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THE COLLAPSE OF THE FIXED EXCHANGE RATE REGIME WITH STICKY WAGES AND IMPERFECT SUBSTITUTABILITY BETWEEN DOMESTIC AND FOREIGN BONDS*

by

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ABSTRACT

The paper extends the recent literature on balance-of-payments crises by allowing real effects to be connected with them. The collapse of the fixed exchange rate regime and the dynamics associated with this regime shift are studied. In addition, the effects of a fiscal expansion under the fixed exchange rate regime are studied, taking into account the fact that the viability of the regime is policy dependent.

1. INTRODUCTION

A fixed exchange rate regime is sustainable only if domestic economic policy is consistent with it. Permanently more expansive monetary policy than elsewhere in the world results in a balance-of-payments crisis and the collapse of the fixed exchange rate regime.

Since the study of Krugman (1979), a growing literature has emerged concerning balance of payments crises and the collapse of the fixed exchange rate system (see e.g. Flood and Garber (1984), Connolly and Taylor (1984), and Obstfeld (1984, 1986 a,b), Grilli (1986) and Buiter (1986)). Common to this literature is the fact that links between real economic developments and balance-of-payments crises are not the focus of interest. This results from the assumption of perfectly flexible wages and prices and uncovered interest parity.

In this paper we study balance-of-payments crises in a framework in which both fiscal and monetary policy measures have real effects. We assume that in the goods market domestic and foreign goods and in the asset market domestic and foreign bonds are not perfect substitutes for each other. We further assume that agents operating in the financial markets (including the foreign exchange market) are rational and that adjustments in these markets are instantaneous. In the goods market, however, adjustment is assumed to be slow due to inertia in the labor market. In accordance with the practice adopted in the literature mentioned above we also assume that, once the foreign reserves have hit some critical lower bound, the central bank will with certainty withdraw from the foreign exchange market i.e. there is a regime shift from the fixed exchange rate to the floating rate regime.[1]

The paper is arranged as follows. In section (2) the model and alternative wage formation schemes are presented. In section (3) the dynamics of the model is studied with unchanged fiscal and monetary policy rules. In section (4) the effects of the anticipated and unanticipated policy changes are studied.

2. THE MODEL

2.1 The Goods and financial markets

Consider a small open economy which specializes in producing a single good but which consumes two goods: home and imported goods. The home good and the imported good are imperfect substitutes for each other. The economy is small in the sense that it faces a given foreign interest rate and given prices of imports. There are two tradeable assets, domestic and foreign bonds, which are imperfect substitutes for each other. There are two moneys, domestic and foreign money, which are nontradeable. The target of monetary policy is to peg the domestic interest rate. This implies a perfectly elastic supply of money. Now the model may be written as:

$$y(t) = \alpha_0[s(t) - p(t)] - \alpha_1[r(t) - \dot{p}(t)] + g(t) \tag{1}$$

$$p(t) = \theta\, w(t) + (1-\theta)s(t) \tag{2}$$

[1]In practice, there are at least two kinds of uncertaintities faced by investors. First there is no fixed critical lower bound to the foreign reserves. It would be more realistic to assume that the critical level of reserves is distributed according to some probability distribution. Secondly, investors cannot be certain about the reactions of the monetary or fiscal authority the moment the reserves hit the critical lower bound. The consistency of the fixed exchange rate target can be attained through a change in monetary or fiscal policy. The effects of this latter kind of uncertainty on the behavior of investors is studied in a paper by Willman (1986).

$$g(t) = \gamma_0 - \gamma_1 p(t) \tag{3}$$

$$B(t) = \beta_0 + \beta_1[s(t) - p(t)] - \beta_2 y(t) \tag{4}$$

$$F(t) = \phi[r^*(t) + \dot{s}(t) - r(t)] \tag{5}$$

$$\dot{R}(t) = B(t) - \dot{F}(t) \tag{6}$$

All parameters in equations (1)-(5) are positive. In addition, the size of the parameter θ is restricted to the interval $[0,1]$. Variables y,s,p and w are the logarithms of the domestic output, the exchange rate, the domestic price level and the wage rate, respectively. As the price of imports in foreign currency is assumed to equal one, s also represents the log of the domestic currency price of imports. The variable g is the index of fiscal policy, which includes both net transfers and government expenditure. The variables r and r* are nominal domestic and foreign interest rates, respectively. In our analysis they are assumed to stay constant. B represents net exports, F net foreign assets held by domestic residents and R the stock of foreign reserves. B, F and R are expressed in terms of foreign currency. A dot over a variable indicates the time derivative.

Equation (1) is a conventional textbook IS curve. Equation (2) is a markup pricing assumption: domestic goods prices are a weighted average of wages and the prices of imported inputs to production measured in domestic currency units. Note that the relative price of imported final goods and imported inputs is assumed constant and for convenience it is set to equal one. Equation (3) is based on the idea that some items in the government budget are constant in real terms and some items are constant in nominal terms e.g. interest payments on the public debt. A rise in the price level decreases the real value of the public debt and hence interest payments in real terms. As other items in the government budget are constant in real terms, a rise in the price level implies a tightening in fiscal policy. Equation (4) states that net exports depend positively on the relative price of the imported and home goods and negatively on domestic activity. Equation

(5) is the portfolio-balance equation for the net demand for foreign assets with constant absolute risk aversion (see e.g. Dornbusch (1983)). Identity (6) defines the change in foreign reserves as the difference between net exports and the net private capital outflow. Interest income in the current account is neglected, because its inclusion would complicate the analysis without any essential effects on the results.

To facilitate the analysis in the sections below we substitute equations (1)-(3) into (4) and obtain

$$B(t) = b_0 + b_1[s(t) - w(t)] + b_2\, s(t) + \theta b_3\, [\dot{s}(t) - \dot{w}(t)] - b_3\, \dot{s}(t) \qquad (7)$$

where $b_0 = \beta_0 + \alpha_1\beta_2 r - \beta_2\gamma_0$; $b_1 = \theta(\beta_1 - \alpha_0\beta_2 - \beta_2\gamma_1)$

$b_2 = \beta_2\gamma_1$; $b_3 = \alpha_1\beta_2$

The signs of the parameters b_0 and b_1 are ambiguous whereas the signs of the parameters b_2 and b_3 are unambiguously positive. In our analysis we assume that the parameter b_1 is positive. If in equation (3) the parameter γ_1 were zero, this assumption would equal the conventional Marshall-Lerner condition. Otherwise it is a somewhat stronger assumption than the Marshall-Lerner condition.

2.2 Wage formation

In this paper we study the collapse of the fixed exchange rate regime under three alternative assumptions on wage formation. The first is the assumption of a fixed nominal wage rate. In the other two formulas the nominal wage rate is rigid in the short run but flexible in the long run. However, while the second formula is Keynesian in the sense that it is backward looking, the third formula is forward looking.

We work with the following backward looking wage formation scheme

$$w(t) = \mu \int_{-\infty}^{t} e^{\mu(\tau-t)} p(\tau) d(\tau) \qquad ; \mu > 0 \tag{8}$$

which after differentiating with respect to time can be written in a more conventional form

$$\dot{w}(t) = \mu \left[p(t) - w(t) \right] \tag{9}$$

Equation (9) can be interpreted to imply that employees have a fixed real wage target, which in expression (8) is assumed to equal unity, but because of inertia in the labor market or lags in indexation of wages to price movements the nominal wage rate cannot instantaneously adjust to changes in the price level (see e.g. Sachs (1980)). However, in the long run equilibrium w(t) = p(t).

Our forward looking wage formation scheme is the overlapping contract model by Calvo (1983). The special feature in this model is that the contract length is not fixed but varies among contracts. We write

$$w(t) = \mu \int_{t}^{\infty} e^{\mu(t-\tau)} p(\tau) d(\tau) \qquad ; \mu > 0 \tag{10}$$

In equation (10) w(t) represents the contract wage rate of new and renewed contracts at the time t. If wage contracts are made, as we assume, between employers and individual employees, then w(t) in (10) represents the marginal labor cost of production and hence is the relevant wage concept in our price equation (2).

Like equation (8), equation (10) also implies that in the long run equilibrium w(t) = p(t). Due to the forward looking nature of equation (10) there is, however, an important difference between equations (8) and (10). In equation (10), if a new policy affecting the future values of p(t) is announced at any time t, then w(t) is free to take any value i.e. it can jump. In equation (8) or equally in (9) w(t) is a predetermined variable. However, as long as the policy announced also remains unchanged in equation (10) w(t) is continuous. This implies that equation (10) has finite right hand time derivatives at all points i.e. also at points where announcements of new policy changes are made. Differentiating (10) with respect to time we obtain

$$\dot{w}(t) = \mu[w(t) - p(t)] \tag{11}$$

We can see that the dependence of a change in the wage rate on the present wage rate in the forward looking equation (10) is the reverse of what it is in the backward looking equation (8).

After substituting equation (2) into (9) and (11) we obtain

$$\dot{w}(t) = m[s(t) - w(t)] \tag{12a}$$

$$\dot{w}(t) = m[w(t) - s(t)] \tag{12b}$$

where $m = \mu(1-\theta)$. Equation (12a) corresponds to equation (9) and equation (12b) corresponds to equation (11).

3. THE DYNAMICS OF THE MODEL

In this section our analysis proceeds in three stages. We first study the dynamics of wages and foreign reserves under a fixed exchange rate regime, secondly wages and exchange rate determination under a floating exchange rate regime, and thirdly the collapse of the fixed exchange rate regime and the dynamics of the model associated with the regime shift.

3.1 The dynamics of wages and foreign reserves in the fixed exchange rate regime

In the case of a fixed nominal wage rate we denote $w(t) = \bar{w}$, where $\bar{w}$ is constant. In the case of sticky backward looking wages the level of the wage rate depends on the whole history of s(t). If the fixed exchange rate regime $s(t) = \bar{s}$ covers the whole past history of s(t), as we assume, then from equations (8) and (2) also $w(t) = \bar{s}$. However, this is not so in the case of sticky forward looking wages. In the fixed exchange rate regime equation (12b) implies

$$w(t) = (w_0 - \bar{s})e^{mt} + \bar{s} \tag{13}$$

where w_0 is the log of the wage rate at t=0. We can see from equation (10) that $w_0 > \bar{s}$ if it is known that the exchange rate will depreciate in the future.

Let us denote by s' and s* the levels of the fixed exchange rates which in the case of the fixed nominal wage rate and in our two cases of the flexible wage rate, respectively, would produce B(t) = 0. Equation (7) implies $s' = (b_1\bar{w} - b_0)/(b_1 + b_2)$ and $s^* = - b_0/b_2$. In the fixed exchange rate regime the trade balance equation (7) can now be written in the form

$$B(t) = (b_1 + b_2)(\bar{s} - s') \tag{14a}$$

$$B(t) = b_2(\bar{s} - s^*) \tag{14b}$$

$$B(t) = b_2(\bar{s} - s^*) - (b_1 + b_3m\theta)(w_0 - \bar{s})e^{mt} \tag{14c}$$

Equation (14a) defines the trade balance in the case of the fixed nominal wage rate, equation (14b) in the case of sticky backward looking wages and equation (14c) in the case of sticky forward looking wages. If $s' > \bar{s}$ in equation (14a) and $s^* > \bar{s}$ in equation (14b) then there is a deficit in the trade balance. If in equation (14c) both s* and w_0 are greater than $\bar{s}$, then the trade balance is unambiguously in deficit. However, as we shall see later in section 3.3.3, w_0 is dependent on $\bar{s}$ and s* and for $w_0 > \bar{s}$ it is necessary that $s^* > \bar{s}$.

Under the fixed exchange rate regime, equation (6) reduces to

$$\dot{R}(t) = B(t) \tag{15}$$

After inserting (14a), (14b) and (14c), in turn, into (15) and solving we obtain

$$R(t) = R_0 + (b_1 + b_2)(\bar{s} - s')t \tag{16a}$$

$$R(t) = R_0 + b_2(\bar{s} - s^*)t \tag{16b}$$

$$R(t) = R_0 + b_2(\bar{s} - s^*)t + c(w_0 - \bar{s})(1 - e^{mt}) \tag{16c}$$

where $c = b_1/m + b_3\theta > 0$, and R_0 is the stock of foreign reserves at time t=0. In equations (16a) and (16b) the reserves diminish linearly whereas in (16c) the reserves diminish exponentially.

3.2 Wage and exchange rate dynamics in the flexible exchange rate regime

When the exchange rate is floating, the change in the foreign reserves is zero and hence equation (6) reduces to

$$B(t) = \dot{F}(t) \tag{17}$$

Differentiating equation (5) with respect to time and inserting it and equation (7) into (17), we obtain

$$\phi\ddot{s}(t) + (1-\theta)b_3\dot{s}(t) - (b_1 + b_2)s(t) = -\theta b_3\dot{w}(t) - b_1w(t) + b_0 \tag{18}$$

Together with alternative wage assumptions, equation (18) defines the dynamics of the model in the flexible exchange rate regime.

<u>The case of the fixed nominal wage rate</u>: In this case the system (18) collapses into

$$\phi\ddot{s}(t) + (1-\theta)b_3\dot{s}(t) - (b_1 + b_2)s(t) = - b_1\bar{w} + b_0 \tag{19}$$

If we denote by λ_1 and λ_2 the characteristic roots of the equation corresponding to the homogeneous part of the second order differential equation (19), we see that $\lambda_1\lambda_2 = -(b_1 + b_2)/\phi < 0$ and $\lambda_1 + \lambda_2 = -(1-\theta)b_3/\phi < 0$. Hence the model has the saddle-point property: there is one stable root (λ_1) and one unstable stable root (λ_2). The particular or steady state solution of equation (19) is $s' = (b_1\bar{w} - b_0)/(b_1 + b_2)$, which in section 3.1 was assumed to be greater than $\bar{s}$.

In the exchange rate literature with perfect foresight it has become standard to assume that the solution for the flexible exchange rate depends only on the market fundamentals. This implies that the arbitrary constant multiplying the time exponential in positive root is set equal to zero. The solution of (19) can be written in the form

$$s(t) = A_1e^{\lambda_1 t} + s' \tag{20}$$

where A_1 is an arbitrary constant. As λ_1 is negative the exchange rate converges in the long run towards the long run equilibrium level s'.

<u>The case of sticky backward looking wages</u>: In this case the pair of equations (18) and (12a) determines the exchange and wage dynamics. Utilizing trial solutions of the form $s(t) = Ae^{\lambda t}$ and $w(t) = De^{\lambda t}$, the homogeneous part of this two equation differential equation system can be transformed into

$$\begin{bmatrix} \phi\lambda^2 + b_3(1-\theta)\lambda - (b_1 + b_2) & b_3\theta\lambda_1 + b_1 \\ - m & \lambda + m \end{bmatrix} \begin{bmatrix} A \\ D \end{bmatrix} = 0 \tag{21}$$

The characteristic equation of (21) is

$$\phi\lambda^3 + [b_3(1-\theta) + m\phi]\lambda^2 - (b_1 + b_2 - mb_3)\lambda - mb_2 = 0 \tag{22}$$

In equation (22) the coefficients multiplying λ^3 and λ^2 are positive. Depending on the size of m the coefficient $(b_1 + b_2 - mb_3)$ can be negative or positive. The term mb_2 is positive. As shown in the appendix, this information implies that equation (22) has one positive (λ_3) and two negative roots (λ_1 and λ_2). As the particular solution of (18) and (12a), we obtain $s^* = w^* = - b_0/b_2$, which on the basis of equation (14) is greater than $\bar{s}$. Equation (21) also combines the arbitrary constants A and D so that $D = mA/(m+\lambda)$. By setting the arbitrary constant multiplying the time exponential in positive root to equal zero, the saddle-point solution of equations (18) and (12a) can now be written in the form

$$s(t) = A_1e^{\lambda_1 t} + A_2e^{\lambda_2 t} + s^* \tag{23}$$

$$w(t) = [m/(m+\lambda_1)]A_1e^{\lambda_1 t} + [m/(m+\lambda_2)]A_2e^{\lambda_2 t} + s^* \tag{24}$$

We see that both s(t) and w(t) converges towards s* when $t\to\infty$.

<u>The case of sticky forward looking wages</u>: Equation (18), together with equation (12b), defines the dynamics of the system. Following the method used in the backward looking case the homogeneous part of this system of two differential equations can be presented in the form corresponding to equation (21). The only difference compared to equation (21) is that the signs preceding the parameter m change. This implies that in the present case the charasticistic equation is of the form

$$\phi\lambda^3 + [b_3(1-\theta) - m\phi]\lambda^2 - (b_1 + b_2 + mb_3)\lambda + mb_2 = 0 \tag{25}$$

We can see that the coefficients ϕ, $(b_1 + b_2 + mb_3)$ and mb_2 are unambiguously positive. Only the sign of the coefficient multiplying λ^2 is ambiguous. This information implies that equation (25) has one negative root (λ_1) and two roots with positive real parts (see appendix). The particular solution is the same as in the backward looking case i.e. $s^* = w^* = - b_0/b_2$. The saddle-point solution of equations (18) and (12b) is now

$$s(t) = A_1 e^{\lambda_1 t} + s^* \tag{26}$$

$$w(t) = [m/(m-\lambda_1)]A_1 e^{\lambda_1 t} + s^* \tag{27}$$

Equations (26) and (27) also imply that in the long run equilibrium $s(t) = w(t) = s^*$.

3.3 The collapse of the fixed exchange rate regime and the dynamics of the model

In section 3.1 we assumed that as a result of trade balance deficit there was a continuous decumulation of the reserves in the fixed exchange rate regime. In the introduction we also assumed that once the foreign reserves have been depleted to some critical lower bound there is a permanent shift from the fixed exchange rate regime to a floating exchange rate regime.[2] For convenience we assume that the critical level of the foreign reserves is zero and known by everybody.

An essential requirement for connecting the fixed exchange rate regime to the post collapse rate regime is that the exchange rate cannot jump discretely when the regime shift occurs. This is the continuity

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[2]One can argue that a central bank facing a perfect world capital market can always create foreign exchange reserves by borrowing. However, as Obstfeld (1986a) has shown, the government sector faces an intertemporal budget constraint analogous to that of the private sector, if the government (like individuals) is prohibited from incurring new debt to meet the interest payments due on its previous borrowing. In our case this would imply that, when the foreign reserves turn negative, the government should raise taxes to service the external debt it incurs. If this is not done the central bank is no longer able to peg the exchange rate.

condition, which the perfect foresight solution of our model must satisfy in order to be unique (see Calvo, 1977). Following Flood and Garber (1984), it is easy to give to this condition an economic interpretation. If we denote the collapse time by T, s(T) cannot be smaller than $\bar{s}$. If $s(T) < \bar{s}$ the domestic currency would appreciaty discretely at T. In this case it would be profitable for agents to sell foreign assets at the moment before the collapse. However, this would increse the foreign reserves and the fixed exchange rate would survive. The exchange rate cannot be greater than $\bar{s}$ either. An upward jump would provide those speculators who attack foreign reserves at T with profits which would accrue at an infinite rate. This gives speculators an incentive to attack prior to T. This, however, is in contradiction with the assumption that the collapse occurs at T. We can conclude that $s(T) = \bar{s}$.

We know on the basis of equation (16a), (16b) and (16c) that the stock of foreign reserves at T preceeding the speculative attack is

$$R(T) = R_0 + (b_1 + b_2)(\bar{s} - s')T \tag{28a}$$

$$R(T) = R_0 + b_2(\bar{s} - s^*)T \tag{28b}$$

$$R(T) = R_0 + b_2(\bar{s} - s^*)T + c(w_0 - \bar{s})(1 - e^{mT}) \tag{28c}$$

We also know that at time T, when the exchange rate regime shift occurs, there is a jump in the rate of depreciation from zero to $\dot{s}(T)$. If $\dot{s}(T) > 0$, this jump causes a portfolio shift from domestic assets to foreign assets. On the basis of equation (5) the size of this shift is

$$\Delta F(T) = \phi\dot{s}(T) \tag{29}$$

It is this portfolio shift which depletes the foreign reserves to zero, and hence $\Delta F(T)$ must be equal to R(T) as determined by equations (16a), (16b) or (16c).

Equations (20), (24) and (26) define the rate of depreciation in the cases of fixed nominal wages, sticky backward looking wages and sticky forward looking wages, respectively. We next study the timing of the collapse of the fixed exchange rate and the dynamics of the model in each of these three cases.

3.3.1 The case of the fixed nominal wage rate

Using $s(T) = \bar{s}$ as the initial condition, equation (20) can be written in the form

$$s(t) = (\bar{s} - s')e^{\lambda_1(t-T)} + s' \qquad ; t > T \tag{30}$$

Differentiating (30) with respect to time at t=T we obtain

$$\dot{s}(T) = \lambda_1(\bar{s} - s') > 0 \tag{31}$$

After substituting (31) into (29) and utilizing the condition $\Delta F(T) = R(T)$ the collapse time can be solved i.e.

$$T = [R_0/(s' - \bar{s}) + \phi\lambda_1]/(b_1 + b_2) \tag{32}$$

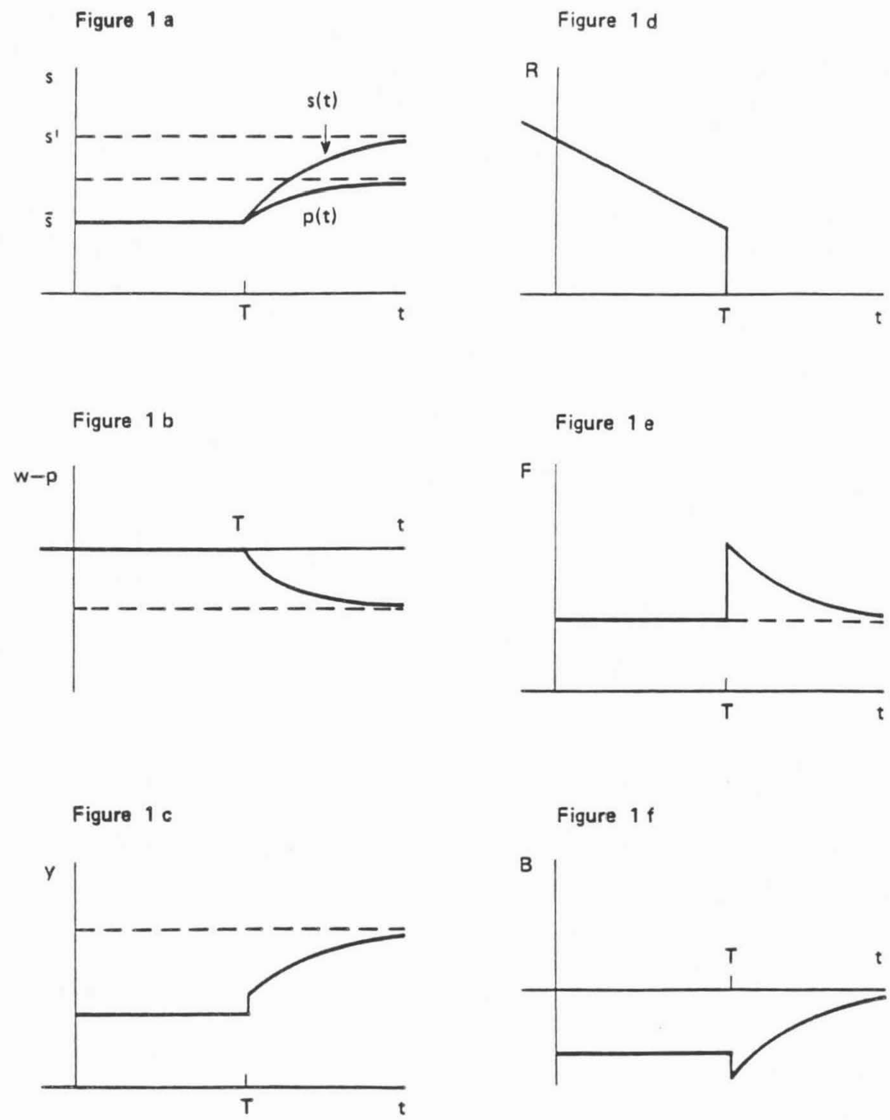
After stating λ_1 and s' in terms of the stuctural parameters of the model, equation (32) can be written

$$T = - R_0/(b_0 + b_2\bar{s}) - (b_3 + \sqrt{b_3^2 + 4\phi_1 b_1})/2(b_1 + b_2) \tag{33}$$

It is easy the see that the smaller is b_0 and the greater are b_3 and ϕ the sooner the collapse of the fixed exchange rate regime occurs. However, the signs of the partial derivatives $\partial T/b_1$ and $\partial T/\partial b_2$ are not unambiguous.

The dynamics of the model in the fixed exchange rate regime and in the post-collapse floating rate regime is shown in figure 1. At time T the exchange rate starts depreciating and the domestic price level rising

Figure 1. THE COLLAPSE OF THE FIXED EXCHANGE RATE REGIME WITH A FIXED NOMINAL WAGE RATE



towards their long-run equilibrium levels (figure 1a). However, because of the fixed nominal wage rate the equilibrium price level is below the equilibrium exchange rate s'. The time path of the real wage rate, which is the mirror image of that of the domestic price level, is shown in figure 1b.

Until T the domestic production is constant but at time T there is a discrete upward jump in production (figure 1c). This is due to the jump in the real interest rate caused by the jump in the depreciation rate of the exchange rate. As a result of the relative price movements, domestic production continues to increase towards the new higher level. Figures 1d and 1e show how the foreign reserves at time T are depleted discretely to zero and the net purchase of foreign assets increases by the same amount. The stock of foreign reserves remains at zero from time T onwards while the stock of foreign assets reconverges to its pre-collapse level when the depreciation rate slows down to zero.

As is shown in figure 1f, the trade balance deficit widens discretely at the moment of the speculative attack. This results from the jump in domestic production at time T. Thereafter the trade balance deficit diminishes towards zero as the exchange rate depreciates towards its long-run equilibrium level.

3.3.2 The case of sticky backward looking wages

At the moment the exchange rate regime shift occurs there are now two predetermined variables i.e. the exchange rate and the wage rate. Using $s(T) = w(T) = \bar{s}$ as initial conditions, equations (23) and (24) can be written

$$s(t) = [-\lambda_2(m + \lambda_1)/m(\lambda_1 - \lambda_2)](\bar{s} - s^*)\, e^{\lambda_1(t-T)} +$$

$$[\lambda_1(m + \lambda_2)/m(\lambda_1 - \lambda_2)](\bar{s} - s^*)e^{\lambda_2(t-T)} + s^* \quad ; \; t > T \qquad (34)$$

$$w(t) = [-\lambda_2/(\lambda_1 - \lambda_2)](\bar{s} - s^*)e^{\lambda_1(t-T)} +$$

$$[\lambda_1/(\lambda_1 - \lambda_2)](\bar{s} - s^*)e^{\lambda_2(t-T)} + s^* \qquad ; t \geqslant T \qquad (35)$$

Differentiating equation (34) with respect to time at point t=T, we obtain

$$\dot{s}(T) = (\lambda_1\lambda_2/m)(s^* - \bar{s}) \qquad (36)$$

As $\dot{s}(T)$ in (36) is positive there is a speculative attack on the currency which instantaneously depletes the foreign reserves at t=T. Equations (28a), (29), (36) and the condition $R(T) = \Delta F(T)$ imply now that

$$T = R_0/b_2(s^* - \bar{s}) - \phi\lambda_1\lambda_2/mb_2 \qquad (37)$$

In equation (37) we know that λ_1 and λ_2 are negative, but we do not know exactly how they are related to the structural parameters of the basic model. We know, however, that they are independent of the parameter b_0, which contains the monetary policy and fiscal policy shift parameters r and γ_0, respectively. Since $s^* = -b_0/b_2$ it can be easily seen that $\partial T/\partial b_0 > 0$ i.e. the more expansive monetary and fiscal policy is the earlier the exchange rate regime shift occurs.

Subtracting (34) from (35) we obtain

$$w(t) - s(t) = \lambda_1\lambda_2(\bar{s} - s^*)[e^{\lambda_1(t-T)} - e^{\lambda_2(t-T)}]/m(\lambda_1 - \lambda_2)$$

$$; t \geqslant T \qquad (38)$$

It is easy to see that at time T equation (38) equals zero and with t > T it is negative but converges to zero when $t \to \infty$. Together with equation (2) this implies that when the exchange rate regime shift occurs the domestic price level adjusts more slowly than the exchange rate to their new long run equilibrium level s* (see figure 2a). Hence the relative price of domestic goods in terms of importables decreases temporarily. The same is true for the real wage rate (see figure 2b).

Since there is no permanent change in relative prices, the long-run equilibrium is attained completely through fiscal contraction (see figure 2c). As in the case of the fixed nominal rate, domestic production increases at the beginning of the floating exchange rate regime (see figure 2d). These positive effects on domestic production are transmitted through the real interest rate and the relative price channels. However, in the longer run these effects die out and as a result of the fiscal contraction domestic production converges to a level which is lower than the level of production under the fixed exchange rate regime.

In the fixed exchange rate regime the time paths of the foreign reserves and the trade balance are similar to those presented in figures 1d and f. The variables F(t) and B(t) also behave as shown in the figures at time T in the long run. However, in the medium term there may be some differences between adjustment paths in these two cases.

3.3.3 The case of sticky forward looking wages

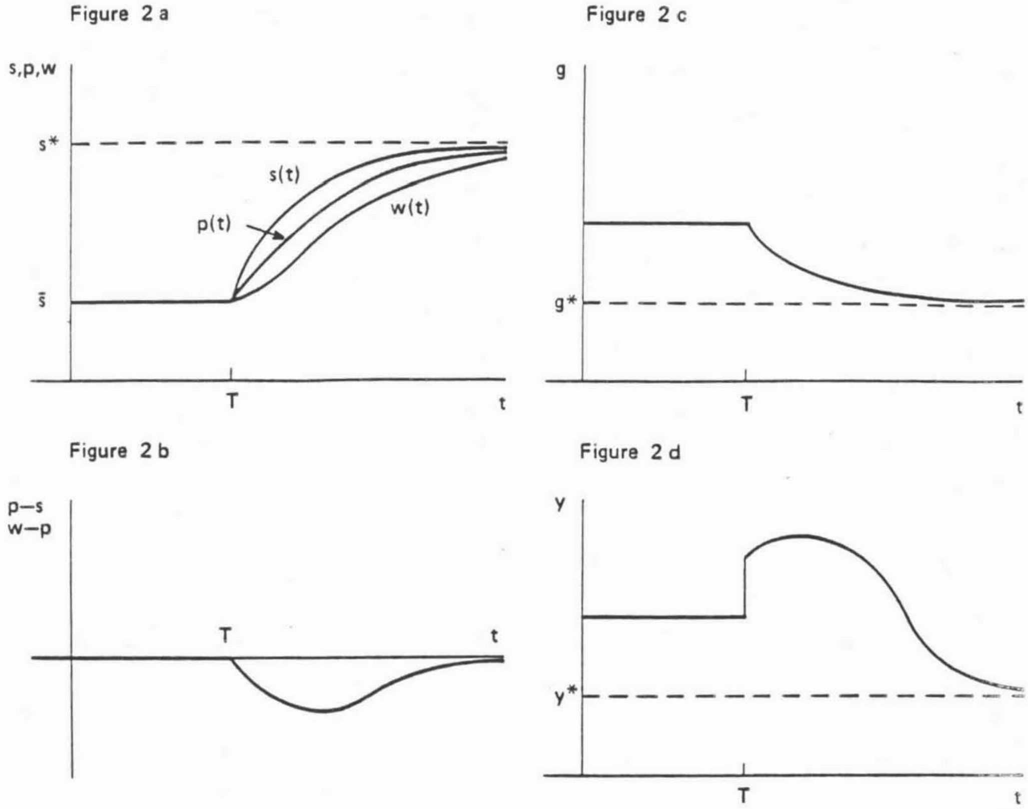
With $s(t) = \bar{s}$ as an initial condition, equations (26) and (27) can be written in the form

$$S(t) = (\bar{s} - s^*)e^{\lambda_1(t-T)} + s^* \quad ; \ t > T \qquad (39)$$

$$w(t) = [m/(m-\lambda_1)](\bar{s} - s^*)e^{\lambda_1(t-T)} + s^* \quad ; \ t > T \qquad (40)$$

Differentiate (39) with respect to time at t=T to obtain

Figure 2. THE COLLAPSE OF THE FIXED EXCHANGE RATE REGIME WITH STICKY BACKWARD LOOKING WAGES



$$\dot{s}(T) = \lambda_1(\bar{s} - s^*) > 0 \tag{41}$$

Equations (28c), (29), (41) and the condition $R(T) = \Delta F(T)$ imply now

$$R_0 + \phi\lambda_1(s^* - \bar{s}) - b_2(s^* - \bar{s})T + c(w_0 - \bar{s})(1 - e^{mT}) = 0 \tag{42}$$

Equation (42) contains two variables which are determined endogenously in the modes i.e. T and w_0. However, we know that at $t=T$ the wage rate yielded by equation (13), which defines movements in $w(t)$ in the fixed exchange rate regime, and the wage rate yielded by equation (40) must be equal. There is no jump in the wage rate at time T. The jump in the wage rate occurs earlier i.e. immediately it becomes known that the fixed exchange rate regime will collapse. This is easy to see from equation (10). We obtain $w_0 = \bar{s} + \lambda_1(\bar{s} - s^*)e^{-mT}/(m - \lambda_1)$. After substituting this relation for w_0 into (42) and dividing (42) with the term $(s^* - \bar{s})$ we obtain

$$R_0/(s^* - \bar{s}) + \lambda_1[\phi - c/(m - \lambda_1)] - b_2T - [c\lambda_1/(m - \lambda_1)]e^{-mT} = 0 \tag{43}$$

Solving T from equation (43) cannot be done analytically. However, in figure 3 the solution of (43) is presented graphically. The value of T corresponding to the intersection of the straight line $R_0/(s^* - \bar{s}) + \lambda_1[\phi - c/(m - \lambda_1)] - b_2T$ and the curve $[c\lambda_1/(m - \lambda_1)]e^{-mT}$ is the solution of equation (43). As $s^* = -b_0/b_2$ and λ_1 and c are independent of b_0 we can see that in figure (3) only the location of the straight line is dependent on the size of b_0. The smaller is b_0 the further to the left is its location. As b_0 contains the monetary and fiscal policy parameters r and γ_0 this implies that the looser is the fiscal-monetary policy mix in the pre-collapse fixed rate regime the earlier the exchange rate regime shift occurs.

Figure 4 presents the dynamic time paths of the variables of the model. The time paths of R(t) and F(t) are excluded because they resemble those shown in figure 1. However, instead of being linear as in figure 1d, the time path of R(t) is exponentially decreasing in the pre-collapse fixed exchange rate regime.

Figure 3. THE COLLAPSE TIME OF THE FIXED EXCHANGE RATE REGIME

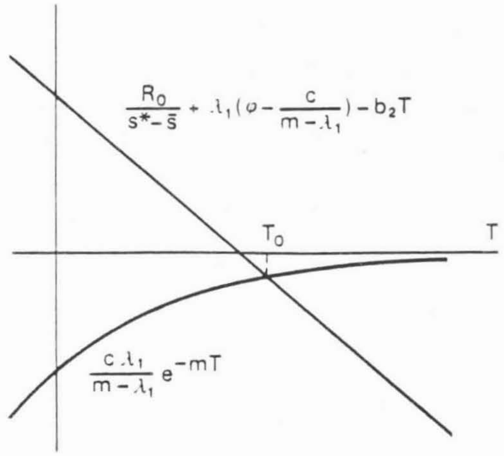
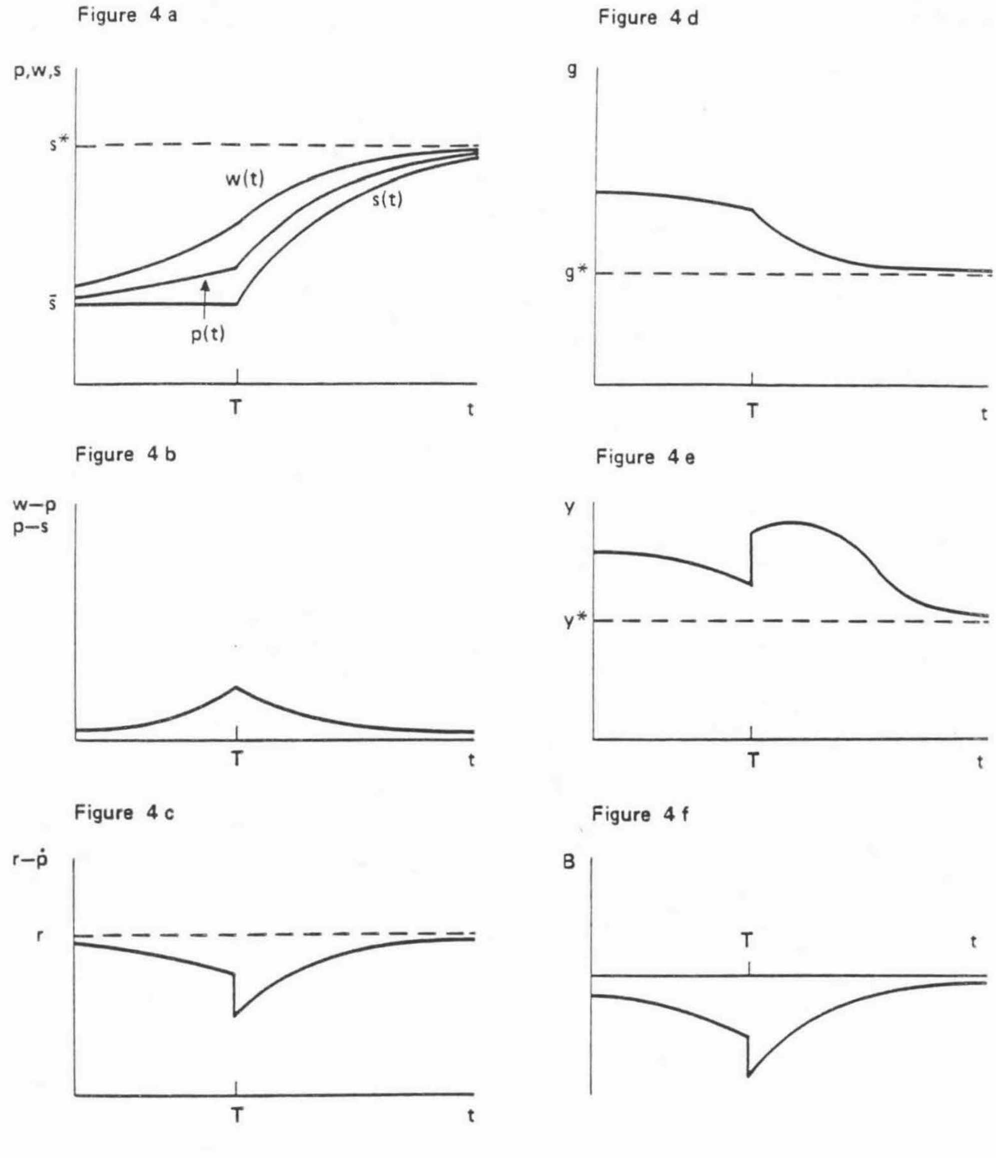


Figure 4. THE COLLAPSE OF THE FIXED EXCHANGE RATE REGIME WITH STICKY FORWARD LOOKING WAGES



In figure 4a, we can see how the wage rate and the price of domestic production already start to adjust towards the long-run equilibrium level s* in the fixed exchange rate regime. The rise in the nominal wage rate increases until T after which it starts to decrease. This can be seen by differentiating equation (13) and (42) twice with respect to time at t=T. The first time derivatives of these equations are equal but the second time derivate implied by (13) is $m^2\lambda_1(\bar{s} - s^*)/(m - \lambda_1)$, which is positive, and the second time derivative implied by (40) is $m\lambda_1^2(\bar{s} - s^*)/(m - \lambda_1)$, which is negative.

Figure 4b shows how the real wage rate w(t) - p(t) and the relative price p(t) - s(t) increase until T and thereafter start to converge towards zero. As a result of developments in inflation, the deviation of the real interest rate from the nominal rate of interest widens in the fixed exchange rate regime (figure 4c). At time T there is an upward jump in the rate of inflation and hence a downward jump in the real interest rate. From T onwards the inflation rate starts to converge towards zero and hence the real interest rate starts to converge towards the nominal rate of interest.

Figure 4d shows how, as a result of a rising domestic price level, the government budget policy becomes more restrictive. It is assumed in figure 4e that the price effects on domestic production, which are transmitted through relative prices and the government budget, dominate those which are transmitted through the real interest rate channel. This implies that until T domestic production decreases. Because of the downward jump in the real interest rate, there is an upward jump in production at t=T. After that, if the real price effect is strong enough, domestic production may continue to grow for some time but later, reflecting the rising real interest rate and the fiscal contraction, production starts to decrease. In the long run production decreases to the level which is consistent with the real wage and external balance requirements.

As a result of the continuous loss of competivenes, in figure 4f the trade balance deteriorates in the pre-collapse fixed exchange rate regime. At time T, reflecting the jump in production, there is a further discrete deterioration in the trade balance. From T onwards the trade balance starts to converge to zero.

4. MACROECONOMIC POLICY AND THE COLLAPSE OF THE FIXED EXCHANGE RATE REGIME

What are the effects of macroeconomic policy under the fixed exchange rate regime? The answers given in the literature to this question are deficient since they are based on analysis which does not take into account the fact that the viability of the fixed exchange rate regime is not independent of the policy pursued. However, the framework we have introduced in this paper takes this into account.

In this section we examine the effects of expansionary macroeconomic policy in cases where the policy change is assumed to be permanent or temporary. In addition, the policy change can be unanticipated or anticipated. Because in our framework the effects of monetary and fiscal policy are quite similar, we assume that it is the fiscal policy shift parameter γ_0 in equation (3) which is changed.

4.1 The effects of a permanent fiscal expansion

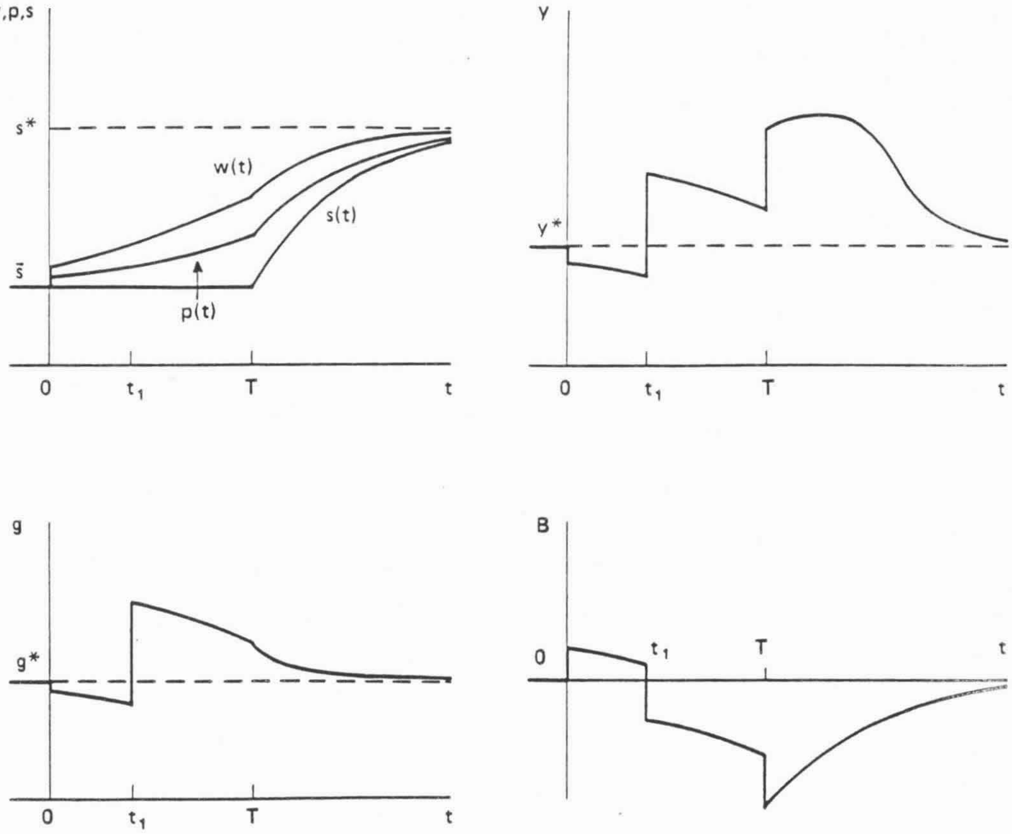
We examine first the effects of a permanent and unanticipated change in fiscal policy. If the reference path is chosen so that it is consistent with the fixed exchange rate target $s(t) = \bar{s}$, the effects of the change in γ_0 can be studied with help of figures 1, 2 and 4. If the nominal wage rate is fixed (figure 1) or the wage formation scheme is backward looking (figure 2) an unanticipated permanent rise in γ_0 implies that at the time of the implementation of the new policy there is an upward shift in g(t) and y(t) and a downward shift in B(t) to the levels plotted in figures 1 and 2. As a result of the trade balance deficit, the foreign reserves start to diminish leading to the collapse of the fixed exchange rate regime at t=T. Figure 4 shows the dynamic adjustment paths of the variables of the model, when the wage formation scheme is forward looking. At the moment an unanticipated permanent change in γ_0 is announced and implemented (at time t=0 in figure 4) the variables w and p jump from the level $\bar{s}$ and the variables g, y and B from the levels g*, y* and zero, respectively, to the levels plotted in figure 4.

If the wage formation scheme is backward looking or the nominal wage rate is fixed, the effects of a permanent fiscal expansion are similar irrespective of whether it is unanticipated or anticipated. The announcement of the policy change, if announced before the implementation, has no effects on the variables of the model. From the point of view of the effects of the change in policy, it is the timing of the implementation of the new policy that matters.

However, if the wage formation scheme is forward looking, there is an upward jump in the wage rate and in the price of the domestic production at the moment the permanent future fiscal expansion is announced. This can easily be seen from equation (10). The announcement of the permanent fiscal expansions makes it known to everybody that the fixed exchange rate regime $s(t) = \bar{s}$ will collapse and that thereafter the exchange rate will start to depreciate towards the level s*. Hence at the moment the fiscal expansion is announced the wage rate and the price of domestic production also jump upward and start to rise towards s*. The dynamic adjustment paths of the variables w, p, s, g, y and B are shown in figure 5. In figure 5, the policy change is announced at t=0, implemented at $t = t_1$ and the collapse time of the fixed exchange rate regime is T.

At t = 0 the upward jump in p causes downward jumps in g, y and upward jump in B i.e. the announcement of the future fiscal expansion affects economic activity contractively at the moment the fiscal expansion is announced. This contraction continues and through relative price developments deepens until $t = t_1$, when the fiscal policy change is implemented. At that point of time g and y jump above their long run equilibrium levels g* and y* and the trade balance moves into deficit. From t_1 onwards the cause of development is similar to that in the case of an unanticipated fiscal expansion.

Figure 5. THE EFFECTS OF AN ANTICIPATED PERMANENT FISCAL EXPANSION



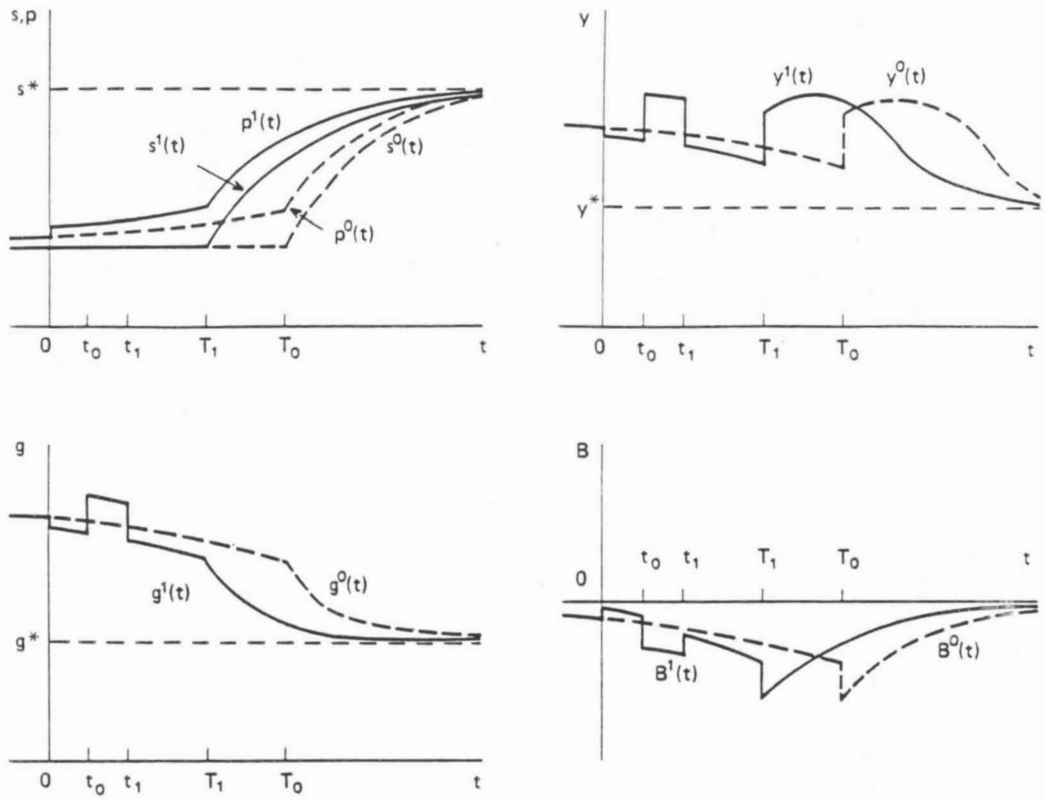
4.2 The effects of a transitory fiscal expansion

If the reference path is the fixed exchange rate equilibrium path (i.e. $B(t) = 0$), then a transitory fiscal expansion need not lead to the collapse of the fixed exchange rate regime. That is the case if the initial stock of foreign reserves is great enough. All that happens is that at the time the fiscal expansion is implemented domestic production rises temporarily above its reference path, the trade balance temporarily shifts into deficit and, corresponding to the cumulative trade balance deficit, the stock of the foreign reserves decreases to a lower level. The effects are similar irrespective of which one of our three wage formation schemes is assumed to be in force or whether the temporary fiscal expansion is anticipated or not.

What are the effects of a temporary fiscal expansion if the reference path also leads to the collapse of the fixed exchange rate regime (i.e. $B(t) < 0$)? If the wage formation scheme is backward looking or the nominal wage rate is fixed, then the only effect in addition to that mentioned above is that the temporary fiscal expansion hastens the timing of the collapse of the fixed exchange rate regime. The post-collapse adjustment paths are similar to those presented in figures 1 and 2.

The effects of an unanticipated and temporary shock when the wage formation scheme is forward looking are shown in figure 6. The reference path is denoted by $x^0(t)$ and the policy induced path by $x^1(t)$ (x refers to p, s, q, y and B). The temporary change in fiscal policy is announced at t=0 and it covers the period from t_0 to t_1. As in the previous cases, the expansionary fiscal shock hastens the timing of the collapse of the fixed exchange rate regime (from T_0 to T_1 in figure 6). At time t = 0, when the policy change is announced, the price of domestic production jumps from the $p^0(t)$ path to the path $p^1(t)$. This implies downward jumps in the variables g and y and an upward jump in B. Because of developments in domestic prices, the variables g and y are below their reference paths in the fixed

Figure 6. THE EFFECTS OF AN ANTICIPATED TEMPORARY FISCAL EXPANSION



exchange rate regime, except during the policy shock period. As the fiscal shock is temporary it does not affect the long-run equilibrium level of the exchange rate. Equations (40) and (2) imply now that $p^1(T_1) = p^0(T)$. As also the left-hand derivative $\dot{p}^1(T_1) = \dot{p}^0(T_0)$, so also $g^1(T_1) = g^0(T_0)$, $y^1(T_1) = y^0(T_0)$ and $B^1(T_1) = \dot{B}^0(T_0)$ as shown in figure 6.

The effects of an unanticipated temporary fiscal expansion are in other respects similar to those shown in figure 6, except that the contractionary effects preceeding the implementation of the policy shock are lacking.

5. SUMMARY AND CONCLUDING REMARKS

Previous studies on balance-of-payments crises have utilized highly simplified frameworks. In these studies no real effects are associated with balance-of-payments crises. This is due to the assumption of perfectly flexible prices and wages. Since, in addition, the current account balance plays no role in these studies, the only reason for balance-of-payments crises is excessive supply of money.

In this paper the assumption of imperfect substitutability between domestic and foreign bonds implies that it is the accumulating trade balance deficit which causes the balance-of-payments crisis. Hence it is not just monetary policy but rather the fiscal, monetary and incomes policy mix which has importance in the analysis. We further assumed that domestic goods are not perfect substitutes for foreign goods and that nominal wages are not perfectly flexible. These assumptions connect economic policy, with real economic developments and balance-of-payments crises.

In our analysis we assumed that at the moment the foreign reserves hit some critical lower bound known by everyone the central bank abandons the fixed exchange rate target and allows the exchange rate to float. The timing of the collapse of the fixed exchange rate regime and the dynamics related to this exchange rate regime shift were studied under the three alternative assumptions of wage formation. Nominal wages were assumed alternatively fixed, sticky and backward looking or sticky and forward looking.

Our model also allowed us to study the effects of an expansionary economic policy in the fixed exchange rate regime while taking into account the fact that the viability of the regime is policy dependent. We found that, if the initial stock of foreign reserves is great enough, a temporary policy change does not lead to the collapse of the fixed exchange rate regime. Hence, conventional stabilization policy, which includes recurrent temporary policy changes in both the expansive and the contractive direction, is possible without giving rise to expectations concerning the exchange rate regime shift. However, an expansive and permanent policy change, if it causes the trade balance deficit, results in the collapse of the fixed exchange rate regime. In addition, if the wage formation scheme is forward looking, this future shift in the exchange rate regime also causes inflationary development from the moment the expansive policy change is announced. Inflation accelerates until the shift in exchange rate regime occurs.

APPENDIX: The signs of the characteristic roots

The case of sticky backward looking wages: Rewrite the charasteristic equation (22)

$$\text{(A1)} \qquad \phi\lambda^3 + [b_3(1-\theta) + m\phi]\lambda^2 - (b_1 + b_2 - mb_3)\lambda - mb_2 = 0$$

where ϕ, $b_3(1-\theta) + m\phi$ and mb_2 are unambiguously positive but the sign of the term $b_1 + b_2 - mb_3$ is ambiguous. Descartes's rule of signs implies that equation (A1) has one and only one positive real root. We denote it by λ_3. We next show that the real parts of two other roots λ_1 and λ_2 are negative.

Write the third degree polynomial (A1) in the form

$$\text{(A2)} \qquad \lambda^3 - (\lambda_1 + \lambda_2 + \lambda_3)\lambda^2 + (\lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_1\lambda_2)\lambda - \lambda_1\lambda_2\lambda_3 = 0$$

(A1) and (A2) imply that

$$\lambda_1 \; \lambda_2 = mb_2/\lambda_3\phi > 0$$

$$\lambda_1 + \lambda_2 = - b_3(1-\theta)/\phi - m - \lambda_3 < 0$$

Since $\lambda_1 \; \lambda_2 > 0$ and $\lambda_1 + \lambda_2 < 0$ the real parts of the roots λ_1 and λ_2 are negative

The case of sticky forward looking wages: Rewrite the equation (25)

$$\text{(A3)} \qquad \phi\lambda^3 + [b_3(1-\theta) - m\phi]\lambda^2 - (b_1 + b_2 + mb_3)\lambda + mb_2 = 0$$

where ϕ, $b_1 + b_2 + mb_3$ and mb_2 are unambiguously positive. Only the sign the term $b_3(1-\theta) - m\phi$ is ambiguous. Descartes's rule of signs implies that equation (A3) has one and only one negative real root, which we denote by λ_1. After transforming (A3) into the form (A2) we get

$$\lambda_1 \lambda_2 \lambda_3 = - mb_2/\phi$$

$$\lambda_1 \lambda_2 + \lambda_1 \lambda_3 + \lambda_2 \lambda_3 = - (b_1 + b_2 + mb_3)/\phi$$

implying

$$\lambda_2 \lambda_3 = - mb_2/\lambda_1\phi > 0$$

$$\lambda_2 + \lambda_2 = (mb_2/\lambda_1 - b_1 - b_2 - mb_3)/\lambda_1\phi > 0$$

We can conclude that the real parts of the roots λ_2 and λ_3 are positive.

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