SHORT-RUN AND LONG-RUN EFFECTS OF EXTERNAL DISTURBANCES UNDER A FLOATING EXCHANGE RATE

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[Revised Version]

1. Introduction

This paper analyzes the short-run (or impact) and long-run (or steady state) effects of a number of external disturbances on output, employment and the price level under a freely floating exchange rate regime. The four disturbances are an increase in the relative price of an imported intermediate input, an increase in the world price of an imported consumption good, an increase in the world rate of interest and an increase in the volume of world trade.

The model differs from existing open economy macro-models in a number of ways. Both in the short run and in the long run the model respects the flow of funds and balance sheet identities or stock-flow constraints that characterize all properly specified sequential temporary (or momentary) general equilibrium[1], open economy models with money and other financial claims. The so called "monetary" approach to the balance of payments represents the simple end of the wide spectrum occupied by this class of models.[2] The determination of the level of real economic activity and of the current account balance is consistent with the absorption approach.[3] The role of import and export price elasticities in the determination of the trade balance is clearly brought out.[4] In spirit the model has a close affinity to the ideas developed by Turnovsky (1977).

The economy is "small," (i.e. a price taker) in the international financial market and in the markets for its imports, but can affect the world price for its exports.

The short-run behaviour of the economy is "Keynesian." The money wage and the price of domestic output are sticky. Domestic output is determined by effective demand. As time passes, both the money wage and the price of domestic output respond to excess demand pressures. The long-run, steady state properties of the model are those of a strictly classical growth model. The model is specified in such a way as to bring out very clearly the importance for the adjustment process of relative price changes. Both exogenous and endogenous changes in relative prices are considered. Changes in the terms of trade will affect the economy by altering real income and real wealth as well as via "substitution" effects.

In monetary models of the balance of payments, exchange rate changes affect private spending and portfolio allocation decisions via the wealth effects of the changes in the general price level that they bring about. Depreciation increases the domestic currency price of traded goods. This reduces the real value of the nominal stock of money balances (and of any other nominally denominated private assets). This inflationary effect of exchange rate depreciation is also present in our model. Exchange rate changes in addition affect the economy through a number of other channels. The private sector has net claims on (liabilities to) the rest of the world that are denominated in foreign currency. Depreciation will increase their domestic currency value; to the extent that, in the short run, the general price level does not increase in the same proportion as the price of foreign exchange, it will also increase their real value.

With the price of domestic output sticky in the short run, exchange rate changes will lead to changes in the relative prices of imports and exports, which will affect the domestic economy through substitution effects, real income effects and wealth effects.

The bulk of the paper is devoted to the analysis of the "Opec-type" disturbance--an increase in the price of the imported intermediate input. This disturbance is shown to impose real costs in the short run and in the long run.

Impact effects or short-run effects are changes in short-run endogenous variables for given values of the short-run exogenous but long-run endogenous (or predetermined) variables. In our model, short-run endogenous variables are the unemployment rate, the exchange rate, domestic output and imports. Predetermined variables include asset stocks (both real and financial), labour force size, state of technology, the money wage rate, the price of domestic output and expectations about the future.[5] Long-run or steady state effects refer to the comparison of balanced growth paths. Such long-run comparative statics will be pertinent only if the dynamic economic system under consideration is either stable or controllable.[6]

2. The Model

There are four commodities and four financial claims. Domestically produced output has domestic currency price p_1 . It can be used as a private consumption good, a public consumption good, and a capital good or it can be exported. An intermediate input into domestic production, with domestic currency price p_2 , is not produced domestically. We shall refer to it as "oil." p_3 is the domestic currency price of a second import, which is only used as a private consumption good. The money wage rate is w .

High-powered money, whose nominal quantity is denoted by H is only held domestically. All foreign exchange reserves are held by the monetary authority. R^* denotes the stock of foreign exchange in terms of foreign currency. Government bonds with fixed nominal market value are only held domestically. The nominal stock of these bonds is denoted B. This bond is a perfect substitute in private portfolios for an internationally traded bond whose market value is fixed in terms of foreign exchange, and for equity—claims on the earnings of domestic real reproducible capital. Equity is not traded. The value, in terms of foreign exchange, of private sector claims on the rest of the world is B^*. B^* can be positive, zero or negative.

Production, Employment and Oil Imports

The production function for domestic output has fixed proportions between oil and a composite bundle of labour and capital services, F. Let Y denote gross output, K the capital stock, N the level of employment of labour in natural units,[7] Π the level of labour augmentation[8] and M the volume of oil imports.

1) $$Y = \min \{\eta_1 F(K, \Pi N), \eta_2 M\} \qquad \eta_1, \eta_2 > 0$$

F is linear homogeneous in K and ΠN with

$F_1, F_2 > 0, F_{11}, F_{22} < 0, F_{12} > 0$.

Let L denote the size of the labour force. Define

$$y \equiv \frac{Y}{\Pi L}, \quad k \equiv \frac{K}{\Pi L}, \quad u \equiv \frac{L-N}{L}, \quad m \equiv \frac{M}{\Pi L}.$$

Through an appropriate choice of units we can now rewrite 1) as:

2) $$y = F(k, 1-u)$$

3) $$m = y$$

Value added is $p_1 y - p_2 m = (p_1 - p_2)y$. Our choice of units requires $p_1/p_2 > 1$ for value added to be positive.

This specification was also adopted by Findley and Rodriguez (1977). It maximizes the harmful consequences of an increase in the price of the imported intermediate input, as no substitution between oil on the one hand and labour-cum-capital on the other hand is permitted, in the short run or in the long run.

Output is demand determined. If firms act as price takers in the markets for their inputs and their output, they will hire labour up to the point where the value of the marginal product of labour equals the wage:

$$(1 - \frac{p_2}{p_1}) F_2(k, 1-u) = \frac{w}{p_1 \Pi}$$

The price level is sticky in the short run, however, and the effective demand for output may either exceed or fall short of the level of output at which, given w, p_1 and p_2 , the value of the marginal product equals the real wage. Firms produce the effective demand level of output even if they incur a short-run loss at the margin by meeting that demand , i.e. if $F_2 (1 - \frac{p_2}{p_1}) < \frac{w}{p_1 \Pi}$.[10] Let μ denote the ratio of the real wage to the value of the marginal product of labour.

4) $$\mu = \frac{w}{p_1 \Pi} [F_2(k, 1-u) (1 - \frac{p_2}{p_1})]^{-1}$$

When $\mu < 1$ firms would, at the existing input and output prices, like to hire more labour and produce more output, if only they could sell the additional output at the going market price. When firms are thus quantity-contrained in the market for their product they will reduce the rate of increase of the price of their product. Analogously, $\mu > 1$ will act as a signal for firms to raise the rate at which they increase the price of domestic output.

Prices and Wages

There are no non-traded produced goods. The "law of one price" prevails for all goods. The world prices in terms of foreign exchange of both imported goods, p_2^* and p_3^* are parametric from the point of view of the home country. Let e denote the spot price of foreign exchange.

5) $$p_2 = ep_2^*$$

6) $$p_3 = ep_3^*$$

The proportional rate of change of the money wage rate is given by an expectations-augmented Phillips curve:[11]

7) $$\hat{w} = \theta + \beta(u-\bar{u}) + x^P \qquad \beta > 0$$ [12]

$\bar{u}$ is the exogenously determined natural rate of unemployment or NAIRU [non-accelerating inflation rate of unemployment]. θ is the proportinal rate of growth of labour productivity. $\theta = \hat{\Pi} \geq 0$. x^p is the expected proportional rate of change of the general price level, p (the cost of living index). Two plausible expectations mechanisms are given in 8a) and 8b).

Perfect foresight (or rational expectations):

8a) $$x^p = \hat{p}$$

Adaptive expectations:

8b) $$\dot{x}^p = \alpha_1(\hat{p}-x^p) \qquad \alpha_1 \geq 0 .$$

$\alpha_1 = 0$ is the special case of static expectations. If this is to make any sense at all, the constant expected rate of inflation should equal the steady state rate of inflation. In what follows we shall mainly make use of the adaptive expectations hypothesis, although some of the consequences of assuming perfect foresight will also be considered.

The proportional rate of change of the price of domestic output is a weighted average of the proportional rates of change of unit labour cost and unit import costs, adjusted by our index of excess demand in the market for domestic output, μ .

9) $$\hat{p}_1 = \mu[\gamma(\hat{w}-\theta) + \gamma'\hat{p}_2] \qquad 0 < \gamma < 1 . \quad \gamma' = 1-\gamma$$

The correct weight, γ , would be $\frac{wN}{wN + p_2M}$ which will not be constant. Our fixed weight can be interpreted as a "normal," long-run weight.

The domestic cost of living index, p , which is the price index relevant to the labour supply decision and represents the correct deflator for nominal income and nominally denominated financial claims should be of the general form:

$$p = p(p_1, p_3) \qquad \frac{\partial p}{\partial p_i} > 0 \qquad i = 1, 3$$

$$jp = p(jp_1, jp_3) \qquad j > 0 .$$

For simplicity we shall adopt the convenient Cobb-Douglas specification[13]

10) $$p = p_1^{\Omega} p_3^{\Omega'} \qquad 0 < \Omega < 1 .^{14}$$
$$\Omega' = 1 - \Omega$$

The world rate of interest in terms of foreign currency, r^*, is exogenous. Perfect arbitrage equates the domestic interest rate, r, minus the forward discount on domestic currency, ε, to the world interest rate: $r^* = r - \varepsilon$. The excess demand for forward exchange is infinitely elastic where the forward discount on domestic currency equals the expected rate of depreciation, x^e.
Therefore:

11) $$r = r^* + x^e$$

Two alternative assumptions about exchange rate expectations, analogous to those made about the general price level in 8a) and 8b) are perfect foresight:

12a) $$x^e = \hat{e}$$

and adaptive expectations.

12b) $\dot{x}^e = \alpha_2(\hat{e}-x^e)$ $\alpha_2 \geq 0.$

We shall mainly consider 12b).

Equilibrium in Goods and Asset Markets

Let C^1 denote private domestic consumption demand for domestic output, I domestic investment demand, G government consumption demand [15] and Z export demand. $c^1 \equiv C^1/\Pi L$, $i \equiv I/\Pi L$, $g \equiv G/\Pi L$, $z \equiv Z/\Pi L$. Domestic output is determined by effective demand:

13) $$y = c^1 + i + g + z$$

Export demand depends on relative prices and on the volume of world trade, Y_f.

14) $$Z = Z\left(\frac{p_2^*}{p_1^*}, \frac{p_3^*}{p_1^*}, Y_f\right) \qquad Z_1 > 0 \; ; \; Z_2 \geq 0 \; ; \; Z_3 > 0 \; .$$

Logarithmically differentiating 14) we obtain:

$$\hat{Z} = \frac{Z_1 p_2/p_1}{Z} (\hat{p}_2-\hat{p}_1) + \frac{Z_2 p_3/p_1}{Z} (\hat{p}_3-\hat{p}_1) + \frac{Z_3 Y_f}{Z} \hat{Y}_f$$

In long run equilibrium relative prices will be constant. Imports, and therefore also exports will have to grow at the natural rate of growth $\hat{L} + \theta = n + \theta$.[16] The product of the rate of growth of world trade and the world trade elasticity of exports must therefore equal $n + \theta$ for balanced growth to be possible. With essential imported intermediate inputs, sustained economic growth requires steady growth of imports which has to be financed by a steady growth of exports. Autarchic growth is not possible. A low elasticity of world demand for a country's exports and/ or a low rate of growth of world trade will make it impossible to achieve sustained real income growth, because the imports required for a steady growth of output can only be obtained at the cost of deteriorating terms of trade. We can therefore view the rate of growth of world demand for a country's exports as a second "natural" rate of growth constraining the "warranted" growth rate of the economy. This problem will be ignored in what follows by respecifying 14) as

14') $$z = z\left(\frac{p_2}{p_1}, \frac{p_3}{p_1}, y_f\right) \qquad z_1 > 0 \; ; \; z_2 \geq 0 \; ; \; z_3 > 0$$

(where $y_f \equiv \frac{Yf}{\Pi L}$) and treating y_f as a parameter.

Consumption demand for domestic output depends on real disposable income, y_d, the relative price of the two consumption goods and real non-human wealth, a.

15) $$c^1 = c^1\left(y_d, \frac{p_3}{p_1}, a\right) \qquad 0 < c_1^1 < 1 \; ; \; c_2^1 \geq 0 \; ; \; c_3^1 > 0$$

The demand function for the imported consumption good is given by:

16) $$c^3 = c^3\left(y_d, \frac{p_3}{p_1}, a\right) \qquad 0 < c_1^3 < 1 \; ; \; c_2^3 \leq 0 \; ; \; c_3^3 > 0$$

Government spending is exogenous: $g = \bar{g}$.

Real disposable income is real value added plus net property income from abroad minus the real value of government spending on goods and services. Government bonds are not regarded as net worth by the private sector, because of the perceived future taxes "required" to service this debt. The entire government budget deficit is viewed as equivalent to current taxes, irrespective of the way in which it is actually financed.[17] Let T denote current taxes, assumed to be lump-sum.

$$y_d = y\left(\frac{p_1 - p_2}{p}\right) + \frac{rB}{\Pi L p} - \frac{r^* eB^*}{\Pi L p} - \frac{T}{\Pi L} - \left[\frac{p_1 g}{p} + \frac{rB}{\Pi L p} - \frac{T}{\Pi L}\right]$$

i.e.

17) $$y_d = (y-g)\frac{p_1}{p} - \frac{p_2}{p} y + \frac{r^* eB^*}{\Pi L p}$$ [18]

Real private non-human wealth is:

18) $$a = \frac{H + eB^*}{\Pi L p} + q\frac{p_1}{p} k$$

q is the ratio of the market value of claims on the existing stock of capital to the value of the capital stock at current reproduction costs. The market value of claims on the capital stock is the present discounted value of future profits. Assuming an infinite horizon, static expectations as regards the future opportunity cost of investment and perfect substitutability in private portfolios between bonds and equity, so that $r(t) - x^P(t)$ is the appropriate discount rate, we have:

19) $$q = \left[y\left(1 - \frac{p_2}{p_1}\right) - \frac{w}{p_1 \Pi} \right] [(r - x^P)k]^{-1}$$

Investment is an increasing function of "q" .

20) $i = i(q) \qquad i' > 0 \qquad i(1) = (n+\theta)k$

With equity and the two bonds perfect substitutes in private portfolios, portfolio balance is given by the equality of the demand for and supply of money balances. The fraction of wealth portfolio holders desire to hold in the form of real money balances, ℓ , is inversely related to the opportunity cost of holding money balances.

$$\ell = \ell(r) \qquad \ell' < 0 .$$

Portfolio balance is characterized by equation 21 .

21) $\ell(r)a = \frac{H}{\Pi L p}$

Asset Dynamics

Equations 22 , 23 and 24 describe the behaviour over time of the capital-labour ratio (in terms of efficiency units), the nominal stock of money balances and the stock of foreign exchange reserves.

22) $\dot{k} = i - (n+\theta)k$

23) $\frac{\dot{H}}{\Pi L p} = \frac{p_1}{p} g + \frac{rB}{\Pi L p} - \frac{T}{\Pi L} + \frac{e\dot{R}^*}{\Pi L p} - \frac{\dot{B}}{\Pi L p}$

24) $\frac{e\dot{R}^*}{\Pi L p} = \frac{p_1}{p} z - \frac{p_2}{p} y - \frac{p_3}{p} c^3 + \frac{r^* e B^*}{\Pi L p} - \frac{e\dot{B}^*}{\Pi L p}$

23) is the public sector financing requirement in an open economy. With a freely floating exchange rate, $\dot{R}^* \equiv 0$. Equation 24 then states that the current account surplus equals the rate of change of net private sector claims on the rest of the world [not counting capital gains or losses due to exchange rate changes]. In order to complete our description of the dynamic behaviour of the model we must specify the way in which the government chooses to finance its deficit. We shall assume that any public sector deficit or surplus is financed by increasing or reducing the money supply: $\dot{B} = B = 0$.

Short-run Equilibrium

Through judicious substitution we can summarize the state of the economy at any moment by the following three equations determining the short-run or momentary equilibrium values of e, u and μ.

$$25)\quad \ell(r^*+x^e)\left(H+eB^*\right)[\Pi L p_1^{\Omega}(ep_3^*)^{\Omega'}]^{-1} + \left(\frac{p_1}{ep_3^*}\right)^{\Omega'}\left[F(k,\ 1-u)\left(1-\frac{ep_2^*}{p_1}\right) - \frac{w}{p_1\Pi}(1-u)\right][r^* + x^e - x^p]^{-1}\Big) = H[\Pi L p_1^{\Omega}(ep_3^*)^{\Omega'}]^{-1}$$

$$26)\quad F(k,\ 1-u) = c^1\left(\left(\frac{p_1}{ep_3^*}\right)^{\Omega'}\left[F(k,\ 1-u)\left(1-\frac{ep_2^*}{p_1}\right) - g\right] + \frac{r^* e^{\Omega} B^*}{\Pi L p_1^{\Omega} p_3^{*\,\Omega'}},\ \frac{ep_3^*}{p_1},\right.$$

$$(H+eB^*)[\Pi L p_1^{\Omega}(ep_3^*)^{\Omega'}]^{-1} + \left(\frac{p_1}{ep_3^*}\right)^{\Omega'}\left[F(k,\ 1-u)\left(1-\frac{ep_2^*}{p_1}\right) - \frac{w}{p_1\Pi}(1-u)\right][r^*+x^e-x^p]^{-1}\Big)$$

$$+\,i\left(\left[F(k,\ 1-u)\left(1-\frac{ep_2^*}{p_1}\right) - \frac{w}{p_1\Pi}(1-u)\right]\left[(r^*+x^e-x^p)k\right]^{-1}\right) +$$

$$g + z\left(\frac{ep_2^*}{p_1},\ \frac{ep_3^*}{p_1},\ y_f\right)$$

27) $\mu = \frac{w}{p_1 \Pi} [F_2(k, 1-u)(1 - \frac{ep_2^*}{p_1})]^{-1}$

Equations 2 and 3 then determine y and m.

We shall not investigate the impact effects and long-run effects of a change in the price of an imported intermediate imput like the Opec oil price increase in 1974 by studying the effects of an increase in the foreign currency price of the intermediate input, p_2^*. For an increase in the world price of an imported intermediate input to have any real effects in the short run under a freely floating exchange rate, either that price change itself or any resulting change in the exchange rate must change "something real." Four possible channels can be distinguished. First, it can change relative prices when there are several imported goods not all of whose prices are increased in the same proportion. In our model this channel will be operative if p_2^* is raised, because we assume p_3^* to remain constant. The second channel is a change in the value of a country's net assets or liabilities denominated in foreign exchange caused by any change in the exchange rate that may result from a change in p_2^*. The third is the change in the general price level (or cost of living) caused by a change in the exchange rate or by the original change in the foreign currency price of the import. This will alter the real value of assets and liabilities denominated in domestic currency. The fourth channel is an effect of import price changes or exchange rate changes on expectations. This last channel is not considered in this paper.

Consider the special case of our model in which the only imported good is the imported intermediate good and there are no net foreign currency denominated claims on the rest of the world:

$$c^3 \equiv 0 \;,\; \Omega = 1 \;,\; \Omega' \equiv 0 \;,\; \frac{ep_3^*}{p_1} \text{ is not an argument in } c^1 \text{ and } z \text{ and } B^* = 0 \;.$$

In this model an increase in p_2^* will have no impact effect on any real variable. Equations 25 , 26 and 27 show that the exchange rate, e , will appreciate by the same proportion as the increase in p_2^* ; leaving both relative prices and the general price level unchanged. [The steady state will also be unaffected as a moment's reflection and/or inspection of the steady state equations 37 -45 below will make clear. Under a fixed exchange rate this economy would be able to inflate itself out of any unfavourable effect of the oil price increase.

Changes in p_2^* will not be "neutral" in our model because of the presence of a second imported commodity and of foreign currency denominated net assets or liabilities. Nevertheless we opt for modelling the oil price increase as an "indexed" increase in the world price of the imported intermediate input. The world price p_2^* is set at a certain target level relative to the price of the imports of the oil exporting countries (the home country's exports): $\frac{ep_2^*}{p_1} = \phi$. If either the exchange rate or the price of domestic output in terms of domestic currency change, the world price of oil is adjusted so as to maintain the value of ϕ . We believe this to be a fairly realistic description of the policy pursued by Opec after the initial massive increase in the price of oil.

Thus an increase in the price of oil will, even if there were no other imported commodity, constitute a change in a relative price [in that case ϕ would constitute "the" terms of trade].[15] We choose to include a second imported commodity in our model to capture more effectively the effect of exchange rate changes on the cost of living, even when the price of domestic output is sticky.

We shall substitute $\phi = \frac{ep_2^*}{p_1}$ into equations 25 , 26 and 27 and derive the short run comparative static effects of changes in ϕ , r^*, y_f and p_3^* . We shall wish to evaluate these short-run multipliers at a position of long-run equilibrium, which we shall now characterize.

The Equations of Motion and the Long-run Equilibrium

A long-run equilibrium is a balanced growth path on which all real stocks and flows grow at the same (natural) rate, relative prices are constant and expectations are realized. To economize on notation we define $h \equiv \frac{H}{\Pi L p}$; $b^* \equiv \frac{eB^*}{\Pi L p}$; $\tau \equiv \frac{T}{\Pi L}$; $v \equiv \frac{w}{p_1 \Pi}$ and $\psi \equiv \frac{ep_3^*}{p_1}$.

Noting that for a given value of ϕ we have $\hat{p}_2 = \hat{p}_1$, and that p_3^* is assumed constant, we can completely describe the behaviour of the model over time (given a set of initial conditions) by the following nine equations.

$$28)\quad \ell(r^*+x^e)\left(h+b^*+\psi^{-\Omega'}[F(k,\ 1-u)(1-\phi)-v(1-u)][r^*+x^e-x^p]^{-1}\right) = h$$

$$29)\quad F(k,\ 1-u) = c^1\left(\psi^{-\Omega'}[F(k,\ 1-u)(1-\phi)-g] + r^*b^*,\psi,\right.$$

$$\left. h+b^*+\psi^{-\Omega'}[F(k,\ 1-u)(1-\phi)-v(1-u)][r^*+x^e-x^p]^{-1}\right)$$

$$+\ i\left([F(k,\ 1-u)(1-\phi)-v(1-u)][(r^*+x^e-x^p)k]^{-1}\right) + g + z(\phi,\psi,y_f)$$

30) $\mu = v[F_2(k,\ 1-u)(1-\phi)]^{-1}$

31) $\dot{h} = g\psi^{-\Omega'} - \tau - \left(\theta + n + \frac{\Omega\mu\gamma}{1-\mu\gamma'}[\beta(u-\bar{u})+x^P] + \Omega'\hat{e}\right) h$

32) $\dot{b}^* = z(\phi,\ \psi,\ y_f)\psi^{-\Omega'} - F(k,1-u)\phi\psi^{-\Omega'} - \psi^{\Omega} c^3\left(\psi^{-\Omega'}[F(k,1-u)(1-\phi)-g]+r^*b^*,\right.$

$\left. h+b^*+\psi^{-\Omega'}[F(k,1-u)(1-\phi)-v(1-u)][r^*+x^e-x^P]^{-1}\right)$

$+ r^*b^* - \left(\theta + n + \frac{\Omega\mu\gamma}{1-\mu\gamma'}(\beta(u-\bar{u})+x^P) - \Omega\hat{e}\right) b^*$

33) $\dot{k} = i\left([F(k,1-u)(i-\phi)-v(1-u)][(r^*+x^e-x^P)k]^{-1}\right) - (\theta+n)\ k$

34) $\dot{v} = \frac{(1-\mu)}{1-\mu\gamma'}\left(\beta(u-\bar{u}) + x^P\right) v$

35) $\dot{\psi} = \left(\hat{e} - \frac{\mu\gamma}{1-\mu\gamma'}(\beta(u-\bar{u})+x^P)\right) \psi$

36a) $x^P = \frac{\Omega\mu\gamma}{1-\mu\gamma'}\left(\beta(u-\bar{u})+x^P\right) + \Omega'\hat{e}$

or

36b) $\dot{x}^P = \alpha_1\left(\frac{\Omega\mu\gamma}{1-\mu\gamma'}(\beta(u-\bar{u})+x^P) + \Omega'\hat{e} - x^P\right)$

12a) $x^e = \hat{e}$

or

12b) $\dot{x}^e = \alpha_2(\hat{e}-x^e)$

31) states that the rate of change of real money balances per unit of efficiency labour, $\dot{h}$, is equal to the government budget deficit per unit of efficiency labour minus the change in money balances required to offset the effect of technical change (θh), population growth (nh) and inflation $(\hat{p}h)$. Equation 32 states that the rate of change of real net claims on the rest of the world per unit of efficiency labour, $\dot{b}^*$, equals the current account surplus per unit of efficiency labour minus $(\theta + n + \hat{p} - \hat{e})b^*$.

The steady state or long run equilibrium conditions are obtained by setting $\dot{h} = \dot{b}^* = \dot{k} = \dot{v} = \dot{\psi} = 0$ and either assuming perfect foresight (36a and 12a) or setting $\dot{x}^e = \dot{x}^p = 0$. This yields

37) $x^e = \hat{e} = x^p = \hat{p} = \hat{p}_1 = \hat{p}_2 = \hat{p}_3 = \hat{w} - \theta.$

38) $u = \bar{u}$

39) $\mu = 1$

40) $v = F_2(1-\phi)$

41) $r^* = F_1(1-\phi)$

42) $g\psi^{-\Omega'} - \tau = (\theta + n + \hat{e})\ h$

43) $z\psi^{-\Omega'} - F\phi\,\psi^{-\Omega'} - c^3\psi^{\Omega} + [r^* - (\theta + n)]\ b^* = 0$

44) $\ell(h+b^{*}+\psi-{}^{\Omega}k) = h$

45) $F = c^{1} + (\theta + n)\, k + g + z$

Equations 38 - 41 determine the steady state values of u, μ, k and v, the variables that are of greatest interest. With equations 42 - 45 they in addition determine the steady-state values of h, b, ψ and $\hat{e}$. The importance of the financial asset stocks and the exchange rate lies mainly in their role in the short-run adjustment processes in the economy. Comparative statics across steady states will be postponed until section 4. In section 3 we shall use the steady state conditions 37 - 45 together with equations 25 - 27 to evaluate the impact effects of changes in the external parameters.

3. Impact Effects of Changes in ϕ, r^{*}, y_f and p_3^{*}

In this section we concentrate on the adaptive expectations case. Equations 25 and 26 with $\frac{ep_2^{*}}{p_1} = \phi$ yield the impact effects of changes in ϕ, r^{*}, y_f and p_3^{*} on e and u. Equation 27 can then be used to derive the effect on μ. Π, L, p_1, w, H, B^{*}, k, x^e and x^p are predetermined. The matrix equation 46 represents these impact effects evaluated at the (initial) long-run equilibrium.

46) $$\begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} de \\ du \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & 0 & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \end{bmatrix} \begin{bmatrix} d\phi \\ dr^* \\ dy_f \\ dp_3^* \end{bmatrix}$$

47a) $$a_{11} = (1-\ell)\frac{H\Omega'}{\Pi Lpe} - \frac{\ell k\Omega'\psi^{-\Omega'}}{e} + \frac{\ell B^*\Omega}{\Pi Lp}$$

47b) $$a_{21} = c_1^1\left(\frac{\Omega' y_d\psi^{-\Omega'}}{e} - \frac{\Omega r^* B^*}{\Pi Lp}\right) - \left(c_2^1+z_2\right)\frac{\psi}{e} + c_3^1\left[\Omega'\left(\frac{k\psi^{-\Omega'}}{e} + \frac{H}{\Pi Lpe}\right) - \frac{\Omega B^*}{\Pi Lp}\right]$$

47c) $$a_{22} = -F_2(1-c_1^1\psi^{-\Omega'}(1-\phi))$$

47d) $$b_{11} = \ell\psi^{-\Omega'}\frac{F}{r^*} > 0$$

47e) $$b_{21} = z_1 - F\left(\left(c_1^1 + \frac{c_3^1}{r^*}\right)\psi^{-\Omega'} + \frac{i'}{r^* k}\right)$$

47f) $$b_{12} = -a\ell' + \ell\psi^{-\Omega'}\frac{k}{r^*} > 0$$

47g) $$b_{22} = c_1^1\frac{eB^*}{\Pi Lp} - c_3^1\psi^{-\Omega'}\frac{k}{r^*} - \frac{i'}{r^*}$$

47h) $$b_{23} = z_3 > 0$$

47i) $$b_{14} = -\left[\frac{(1-\ell)H\Omega'}{\Pi Lpp_3^*} - \frac{\ell k\Omega'\psi^{-\Omega'}}{p_3^*} - \frac{\ell eB^*\Omega'}{\Pi Lpp_3^*}\right]$$

$$47j) \quad b_{24} = -c_1^1\left(\frac{\Omega' y_d \psi^{-\Omega'}}{p_3^*} + \Omega' \frac{r^* B^*}{\Pi\ Lp} \frac{e}{p_3^*}\right) + (c_2^1 + z_2)\frac{\psi}{p_3^*} - c_3^1\left[\Omega'\left(\frac{k\psi^{-\Omega'}}{p_3^*} + \frac{H}{\Pi Lpp_3^*}\right) + \frac{\Omega' B^*}{\Pi Lp}\frac{e}{p_3^*}\right]$$

a_{11} will be positive if a depreciation of the exchange rate creates an excess demand for money balances. With p_1 and p_3^* given, an increase in e increases the cost of living, p, thus reducing the real supply of money balances. The increase in the general price level will affect all three items in private sector portfolios. The real stock of money balances is reduced. The real value of claims on the domestic stock of real reproducible capital is reduced because these are claims on profits derived from the production of domestic output, whose relative price declines. In addition, the depreciation and the increase in p cause the real value of net foreign assets to increase. The domestic currency value of these assets increases in proportion with the depreciation of the exchange rate but the general price level increases less than in proportion, because imports constitute only part of the domestic consumption bundle ($0<\Omega<1$) and the price of domestic output is sticky in the short run. We shall assume that after allowing for these wealth effects on the demand for money, the supply of money is reduced by more than the demand: $a_{11} > 0$. a_{21} will be positive if depreciation of the exchange rate causes excess supply in the market for domestic output. Given p_3^* and p_1, an increase in e will make domestic output cheaper relative to imported final goods. This will stimulate domestic and foreign demand for domestic output via what may be loosely referred to as the "substitution effect": $(c_2^1+z_2)\frac{\psi}{e}$. [By assumption, the other relative price, ϕ, is kept constant when e changes, through appropriate offsetting variations in p_2^*]. The increase in e also reduces real income by lowering the purchasing power of domestic value added in terms of the country's bundle of consumption goods. If B^* is positive, the real value of net property income from abroad will increase. If it is negative, real income will be correspondingly lower. A higher value of e reduces the real value of the stock of money and of claims on the domestic capital stock. The real value of B^* will increase; the effect on net worth depends on whether the country is a net borrower or lender. We shall make the "monetarist" assumption that adverse real income and wealth effects on effective demand for domestic output outweigh the stimulating substitution effects and the potentially positive income and wealth effects due to the presence in domestic portfolios of assets denominated in foreign currency: $a_{21} > 0$. $a_{22} < 0$ because an increase in output increases domestic demand for domestic consumption goods by less than the increase in output. $b_{11} > 0$ because an increase in ϕ reduces the value added corresponding to any level of gross output. This reduces real wealth and the demand for real money balances. An increase in ϕ stimulates export demand, but reduces consumption and investment demand for domestic output by reducing real income and the value of claims on the stock of capital. These adverse relative price or terms of trade effects on real income and wealth are important. Relatively little attention has been given to it in formal conventional macroeconomic analysis. Most monetary models of the balance of payments have adopted a one-commodity specification. Those that differentiate between different kinds of commodities [e.g. between traded and non-traded goods] tend to ignore the problem.[21] We assume that the terms of trade effect on real income and wealth dominates: $b_{21} < 0$. An increase in the rate of interest will create an excess supply of money balances, both by increasing the opportunity cost of holding money balances and by reducing wealth: $b_{12} > 0$. Unless net claims on the rest of the world are vast, an increase in r^* will, by reducing consumption demand and investment demand, create an excess supply of domestic output: $b_{22} < 0$. An increase in world trade stimulates the demand for domestic output: $b_{23} > 0$. If $B^* = 0$, a given proportional increase in p_3^* has the same effect on portfolio balance and the excess demand for domestic output as an equal proportional depreciation of the exchange rate: when $B^* = 0$, $b_{14} = -a_{11} \frac{e}{p_3^*}$ and $b_{24} = -a_{21} \frac{e}{p_3^*}$. If B^* is not equal to zero an increase in p_3^* , by raising the general price level while leaving the domestic currency value of B^* unchanged, will reduce the real value of B^* . The wealth effect of an increase in p_3^* via $\frac{eB^*}{p}$ is therefore in the opposite direction from that of an increase in e . We assume $b_{14} < 0$ and and $b_{24} < 0$..

The impact effects are:

48a) $$\frac{\partial e}{\partial \phi} = \frac{b_{11}}{a_{11}} > 0$$

48b) $$\frac{\partial u}{\partial \phi} = \frac{a_{11}b_{21} - a_{21}b_{11}}{a_{11}a_{22}} > 0$$

48c) $$\frac{\partial e}{\partial r^*} = \frac{b_{12}}{a_{11}} > 0$$

48d) $$\frac{\partial u}{\partial r^*} = \frac{a_{11}b_{22} - a_{21}b_{12}}{a_{11}a_{22}} > 0$$

48e) $$\frac{\partial e}{\partial y_f} = 0$$

48f) $$\frac{\partial u}{\partial y_f} = \frac{b_{23}}{b_{22}} < 0$$

48g) $$\frac{\partial e}{\partial p_3^*} \cdot \frac{p_3^*}{e} = -1 \quad \text{if} \quad B^* = 0 \; , \quad \frac{\partial e}{\partial p_3^*} = \frac{b_{14}}{a_{11}} < 0 \quad \text{if} \quad B^* \neq 0$$

48h) $$\frac{\partial u}{\partial p_3^*} = 0 \quad \text{if} \quad B^* = 0 \; , \quad \frac{\partial u}{\partial p_3^*} = \frac{a_{11}b_{24}-a_{21}b_{14}}{a_{11}a_{22}} \quad \text{if} \quad B^* \neq 0$$

An increase in ϕ reduces the real value added corresponding to any level of gross domestic output. This reduces the demand for real money balances. Given the fixed nominal stock of money balances, the incipient excess supply of money is eliminated by a depreciation of the exchange rate. We assumed before that the contractionary effect on effective demand of an increase in ϕ via adverse terms of trade effects on consumption and investment demand is likely to outweigh the expansionary effect via an increase in export demand. The depreciation of the exchange rate will, given our assumptions, reinforce this contractionary effect; the substitution effect towards exports and domestically produced consumption goods is weaker than the adverse terms of trade effects. It is instructive to note how in our model the unambiguously contractionary effect of a depreciation of the exchange rate characteristic of the one-commodity monetary models (which rely exclusively on the real balance effect) is qualified by reintroducing the relative price changes that are characteristic of the elasticities approach. Still, given our assumptions there is little doubt that unemployment will increase. The real product wage:

$\frac{w}{p_1}$ is given in the short run, but the worker's real wage in terms of purchasing power over consumption goods will be reduced by the depreciation of the exchange rate and the resulting increase in the price of the imported consumer goods. The change in ϕ per se, as it is the relative price of an intermediate imput, will not have any short-run effect on the real wage. With k constant in the short run, gross domestic output $F(k, 1-u)$ will decline as u increases. Value added $(1-\phi)F$ will be reduced a fortiori. The purchasing power of this value added over consumable commodities $F(1-\phi)(p_1/ep^*_{3-})^{\Omega'}$ declines even more. The current account of the balance of payments will in all likelihood <u>improve</u> as a result of the increase in ϕ. The volume of intermediate imports (which given our choice of units is the same as the volume of gross domestic output) declines. The depreciation of the exchange rate causes a decline in the volume of final imports. This decline in the volume of final imports does not only reflect the substitution effect of a higher relative price but also the adverse real income and wealth effects a change in the terms of trade. The volume of exports will increase. If the Marshall-Lerner condition, which ignores the income and wealth effects of a change in the terms of trade, is satisfied, then the total impact on the trade balance, which includes these effects, will certainly be an improvement. The reasons for the deterioration in the current account positions of many oil importing countries after the Opec oil price increase are four. First, there could be a J-curve effect reflecting low short-run price elasticities of import and export demand. Second, almost no country had a cleanly floating exchange rate. Many intervened to bolster the values of their currencies. Third, many countries took expansionary fiscal and monetary measures to counter the adverse effect on unemployment of the oil price increase. An increase in g can easily be seen to reduce unemployment without affecting the exchange rate.[22] A deterioration of the trade balance is certain. From 27) it can be seen that, by reducing u, and increase in g will raise μ. As the fall in u will also raise the rate of wage inflation, the rate of price inflation will be boosted on two accounts. In this paper our analysis is predicated on a "passive" government response: g and the way in which the government finances its deficit are given. Fourth, y_f is some weighted average of the import demands of oil exporting countries and of other oil importing countries. If the size and composition of the increase in import demand by the oil-rich part of the world is different from the size and composition of the reduction in import demand by the other oil-importing countries, y_f will be a function of ϕ. It has been argued that because of structural bounds on the oil-rich nations' capacity to increase imports, y_f may be negatively related to ϕ, at any rate in the short run.

We can now go quickly through the other impact effects. An increase in the world rate of interest will, with adaptive expectations, raise the nominal and real domestic rate of interest. This reduces the demand for real money balances. To equate the demand for money with the fixed nominal supply, the exchange rate depreciates, raising the cost of living. The increase in the interest rate reduces consumption demand and investment demand for domestic output. The unemployment rate increases.

This is an appropriate point to remind ourselves that the impact effects, but not the steady state effects, of external and internal disturbances depend crucially on the specification of the expectations mechanism. Take e.g. the extreme case of rational expectations, which in our deterministic model is equivalent to perfect foresight. Given our assumptions about the shape of the excess demand schedule for forward exchange we have $x^e = \hat{e} = \varepsilon$. The only impact effect of an increase in r^* will now be an equal change in the opposite direction of $\hat{e}$. If the world rate of interest increases, the proportional rate of depreciation (appreciation) of domestic currency decreases (increases), neutralizing any other short-run effects on output, employment or the level of the exchange rate. The dynamic equations (especially 31), 32) and 35)) show that as time passes, the lower rate of depreciation (higher rate of appreciation) of the domestic currency will affect ψ and the real value of the stocks of money and bonds. Thus the absence of a real impact effect can be reconciled with a steady state effect that has an increase in r^* result in capital shallowing (see below).

An increase in the volume of world trade reduces unemployment by increasing export demand but does not affect the excess demand for real money balances and thus leaves the exchange rate unchanged.

Given ϕ , an increase in p_3^* when $B^* = 0$ will cause an equi-proportional appreciation of the exchange rate, leaving the domestic currency price of imported consumption goods unchanged. No other real or nominal variables are affected. When $B^* \neq 0$ the effect of an increase in p_3^* is ambiguous.[23]

Finally, from $\mu = \frac{w}{p_1 \Pi} [F_2(k, 1-u)(1-\phi)]^{-1}$ it is readily seen that

$$\frac{\partial \mu}{\partial r^*} < 0 \; ; \; \frac{\partial \mu}{\partial p_3^*} = 0 \;\text{ if }\; B^* = 0, \text{ ambiguous otherwise}; \; \frac{\partial \mu}{\partial y_f} > 0 \; ; \; \frac{\partial \mu}{\partial \phi} \gtrless 0 \; .$$

An increase in ϕ increases unemployment. This increases the marginal product of labour. The increase in ϕ by itself, however, reduces the marginal value product of labour. The net effect is ambiguous.

4. Long-run Effects of Changes in ϕ, r^*, y_f and p_3^*

Equation 37 states that in steady state equilibrium all expectations are realized, relative prices remain constant and the real wage grows at the rate of Harrod-neutral technical change. Equation 38 states that the steady state rate of unemployment is the natural rate. It should be noted that in an open economy like the one described here, the short-run or momentary Phillips curve does not become vertical when there is perfect foresight. Equation 7, with perfect foresight is

$$7') \qquad \hat{w} = \theta + \beta(u-\bar{u}) + \hat{p} \qquad 24$$

This can be rewritten as:

$$49) \quad \hat{w} = \theta + \frac{(1-\mu\gamma')\beta}{1-\mu\gamma'-\Omega\mu\gamma}(u-\bar{u}) + \frac{\Omega'(1-\mu\gamma')}{1-\mu\gamma'-\Omega\mu\gamma}\hat{e}$$

With different prices or price indices influencing employer and worker behaviour the realization of expectations is no longer a sufficient condition for the non-existence of a short-run Phillips trade-off. Under both fixed and flexible exchange rates rational expectations permit an unemployment rate systematically below or above the natural rate, because the rate of change of the price of domestic output can be systematically different from the rate of change of the price of imported commodities. For $u < \bar{u}$ this would lead to an increase in the relative price of domestic output which would lead to a deteriorating trade balance. The effects on private wealth of a growing current account deficit would make such a situation unsustainable in the long run. Under a fixed exchange rate regime reserve losses may put a stop to it earlier. Nevertheless, the ability of the economy to depart from the natural rate of unemployment, even with rational expectations, in models in which the price of domestic output is not rigidly linked in the short run to the price of imported commodities, is important from the point of view of policy formulation.

Equation 39 tells us that the percentage mark-up on normal unit variable cost is constant in the steady state. From 41) we see that the mark-up is such that the marginal product of capital (in terms of value added) equals the world rate of interest.[25] Equation 40 states that the marginal product of labour, in terms of value added, equals the real product wage. Thus in the steady state the competitive equilibrium conditions are all satisfied: utility and profit maximizing programmes based on price taking behaviour are consistent.

From 41) it is clear that an increase in ϕ requires a lower steady state k. With unemployment constrained to be at the natural rate an increase in ϕ lowers the marginal product of capital (in terms of value added). A lower capital-labour ratio is required to bring the domestic rate of profit back to the world level. Thus:

50a) $$k = k(\phi) \quad \text{and}$$

50b) $$\frac{dk}{d\phi} = \frac{F_1}{F_{11}(1-\phi)} < 0$$

With labour and capital services complements in the production of value added ($F_{21} = F_{12} > 0$) and increase in ϕ will lower the employer's real product wage v. It will do this both directly, by reducing the value added marginal product of labour corresponding to any gross marginal product of labour and indirectly by lowering the capital labour ratio.

51) $$\frac{dv}{d\phi} = F_{21}(1-\phi)\frac{dk}{d\phi} - F_2 = \frac{F_{21}F_1}{F_{11}} - F_2 < 0$$

Value added in terms of domestic output $(1-\phi)F(k, 1-\bar{u})$ will therefore be reduced unambiguously by an increase in ϕ. The effect of an indexed oil price increase on value added in terms of purchasing power over consumption goods $\psi^{-\Omega'}F(k, 1-\bar{u})(1-\phi)$ cannot be determined unambiguously until we know what happens to ψ. Conceivably imported consumer goods could become so much cheaper relative to domestic output that it offsets the negative effects on value added in terms of domestic output of a higher ϕ and a lower k.

An increase in r^* will raise the steady state marginal product of capital. With $u = \bar{u}$ this requires capital shallowing and a reduction in value added. From equation 41 one can also see that to maintain the steady state level of per capita output after an increase in ϕ one would have to lower the rate of return on investment abroad and reduce the cost of borrowing from abroad. A tax on interest and profit income from abroad and a subsidy on borrowing from abroad will generate a higher steady-state capital labour ratio,[26] at the expense of course of a costly--in terms of consumption foregone--transition to the new steady state.[27]

An increase in y_f will have no impact on the steady-state capital labour ratio (nor on steady-state u and μ). An increase in p_3^* will have no steady state effects on any of the eight steady state variables (u, μ, k, v, h, b, ψ and $\hat{e}$) determined by equations 38) - 45). This is natural, as with ϕ fixed, an increase in p_3^* only constitutes a relative price change in the short run because the price of domestic output is sticky. In the long run when p_1 becomes flexible (and B^* is endogenous) an increase in a money price like p_3^* will have no real effects. If p_2^* rather than ϕ were exogenous, a change in p_3^* (or in p_2^*) would constitute a relative price change in the long run as well as in the short run.

Consider the remaining steady state equations: 42) - 45). 42) indicates that in long-run equilibrium the proportional rate of depreciation (appreciation) of the exchange rate is equal to the excess (shortfall) of the proportional rate of growth of domestic credit

$$\frac{\dot{H}}{H} = (g\psi^{-\Omega'} - \tau)/h$$

over (from) the natural rate of growth of the economy, $\theta + n$, which equals the steady state rate of growth of demand for real money balances.

From equation 43 it can be seen that the current account need not be balanced in steady state equilibrium. Real net claims on the rest of the world per unit of efficiency labour, b^*, are constant. From equation 43 and equation 24 with $\dot{R}^* = 0$, we conclude that in the steady state, $\dot{B}^* = \theta + n$, [unless $B^* = 0$]. With all money prices and the exchange rate growing at the same rate, the real value of a given number of foreign currency denominated bonds remains constant.

To satisfy portfolio demand for bonds when there is labour force growth and technical change, the number of foreign currency denominated bonds owned (if $B^* > 0$) or owed (if $B^* < 0$) must grow at the natural rate. In the first case there will be a steady state current account surplus, in the second case a deficit.

Consider the special case in which there is no domestic credit creation. The government always balances its budget. The growing demand for real money balances can now only be satisfied by a steady proportional fall in the price level, i.e. by a steady appreciation of the exchange rate: $-\hat{e} = \theta + n$

While the a priori restrictions we have imposed do not suffice to unambiguously determine the signs of the steady state effects of h, b^* and ψ, a consistent combination would be: $\frac{\partial h}{\partial \phi} < 0$, $\frac{\partial b^*}{\partial \phi} < 0$ and $\frac{\partial \psi}{\partial b} > 0$. The increase in ϕ reduces steady state k and thereby the demand for real money balances.(44). With the interest rate fixed a reduction in h will eliminate the excess supply of money. A moderate reduction in b and increase in ψ can be offset by a more sizeable reduction in h. The lower financial wealth and the higher ψ will also be consistent with domestic output market equilibrium (45) because they will help bring down the effective demand for domestic output to the lower level of production.

If we abstract from changes in real asset stocks, the higher values of ϕ and ψ will tend to create a current account surplus (43) if the Marshall-Lerner conditions are satisfied. Lower values of h, b^* and k will reduce the demand for imported consumer goods. Assuming b^* to be positive, interest income from the rest of the world will be reduced. The effect of a lower k on the demand for imported intermediate inputs goes the other way and increase the steady state current account surplus.

5. Conclusion

The impact and steady state effects of a number of foreign disturbances have been analyzed in a fairly general but still analytically tractable model. The conclusions as regards the effects of an indexed increase in the price of an essential imported intermediate input under a freely floating exchange rate are fairly gloomy. In the short run unemployment will increase, the exchange rate will depreciate and output, real income and real wages will decline. In the long-run the economy is placed on a permanently lower balanced growth path (although the natural rate of growth itself is not affected).

In the short run unemployment can be reduced by traditional Keynesian fiscal and monetary demand management techniques, but only at the expense of a higher rate of inflation. In the long run, the original steady state can only be reached again by a "traverse" involving a higher rate of investment and lower consumption levels.

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FOOTNOTES

[1]"Equilibrium" should be interpreted sufficiently broadly so as to include effective demand or supply constrained unemployment or unfilled vacancy temporary equilibria.

[2]A useful survey of the monetary approach to the balance of payments is Frenkel and Johnson (1976). A classical reference is Johnson (1958). See also Hahn (1977), Johnson (1977a) and (1977b) and International Monetary Fund (1977).

[3]A clear statement of the absorption approach together with an attempt to integrate it with the elasticities approach is Tsiang (1961).

[4]See e.g. Haberler (1949).

[5]In a rational expectations or perfect foresight model expectations about the future will be short-run endogenous rather than predetermined variables.

[6]Controllability, perhaps more appropriately referred to as dynamic controllability is an important property of dynamic systems and is probably more relevant as a characterization of the options actually open to the policy authority than stability. A dynamic system is controllable if through the choice of an appropriate trajectory for its controls, the policy authority can transfer any initial state to any target state in specified finite time [see, e.g. Aoki (1976)]. As controllability is a rather weak requirement which is likely to be satisfied by most economic systems, I shall have no qualms about doing the long-run comparative statics. Note that controllability implies stabilizability.

[7]The flows of capital services and labour services are proportional to the stock of capital and the size of the labour force, respectively. The constants of proportionality are set equal to unity.

[8]Technical change is disembodied and labour augmenting.

[9]A more desirable specification would be to combine ex-ante substitutability with ex-post fixed coefficients. We chose the ex-ante and ex-post fixed coefficients technology for its much greater simplicity.

[10]The smaller of the notional and the effective supplies of labour is assumed to be not less than the amount of labour required to produce the effective demand level of output.

[11]For any variable, say, X we define $\dot{X} \equiv \frac{d}{dt} X$ and $\hat{X} \equiv \dot{X}/X$.

[12]β could be a strictly convex function, with $\beta' < 0$, $\beta'' > 0$ and $\beta(0) = 0$.

[13]We could generalize this by replacing μ by $\lambda(\mu)$ with the properties: $\lambda' > 0$; $\lambda(1) = 1$.

[14]We are fully aware that this is not the ideal price index in view of our specification of the consumption functions below. To derive the correct price index for a sequential decision-making process when there are real and financial assets is beyond the scope of this paper. Our specification seems unlikely to lead to seriously misleading conclusions. See Samuelson and Swamy (1974).

[15]Ω could be identified with the share of consumption of domestic output in total consumption. These weights will change when relative prices change. Our assumption of a constant Ω rules out "perverse" cases such as an increase in p_1 causing such a decline in the share of home goods consumption that the current-weighted price index actually declines.

[16]Note that the government only purchases domestic output.

[17]$\hat{L} = n \gtrless 0$.

[18]These issues are discussed in detail in Buiter (1977).

[19]We assume g to be sufficiently small, so that $y_d > 0$.

[20]Without either a second imported commodity or non-zero domestic holdings of assets denominated in foreign currency, the short-run equilibrium is <u>overdetermined</u> if the terms of trade are exogenously set at ϕ . As the exchange rate now enters the model only through $\phi = \frac{ep_2^*}{p_1}$, exchange rate changes will not affect private sector behaviour in any way. With p_1 given in the short run, p_2^* is varied when e changes in such a way as to keep ϕ constant, which precludes effects of changes in e on the cost of living. Only under perfect foresight will the model again become consistent, with $\hat{e} = \varepsilon$ (the forward premium on foreign exchange) becoming a short-run endogenous variable.

[21] While there is nothing intrinsic in the monetary approach to the balance of payments that limits it to one-commodity models, most authors claiming to follow that approach have worked with such simple examples. Models involving traded and non-traded goods have been developed in some detail (e.g. Dornbusch (1973)). Furthermore, our model does not have the feature that the exchange rate is determined in "the market for money" [a rather bizarre market!]. Such extreme dichotomization of a general equilibrium model is only possible in rather simplistic approaches. This model has the exchange rate and the level of real economic activity jointly determined by the portfolio balance condition and the output market equilibrium condition.

[22] $\frac{\partial e}{\partial g} = 0 \; ; \; \frac{\partial u}{\partial g} = \frac{1}{a_{22}} < 0 \; .$

[23]

$$\frac{\partial u}{\partial p_3^*} = \frac{B^*}{p_3^* \Pi L p} \left[-c_3^1 \frac{H\,\Omega'}{\Pi L p} + \ell(c_2^1 + z_2)\psi + c_1^1 \Omega' [\ell r^* k \psi^{-\Omega} - \ell y_d \psi^{-\Omega} - (1-\ell)\frac{Hr^*}{\Pi L p}] \right]$$

[24] $\hat{p} = \Omega \hat{p}_1 + \Omega' \hat{p}_3$. With p_3^* given, $\hat{p}_3 = \hat{e}$. $\hat{p}_1 = \mu(\gamma(\hat{w} - \theta) + \gamma' \hat{p}_2)$.

With ϕ given, $\hat{p}_1 = \hat{p}_2$, i.e. $\hat{p}_1 = \frac{\mu\gamma}{1-\mu\gamma'}(\hat{w} - \theta)$ and

$$\hat{p} = \frac{\Omega\mu\gamma}{1-\mu\gamma'}(\hat{w} - \theta) + \Omega' \hat{e}$$

[25] This equation is derived using the linear homogeneity of the production function and Euler's Theorem.

[26] John Black saved me from error at this juncture.

[27] If r^* is below $\theta + n$, the natural rate of growth, the steady state is inefficient and it is in the policy-maker's interest to lower steady-state k . We assume $r^* \geq \theta + n$.

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