Central Bank Equations

Equations 56 to 57 note that high powered money, denoted H^i, and bills are supplied to households on demand in a manner consistent with horizontalist models of the money supply process (c.f. Moore, 1988). Similarly, equation 58 states that domestic bills are supplied to the CB on demand. Equation 59 states that the bill rate of interest is set exogenously as the policy instrument of the CB.

$$H^i_s = H^i_d \quad (56)$$
$$B^i_{is} = B^i_{id} \quad (57)$$
$$B^i_{cbis} = B^i_{cbid} \quad (58)$$
$$r^i = \overline{r^i} \quad (59)$$

The balance sheets of the CBs differ because CB B is assumed to hold bills issued in country A for settlement purposes in an unreciprocated fashion. The value of these bills may change in accordance with exchange rate fluctuations, raising the possibility of capital gains and losses for CB B. Moreover, the price of gold, p_g, is fixed in currency A so the price faced by CB B will also fluctuate with the exchange rate (equations 60 and 61). Hence, while the balance sheet of CB A may be evaluated in levels form, that of CB B must be considered in differences (equations 62 and 63)[4]. Finally, equations 64 and 65 define the operating profits of the CBs, F^i_{cb}, consisting of interest income on their bill holdings. Recall that these profits are transferred in their entirety to central government.

$$p^A_g = \overline{p^A_g} \quad (60)$$
$$p^B_g = p^A_g \cdot xr^A \quad (61)$$
$$B^A_{cbAd} = H^A_s - au^A \cdot p^A_g \quad (62)$$
$$B^B_{cbBd} = B^B_{cbBd-1} + \Delta H^B_s - \Delta B^A_{cbBs} \cdot xr^A - \Delta au^B \cdot p^B_g \quad (63)$$
$$F^A_{cb} = r^A_{-1} \cdot B^A_{cbAs-1} \quad (64)$$
$$F^B_{cb} = r^B_{-1} \cdot B^B_{cbBs-1} + r^A_{-1} \cdot B^A_{cbBs-1} \cdot xr^A \quad (65)$$

The basic model is completed by a discussion of exchange rate determination. Equa-

[4]The final term in equation 63 refers to the change in the stock of gold. Following Godley and Lavoie, it is assumed that no gold changes hands at present, but it is included here to permit further experimentation with the use of gold as a settlement asset rather than bills issued in country A.

tions 66 and 67 define the equivalence of the supply and demand for foreign bill holdings measured in a common currency. Recall that demand for a foreign asset is measured in the domestic currency, while supply is denominated in the foreign currency. The supply of bills from country A to CB B, B^A_{cbBs}, is exogenously determined (equation 68) while the supply of A bills to households in country B, B^A_{Bs}, is a residual magnitude (equation 69).

$$\begin{aligned}
B^B_{As} &= B^B_{Ad} \cdot xr^A && (66)\\
B^A_{cbBd} &= B^A_{cbBs} \cdot xr^A && (67)\\
B^A_{cbBs} &= \overline{B^A_{cbBs}} && (68)\\
B^A_{Bs} &= B^A_s - B^A_{cbBs} - B^A_{As} - B^A_{cbAs} && (69)\\
xr^B &= \frac{B^A_{Bs}}{B^A_{Bd}} && (70)\\
xr^A &= 1/xr^B && (71)\\
rxr^i &= xr^i \cdot \frac{p^i_{ds}}{p^j_{ds}} && (72)
\end{aligned}$$

The exchange rate xr^B is determined endogenously as the ratio of foreign bills supplied to country B households relative to the demand for these bills (equation 70). As usual, the exchange rate xr^A is the reciprocal of xr^B and the real exchange rate for country $i = s$ is defined by equation 72. Finally, the redundant equation below is satisfied to a high degree of precision in all simulated scenarios.

$$B^B_s = B^B_{Bs} + B^B_{As} + B^B_{cbBs} \tag{73A}$$

2 Model Closures: Stabilisation Policies

The basic structure of the model is complete; all that remains is to model the following candidate stabilisation policies: (i.) a simple IT rule; (ii.) a modified IT rule where CB B reacts to the rate set by CB A; (iii.) a combination of (i.) with countercyclical fiscal policy; and (iv.) a combination of (ii.) with countercyclical fiscal policy.

2.1 Procyclical Inflation-Targeting Monetary Policy

A simple IT interest rate rule may be modelled by endogenising the bill rates:

$$\begin{aligned}
r^i &= \left\{\widetilde{rr^i} + \pi^i_{ds} + \varrho^i \cdot \left(\pi^i_{ds} - \widetilde{\pi^i_{ds}}\right)\right\} \cdot z5^i && \text{(59-IT)}\\
z5^i &= 1 \quad \text{iff} \quad r^i > 0 && \text{(74-IT)}
\end{aligned}$$

where equation 59-IT replaces equation 59 and ϱ^i defines the strength of the monetary policy response to the inflation gap. Using the initial steady state rate of inflation as the target ensures that the initial equilibrium is one in which the inflation gap is zero. Hence, the shocks simulated below represent a perturbation which moves the system away from this equilibrium. The $z5$ parameter ensures that the nominal zero lower bound is respected. This is model 'IT'.

2.2 Leader-Follower Interest Rate Setting

An extensive literature has grown around the observation of cointegrating relationships among various international interest rates, leading to the suggestion that global interest rates may be converging (see Devine, 1997, for a critical survey). Regional convergence has been attributed to the emergence of leader-follower relationships among CBs, notable examples including Goodhart (1990, pp. 478-9), Pain and Thomas (1997) and Laopodis (2001). It is straightforward to model a system in which CB B responds to the interest rate decisions of CB A by endogenising the bill rates as follows, yielding model 'LF':

$$r^i = \left\{\zeta^i \cdot \left(\widetilde{rr^i} + \pi^i_{ds} + \varrho^i \cdot \left(\pi^i_{ds} - \widetilde{\pi^i_{ds}}\right)\right) + \left(1 - \zeta^i\right) \cdot r^j\right\} \cdot z5^i \qquad \text{(59-LF)}$$

where ζ^i determines the degree to which the CB responds to domestic inflationary pressures relative to foreign interest rates, $0 \leq \zeta^B < 1$ and $\zeta^A = 1$ by assumption and $z5$ again ensures that the zero bound is respected.

2.3 Countercyclical Fiscal Policy

In principle, fiscal policy could be deployed to combat inflation, a possibility that has been entertained not just by Godley and Lavoie (2007a) but also Setterfield (2007). A simple countercyclical anti-inflationary government spending policy can be modelled as follows:

$$\begin{aligned} g^i &= g^i_{-1} - \varsigma^i_1 \cdot z6^i + \varsigma^i_2 \cdot z7^i && \text{(28-CFP)} \\ z6^i &= 1 \quad \text{iff} \quad \pi^i_{ds-1} > \pi^{iU}_{ds} && \text{(75-CFP)} \\ z7^i &= 1 \quad \text{iff} \quad \pi^i_{ds-1} < \pi^{iL}_{ds} && \text{(76-CFP)} \end{aligned}$$

Instead of employing the previous point target, the $z6$ and $z7$ parameters define an acceptable range for inflation and the ς^i parameters define the amount by which government spending changes when these bounds are breached.

When used in conjunction with the interest rate rules described above, models 'CF-PIT' and 'CFPLF' result. In this case, the use of a band target for fiscal policy introduces a policy hierarchy. When inflationary pressures are viewed as severe (i.e. $\pi^i_{ds-1} > \pi^{iU}_{ds}$), the government will reign in its spending in order to cool the economy. Similarly, when inflation is low (i.e. $\pi^i_{ds-1} < \pi^{iL}_{ds}$), the government will engage in fiscal stimulus, taking advantage of the opportunity to increase GDP growth without causing excessive inflation. At all other times (i.e. $\pi^{iL}_{ds} \leq \pi^{i}_{ds-1} \leq \pi^{iU}_{ds}$), the responsibility for inflation-targeting lies with the CB. Hence, the primary policy aimed at controlling inflation in this context is monetary policy, while government spending will only be changed if inflation is either uncomfortably high or sufficiently low to provide an opportunity to engage in fiscal stimulus without creating excessive inflation. Furthermore, the combination of this spending policy with procyclical proportionate income taxation will yield a countercyclical budget deficit consistent with Minsky's (1982; 1986) view of a stabilising 'Big Government'.

3 Parameterisation and Initial Conditions

Parameters		
$\widetilde{\alpha_1^B}$	0.900000	Value of country B's mpc out of income in the initial steady state
$\widetilde{\alpha_1^A}$	0.900000	Value of country A's mpc out of income in the initial steady state
α_{1L}^B	0.810000	Lower bound of country B's mpc out of income
α_{1L}^A	0.810000	Lower bound of country A's mpc out of income
α_{1U}^B	0.990000	Upper bound of country B's mpc out of income
α_{1U}^A	0.990000	Upper bound of country A's mpc out of income
$\widetilde{\alpha_2^B}$	0.150000	Value of country B's mpc out of wealth in the initial steady state
$\widetilde{\alpha_2^A}$	0.150000	Value of country A's mpc out of wealth in the initial steady state
α_{2L}^B	0.100000	Lower bound of country B's mpc out of wealth
α_{2L}^A	0.100000	Lower bound of country A's mpc out of wealth
α_{2U}^B	0.200000	Upper bound of country B's mpc out of wealth
α_{2U}^A	0.200000	Upper bound of country A's mpc out of wealth
ϵ_0	-2.100000	Parameter in country B's real exports equation
ϵ_1	0.700000	Parameter in country B's real exports equation
ϵ_2	1.000000	Parameter in country B's real exports equation
λ_{10}	0.300000	Parameter in country B's household portfolio equations
λ_{11}	1.000000	Parameter in country B's household portfolio equations
λ_{12}	1.000000	Parameter in country B's household portfolio equations
λ_{20}	0.100000	Parameter in country B's household portfolio equations
λ_{21}	1.000000	Parameter in country B's household portfolio equations

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λ_{22}	1.000000	Parameter in country B's household portfolio equations
λ_{40}	0.300000	Parameter in country A's household portfolio equations
λ_{41}	1.000000	Parameter in country A's household portfolio equations
λ_{42}	1.000000	Parameter in country A's household portfolio equations
λ_{50}	0.100000	Parameter in country A's household portfolio equations
λ_{51}	1.000000	Parameter in country A's household portfolio equations
λ_{52}	1.000000	Parameter in country A's household portfolio equations
μ_0	-2.100000	Parameter in country B's real imports equation
μ_1	0.700000	Parameter in country B's real imports equation
μ_2	1.000000	Parameter in country B's real imports equation
$\mu_{\alpha 1}^B$	0.500000	Parameter determining the responsiveness of country B's mpc out of income to the real interest rate
$\mu_{\alpha 1}^A$	0.500000	Parameter determining the responsiveness of country A's mpc out of income to the real interest rate
$\mu_{\alpha 2}^B$	0.200000	Parameter determining the responsiveness of country B's mpc out of wealth to the real interest rate
$\mu_{\alpha 2}^A$	0.200000	Parameter determining the responsiveness of country A's mpc out of wealth to the real interest rate
ν_0	-0.000010	Parameter in country B's import price equation
ν_1	0.700000	Parameter in country B's import price equation
$\widetilde{rr^B}$	0.015302	Country B real interest rate in the initial steady state
$\widetilde{rr^A}$	0.015301	Country A real interest rate in the initial steady state
Ω_0^B	0.000000	Parameter in country B's real wage target equation
Ω_0^A	0.000000	Parameter in country A's real wage target equation
Ω_1^B	1.000000	Parameter in country B's real wage target equation
Ω_1^A	1.000000	Parameter in country A's real wage target equation
Ω_2^B	1.500000	Parameter in country B's real wage target equation
Ω_2^A	1.500000	Parameter in country A's real wage target equation
Ω_3^B	0.150000	Parameter determining the speed of wage adjustment in country B
Ω_3^A	0.150000	Parameter determining the speed of wage adjustment in country A
$\widetilde{\pi_{ds}^B}$	0.004698	Initial steady state value of inflation in country B
$\widetilde{\pi_{ds}^A}$	0.004699	Initial steady state value of inflation in country A
π_{ds}^{BL}	0.000000	Lower bound of country B's inflation target range (fiscal policy)

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π_{ds}^{AL}	0.000000	Lower bound of country A's inflation target range (fiscal policy)
π_{ds}^{BU}	0.010000	Upper bound of country B's inflation target range (fiscal policy)
π_{ds}^{AU}	0.010000	Upper bound of country A's inflation target range (fiscal policy)
ϱ^B	0.500000	Parameter determining the strength of the anti-inflationary response of CB B
ϱ^A	0.500000	Parameter determining the strength of the anti-inflationary response of CB A
ς_1^B	0.150000	Parameter in country B's countercyclical fiscal policy rule
ς_1^A	0.150000	Parameter in country A's countercyclical fiscal policy rule
ς_2^B	0.150000	Parameter in country B's countercyclical fiscal policy rule
ς_2^A	0.150000	Parameter in country A's countercyclical fiscal policy rule
υ_0	-0.000010	Parameter in country B's export price equation
υ_1	0.500000	Parameter in country B's export price equation
ϕ^B	0.250000	Price mark-up in country B
ϕ^A	0.250000	Price mark-up in country A
θ^B	0.200000	Income tax rate in country B
θ^A	0.200000	Income tax rate in country A
ζ	0.500000	Parameter determining the degree of foreign influence over country B's monetary policy

Indicator Variables		
$z1^B$	–	Takes the value 1 when $\alpha_1^B < \alpha_{1L}^B$
$z1^A$	–	Takes the value 1 when $\alpha_1^A < \alpha_{1L}^A$
$z2^B$	–	Takes the value 1 when $\alpha_1^B > \alpha_{1U}^B$
$z2^A$	–	Takes the value 1 when $\alpha_1^A > \alpha_{1U}^A$
$z3^B$	–	Takes the value 1 when $\alpha_2^B < \alpha_{2L}^B$
$z3^A$	–	Takes the value 1 when $\alpha_2^A < \alpha_{2L}^A$
$z4^B$	–	Takes the value 1 when $\alpha_2^B > \alpha_{2U}^B$
$z4^A$	–	Takes the value 1 when $\alpha_2^A > \alpha_{2U}^A$
$z5^B$	–	Takes the value 1 when $r^B > 0$ to ensure the zero lower bound is respected in country B
$z5^A$	–	Takes the value 1 when $r^A > 0$ to ensure the zero lower bound is respected in country A

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$z6^B$	–	Takes the value 1 when $\pi^B_{ds-1} > \pi^{BU}_{ds}$ for use in country B's fiscal policy rule
$z6^A$	–	Takes the value 1 when $\pi^A_{ds-1} > \pi^{AU}_{ds}$ for use in country A's fiscal policy rule
$z7^B$	–	Takes the value 1 when $\pi^B_{ds-1} < \pi^{BL}_{ds}$ for use in country B's fiscal policy rule
$z7^A$	–	Takes the value 1 when $\pi^A_{ds-1} < \pi^{AL}_{ds}$ for use in country A's fiscal policy rule

Exogenous Variables		
au^B	7.000000	Gold held by country B's central bank
au^A	7.000000	Gold held by country A's central bank
B^A_{cbBs}	0.020000	Supply of country A bills to country B's central bank
dxr^B_e	0.000000	Expected currency B exchange rate change
dxr^A_e	0.000000	Expected currency A exchange rate change
g^B	16.000000	Real expenditure of country B's government†
g^A	16.000000	Real expenditure of country A's government†
N^B_{fe}	70.000000	Full employment level in country B
N^A_{fe}	70.000000	Full employment level in country A
p^A_g	1.000000	Price of gold in country A Dollars
pr^B	1.333000	Country B labour productivity
pr^A	1.333000	Country A labour productivity
r^B	0.020000	Interest rate on country B bills♣
r^A	0.020000	Interest rate on country A bills♣
xr^B_e	1.000959	Expected value of exchange rate converting currency B magnitudes to currency A
xr^A_e	0.999042	Expected value of exchange rate converting currency A magnitudes to currency B

Endogenous Variables – Starting Values		
α^B_1	0.900000	Marginal propensity to consume out of income in country B
α^A_1	0.900000	Marginal propensity to consume out of income in country A
α^B_2	0.150000	Marginal propensity to consume out of wealth in country B
α^A_2	0.150000	Marginal propensity to consume out of wealth in country A
B^B_{cbBd}	154.399000	Demand for country B bills arising from country B's central bank

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B^B_{cbBs}	154.399000	Supply of domestic bills to country B's central bank
B^A_{cbBd}	0.020257	Demand for country A bills arising from country B's central bank
B^A_{cbAd}	154.639700	Demand for country A bills arising from country A's central bank
B^A_{cbAs}	154.639700	Supply of domestic bills to country A's central bank
B^B_s	262.001900	Total supply of country B bills
B^B_{Bd}	80.708960	Demand for country B bills arising from country B households
B^B_{Bs}	80.708960	Supply of domestic bills to country B households
B^A_{Bd}	26.902990	Demand for country A bills arising from country B households
B^A_{Bs}	26.940300	Supply of country A bills to country B households
B^A_s	262.420700	Total supply of country A bills
B^B_{Ad}	26.940130	Demand for country B bills arising from country A households
B^B_{As}	26.902820	Supply of country B bills to country A households
B^A_{Ad}	80.820380	Demand for country A bills arising from country A households
B^A_{As}	80.820380	Supply of domestic bills to country A households
c^B	64.363110	Real consumption of country B households
c^A	64.363340	Real consumption of country A households
CA^B	0.000034	Current account balance of country B's economy
CA^A	-0.000034	Current account balance of country A's economy
C^B	403.728200	Nominal consumption of country B households
C^A	404.282800	Nominal consumption of country A households
ds^B	80.363110	Real domestic sales in country B
ds^A	80.363340	Real domestic sales in country A
DS^B	504.090900	Nominal domestic sales in country B
DS^A	504.783000	Nominal domestic sales in country A
F^B_{cb}	3.073291	Profits of country B's central bank
F^A_{cb}	3.077675	Profits of country A's central bank
G^B	100.362600	Nominal expenditure of country B's government
G^A	100.500100	Nominal expenditure of country A's government
H^B_d	161.417900	Country B households demand for high powered money
H^B_s	161.417900	Supply of high powered money to country B households
H^A_d	161.640800	Country A households demand for high powered money
H^A_s	161.640800	Supply of high powered money to country A households
im^B	9.841122	Country B real imports

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im^A	9.841028	Country A real imports
IM^B	61.728710	Country B nominal imports
IM^A	61.813950	Country A nominal imports
KA^B	-0.000034	Country B capital account balance including official settlement accounts
KA^A	0.000034	Country A capital account balance including official settlement accounts
KAX^B	-0.000034	Country B capital account balance excluding official settlement accounts
KAX^A	0.000034	Country A capital account balance excluding official settlement accounts
N^B	60.273770	Country B employment
N^A	60.274080	Country A employment
ω^{TB}	1.065303	Real wage target of country B workers
ω^{TA}	1.065312	Real wage target of country A workers
p_{ds}^B	6.272665	Country B domestic sales price
p_{ds}^A	6.281259	Country A domestic sales price
p_g^B	0.998615	Price of gold in units of currency B
π_{ds}^B	0.004698	Country B domestic price inflation
π_{ds}^A	0.004699	Country A domestic price inflation
π_s^B	0.004698	Country B sales price inflation
π_s^A	0.004699	Country A sales price inflation
p_m^B	6.272528	Price of country B imports
p_m^A	6.281249	Price of country A imports
p_s^B	6.272653	Country B sales price
p_s^A	6.281256	Country A sales price
p_x^B	6.272550	Price of country B exports
p_x^A	6.281227	Price of country A exports
p_y^B	6.272668	Country B GDP deflator
p_y^A	6.281257	Country A GDP deflator
$PSBR^B$	1.257699	Country B public sector borrowing requirement
$PSBR^A$	1.259989	Country A public sector borrowing requirement
s^B	90.204140	Real country B sales
s^A	90.204460	Real country A sales
S^B	565.819200	Nominal value of country B sales

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S^A	566.597300	Nominal value of country A sales
T^B	101.246500	Nominal value of country B tax receipts
T^A	101.385700	Nominal value of country A tax receipts
v^B	42.889240	Real wealth of country B households
v^A	42.889690	Real wealth of country A households
V^B	269.029900	Nominal wealth of country B households
V^A	269.401300	Nominal wealth of country A households
W^B	6.485851	Nominal wages in country B
W^A	6.494730	Nominal wages in country A
x^B	9.841028	Real country B exports
x^A	9.841122	Real country A exports
X^B	61.728340	Nominal country B exports
X^A	61.814320	Nominal country A exports
xr^B	1.001387	Exchange rate converting currency B magnitudes to currency A
xr^A	0.998615	Exchange rate converting currency A magnitudes to currency B
y^B	80.363020	Real country B output
y^A	80.363440	Real country A output
Y^B	504.090500	Nominal country B output
Y^A	504.783400	Nominal country A output
YD^B	404.986200	Nominal disposable income of country B households
YD^A	405.542800	Nominal disposable income of country A households
yd_{hs}^B	64.363120	Country B real Haig-Simons disposable income
yd_{hs}^A	64.363340	Country A real Haig-Simons disposable income
yd_{hse}^B	64.363120	Expected country B real Haig-Simons disposable income
yd_{hse}^A	64.363340	Expected country A real Haig-Simons disposable income

† These variables are endogenous in models IT, LF, CFPIT and CFPLF.

♣ These variables are endogenous in models CFPIT and CFPLF.

4 Eviews 6.0 Macros

All Eviews code used in the paper is available online at `www.greenwoodeconomics.com`. See the file `readme.txt` included in the zip archive with the programmes for further details.

4.1 Recreating the Main Results

To recreate the results in the paper using the original parameterisation and initial conditions run `sfc_rev2.prg`. This programme calls the following procedures:

- `define_objects.prg`

  This procedure creates all the objects that Eviews will be working with

- `initial.prg`

  This procedure sets the initial conditions and parameters for the model. You can edit these by updating this file. I recommend that you set your desired values in the Excel file `initial_values.xlsx` and then copy and paste into the Eviews prg

- `model_eqs.prg`

  This procedure introduces the equations into the model

- `closures.prg`

  This procedure defines the 6 closures of the model:

  BL - Baseline solution (no stabilisation policy)

  IT - Procyclical IT

  LF - Leader-follower

  FP - Countercyclical fiscal policy

  C1 - IT and fiscal policy (this is called CFPIT in the paper)

  C2 - LF and fiscal polict (CFPLF in the paper)

  Note that the use of shortened names is necessitated by Eviews' naming conventions for scenario aliases

- `redundant.prg`

  This procedure introduces the redundant equation into the model

- `expt1.prg`

  This procedure solves experiment 1 and plots the graphs

- `expt2.prg`

  This procedure solves experiment 2 and plots the graphs

- `expt3.prg`

  This procedure solves experiment 3 and plots the graphs

4.2 Recreating the Sensitivity Analysis

To reproduce the sensitivity analysis conducted in the paper run `sensitivity.prg`. This programme calls the following procedures listed above:

- `define_objects.prg`
- `initial.prg`
- `model_eqs.prg`
- `closures.prg`

You can choose which experiment to use for sensitivity analysis by changing the value of `!test_op` within `sensitivity.prg`. The programme will then call the appropriate procedures out of the following list that simply modify either `expt1.prg`, `expt2.prg` or `expt3.prg` to make them loop over candidate parameterisations:

- `senstest1_1.prg` / `senstest1_2.prg` / `senstest1_3.prg`

  These procedures conduct sensitivity analysis relating to the ς's

- `senstest2_1.prg` / `senstest2_2.prg` / `senstest2_3.prg`

  These procedures conduct sensitivity analysis relating to the μ_α's

- `senstest3_1.prg` / `senstest3_2.prg` / `senstest3_3.prg`

  These procedures conduct sensitivity analysis relating to the ζ's

- `senstest4_1.prg` / `senstest4_2.prg` / `senstest4_3.prg`

  These procedures conduct sensitivity analysis relating to the ϱ's

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