0440

IMF WORKING PAPER

WP/90/25

INTERNATIONAL MONETARY FUND

Research Department

Dynamic Responses to Policy and Exogenous Shocks in an Empirical Developing-Country Model with Rational Expectations*

Prepared by Nadeem U. Haque and Peter Montiel

Authorized for Distribution by Mohsin S. Khan

March 1990

Abstract

The dynamic responses of a developing economy to a variety of policy and external shocks are studied using an empirical macroeconomic model which embodies rational expectations, perfect capital mobility, and import rationing. These features, which are relatively new in developing-country modelling, prove to be quite important in determining the model's dynamic properties. This suggests that macroeconomic management in developing countries--such as that involved in short-run stabilization--requires that such features be explicitly taken into account.

JEL Classification Numbers:

131, 431

*The authors are grateful to Mohsin Khan for helpful comments, and to Ravina Malkani for excellent research assistance.

Contents

I. Introduction

Shocks emanating from domestic policies or from changes in the external economic environment in developing countries invariably set off a dynamic process of adjustment which frequently takes some time to work itself out. Although analysis of the macroeconomic effects of such shocks typically focuses on impact effects or on the eventual steady state at which the economy settles, it is the intermediate run--i.e., the "real time" effect of such shocks--that is often of equal if not even greater concern to policymakers in developing countries. While explicit dynamic solutions to small analytical models can yield valuable insights into particular aspects of the economy's response to such shocks, general-equilibrium interactions can only be studied in the context of larger models that, unfortunately, do not often prove to be analytically tractable. Thus, numerical simulation experiments with dynamic macroeconomic models become the tool of choice for understanding the "real time" effects of policy measures and external shocks in developing countries.

In such macroeconomic models, dynamic behavior may arise from a number of sources, the most familiar of which are partial adjustment of the endogenous variables and the formation of expectations. Regarding the latter, while the assumption that agents' expectations are formed rationally now pervades policy-oriented discussions involving developing-country macroeconomic problems, 1/ medium-sized dynamic macroeconomic models estimated under the rational expectations assumption are not available for such countries. Moreover, research on adjustment paths produced in response to policy and exogenous shocks in developing countries under rational expectations is not much advanced. 2/

This paper builds on recent research by Haque, Lahiri and Montiel (1990), in which a fairly small developing-country macroeconomic model was specified and estimated under the assumption of rational expectations. Our purpose in this paper is to explore the model's implications for the economy's path of adjustment to the types of shocks mentioned above--i.e., domestic policy shocks and changes in the external environment--on the assumption that expectations are formed rationally. We shall examine the dynamic effects of policy shocks--devaluation, expansionary fiscal policy, and an expansion of domestic credit--as well as of changes in external demand and in foreign interest rates.

1/ For a discussion of this issue, see Corden (1989).

2/ The best-known macroeconomic simulation model for developing countries is by Khan and Knight (1981). That model is estimated and simulated with adaptive expectations. Haque, Montiel, and Symanski (1989) construct a developing-country simulation model and use it to examine the dynamic effects of several policy and external shocks with forward-looking expectations. Recently Agenor (1990) has estimated and simulated a small developing-country rational-expectations model.

The paper is organized as follows: the next section presents a brief description of the model and some of its more relevant properties. Section III examines the effects of the policy shocks, while the external shocks are analyzed in Section IV. A final section summarizes the findings, focusing specifically on the role of expectations in determining the nature of the adjustment paths generated by the shocks.

II. The Model

The model that we intend to utilize in our simulation exercises represents a small open economy with a Mundell-Fleming production structure, a fixed exchange rate, perfect capital mobility, and continuous full employment. 1/ Its behavioral equations consist of conventional, widely-used specifications, since the model was intended to provide "representative" developing-country estimates of parameters that figure prominently in policy discussions. The parameters were estimated using a large pooled cross section-time series sample of countries, a consistent data set, and appropriate empirical techniques. The Mundell-Fleming structure is typically adopted for developing-country empirical models because of the difficulty of conforming the data to the traded-nontraded distinction required by the analytically-preferable "dependent economy" framework. Fixed exchange rate arrangements are common among developing countries, and were even more so during the period of our sample. 2/ The empirical model was designed to test for the degree of effective capital mobility, and proved unable to reject the hypothesis of perfect capital mobility (i.e., uncovered interest parity) for the group of countries in the sample. Finally, the full employment assumption is controversial, but the question of the existence of Keynesian unemployment in developing countries arising from sluggish price adjustment is unsettled, and we have chosen to work with the polar case of complete price flexibility.

As indicated above, the behavioral equations of the model consist of standard empirical specifications. One feature which is worth highlighting, however, is the presence of the reserve-import ratio in the import demand function (equation (6) in Appendix I). This is a common specification in the developing-country context, and is meant to capture, albeit in a crude way, the importance of quantitative import restrictions

---

1/ The model is presented in Appendix I, which also contains variable definitions. The parameters reported in Appendix I were estimated empirically, using an error-components three-stage least squares technique, for a pooled cross section-time series sample of 31 developing countries. Details of the estimation, including diagnostic statistics, are provided in Haque, Lahiri, and Montiel (1990). That paper also contains a detailed equation-by-equation description of the model, so the exposition in this section will be brief.

2/ As of June 30, 1989, 84 developing-country members of the International Monetary Fund defended an exchange parity for their currencies; see IMF (1989).

based on foreign exchange reserves in developing countries. 1/ As will be shown, this feature turns out to affect both the dynamics of adjustment and the steady-state effects of shocks in a significant fashion. Rational expectations enter the model in two ways. First, expectations of devaluation of the official nominal exchange rate enter the interest-parity condition (equation (11) in Appendix I) which determines the domestic nominal exchange rate. Second, the real interest rate, which affects both consumption and investment behavior and is given by equation (14) of the Appendix, is assumed to incorporate a rational forecast of next period's price level.

To better understand the policy simulations, it is useful to examine the steady-state version of the model. This is given in Appendix II, where the model is presented in recursive blocks, according to its solution algorithm. This solution works as follows: since in this paper we work with steady states for which the nominal exchange rate (e) is fixed, we have $E_t (e_{t+1} \mid \Omega_t) = e_{t+1} = e_t$, where Ω_t denotes the set of information available at time t and E is the expectations operator. Since the real exchange rate must be constant in the steady state, the domestic price level must be as well, so $E_t (P_{t+1} \mid \Omega_t) = P_{t+1} = P_t$. With these conditions, equations (13) and (16) of Appendix I yield the steady-state values of the domestic nominal (i_t) and real (r_t) interest rates, both of which equal the foreign nominal interest rate i^*. These equations thus appear in block I of Appendix II. This solution for r derived from block I, together with the use of the steady-state condition $K_t = K_{t-1}$ for the capital stock in Appendix I equation (9), permits block II, consisting of the equations (5), (8), and (9) from Appendix I, to be solved for real GDP (Y), the capital stock (K), and investment (I). The solutions will take the form $Y = Y(i^*)$, $K = K(i^*)$, and $I = I(i^*)$, with $Y', K', I' < 0$.

The third block contains the monetary equations (10), (11), and (12). The steady-state version of (12) reflects the conditions that $Y_t = Y_{t-1} = Y(i^*)$, with its implication that the money supply (M) is constant--i.e., $M_t = M_{t-1}$. Substituting (10) and (11) into this version of (12) yields an equation of the form:

$$\log \left(\frac{eR + DC_P + DC_G}{P} \right) = \beta_0 + \beta_1 i^* + \beta_2 Y(i^*). \qquad (12')$$

where R is the foreign-currency value of international reserves and DC_P and DC_G denote central bank credit to the private and public sectors, respectively. Since i and Y are determined in blocks I and II respectively, and since e, DC_P, and DC_G are exogenous, this equation contains only two endogenous variables--R and P. To display the solution

1/ See Khan and Knight (1988) for a discussion of such a specification.

of the steady-state model diagrammatically, we can depict the combinations of R and P that satisfy (12′) as the locus MM in Figure 1. The slope of this locus is:

$$\left.\frac{dR}{dP}\right|_{MM} = M/eP > 0$$

The remainder of the model is grouped into the fourth block, which we have termed the demand block. Using equations (14), (15) and (17) of Appendix I in (3′) we can rewrite private disposable income (Y^d) as:

$$Y^d = Y + \frac{eP^* Z}{P} - (G + X)$$

where P^* is the level of foreign prices, Z is the volume of imports measured in units of the foreign good, G is real government spending, and X denotes real exports. Substituting this in (2) and then using (2), (6), (7) and (9) in (1), we have:

$$Y(i^*) = C(i^*, Y(i^*) + \frac{eP^*}{P} Z(eP^*/P, Y(i^*), R/P^*)) \qquad (1')$$

$$+ I(i^*) + G + X(eP^*/P, Y^*) - \frac{eP^*}{P} Z(\frac{eP^*}{P}, Y(i^*), \frac{R}{P^*})$$

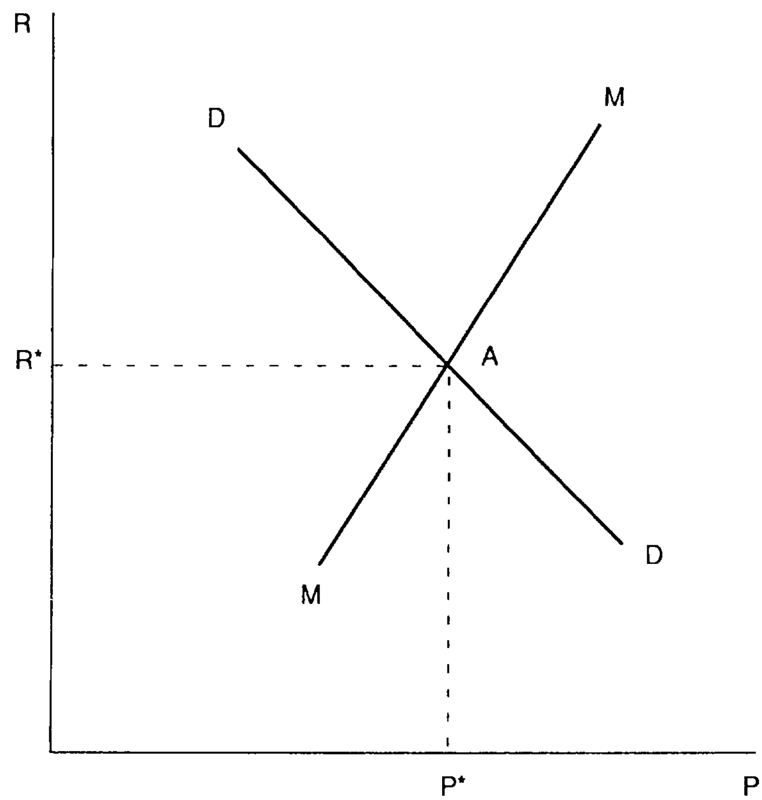
Since e, G, i^*, and Y^* are exogenous, this equation only contains the endogenous variables R and P. Block IV therefore also generates a locus in (R,P) space, which is given by equation (1′). This locus is denoted by DD in Figure 1. Its slope is negative, i.e.:

$$\left.\frac{dR}{dP}\right|_{DD} = - \frac{Z(\eta_X X/Z + \eta_Z - 1)}{dZ/dR} < 0,$$

where η_X and η_Z are the relative-price elasticities of exports and imports, respectively.

Figure 1

SOLUTION OF THE STEADY-STATE MODEL



The key endogenous variables in the steady-state version of the model are thus the stock of international reserves R and the domestic price level P. The solution of the model is depicted by the intersection of the MM and DD loci at point A in Figure 1. The model's exogenous variables consist of policy variables, namely the nominal exchange rate e, the stocks of credit to the private and government sectors respectively, (DC_p and DC_G), and government spending on home goods G, as well as external variables, consisting of the external interest rate i^*, foreign demand Y^* and the foreign price P^*. Once the solution values for R and P are determined as in Figure 1, the values of the remaining endogenous values in block IV (i.e. C, X, Z, Y^d, F_p, CA, and GZ), can be found.

The stability of the steady-state equilibrium at A can be verified by computing the model's characteristic roots. We computed these roots via using the parameter estimates in Appendix I and linearizing around an artificial steady state generated by values of the exogenous variables intended to capture a "representative" developing-country configuration. 1/ We found a single root with modulus above unity. Since our model contains a single "jump" variable (the domestic price level), it thus exhibits saddlepoint stability (see Blanchard and Kahn (1980)).

With the nature of the steady state described and the model's stability established, we now turn to an examination of the adjustment paths. In the next section we examine responses to shocks in the domestic policy variables--the exchange rate, the stock of credit, and government spending on domestic goods. Section IV looks at the dynamic effects of shocks in the external environment--specifically changes in world interest rates and foreign demand.

III. Dynamic Responses to Policy Shocks

Before considering the simulated economy's response to domestic policy shocks taken individually, it may be useful to verify the model's neutrality by examining the effects of a particular combination of nominal shocks--i.e., an equiproportional exchange rate devaluation and increase in both (private and public) domestic credit stocks. Notice that an x percent increase in e, DC_p, and DC_G would continue to satisfy equation (12') if P also increased by x percent. The same is true of equation (1'), where DC_p and DC_G do not appear. Thus, the model is homogeneous of degree one in e, DC_p, and DC_G--since all nominal values change in the same proportion, real variables are unaffected, and the model's neutrality is verified. In terms of Figure 1, both the MM and DD loci shift to the right by x percent, increasing the equilibrium price level by this amount, but leaving the equilibrium stock of reserves and all other real variables unchanged.

1/ The roots were computed through the subroutine LIMO in TROLL.

A. Devaluation

As indicated above, a neutral shock in this model is one in which the nominal exchange rate and the credit stock are changed in the same proportion. An exchange-rate change by itself (i.e. a devaluation coupled with unchanged domestic credit targets) is therefore not a neutral shock. For our first exercise we consider a nominal exchange-rate devaluation of ten percent. The steady-state effects of this shock are depicted in Figure 2. Since the stock of domestic credit does not affect equation (12'), the DD curve shifts horizontally to the right, say to D'D', in proportion to the devaluation (i.e. by ten percent) as in the case of the neutral shock. Because DC_p and DC_G are unchanged, however, the proportional shift in MM, which can be derived from (1'), amounts to:

$$\frac{dP}{de}\frac{e}{P}\bigg|_{MM}\hat{e} = \frac{R/P}{M/P^2}\frac{e}{P}\hat{e}$$

$$= (eR/M)\,\hat{e} < \hat{e}$$

since $eR/M < 1$. 1/ Thus the shift of MM, to M'M' in Figure 2, falls short of the neutral shift. As a result, the steady-state stock of reserves increases (which presumably motivated the devaluation in the first place) and the steady-state real exchange rate depreciates.

The long-run real depreciation comes about through the effect of reserve accumulation on the intensity of import restrictions. This can be verified from equation (12'). An increase in the stock of reserves increases imports by reducing the severity of such restrictions, and since this diverts demand from domestic to foreign producers, it has a contractionary impact which must be offset by a lower domestic price level. 2/ This is the intuition behind the negative slope of DD in Figure 1. In the absence of this mechanism, the increase in the stock of reserves would not affect demand, and the DD curve would be vertical. In this case, as can be verified from Figure 2, the domestic price level would increase fully in proportion to the devaluation, i.e. the steady-state real exchange rate would be unchanged. Because of the larger increase in the domestic price level in these circumstances, the steady-state stock of reserves would also be larger.

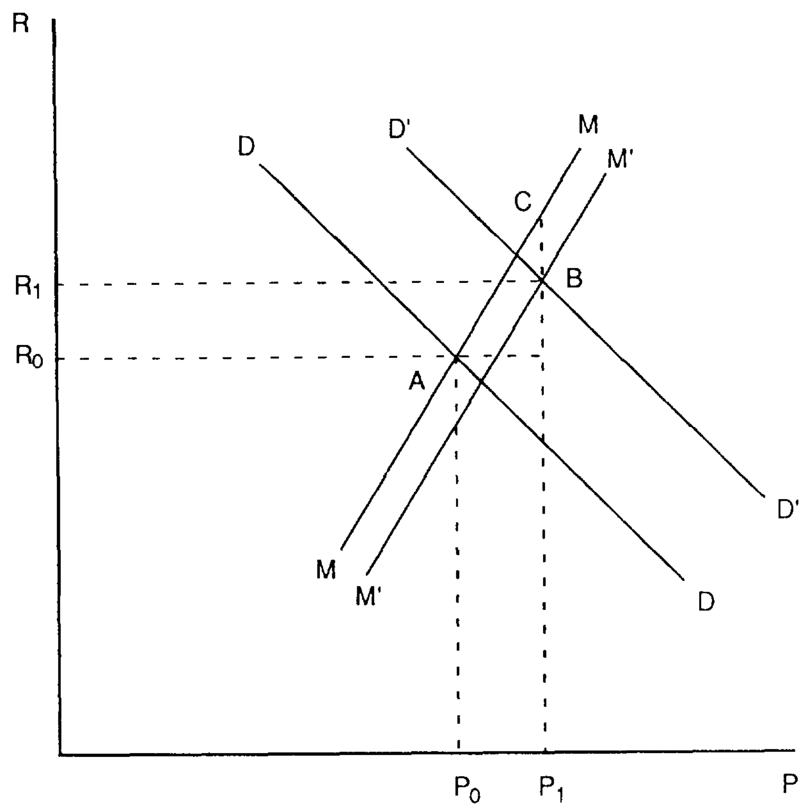
It may be worth pointing out that the only endogenous variables whose steady-state values are affected by devaluation are those determined in blocks III and IV of Appendix II. Specifically, real output, which

---

1/ The symbol "∧" denotes a proportionate rate of change.
2/ For an analysis of the aggregate demand effects of import restrictions in developing countries, see Ocampo (1987).

Figure 2

STEADY-STATE EFFECTS OF DEVALUATION



emerges from block II, is not affected. Thus devaluation is neither expansionary nor contractionary in the long run. The reason is that the domestic real interest rate, which determines the capital stock, continues to be determined by the unchanged foreign interest rate. Thus, the output effects of devaluation are temporary, appearing only during the process of adjustment.

We now examine the dynamics of adjustment, considering first the case in which the devaluation is unanticipated, and then that of an anticipated devaluation.

1. Unanticipated devaluation

On impact, devaluation creates an incipient excess demand for domestic goods through substitution effects. Since output is supply-constrained, this implies an increase in the domestic price level in the first period. However, the price level cannot immediately settle at its new steady-state level. Were it to do so, the commodity market would not clear in the first period. The reason is that the real depreciation implied by the steady-state price increase leads to increased exports (equation (6)) and reduced imports (equation (9)). Thus, the trade balance improves. 1/ Since the domestic real interest rate would be unchanged in this case (given that the price level would be expected to remain at its steady-state level), output, consumption, and investment would be unchanged. From equation (1), an improvement in the trade balance with unchanged output and absorption would result in an excess demand for domestic goods.

On impact, therefore, the domestic price level must overshoot its steady-state value (see Chart 1a). This promotes equilibrium in the commodity market in two ways--since the movement in the real exchange rate is dampened, the trade balance improvement is muted. Also, since the price level will now be expected to fall, the domestic real interest rate will rise, as shown in Chart 1d. This chokes off both consumption and investment demand.

The expected reduction in the domestic price level mentioned above materializes in the next period (as it must, under rational expectations) because the economy is then subjected to a deflationary shock in that period. The first-period price increase raises the demand for money, giving rise to a capital inflow and a reserve gain which exceeds the steady-state increase in the stock of reserves. This is shown in Chart 1c. This first-period reserve gain induces the authorities to permit an easing of import restrictions in period 2, and the resulting increase in

1/ The Marshall-Lerner condition is satisfied by the model of Appendix I. Notice that the perfect capital mobility assumption implies that the higher domestic price level results in a capital inflow and a substantial reserve gain. While this operates to ease import restrictions and increase the trade deficit, this effect appears with a one-period lag.

imports diverts demand away from domestic goods, causing the price level to fall below its steady-state level (Chart 1a). Since the nominal interest rate continues to be held in place by the interest parity condition, and since no further price decreases are forthcoming, the real interest rate falls sharply--to below its steady-state value--in period 2 (Chart 1d).

After the second period, the economy remains close to its steady-state configuration, with the small deviations from that configuration being eliminated very gradually. The price level gradually rises, (keeping the real interest rate below its steady-state value) then overshoots its steady-state level, gradually approaching that level from above. In consequence, the real interest rate also moves to its steady-state level from above (Chart 1d).

The behavior of real output during the adjustment period merits particular attention. The first-period increase in real interest rates reduces investment, causing the capital stock to decline. Output therefore falls (Chart 1b)--i.e., devaluation has a contractionary effect on output in the short run. This contractionary effect is fundamentally brought about by the price level overshooting and its incorporation into the domestic real interest rate via rational expectations. This result underlines the importance of dynamic analysis and expectational phenomena in assessing the macroeconomic impacts of devaluation. 1/ As the real interest rate falls below its original (and final) level in period 2, investment recovers. However, the capital stock remains below its steady-state level, and so does real output. As the capital stock begins to increase, output recovers (Chart 1b), but before it reaches its steady-state level, the real interest rate overshoots, thus depressing investment and again causing the capital stock to decline. Real output follows the capital stock, which implies that output recovers its steady-state value from below (Chart 1b). In sum, devaluation causes real output to decline in the short and medium terms in this model, primarily because of its short-run impact on domestic real interest rates. 2/

2. Anticipated devaluation

The anticipation of a future devaluation will itself have macroeconomic effects in this model. To investigate these, we simulated the effects of a devaluation which is expected to--and actually does--take place in the second period of the simulation. The steady-state outcomes are, of course, the same as in the case of an unanticipated devaluation, since these are independent of the initial conditions when the devaluation is implemented. Because of the forward-looking expectations, however, the macro effects of the devaluation begin to be felt when the expectations

---

1/ See Lizondo and Montiel (1989).

2/ This result is sensitive to the assumptions of perfect wage-price flexibility and perfect capital mobility. For an analysis directed specifically to these issues, see Haque and Montiel (1990).

Unanticipated Devaluation
(first period)

Chart 1a

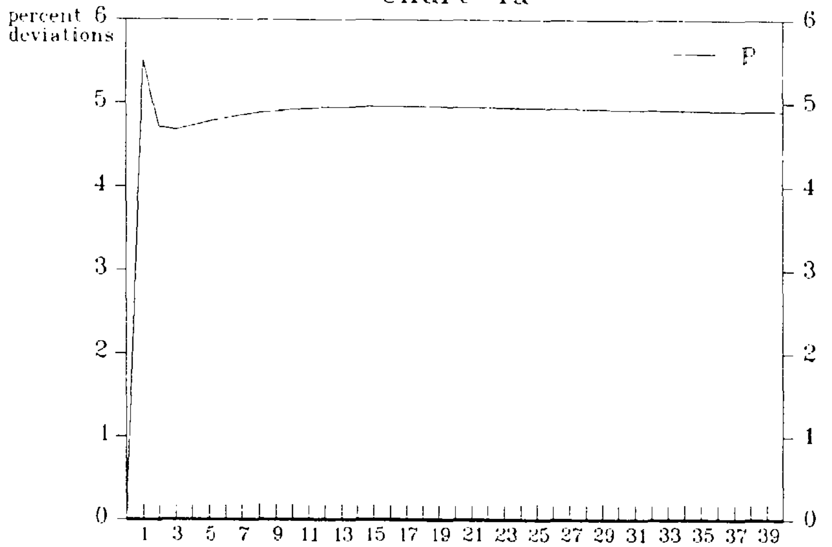


Chart 1b

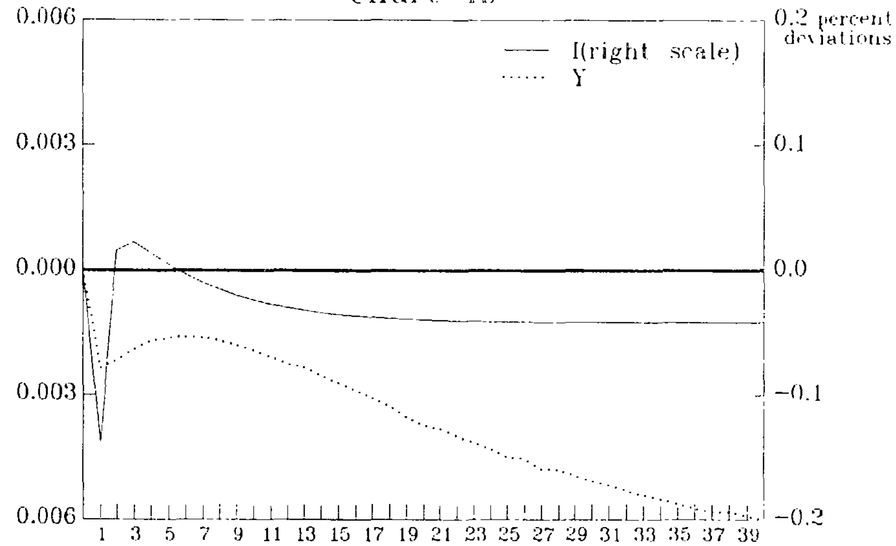


Chart 1c

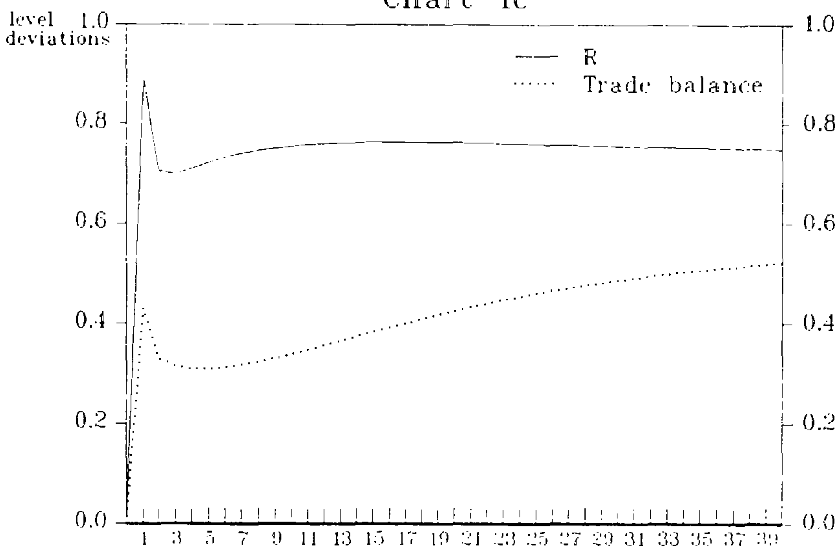
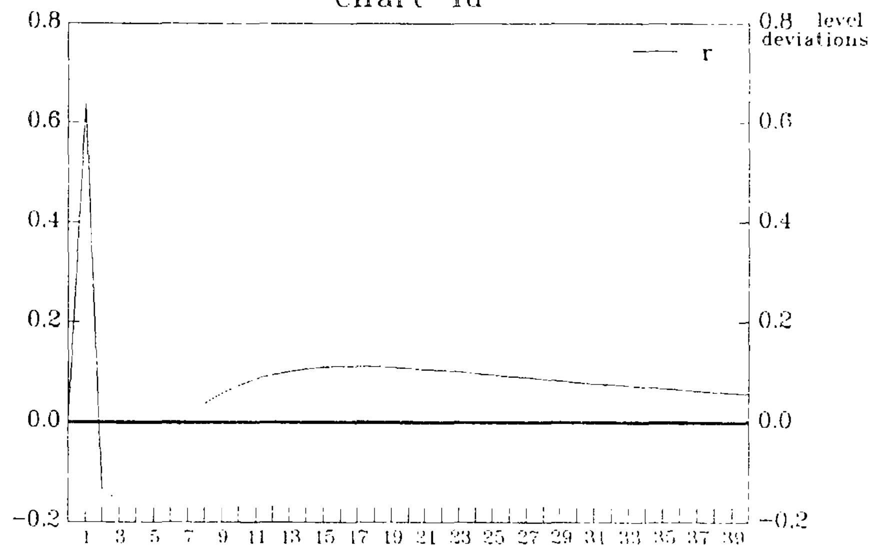


Chart 1d



Note: all charts reflect deviations from the steady state.

are formed, rather than when the devaluation actually takes place. These effects are summarized in Charts 2a-2d.

Since domestic interest rates are determined by the uncovered interest parity condition, the expectation of a ten percent devaluation next period immediately raises the domestic nominal interest rate in the first period by an equivalent amount. Since the devaluation is also expected to raise the domestic price level when it is implemented, however, domestic real interest rates do not rise by this amount. As shown in the previous section, a nominal devaluation results in a real devaluation both on impact and in the steady state in this model. Thus domestic prices are expected to rise by less than the rate of devaluation, and this expected real depreciation means that the domestic real interest rate will rise (though by substantially less than the nominal rate) in the first period (Chart 2d). As a result, both domestic consumption and investment are discouraged, and the domestic price level falls in the first period (Chart 2a). The reduction in domestic investment causes the capital stock to fall, which reduces output (Chart 2B)--i.e., the mere expectation of devaluation is itself contractionary in its effects on real output.

The combination of higher domestic nominal interest rates, lower real output, and lower domestic prices lowers the nominal demand for money, giving rise to a capital outflow and associated reserve loss (Chart 2c). Thus, the expectation of devaluation in the model permits us to simulate an episode of capital flight. When the devaluation takes place, this capital flight is reversed. The nominal interest rate falls, returning to its original level, and domestic prices rise (chart 2b) for the reasons described in the preceding subsection. Though real output continues to fall, this effect is slight in comparison. Thus the demand for money increases, motivating the reflow of capital, and causing reserves to rise sharply (Chart 1c). From this point on, the dynamics reproduce those of an unanticipated devaluation.

Though it is not obvious from a comparison of Charts 1a and 2a, the initial price increase in the period when the devaluation is actually implemented is greater when the devaluation was previously anticipated than when it comes as a surprise. The reason is that the loss of reserves brought about by capital flight in anticipation of devaluation implies the presence of tighter import restrictions when the devaluation was anticipated than when it comes as a surprise. Imports are thus lower when devaluation was anticipated, and domestic demand pressures are consequently higher.

B. Government spending shock

In this subsection we consider the effects of an increase in government spending on domestic goods, financed by an equivalent reduction in government imports. We analyze three cases: an unanticipated permanent increase in spending, an increase in spending which is expected to occur in the future and be permanent, and an unanticipated increase in spending which is transitory in nature.

1. Unanticipated permanent spending increase

The steady-state effects of an increase in government spending on home goods are depicted in Figure 3. Since the level of government spending on such goods affects only the demand block (equation (12')) and not the monetary block (equation (1')), only the DD curve is affected. Because the change in the spending mix is expansionary, the domestic price level must increase at a given value of R--i.e., the DD curve must shift to the right, while the MM curve is stationary. The new equilibrium will thus be found at a point like B, with higher reserves and a higher domestic price level--in other words, the shock will result in a real exchange rate appreciation. The reason for the reserve increase is that the higher domestic price level increases the demand for money. Since the spending increase on home goods is financed by curtailing government imports and not by domestic credit expansion, the increased demand for money can be satisfied only by a reserve inflow.

This reserve inflow tends to mute the inflationary consequences of the spending shift, because the relaxation of import restrictions that it entails shifts private demand away from domestic products, thus in part offsetting the shift of government demand toward such products. In the absence of this effect the DD curve would be vertical in Figure 3, and D'D' would pass through the point D on MM. Thus the new steady state would exhibit both higher prices and larger reserves than that at B.

It may be worth noting that the spending shift has no effect on domestic interest rates or output in the long run. Again, this is a consequence of the interest parity condition and the determination of output in block II, which is unaffected by the composition of government spending.

The dynamics of adjustment are similar in many ways to those of an unanticipated devaluation. The shock increases domestic demand on impact, and therefore results in a price increase (Chart 3a). Although, as shown above, domestic prices also rise in the steady state, the price increase on impact must exceed its steady-state value. The reason is that in the first period import restrictions are unchanged, whereas in the steady state such restrictions are eased due to the higher steady-state stock of reserves. Since this easing relieves domestic demand pressure, the price increase needed to clear the home commodity market is greater in its absence. The higher domestic price level induces a first-period capital inflow, increasing the stock of foreign exchange reserves (Chart 3c). Prices must fall in the second period, as the higher first-period reserve stock leads to an easing of import restrictions. Because rational agents expect this to happen, the first-period domestic real interest rate rises dramatically (Chart 3d). This crowds out investment and depresses output, so the increase in government spending on home goods is actually contractionary on impact (Chart 3b).

Anticipated Devaluation
(second period)

Chart 2a

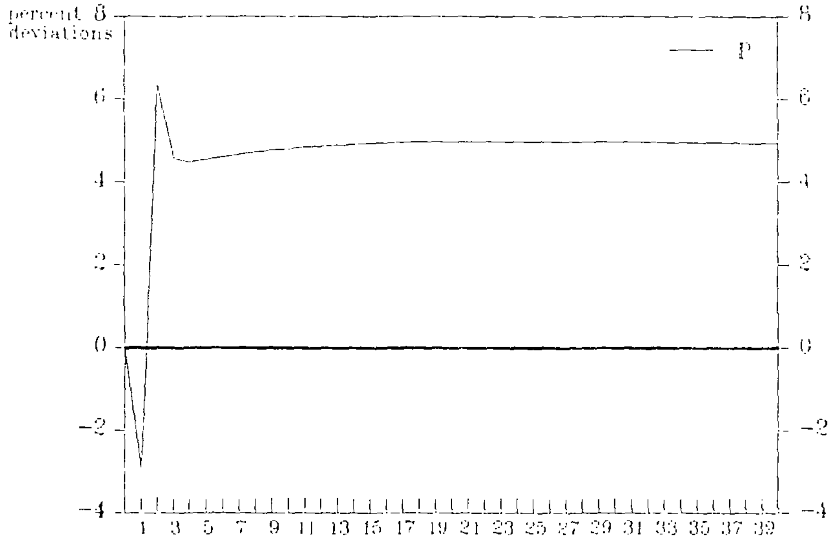


Chart 2b

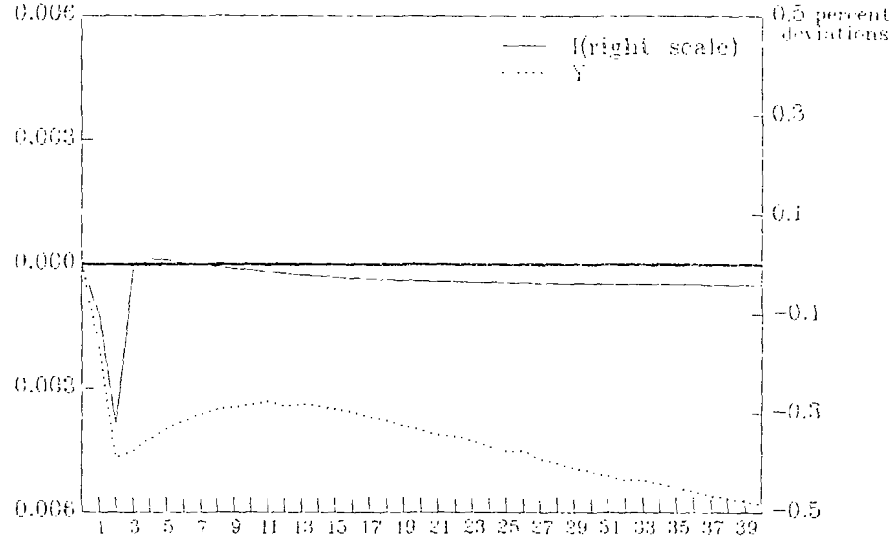


Chart 2c

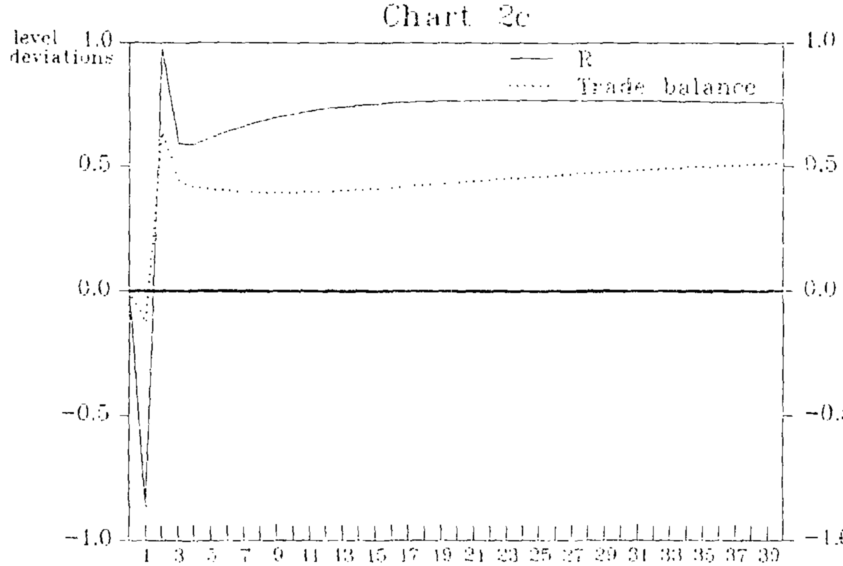
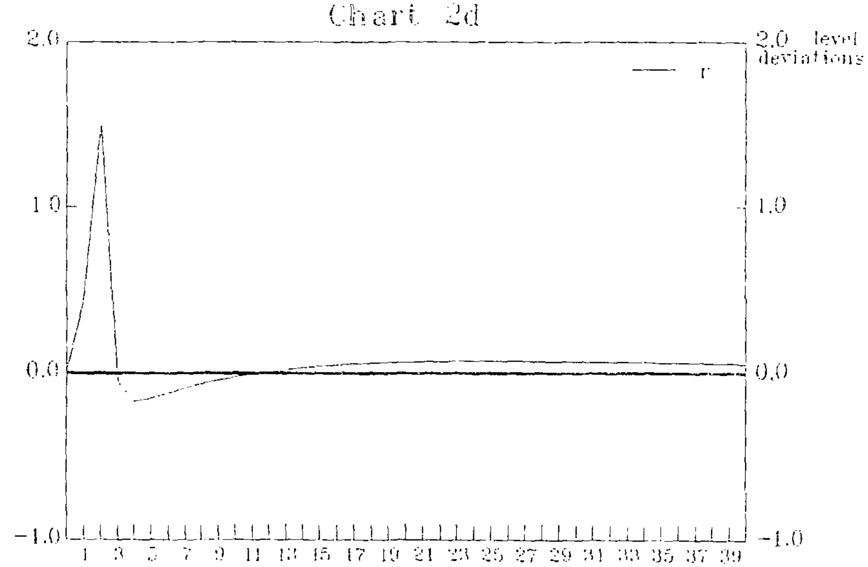


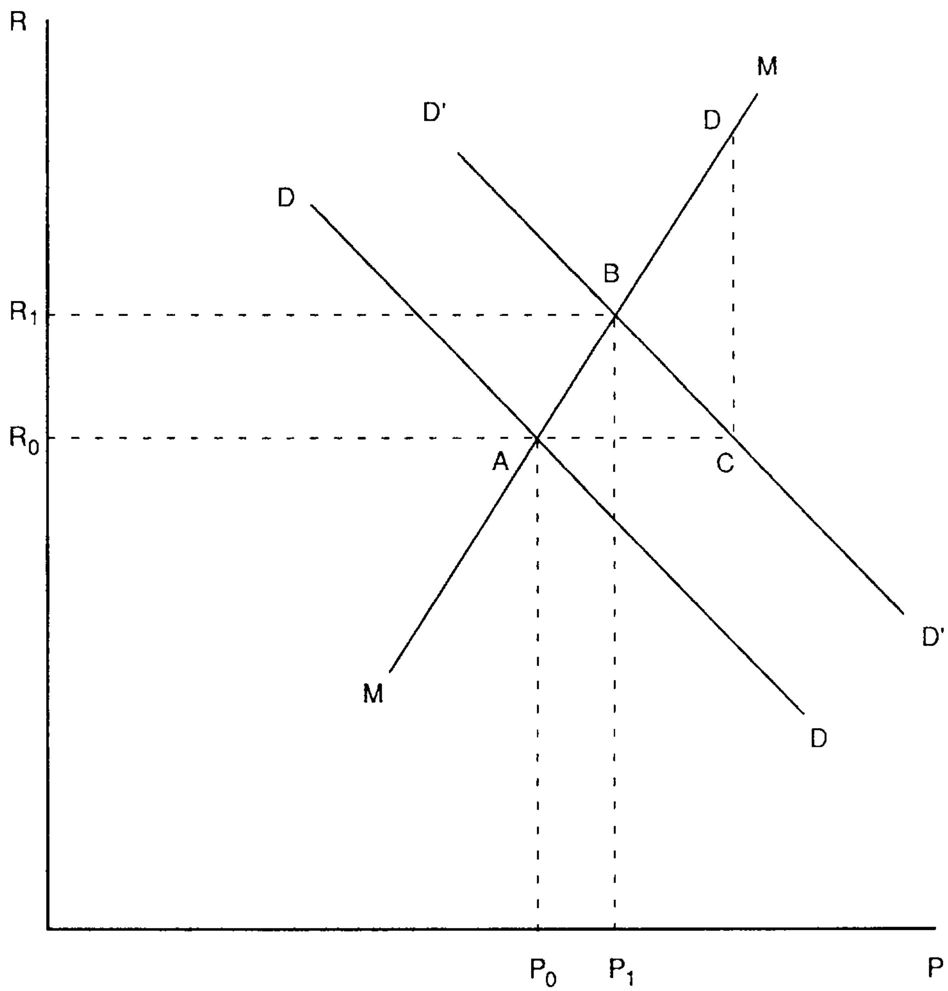
Chart 2d



Note: all charts reflect deviations from the steady state.

Figure 3

STEADY-STATE EFFECTS OF INCREASED GOVERNMENT SPENDING ON DOMESTIC GOODS



Unanticipated Permanent Fiscal Shock
(first period)

Chart 3a

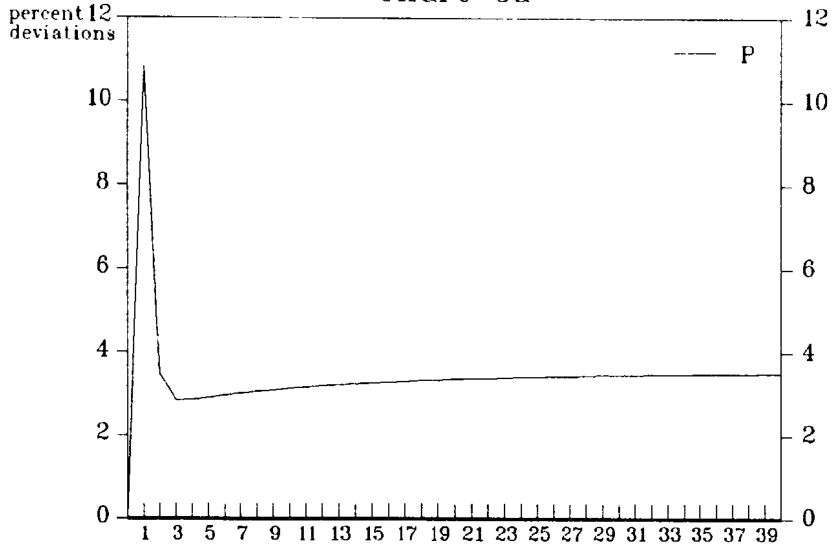


Chart 3b

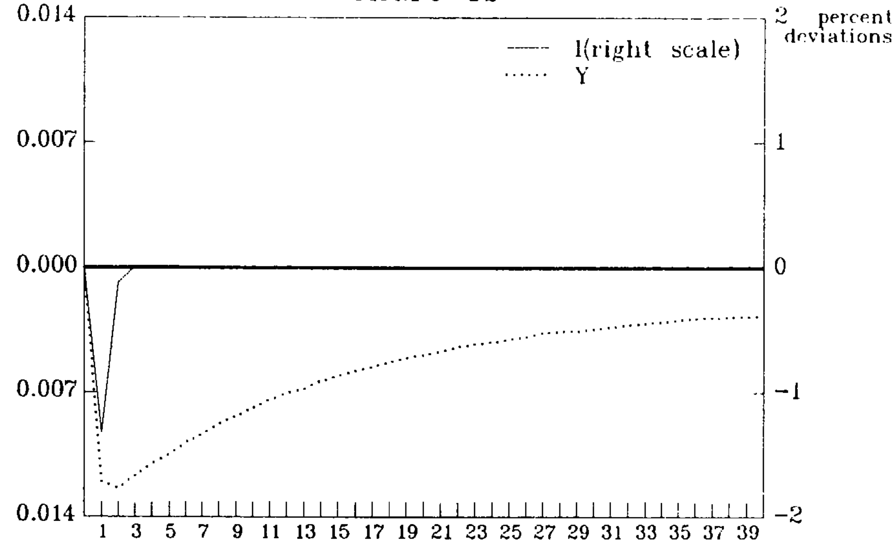


Chart 3c

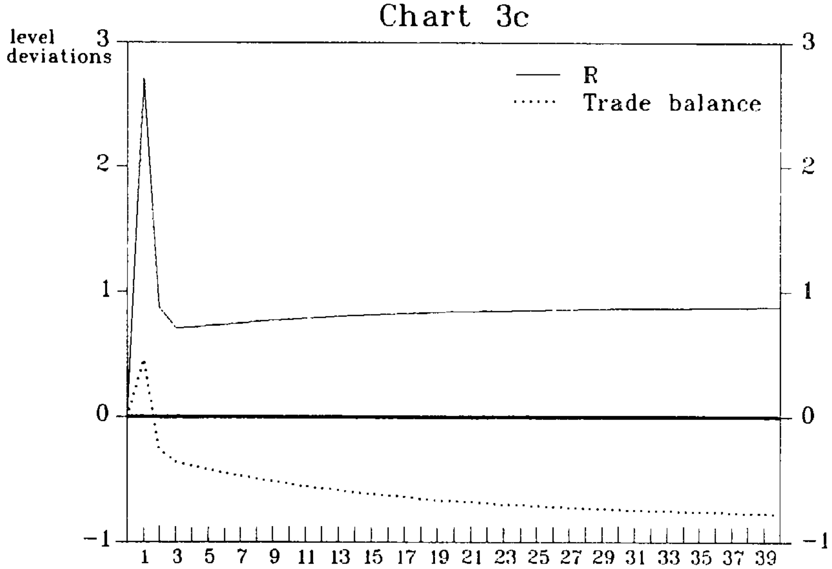
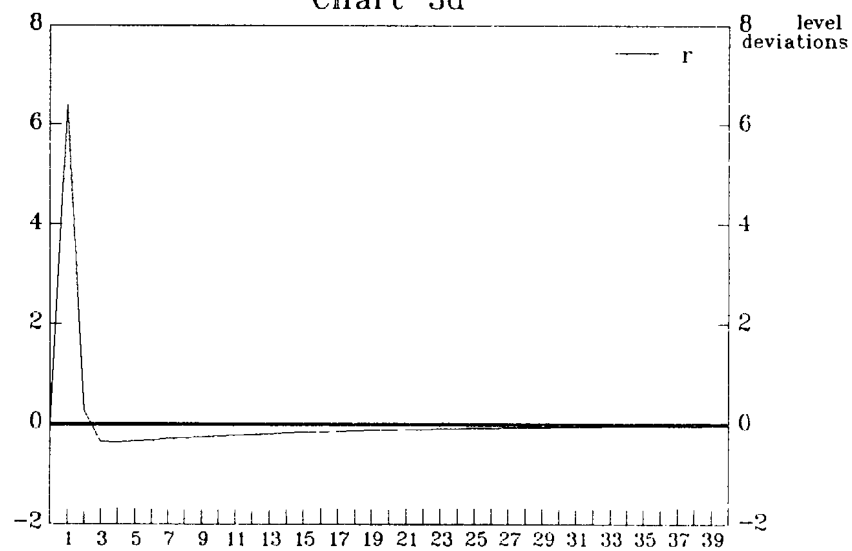


Chart 3d



Note: all charts reflect deviations from the steady state.

As already mentioned, prices fall in the second period. However, this decrease still leaves the price level above its steady-state level (Chart 3a). The reason for this is that, due to slow adjustment of exports and imports, a larger real appreciation is necessary in the short run to clear the home goods market in the presence of the increase in government demand than is needed in the steady state. Because prices remain relatively high in the second period, the real interest rate remains slightly above its steady-state level (Chart 3d), thus continuing to exert a depressing influence on domestic investment. By the third period, the domestic price level has fallen below its steady-state value, which it thereafter approaches from below. Since the price level is gradually rising, therefore, the domestic real interest rate also approaches its steady-state value from below.

The dynamic path of real output is governed by the effects of the real interest rate path described above on investment and thus on the domestic capital stock. After the initial drop in output, recovery sets in as the depleted capital stock stimulates a temporary increase in investment. Though investment remains slightly above its steady-state value for some time after the initial two periods, it takes time to restore the capital stock, so output remains below its equilibrium value, though on a rising trend, in the medium term (Chart 3b). In this model, therefore, the spending shift induces a dynamic response on the part of real output that can be described as contractionary in both the short run and the medium term, but with no change in the long run.

2. Anticipated permanent spending increase

The anticipation of a future increase in government spending on domestic goods has macroeconomic consequences before the spending shifts comes into play. These are brought about through the implications of such expectations for the domestic real interest rate. As shown above, the shift in spending will increase domestic prices on impact. The expectation of these higher future prices lowers the real interest rate in the first period, since arbitrage holds the nominal interest rate at its initial level (Chart 4d). Lower real interest rates stimulate both consumption and investment demand, thereby causing an immediate increase in the domestic price level (Chart 4a), which is accompanied by a capital inflow and an accumulation of foreign exchange reserves (Chart 4c). The higher level of investment increases the capital stock, raising real output in the first period (Chart 4b). The anticipated spending shift thus has expansionary output effects before the shock itself actually takes place.

When the spending shift occurs (in period 2), prices rise further and the real interest rate increases sharply (Charts 4a and 4d). These results are the same as observed when the spending shift is unanticipated. However, comparison of charts 4a and 3a indicates that the price level effect of the shift at the instant it occurs is greater when it is not anticipated than when it is. The mechanism that produces this result is similar to that which was described in connection with devaluation--i.e., the reserve increase in anticipation of the spending shift causes the latter to take place in the presence of less stringent import restrictions. The higher level of imports absorbs some of the demand pressure, muting the effect on prices. After the change in government spending is in place, the dynamics are again qualitatively similar to those that follow an unanticipated spending shift.

3. Temporary government spending increase

The dynamics of a temporary shift in government spending toward home goods are given in Charts 5a-5d. We have assumed that the shock takes place one period ahead and remains in place for five periods, after which it is completely removed. Notice that in this case the economy must return to its initial steady-state configuration, because the shock is not permanent.

For the period that the shock is announced (or becomes anticipated), and through the first two periods of the shock's duration, the economy's dynamic responses are qualitatively very similar to the case of an anticipated permanent fiscal shock, described above. Quantitatively, however, comparison of Charts 5a and 5d to Charts 4a and 4d reveals that in the case of the transitory shock the initial burden of demand adjustment falls relatively less heavily on the price level and more heavily on the real interest rate--i.e., the peak increase in the price level is smaller in the present case than in the case of the permanent shock, and the opposite is true of the real interest rate.

The reason for this is the forward-looking nature of expectations. When the spending shift is reversed at the end of the sixth period, domestic prices must fall (this corresponds to the lowest point for P in Chart 5a). In anticipation of this, the real interest rate must be high in the previous (i.e., the fifth) period. But because demand is being restrained by the high real interest rate in that period, the price level can be correspondingly lower. This lower price level, in turn, sustains a high (but not quite so high) real interest rate in the previous (i.e., the fourth) period, and so on. Thus, the real interest rate remains above its steady-state level while the shock is in place, and indeed rises toward the end of the shock (Chart 5d), while the price level falls increasingly below its own steady-state level--despite the exogenous increase in demand for domestic goods represented by the spending shift--for the duration of the shock. For the last three periods of the shock, the burden of demand restraint falls increasingly on the real interest rate and decreasingly on the price level. When the shock is removed, the price level and the real interest rate both fall, the latter in anticipation of a price level recovery in the subsequent period, when further demand shocks are anticipated. Reserve dynamics follow the path of prices (Chart 5c), while the behavior of output is governed by the spell of high real interest rates that accompanies the fiscal shock while it is in place (Charts 5d and 5c).

Anticipated Fiscal Shock
(second period)

Chart 4a

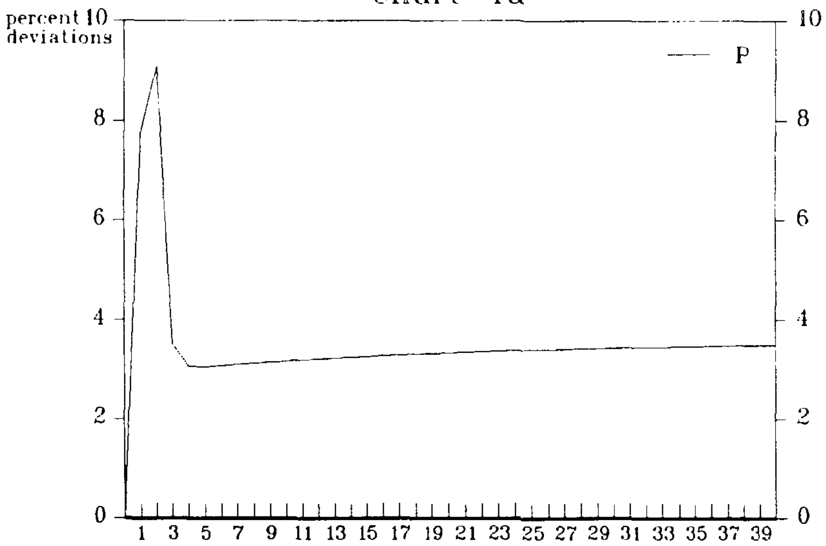


Chart 4b

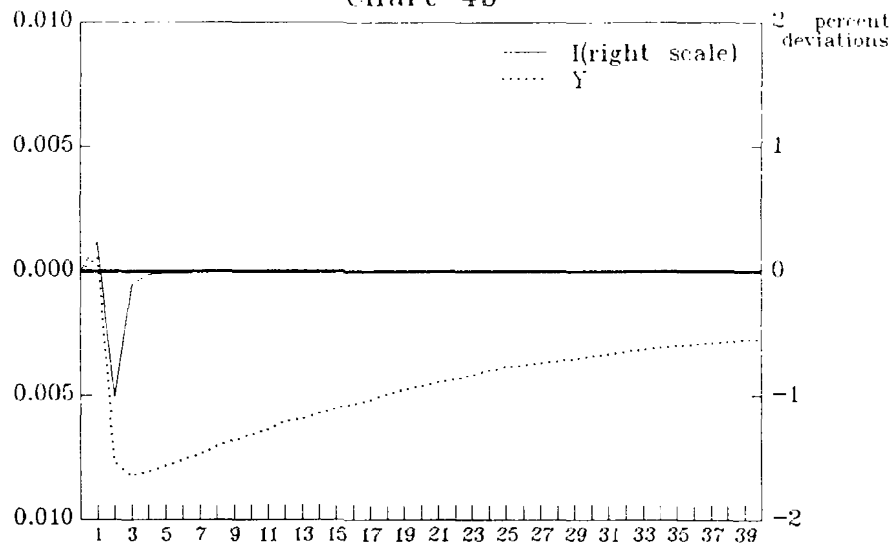


Chart 4c

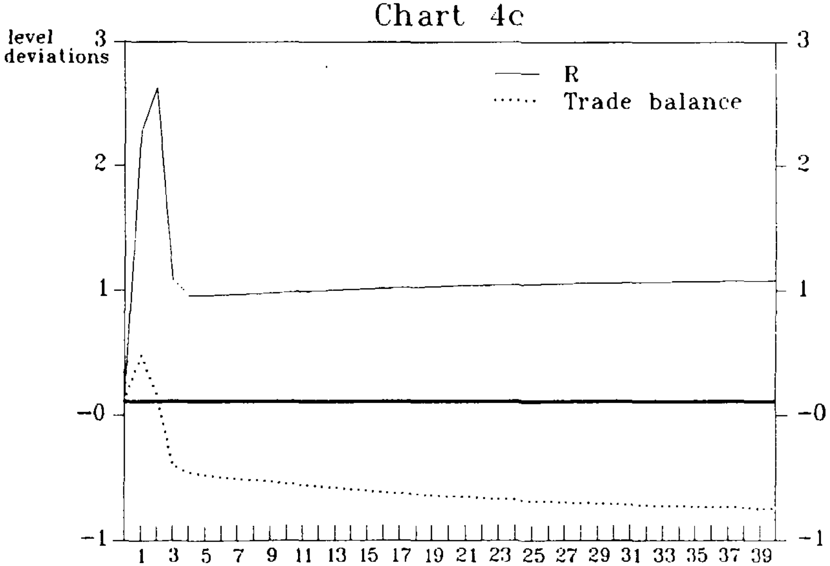
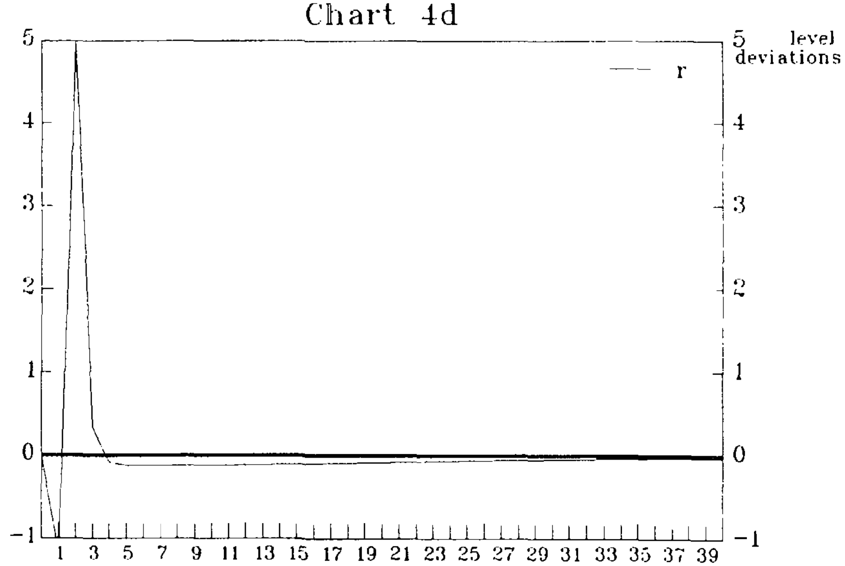
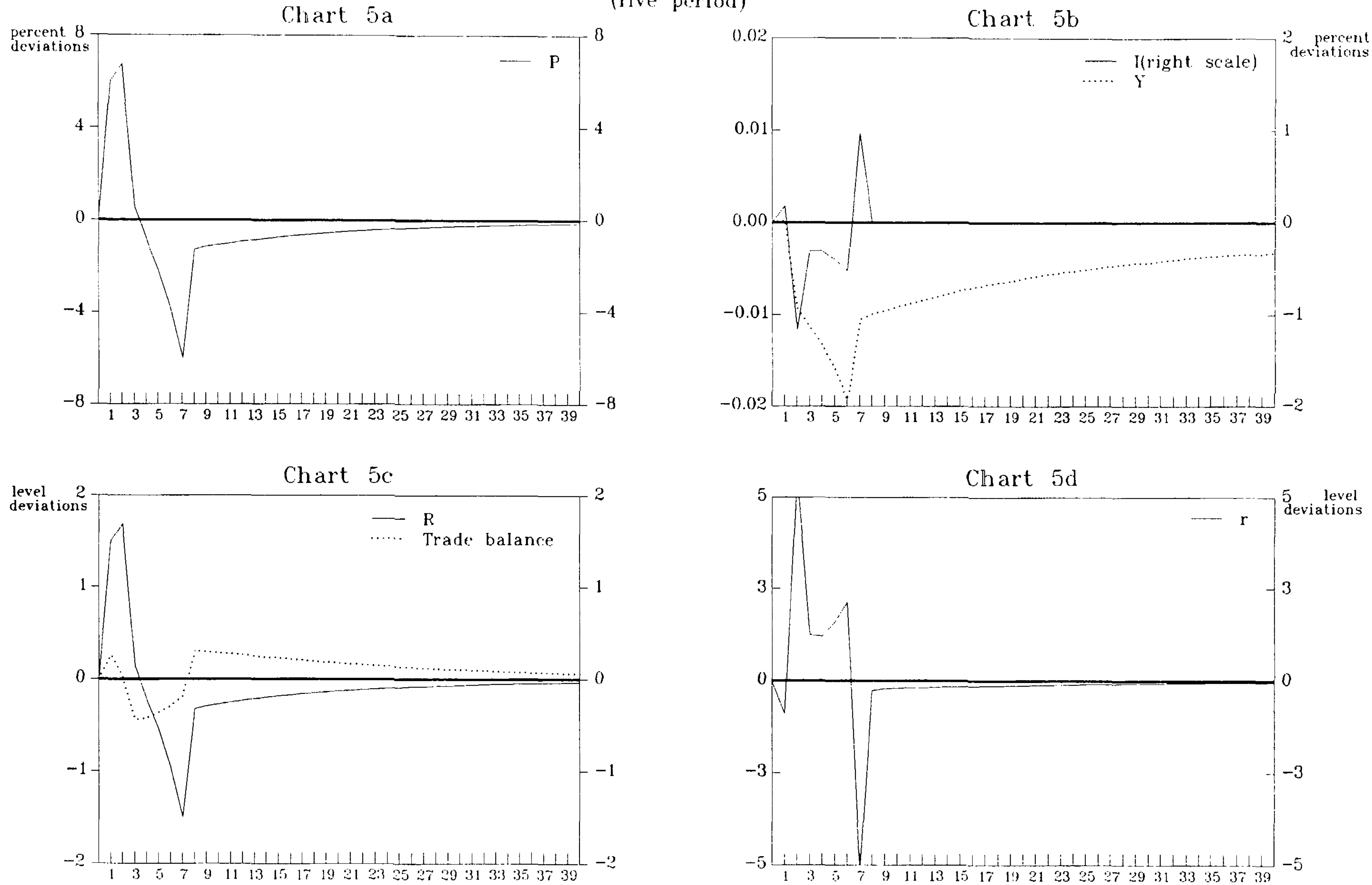


Chart 4d



Note: all charts reflect deviations from the steady state.

Temporary Fiscal Shock
(five period)



Note: all charts reflect deviations from the steady state.

C. Domestic credit shock

The final policy shock examined is a permanent increase in the stock of domestic credit to the private sector, announced and implemented simultaneously in the first period. Since this economy is characterized by perfect capital mobility--in the sense that uncovered interest parity holds continuously--the standard "monetary approach to the balance of payments" (MABP) analysis would suggest that the credit expansion would displace an equivalent amount of reserves in the central bank's balance sheet, leaving all else unaffected. This does not happen in the model under examination, however, because of the role of the reserve stock in determining the severity of import restrictions--i.e., because the authorities look at their own gross stock of reserves when setting the degree of import restrictions. 1/ Thus the reserve outflow caused by a credit expansion gives rise to an increase in the severity of import restrictions which produces long-lasting macroeconomic effects.

This is illustrated for the steady-state configuration in Figure 4. Since DC_p only appears in equation (12'), only the locus MM is affected by the credit expansion. Since (12') would continue to hold if $edR = -dDC_p$, the MM locus shifts downward by the amount of the credit expansion, to a point like C at the original domestic price level P_0. The consequent loss of reserves at C, amounting to $(R_0 - R_2)$ in Figure 4, is that which would be observed in the MABP case, since without the feedback from reserves to imports the locus DD would be vertical, passing through both A and C and resulting in a new steady-state equilibrium at C. In this model, however, the loss of reserves triggers a tightening of import restrictions. This shifts demand toward the domestic good, raising the domestic price level and thereby containing the loss of reserves. This mechanism results in a new steady-state equilibrium at B, rather than C, with both reserves and output higher than would be observed in the MABP case, but nevertheless with lower reserves and higher prices than in the absence of the credit expansion.

The dynamics of adjustment to the new steady state at B are rather simple, and are depicted in Charts 6a-6d. The initial credit expansion generates a capital outflow which results in a loss of reserves (Chart 6c). Since this will induce a tightening of import restrictions in the

---

1/ Under perfect capital mobility, one might question why they should do so, since a reserve target could readily be attained by altering the stock of domestic credit, thereby inducing private capital flows that would permit achievement of a reserve target. Implicitly, it is assumed that the authorities face constraints--perhaps in the form of imperfect control over the supply of domestic credit--that do not permit credit policy to be flexibly adjusted to this end. An alternative specification--in which import restrictions depend on the sum of the foreign exchange held by the central bank and the private sector (which might be more reasonable when capital mobility is high)--is explored in a separate paper (see Haque and Montiel (1990)).

next period, domestic prices will rise at that time, in anticipation of which the first-period real interest rate falls (Chart 6d). But this decline in the real interest rate stimulates domestic consumption and investment, which means that domestic prices must also rise on impact (Chart 6a). Because investment has risen, the capital stock increases, and output rises (Chart 6b). Thus the credit increase works through a reduction in the real interest rate to exert expansionary effects on both domestic prices and output on impact.

As the import restrictions take hold in the second period, domestic prices rise as expected (Chart 6a). Reserves consequently recover somewhat (Chart 6c). The price level must overshoot its steady-state value in the second period, because short-run trade elasticities are smaller than long-run elasticities, requiring a larger real appreciation to clear the domestic goods market. Since the price level will be expected to fall from this point, the real interest rate exceeds its steady-state value in the second period (Chart 6d). This recovery in the real interest rate depresses investment and halts the output expansion (Chart 6b). From this point, the price level and the real interest rate begin to fall toward their steady-state values, with international reserves following domestic prices due to the impact of the latter on money demand.

IV. Dynamic Responses to External Shocks

The economy modelled in Appendix I is affected by changes in both foreign interest rates and incomes. Because the country is small and uncovered interest parity holds continuously, the fixed nominal exchange rate implies that the domestic nominal interest rate must adjust to the nominal interest rate that prevails externally. Also, since domestic output is an imperfect substitute for the output of the rest of the world, foreign incomes affect the foreign demand for domestic output. 1/ In this section we examine the effects of unanticipated permanent shocks in both of these variables, foregoing the analysis of anticipated or transitory shocks to avoid taxonomy.

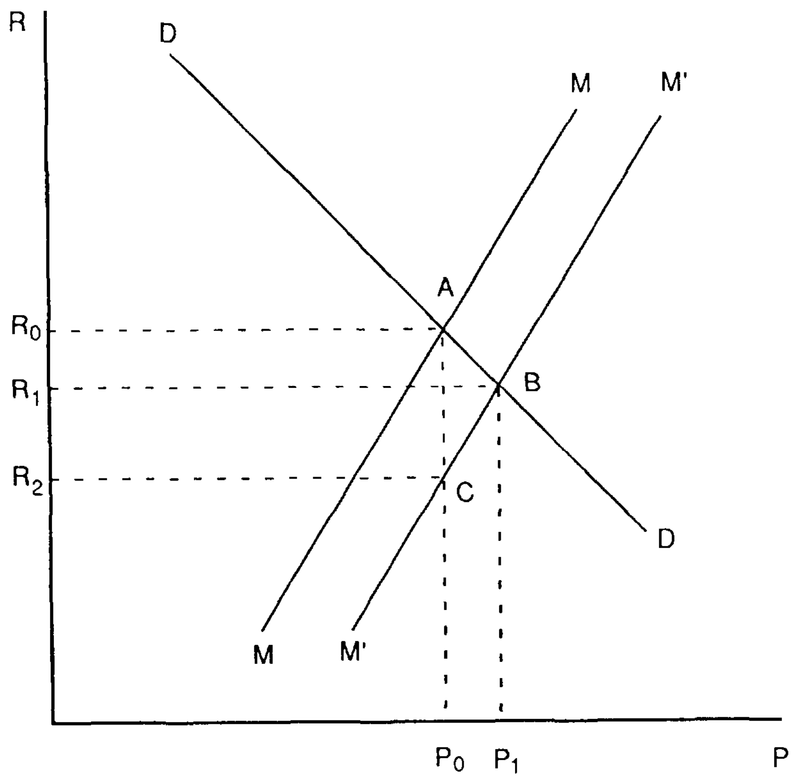
A. Permanent increase in the external interest rate

Unlike the previous shocks, an increase in the external interest rate affects both of the steady-state loci described above, because the foreign interest rate enters both equation (12') and (1'). An increase in i^* reduces the real demand for money, requiring an increase in the price level to clear the money market, thus causing MM to shift to the right, to a position such as $M'M'$ in Figure 5. At the same time, the increase in i^* has contractionary effects on the demand for domestic

1/ A third link to the rest of the world, through foreign prices, is also present in the model. To save space, however, we will not describe the effect of shocks to this variable.

Figure 4

STEADY-STATE EFFECTS OF DOMESTIC CREDIT EXPANSION



Credit Shock

Chart 6a

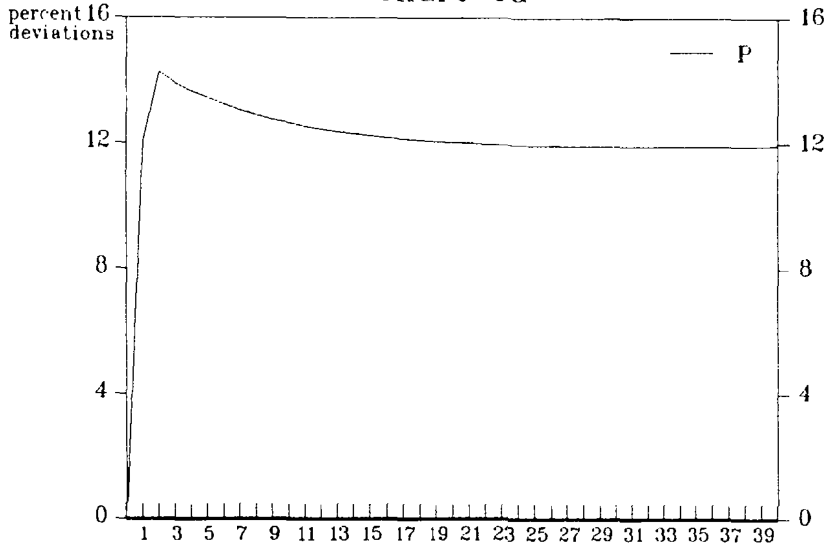


Chart 6b

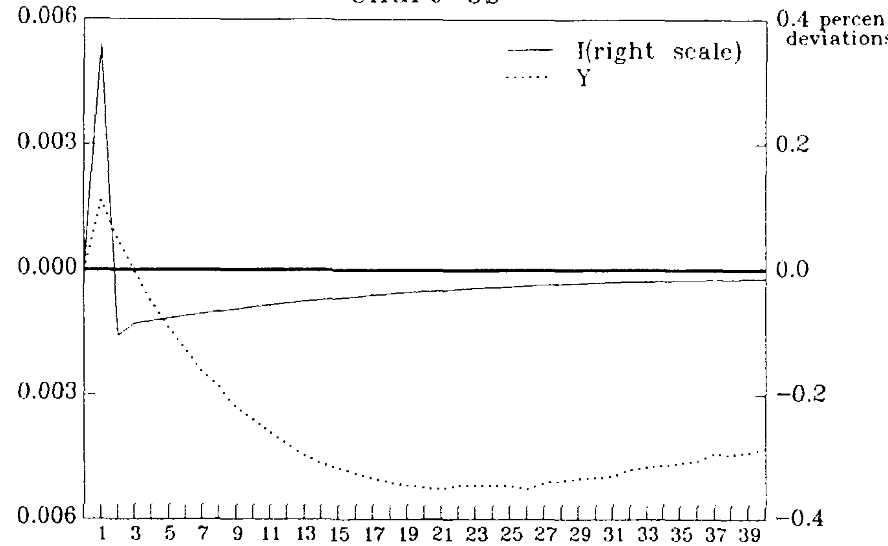


Chart 6c

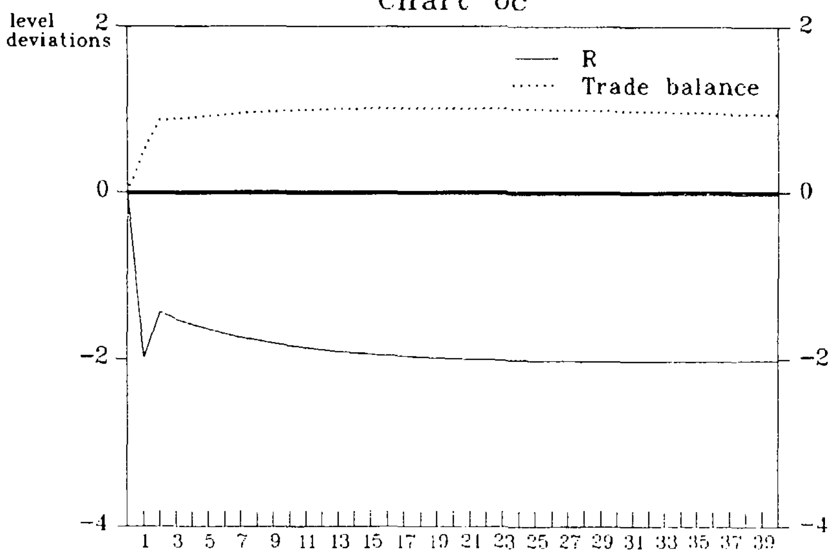
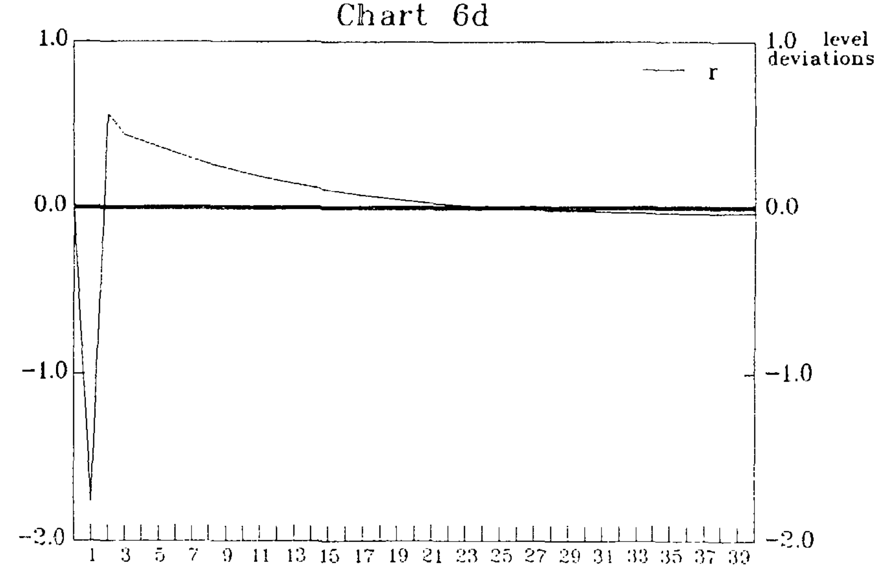


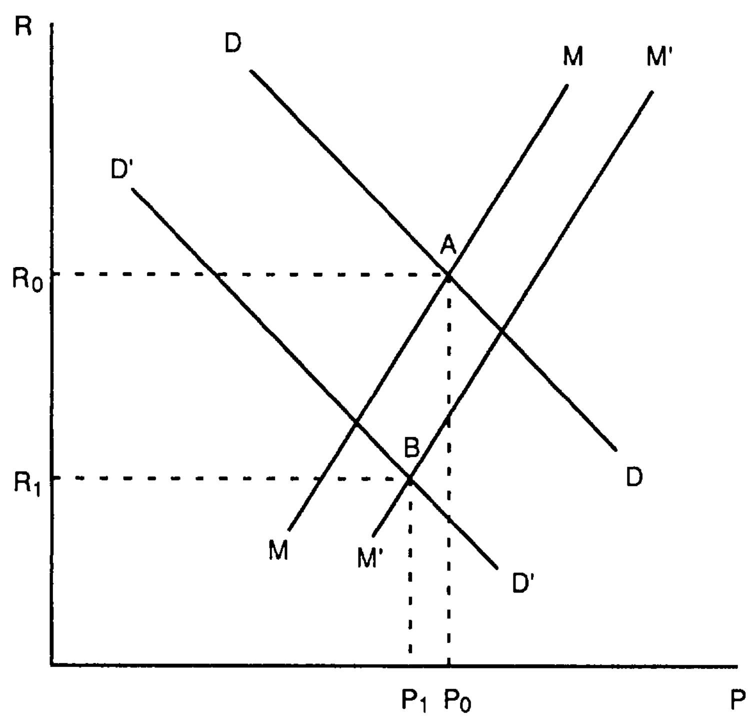
Chart 6d



Note: all charts reflect deviations from the steady state.

Figure 5

STEADY-STATE EFFECTS OF AN INCREASE IN THE EXTERNAL INTEREST RATE



output, so DD shifts to the left, to a position such as D´D´ in Figure 5. The steady-state effect on international reserves is theoretically unambiguous--they must fall, as depicted in Figure 5. On the other hand, while the effect on domestic prices is ambiguous in theory, our estimated parameters and reference data imply that the domestic price level must fall--i.e., the equilibrium real exchange rate depreciates, because the downward shift in the DD curve exceeds that in the MM curve. Incidentally, notice that this is the result that would, in any case, emerge if DD were vertical--in other words, if the effect of reserves on import restrictions were absent from the model.

It is worth noting as well that in this case, unlike all the others analyzed in this paper, the long-run level of output is affected. The increase in the steady-state interest rate depresses investment, which in turn implies a reduction in the size of the capital stock that can be maintained in the long run, and consequently in the level of output produced.

The dynamics of adjustment to the new steady-state equilibrium are again rather simple. Since no devaluation is anticipated, the domestic nominal interest rate adjusts immediately to the new level of the external rate. Because of lags in the response of domestic absorption to a change in the real interest rate, however, the price level cannot adjust immediately to its new lower steady-state value. If it did so, a state of excess demand would exist in the domestic commodity market, since domestic absorption would remain in excess of its steady-state level. Thus, the price level must fall in the first period, but not all the way to its steady-state value. Since reserves fall in the first period, following domestic prices (Chart 7c), import restrictions are tightened in period 2, causing a slight increase in the price level. Because this is anticipated in the first period, the increase in the first-period domestic real interest rate falls short of its steady-state value. On impact, therefore, both prices and the real interest rate move partially toward their steady-state value.

Since domestic prices resume their downward adjustment after the second period, the real interest rate must overshoot its steady-state value from the second period on (Chart 7d). Adjustment in both prices and the real interest rate is monotonic and quite prolonged. As in previous cases, the behavior of real output follows that of the real interest rate. Output falls sharply on impact and in the second period. It continues to fall gradually to its lower steady-state value, as the prolonged duration of high real interest rates depresses investment and gradually depletes the capital stock. This shock is contractionary on impact, during the transition, and in the long run.

B. <u>An increase in external demand</u>

An increase in external demand (Y^* in Appendices I and II) affects the demand block (block IV) in the steady-state model, but not the monetary block (block III). An increase in export demand is expansionary, requiring an increase in domestic prices at a given value of R to restore equilibrium in the domestic commodity market. Thus the DD curve shifts to the right. Qualitatively, the situation is similar to that which arises from a permanent shift in government spending toward home goods depicted in Figure 2--international reserves rise and the real exchange rate appreciates in steady state.

The dynamics of adjustment take on a now-familiar form. Prices rise on impact, reflecting the expansionary demand stimulus from abroad (Chart 8a). The real interest rate shows a small initial increase, reflecting an anticipated reduction in the price level in period 2 due to an easing of import restrictions induced by a first period reserve gain (chart 8c). Due to partial adjustment in the export function, the demand stimulus arising from the increase in foreign income builds gradually over time to its steady-state level. Since this source of demand pressure thus rises over time, domestic prices must follow a rising trend after period 2. This means that the real interest rate must lie below its steady-state value during this time (Chart 8d). The requirement that the domestic price level rise to its steady-state value explains why the period 2 level of prices must be below that value (Chart 8a). Finally, even after the adjustment of exports to the (once and for all) foreign demand shock is effectively complete, adjustment lags in the export and import functions imply that the trade balance will not have fully adjusted to past price changes. Thus the domestic price (and consequently the real interest rate as well) must slightly overshoot its steady-state level, approaching that level from above.

The dynamics of reserves and real output follow those of prices and the real interest rate, respectively. Reserves rise on impact and decrease slightly (following the price level) the second period, recovering gradually thereafter in close similarity to the path of the domestic price level (Chart 8c). Output falls in the short run, due to the effect of the higher domestic real interest rate on the capital stock. As the real interest falls below its steady-state level and remains there for a prolonged period, however, investment and the capital stock recover, pushing output toward its steady-state level (Chart 8b). The overshooting of the real interest rate causes investment to once again fall below its steady-state value, bringing the expansion of output to a halt. Investment and output gradually recover their steady-state levels from below.

V. Summary and Conclusions

In each of the simulations described above, the dynamic response of the economy to a shock emerges from the interaction of several important features of the model employed. These include price flexibility, rational expectations, perfect capital mobility, and endogenous import restrictions. The qualitative properties of the adjustment paths generated by the shocks we have studied depend on these properties, and are not very sensitive to parameter values (such as response speeds in the behavioral

Foreign Interest Rate Shock

Chart 7a

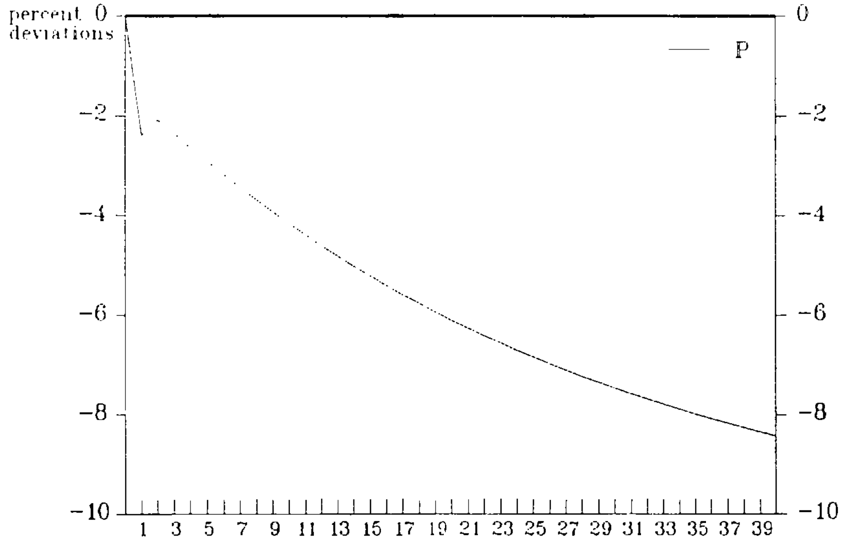


Chart 7b

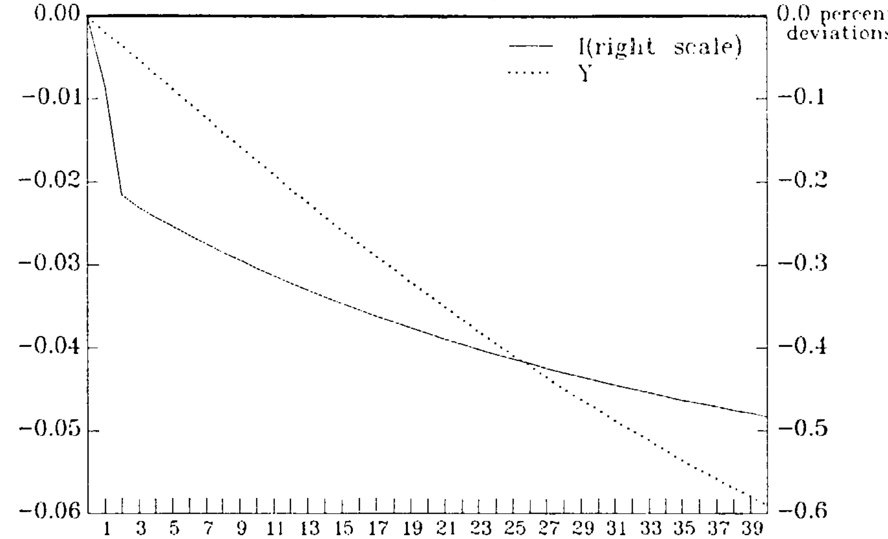


Chart 7c

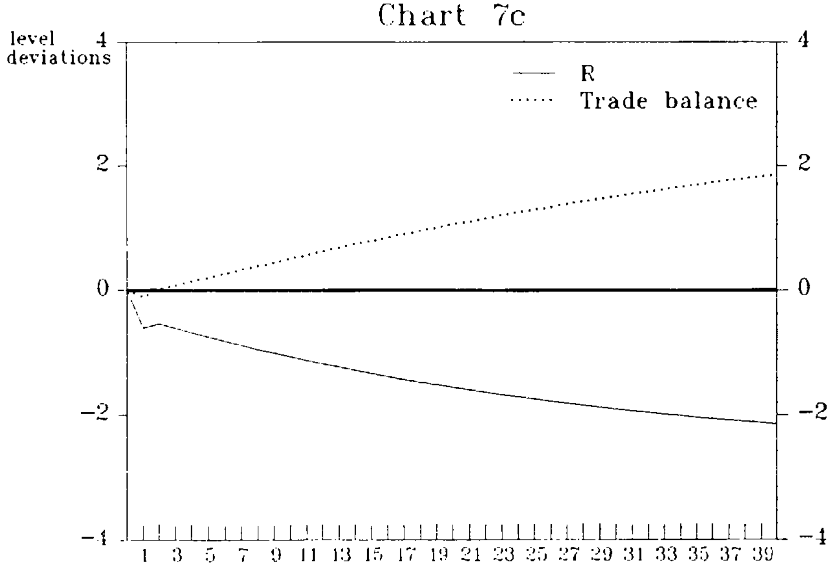
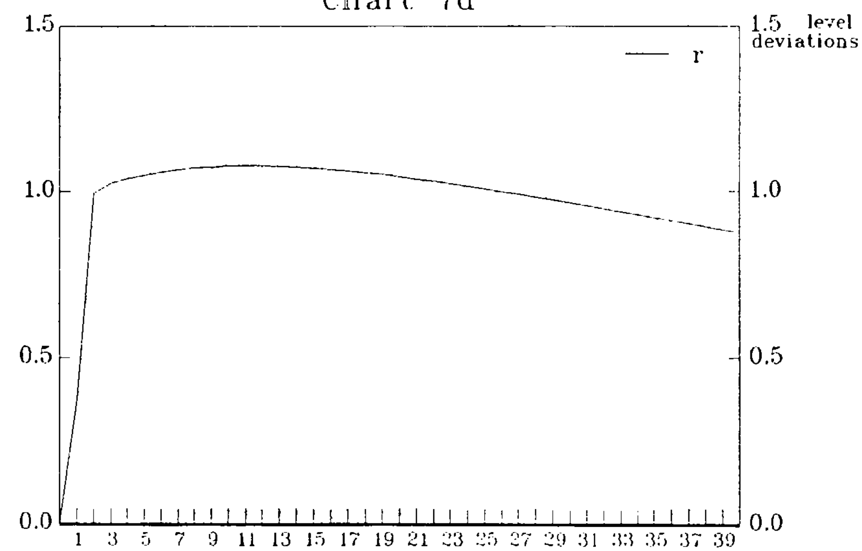


Chart 7d



Note: all charts reflect deviations from the steady state.

External Demand Shock

Chart 8a

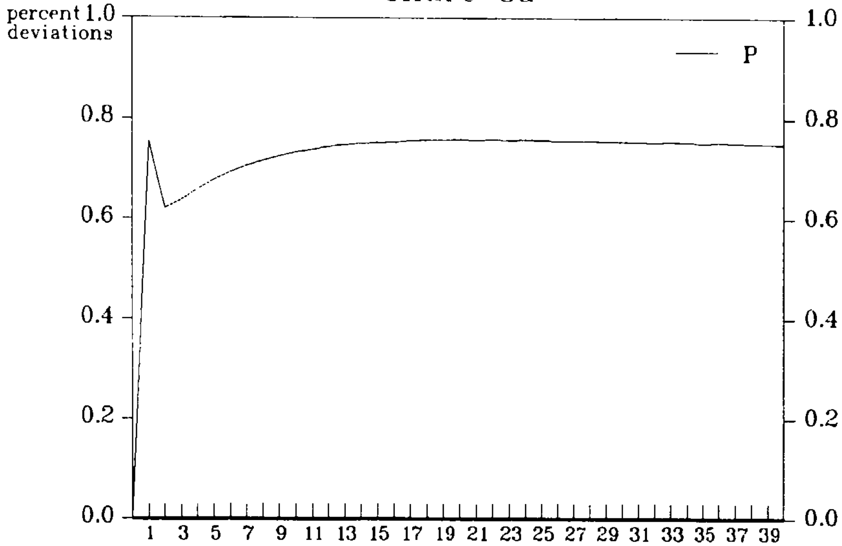


Chart 8b

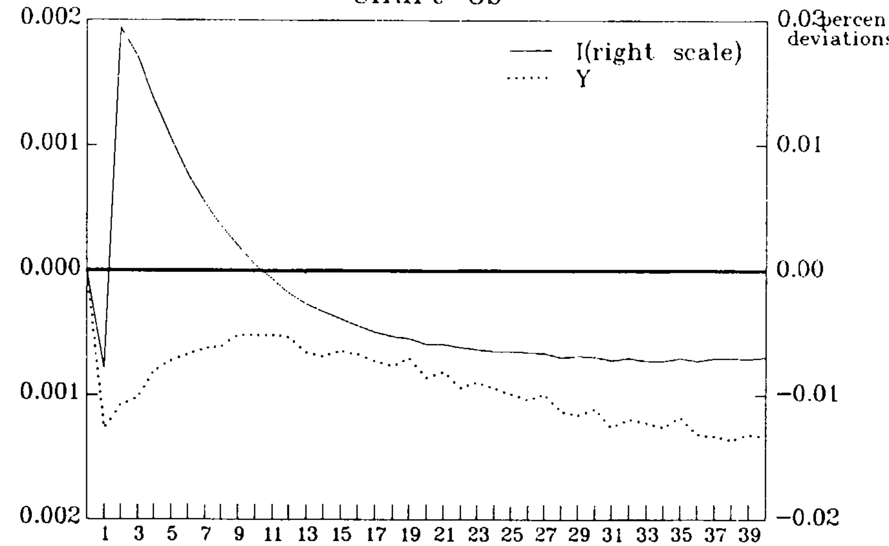


Chart 8c

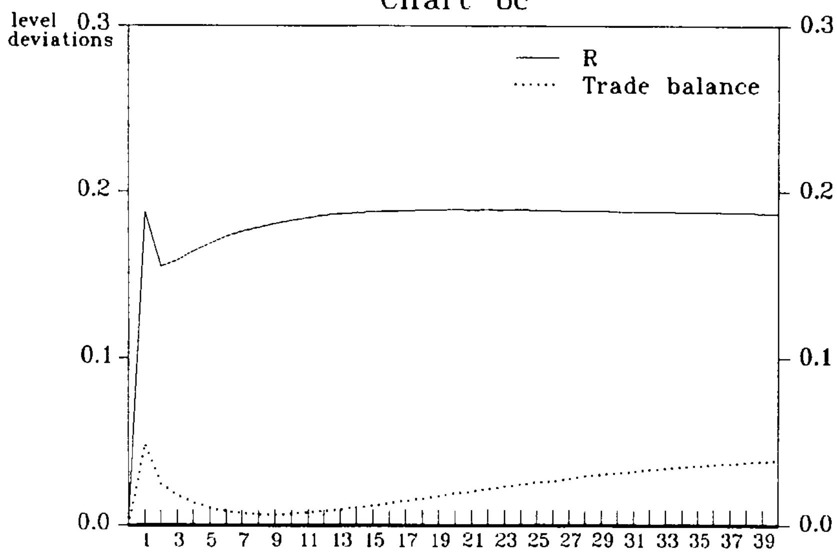
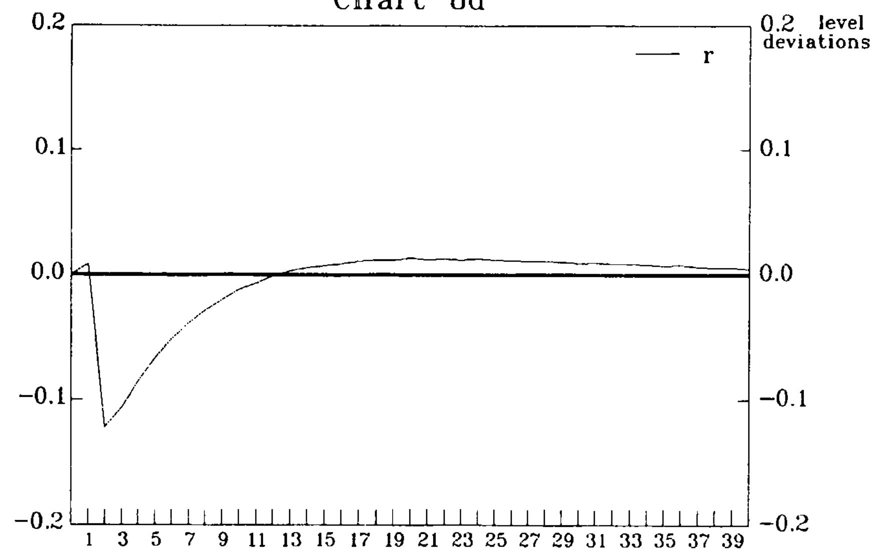


Chart 8d



Note: all charts reflect deviations from the steady state.

equations) that leave these features unchanged. At the most general level, therefore we would offer the following conclusion. Properties of developing-country economies about which no consensus currently exists among knowledgeable observers (i.e., the degree of wage-price flexibility, the extent of capital mobility, etc.) are crucially important for determining the "real time" response of such economies to both policy and exogenous shocks. 1/ While a convergence of views may emerge about certain steady-state properties of developing-country models, say for example, that expectations should be correct, prices flexible, and capital mobility perfect, these tell little about the process of adjustment.

This conclusion has important implications for both policy and research on developing-country macroeconomics. Regarding policy, the implication is that the state of our knowledge for most developing countries suggests that real-time macroeconomic "fine-tuning" is likely to be very difficult, because the dynamic responses of the system to the policies one might choose to administer will in most cases be highly uncertain. With respect to research, the obvious suggestion is that much needs to be learned about the empirical relevance in particular developing economies of structural features such as those listed above that proved to be critical in determining the nature of adjustment paths in our model. The empirical approach adopted in Haque, Lahiri, and Montiel (1990) yields evidence about the degree of capital mobility, while maintaining the hypotheses of price flexibility and rational expectations. More research is needed on both of the latter. However, given data limitations in developing countries, progress is likely to be slow.

In the meantime, the relevance of the particular substantive results derived in our simulations depends, of course, on one's readiness to accept these maintained hypotheses. Conditional on their validity, some of our salient findings are as follows:

- The speed of adjustment, even to permanent shocks that are perceived as such, can differ markedly across shocks. In the case of devaluation and a permanent shift in government spending, for example, after three years the economy is essentially in the vicinity of its steady state. By contrast, adjustment to an external interest rate shock is quite protracted.

- As is familiar in rational expectations models, the macroeconomic effects of shocks depend on whether they are anticipated or not. In this model, an important difference between anticipated and unanticipated shocks is that, in the context of endogenous import restrictions, the degree of severity of such restrictions in place when the shock actually occurs depends on whether the shock had previously been anticipated.

1/ This is confirmed in Haque and Montiel (1990), where the dynamic effects of devaluation are shown to be highly sensitive to features of this type.

• As is also familiar from such models, shocks begin to exert macroeconomic effects when they first become anticipated, rather than when they actually occur. This is particularly evident in the case of devaluation, where the anticipation of an impending change in the exchange rate gives rise to capital flight, which in turn causes a tightening of import restrictions that later increase the price level effects of devaluation.

• Output dynamics suggest that it is meaningless to ask whether particular shocks are contractionary unless the time frame is specified. In the case of devaluation, for example, we found a contractionary effect in the short run, but no effect in the long run.

• Finally, endogenous import restrictions were found to have important effects, not only on the dynamics, but also in the steady state. Because of such restrictions, a nominal devaluation results in a long-run real depreciation in our model, and changes in the stock of domestic credit have real effects, even in the presence of perfect capital mobility.

These conclusions, while conditional on the specified model and the form of the simulation experiments, may not appear particularly controversial. Nonetheless, without a model at hand of the type we have employed, they would be difficult to verify. Certainly getting a handle on the time paths taken by the key macroeconomic variables after a shock would be out of the question. The next stage in the exercise could be the derivation of the paths of the policy variables, either taken individually or in a combination, to achieve the desired impact, transition, and steady-state values of the target variables--output, balance of payments, prices, real exchange rate, etc. The model we have developed and analyzed can be readily used towards such an end.

Structure of the Dynamic Model

$$Y_t = C_t + I_t \; X_t - \frac{e_t P^*_t Z_t}{P_t} + G_t \tag{1}$$

$$\log C_t = \alpha_o - 0.12 \; r_t + 0.99 \log C_{t-1} + 0.34 \log Y^d_t - 0.33 \log Y^d_{t-1} \tag{2}$$

$$Y^d_t = Y_t + i^*_t e_t \frac{F_{p,t}}{P_t} - i_t \frac{DC_{p,t}}{P_t} - T_t \tag{3}$$

$$Y^d_t = C_t + I_t + \left\{(M_t - M_{t-1}) + e_t(F_{p,t} - F_{p,t-1}) - (DC_{p,t} - DC_{p,t-1})\right\}/P_t \tag{4}$$

$$\log I_t = k_o - 0.207 \; r_t + 0.199 \log Y_t + 0.815 \log K_{t-1} \tag{5}$$

$$\log X_t + \tau_o + 0.054 \frac{e_t P^*_t}{P_t} + 0.106 \log Y^*_t + 0.927 \log X_{t-1} \tag{6}$$

$$\log (e_t \; Z_t/P_t) = \delta_o - 0.129 \log \frac{e_t P^*_t}{P_t} + 0.135 \log Y_t$$

$$+ 0.061 \log \frac{R_{t-1}}{P^*_{t-1} Z_{t-1}} + 0.847 \log \frac{e_{t-1} Z_{t-1}}{P_{t-1}} \tag{7}$$

$$\log Y_t + q_o + 0.162 \log K_t + 0.838 \log L_t \tag{8}$$

$$K_t = I_t + 0.95\, K_{t-1} \tag{9}$$

$$M_t = e_t\, R_t + DC_t \tag{10}$$

$$DC_t = DC_{p,t} + DC_{G,t} \tag{11}$$

$$\log \left(\frac{M_t}{P_t} \right) = \beta_o - 0.055\, i_t + 0.203 \log Y_t + 0.796 \log \left(\frac{M_{t-1}}{P_{t-1}} \right) \tag{12}$$

$$i_t = i^*_t + \frac{E_t e_{t-1} - e_t}{e_t} \tag{13}$$

$$CA_t + p_t\, X_t - e_t\, p^*_t\, Z_t + i^*_t\, e_t\, (F_{p,t-1} + F_{G,t-1}) \tag{14}$$

$$e_t \Delta R_t = CA_t - e_t(\Delta F_{G,t} + \Delta F_{p,t}) \tag{15}$$

$$r_t = i_t - \frac{E_t P_{t+1} - P_t}{P_t} \tag{16}$$

$$\Delta F_{G,t} - \Delta DC_{G,t} = P_t \; (T_t - G_t - (e_t P^*_t / P_t) \; GZ_t) + i^*_t \; e_t \; F_{G,t-1} - i_t DC_{G,t} \tag{17}$$

$$e_{t+1} = E_t \left(e_{t+1} | \Omega_t \right) \tag{18}$$

$$P_{t+1} = E_t \left(P_{t+1} | \Omega_t \right) \tag{19}$$

Definition of Variables

Y = real GDP

C = real private consumption expenditures

I = total real investment expenditures

G = government expenditure on domestic goods

X = real exports

e = nominal exchange rate (price of foreign currency in domestic currency terms

P^* = foreign-currency price of imports

P = domestic-currency price of domestic goods

Z = real imports in terms of the foreign goods

r = real rate of interest

Y^d = real disposable income

F_p = stock of foreign assets held by the private sector (measured in foreign currency terms)

DC_p = stock of domestic bank credit held by the private sector

i = nominal interest rate

T = real taxes

M = money supply (nominal)

K = aggregate capital stock

Y^* = real foreign income

R = reserves

DC = total domestic credit

DC_G = domestic credit to the public sector

CA - current account of the balance of payments

F_G - foreign assets held by nonfinancial public sector

L_t - population

Structure of the Steady-state Model

I. Interest Rates

$$i_t = i_t^*$$ (13)

$$r_t = i_t$$ (16)

II. Output-Capital block

$$\log I = k_o - 0.207\ r + 0.199 \log Y + 0.815 \log K$$ (5)

$$\log Y = q_o + 0.162 \log K + 0.838 \log L$$ (8)

$$I = 0.05K$$ (9)

III. Monetary block

$$M = eR + DC$$ (10)

$$DC = DC_p + DC_G$$ (11)

$$\log (M/P) = \tilde{\beta}_o - 0.27\ i + \log Y$$ (12)

IV. Demand block

$$Y = C + I + G + X - eP^*Z/P$$ (1)

$$\log C = \alpha_o + 12\ r + \log Y^d$$ (2)

$$Y^d = Y + \frac{i^* e\ F_p}{P} - i\ \frac{DC_p}{P} - T$$ (3´)

$$\log X = \tilde{\gamma}_o + 0.74 \log(eP^*/P) + 1.45 \log Y^*$$ (6)

$$\log Z = \tilde{\delta}_o + 0.84 \log (eP^*/P) + 0.882 \log Y + 0.399 \log (R/P^*Z)$$ (7)

$$CA = PX - eP^* (Z + GZ) + i^*e\ (F_p + F_G + R)$$ (8)

$$CA = 0$$ (9)

$$eP^*GZ = P(T - G) + i^*e\ (F_G + R) + iDC_p$$ (17)

References

Agenor, P. R., "Stabilization Policies in Developing Countries with a Parallel Market for Foreign Exchange: A Formal Framework," IMF unpublished (January 1990).

Blanchard, O. and C. Kahn, "The Solution of Linear Difference Models Under Rational Expectations," Econometrica, Vol. 48, No.5 (July 1980), pp. 1305-1311.

Corden, W. M., "Macroeconomic Adjustment in Developing Countries," World Bank Research Observer, Vol. 4, (January 1989) pp. 51-64.

Haque, N., K. Lahiri, and P. Montiel, "An Econometric Rational Expectations Macroeconomic Model for Developing Countries with Capital Controls," IMF unpublished (February 1990).

Haque, N., and P. Montiel, "Is Devaluation Contractionary? The Roles of Wage Flexibility and Capital Mobility," Draft (March 1990).

_____, P. Montiel, and S. Symanski, "A Forward-Looking Macroeconomic Simulation Model for a Developing Country," International Monetary Fund, WP/89/53 (June 1989).

International Monetary Fund, IMF Survey, (July 15, 1989).

Khan, M. and M. Knight, "Stabilization Programs in Developing Countries: A Formal Framework," IMF Staff Papers, Vol. 28 (March 1981), pp. 1-53.

_____, "Import Compression and Export Performance in Developing Countries," Review of Economics and Statistics, (May 1988), pp. 315-321.

Lizondo, S., and P. Montiel, "Contractionary Devaluation in Developing Countries: An Analytical Overview," IMF Staff Papers, Vol. 36 (March 1989), pp. 182-227.

Ocampo, J. A., "The Macroeconomic Effect of Import Controls: A Keynesian Analysis," Journal of Development Economics, Vol. 27 (October 1987), pp. 285-305.