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MONETARY AND FISCAL POLICY UNDER PERFECT FORESIGHT: A SYMMETRIC TWO COUNTRY ANALYSIS

Stephen J. Turnovsky

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ABSTRACT

This paper analyzes the effects of anticipated and unanticipated domestic monetary and fiscal expansions on both the domestic and foreign economies. The analysis is based on symmetric behavior, which is not only not an unreasonable first approximation, but also offers significant analytical advantages. Specifically, it enables the dynamics of the system to be decoupled into (a) averages and (b) differences of relevant variables. Not only does this render the analysis tractable, but it also helps provide economic insight. One striking aspect is that the differences, but not the averages, respond to announcements. The consequences of this for the dynamic adjustments of the two economies to the various disturbances are discussed at length.

Stephen J. Turnovsky
Department of Economics
University of Illinois
1206 South Sixth Street
Champaign, IL 61820
(217) 333-2354

1. INTRODUCTION

The last decade has witnessed an explosion of literature analyzing exchange rate dynamics under rational expectations and efficient markets. This work focuses almost exclusively on small open economies, with virtually no attention being devoted to large two country models.[1/] Presumably, the main reason for this neglect is the technical difficulty of computing and analyzing rational expectations equilibria in these more complex models.

In this paper we analyze the effects of monetary and fiscal policies in a two country macro model of two symmetric economies. The assumption of symmetry is not unreasonable as a first approximation, since there is no a priori reason for say the United States and Europe to differ in terms of their aggregate behavior in any systematic way. Further, this assumption is being adopted extensively in the current literature applying game theory to problems of international policy coordination.[2/] It has the enormous advantage of allowing one to exploit a method introduced by Aoki (1981). This procedure enables the dynamics of the system to be decoupled into: (a) averages and (b) differences of the relevant variables. Not only does this render the analysis tractable, but it also helps provide insight into the analysis.

The main focus of our analysis will be on the impact of monetary and fiscal expansions in one economy, say the domestic, on both the domestic and foreign economies. The decomposition of the dynamics into averages and differences makes it clear how the anticipations of future policy changes, which operate through their impact on the current exchange rate, affect the two economies in offsetting ways in the short run. Thus, for example, we shall demonstrate how the anticipation of a future domestic monetary expansion will, in the short run, generate increased output and inflation domestically, while causing a recession and deflation abroad. The anticipation of a fiscal expansion has the opposite effects in the two economies during the initial phase of the adjustment.

The remainder of the paper is as follows. Section 2 describes the model. The steady state and the solution to the dynamics are discussed in the following two sections. The effects of both unanticipated and anticipated domestic monetary expansions are analyzed in Section 5 while Section 6 deals with fiscal expansion. The conclusions are contained in Section 7. The formal details of the solution are contained in the appendix.

2. A TWO COUNTRY MACROECONOMIC MODEL

We consider the following two country macroeconomic model which is a direct extension of the standard Dornbusch (1976) framework; see, e.g., Gray and Turnovsky (1979). It describes two economies each specializing in the production of a distinct good and trading a single common bond.

$$Y = d_1Y^* - d_2(I - \dot{C}) + d_3(P^* + E - P) + G \qquad (1)$$

$$Y^* = d_1Y - d_2(I^* - \dot{C}^*) - d_3(P^* + E - P) + G^* \qquad (1')$$

$$0 < d_1 < 1,\ d_2 > 0,\ d_3 > 0$$

$$M - C = \alpha_1Y - \alpha_2I \qquad (2)$$

$$\alpha_1 > 0,\ \alpha_2 > 0$$

$$M^* - C^* = \alpha_1Y^* - \alpha_2I^* \qquad (2')$$

$$I = I^* + \dot{E} \tag{3}$$

$$C = \delta P + (1 - \delta)(P^* + E) = P + (1 - \delta)(P^* + E - P) \tag{4}$$

$$C^* = \delta P^* + (1 - \delta)(P - E) = P^* - (1 - \delta)(P^* + E - P) \tag{4'}$$

$$\frac{1}{2} < \delta < 1$$

$$\dot{P} = \gamma Y \tag{5}$$

$$\gamma > 0$$

$$\dot{P}^* = \gamma Y^* \tag{5'}$$

where

Y = real output, measured as a deviation about its natural rate level,

P = price of output, expressed in logarithms,

C = consumer price index, expressed in logarithms,

E = exchange rate, (measured in terms of units of foreign currency per unit of domestic currency), measured in logarithms,

I = nominal interest rate,

M = nominal money supply, expressed in logarithms,

G = real government expenditure.

Domestic variables are unstarred; foreign variables are denoted with an asterisk.

Equations (1), (1') describe goods market equilibrium in the two economies. Private demand depends upon the real interest rate, output in the other country, and relative price.[3/] The corresponding effects across the two economies are identical, with the relative price influencing demand in exactly offsetting ways. The money market equilibrium in the economies are standard and are described by (2) and (2').[4/] The perfect substitutability of the domestic and foreign bonds is described by the interest parity condition (3). Equations (4) and (4') describe the CPI at home and abroad. The assumption is made that the proportion of consumption δ spent on the respective home good is the same in the two economies. We assume $\delta > \frac{1}{2}$, so residents in both countries have a preference for their own good. Finally, equations (5) and (5') define the price adjustment in the two economies in terms of simple Phillips curves.

The complete world system described by equations (1)-(5) consists of a third order dynamic system in the prices of the two outputs, P, P*, and the exchange rate E. We assume that the prices P, P* adjust continuously everywhere, while the exchange rate is free to jump in response to new information. The analysis can be simplified by defining the averages and differences for any variable X say

$$X^a \equiv \frac{1}{2}(X + X^*)$$

$$X^d \equiv X - X^*$$

Eliminating C, C*, the dynamics can be written in terms of the following decoupled system:

<u>Averages</u>:

$$(1 - d_1 - d_2\gamma)\dot{Y}^a = -d_2 I^a + G^a \tag{6a}$$

$$M^a - P^a = \alpha_1 Y^a - \alpha_2 I^a \tag{6b}$$

$$\dot{P}^a = \gamma Y^a \tag{6c}$$

Differences:

$$(1 + d_1)Y^d = d_2(1 - 2\delta)(\dot{E} - \dot{P}^d) + 2d_3(E - P^d) + G^d \tag{7a}$$

$$M^d - 2(1 - \delta)E + (1 - 2\delta)P^d = \alpha_1 Y^d - \alpha_2 \dot{E} \tag{7b}$$

$$\dot{P}^d = \gamma Y^d \tag{7c}$$

Equations (6a)-(6c) describe the aggregate world economy. The aggregate IS and LM curves (6a) and (6b) determine the average output level and average nominal interest rate in terms of the average price level, the evolution of which is described by the Phillips curve (6c). We assume

$$1 - d_1 - \gamma d_2 > 0$$

so that the IS curve in Y^a, I^a space is downward sloping. Equations (7) describe the differences in the two economies, together with the exchange rate. It is shown below that the dynamics of P^d and E is a saddlepoint.

3. STEADY STATE

Since the analysis is based on perfect foresight, the dynamics, which is our prime concern, is determined in part by the steady state. It is therefore convenient to begin with a characterization of this equilibrium. Denoting the steady state by bars, it is attained when $\dot{P} = \dot{P}* = \dot{E} = 0$, so that $\bar{Y} = 0$, $\bar{I} = \bar{I}*$. Thus the equilibrium in the goods and money markets of the two economies is

$$d_2\bar{I} - d_3(\bar{P}^* + \bar{E} - \bar{P}) = G \tag{8a}$$

$$d_2\bar{I} + d_3(\bar{P}^* + \bar{E} - \bar{P}) = G^* \tag{8b}$$

$$M - \bar{P} - (1 - \delta)(\bar{P}^* + \bar{E} - \bar{P}) = -\alpha_2\bar{I} \tag{9a}$$

$$M^* - \bar{P}^* + (1 - \delta)(\bar{P}^* + \bar{E} - \bar{P}) = -\alpha_2\bar{I} \tag{9b}$$

The solutions to these equations are

$$\bar{I} = \frac{1}{2d_2}(G + G^*) \tag{10a}$$

$$\bar{\sigma} \equiv \bar{P}^* + \bar{E} - \bar{P} = \frac{1}{2d_3}(G^* - G) \tag{10b}$$

$$\bar{P} = M + \left[\frac{\alpha_2}{2d_2} + \frac{(1-\delta)}{2d_3}\right]G + \left[\frac{\alpha_2}{2d_2} - \frac{(1-\delta)}{2d_3}\right]G^* \tag{10c}$$

$$\bar{P}^* = M^* + \left[\frac{\alpha_2}{2d_2} - \frac{(1-\delta)}{2d_3}\right]G + \left[\frac{\alpha_2}{2d_2} + \frac{(1-\delta)}{2d_3}\right]G^* \tag{10d}$$

$$\bar{E} = M - M^* + \left(\frac{1-2\delta}{2d_3}\right)(G - G^*) \tag{10e}$$

It is seen that in the long run, an increase in government expenditure at home or abroad will raise the equilibrium interest rate equally. An increase in domestic government expenditure will raise the relative price of domestic goods, while an increase in foreign government expenditure will have the reverse effect. The increase in the world interest rate lowers the demand for money in both countries. The rise in the relative price of domestic goods increases the real stock of domestic money. Given that the nominal stock remains fixed, the price of domestic output, $\overline{P}$, must increase in order to reduce the real supply of money and maintain money market equilibrium. On the other hand, the rise in the relative price of foreign goods causes the real stock of foreign money to decrease. This requires the foreign price level to increase less than the domestic and indeed, in extreme cases it may even fall. The effects of an increase in foreign government expenditure on the two price levels are symmetric. The nominal exchange rate depends upon the differential government expenditure in the two economies. With $\delta > \frac{1}{2}$, the increase in domestic government expenditure causes a nominal appreciation of the domestic currency, while the opposite applies with respect to an increase in G*.

An increase in the domestic money supply increases the domestic price level proportionately, causing the domestic nominal exchange rate to depreciate proportionately. The foreign price level, as well as the real exchange rate and world interest rate remain unchanged. The effects of an increase in the foreign money supply are analogous.

4. SOLUTIONS TO DYNAMICS

The solution to the dynamic adjustment of the economy is obtained in two parts, first for the average variables, then for the differences. These solutions are then transformed to the original variables. We assume that at time 0 the world economy is in steady state with $P = \overline{P}_1$, $P^* = \overline{P}^*_1$, $E = \overline{E}_1$. At time 0 a policy change is anticipated to take effect at time T. The new steady state corresponding to the disturbed system is $P = \overline{P}_2 = \overline{P}_1 + d\overline{P}$, $P^* = \overline{P}^*_2 = \overline{P}^*_1 + d\overline{P}^*$, $E = \overline{E}_2 = \overline{E}_1 + d\overline{E}$.

By substitution, equations (6a)-(6c) describing the behavior of the average world economy can be expressed by the following equation in the average price level,

$$\dot{P}^a = \frac{-\gamma d_2}{D}(P^a - \overline{P}^a) \equiv \lambda_1(P^a - \overline{P}^a) \qquad (11)$$

where

$$D \equiv \alpha_2(1 - d_1 - d_2\gamma) + \alpha_1 d_2 > 0$$

$$\overline{P}^a = \frac{1}{2}(\overline{P}_1 + \overline{P}^*_1) = \text{steady state value of } P^a \, .$$

Integrating equation (11), the solution to the average economy is:

$0 < t < T$:

$$P^a = \overline{P}^a_1 \qquad (12a)$$

$$Y^a = 0 \qquad (12b)$$

$$I^a = \overline{I}^a_1 \qquad (12c)$$

$t \geqq T$:

$$P^a = \overline{P}^a_2 + (\overline{P}^a_1 - \overline{P}^a_2)e^{\lambda_1(t-T)} \qquad (13a)$$

$$Y^a = -\frac{d_2}{D}(\overline{P}^a_1 - \overline{P}^a_2)e^{\lambda_1(t-T)} \qquad (13b)$$

$$I^a = \overline{I}^a_2 + \frac{(1-d_1-d_2\gamma)}{D}(\overline{P}^a_1 - \overline{P}^a_2)e^{\lambda_1(t-T)} \qquad (13c)$$

where $\overline{I}^a_1$, $\overline{I}^a_2$ denote steady state values with $\overline{I}^a_2 = \overline{I}^a_1 + d\overline{I}^a$. With the dynamics of the average economy being determined by the average price level, which is sluggish, these variables do not respond in anticipation of a future disturbance, but instead remain stationary until the moment it actually occurs. This simple fact turns out to be important in our subsequent discussion of the transition of policy changes. After the disturbance, the world economy converges monotonically to its new steady state.

By substitution, equations (7a)-(7c) can be written to express the dynamics of price differentials and the exchange rate by the following equation

$$\begin{bmatrix} \dot{E} \\ \dot{P}^d \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} E - \overline{E} \\ \overline{P}^d - \overline{P}^d \end{bmatrix} \tag{14}$$

where [5/]

$$h_{11} \equiv \{2d_3\alpha_1 + 2(1 - \delta)[(1 + d_1) + d_2\gamma(1 - 2\delta)]\}/\Delta > 0$$

$$h_{12} \equiv \{-2d_3\alpha_1 - (1 - 2\delta)[(1 + d_1) + d_2\gamma(1 - 2\delta)\}/\Delta$$

$$h_{21} \equiv \{2d_3\gamma\alpha_2 + 2\gamma d_2(1 - \delta)(1 - 2\delta)\}/\Delta$$

$$h_{22} \equiv -\{2d_3\gamma\alpha_2 + \gamma d_2(1 - 2\delta)^2\}/\Delta < 0$$

$$\Delta \equiv -\alpha_1 d_2(1 - 2\delta) + \alpha_2[d_2\gamma(1 - 2\delta) + 1 + d_1] > 0$$

It can be verified that $h_{11}h_{22} - h_{12}h_{21} < 0$, so that (14) describes saddlepoint behavior of E and P^d.

We shall focus on the bounded solution to (14). This is given by

$0 < t < T$:

$$P^d = \overline{P}_1^d + A_2 e^{\lambda_2 t} + A_3 e^{\lambda_3 t} \tag{15a}$$

$$E = \overline{E}_1 + \frac{h_{12}\ A_2 e^{\lambda_2 t}}{\lambda_2 - h_{11}} + \frac{h_{12}\ A_3 e^{\lambda_3 t}}{\lambda_3 - h_{11}} \tag{15b}$$

$t \geq T$:

$$P^d = \overline{P}_2^d + A_2' e^{\lambda_2 t} \tag{16a}$$

$$E = \overline{E}_2 + \frac{h_{12}\ A_2'}{\lambda_2 - h_{11}} e^{\lambda_2 t} \tag{16b}$$

where $\lambda_2 < 0$, $\lambda_3 > 0$ are the (real) eigenvalues of the system. The arbitrary constants A_2, A_3, A_2' are determined by

$$A_2 + A_3 = 0 \tag{17a}$$

$$(A_2 - A_2')e^{\lambda_2 T} + A_3 e^{\lambda_3 T} = d\overline{P}^d = d\overline{P} - d\overline{P}^* \tag{17b}$$

$$\frac{h_{11}}{\lambda_2 - h_{11}} (A_2 - A_2')e^{\lambda_2 T} + \frac{h_{12}}{\lambda_3 - h_{11}} A_3 e^{\lambda_3 T} = d\overline{E} \tag{17c}$$

where the changes in the steady state equilibrium are dependent upon the specific disturbance. Equation (17a) is obtained from the initial condition on the price level, and the assumption that P_1 and P_2 move continuously everywhere. The latter two equations are obtained by assuming that prices and the exchange rate move continuously at time T. By contrast, we allow the exchange rate to undergo an initial jump at the announcement date $t = 0$, in response to the new information impinging on the economy at that time. It is this jump that brings about the eventual stability of the system. After the change occurs at time T, the P^d and E converge monotonically to their new equilibrium values at a rate λ_2.

It is seen from the solutions (15b), (16b) that the nature of the time path of the nominal exchange rate, and in particular, whether at any stage it overshoots or undershoots its equilibrium response to an anticipated monetary disturbance depends upon the sign of h_{12}. If output is fixed, $h_{12} > 0$, but with output endogenous, in general $h_{12} \gtrless 0$. For the sake of being concrete, we shall base our exposition on the assumption

$$h_{12} > 0$$

Loosely speaking, this condition will be met if the income effect in the demand for money is sufficiently small.[6/] We shall also assume

$$h_{21} > 0$$

A sufficient condition for this to be met is $d_3 > d_2/8\alpha_2$, which for plausible parameter values will surely be met.[7/] The economic explanation of the results will require minor modification if either of these inequalities is reversed, as in principle they may be.

Combining (12), (13), (15), (16), the solution of the system in terms of the original variables P, P*, and E is as follows:

$0 \leqq t < T$:

$$P = \bar{P}_1 + \frac{1}{2}\left[A_2 e^{\lambda_2 t} + A_3 e^{\lambda_3 t}\right] \tag{18a}$$

$$P^* = \bar{P}^*_1 - \frac{1}{2}\left[A_2 e^{\lambda_2 t} + A_3 e^{\lambda_3 t}\right] \tag{18b}$$

$$E = \bar{E}_1 + \frac{h_{12}}{\lambda_2 - h_{11}} A_2 e^{\lambda_2 t} + \frac{h_{12}}{\lambda_3 - h_{11}} A_3 e^{\lambda_3 t} \tag{18c}$$

$t \geq T$:

$$P = \bar{P}_2 - \frac{1}{2}[d\bar{P} + d\bar{P}^*]e^{\lambda_1(t-T)} + \frac{1}{2} A_2' e^{\lambda_2 t} \qquad (19a)$$

$$P^* = \bar{P}_2^* - \frac{1}{2}[d\bar{P} + d\bar{P}^*]e^{\lambda_1(t-T)} - \frac{1}{2} A_2' e^{\lambda_2 t} \qquad (19b)$$

$$E = \bar{E}_2 + \frac{h_{12} A_2'}{\lambda_2 - h_{11}} e^{\lambda_2 t} \qquad (19c)$$

where the constants A_2, A_3, A_2' satisfy (17).

The solutions (18)-(19) form the basis for our analysis. From these solutions, those of Y, Y*, I, I*, as well as the real exchange rate and real interest rates can be derived.

5. DOMESTIC MONETARY EXPANSION

Consider a unit increase in the domestic money supply, with the foreign money supply held constant; that is, $dM = 1$, $dM^* = 0$. It follows from (10) that $d\bar{P} = d\bar{E} = 1$, $d\bar{P}^* = 0$.

A. Unanticipated Monetary Expansion

The formal solution to the model in the case of an unanticipated monetary disturbance is given in equation (A.1) of the appendix and is illustrated in Figure 1, on the assumption $h_{12} > 0$. In this case, the exchange rate overshoots on impact its long-run response, thereafter appreciating towards its new steady state level. The price of domestic output gradually increases, while domestic output initially increases, thereafter falling monotonically towards its natural rate level. The monetary expansion causes an immediate fall in the domestic interest rate, which thereafter rises monotonically towards its equilibrium. All of these effects are familiar from the Dornbusch model or its immediate variants.

The effects of the domestic monetary expansion on the foreign economy are less clear cut. The rate of inflation of foreign goods, $\dot{P}^*$, and the level of output abroad will rise or fall on impact, depending upon whether $\lambda_2 \gtrless \lambda_1$. The monetary expansion in the domestic economy increases both the average world output, Y^a, and the difference, Y^d. While this obviously implies a rise in the domestic level of output, foreign output will rise if and only if the increase in average output exceeds half the increase in the difference.

More intuitively, the appreciation of the foreign currency vis-a-vis the domestic, following the domestic monetary expansion, leads to an increase in the relative price of foreign goods, leading to a fall in demand, and hence in output and in inflation abroad. On the other hand, the fact that the foreign currency immediately begins to depreciate following its initial (discrete) appreciation, increases the rate of inflation abroad, thereby reducing the foreign real rate of interest. This leads to a positive effect on foreign demand, output, and inflation. In addition, the increase in domestic output leads to an increase in imports by the domestic economy and this too leads to an increase in output and inflation abroad. The net effect on output and inflation abroad depends upon which of these two opposing effects dominates. However, if the foreign level of output does initially rise, it will immediately begin to fall, and vice versa. This is because if foreign output does increase initially, the accompanying rise in the foreign inflation rate will begin to raise the foreign price level. Thus the level of the real foreign money supply will begin to fall, thereby inducing a contraction in foreign output. Indeed, as long as foreign output is above its equilibrium level and the foreign price level continues to rise, the contractionary force on foreign output will continue. It can be shown from (A.1e) that Y* will always fall below its original level during the transition, giving rise to the overshooting pattern shown in Figure 1.C.[8/] The time path is reversed in the case of an initial fall in foreign output. With $h_{12} > 0$ and the domestic currency appreciating following the initial monetary expansion, it follows that the fall in the domestic nominal interest rate exceeds that of the foreign rate, which in fact may either rise or fall. On the one hand, the initial appreciation of the foreign currency causes the foreign real stock of money to rise, leading to a fall in the foreign interest rate. On the other hand, the rise or fall in the foreign level of income may generate an increase or decrease in the demand for money abroad, thereby rendering the overall effect on the foreign interest rate indeterminate.[9/] Both alternative time paths for Y*, P*, and I* are illustrated.[10/]

B. Announced Monetary Expansion

Consider now the behavior of the economy in response to a monetary expansion which the authorities announce at time 0 to take place at some future time $T > 0$. The formal solution is given in (A.3), (A.3'), while the time paths for the relevant domestic and foreign variables are illustrated in Figure 2.

At the time of announcement, $t = 0$, the domestic currency immediately depreciates in anticipation of the future monetary expansion. Whether the initial jump involves overshooting of the exchange rate, depends upon the lead time T. Following the announcement, the domestic currency continues to depreciate until time T, when it reaches a point above the new long-run equilibrium. Thereafter, it appreciates steadily until the new steady state equilibrium is reached This behavior is identical to that in the Gray-Turnovsky (1979) model.

The anticipation of the future monetary expansion causes the domestic price level to begin rising at time 0. The inflation rate increases during the period 0 to T, when the monetary expansion occurs. This expansion causes a further increase in the inflation rate, which thereafter begins to slow down as the new equilibrium price level is approached. The behavior of the inflation rate is mirrored in the level of output. The positive inflation rate generated by the announcement is accompanied by an immediate increase in output, which increases continuously until the monetary expansion occurs at time T. At that time a further discrete increase in output occurs. Thereafter, as the domestic currency appreciates, the relative price of domestic goods rises and demand and domestic output gradually decline to its equilibrium level.

The initial depreciation of the domestic currency causes an immediate jump in the domestic CPI, which with the domestic nominal money supply fixed (prior to time T), creates an initial fall in the real money supply. At the same time, the initial increase in domestic real output, stimulated by the depreciation of the domestic currency as a result of the announcement, increases the demand for real money balances. In order for domestic money market equilibrium to be maintained, the domestic nominal interest rate must rise. As the price of domestic output increases during the period prior to the monetary expansion, the real domestic money supply contracts further, while the increasing real income causes the real money demand to continue rising. In order for money market equilibrium to be maintained, the domestic nominal interest must therefore continue to rise. At time T, when the anticipated monetary expansion takes place, the domestic interest rate drops, falling to level below its long run equilibrium. Thereafter, it rises steadily back towards its (unchanged) long run equilibrium.

As we have seen, the average world economy remains unchanged by the anticipation of the impending monetary expansion until the moment it is actually implemented. Thus during the period $0 \leq t < T$, the averages of the domestic and foreign variables all remain fixed at their initial equilibria. Since all adjustments during this phase stem entirely from the initial announcement and the jump in the exchange rate this generates, it follows that given the symmetry of the two economies, the adjustment in theforeign economy is an exact mirror image of that in the domestic economy.

Thus during the period prior to the monetary expansion, the rising price of domestic output is matched by a falling price of foreign output, which arises from the appreciating foreign currency. At time T, following the domestic monetary expansion, the domestic currency begins to appreciate, as we have noted. This depreciation of the foreign currency puts upward pressure on the price of foreign output. The downward trend is therefore gradually reversed and eventually the price of foreign output increases back up to its original equilibrium level.

Similarly, the behavior of foreign output mirrors that of domestic output during the initial phases. The initial appreciation of the foreign currency at the announcement date causes an immediate fall in foreign output, which continues to fall further in response to the continuing appreciation of the foreign currency. The increase in the foreign inflation rate occurring at time T causes the real interest rate abroad to decline, thereby stimulating foreign demand and foreign output at that time. During the subsequent transition, the depreciating foreign currency stimulates foreign output sufficiently to cause it to rise above its national rate level, after which it declines monotonically.[11/]

The appreciation of the foreign currency at the time of announcement causes the real money supply abroad to increase, while the fall in foreign output leads to a decline in the foreign demand for money. These two effects together ensure an immediate reduction in the foreign interest rate. This continues to be so with the appreciating foreign currency, the declining foreign output, and its price level during this initial phase. At time T, when the domestic monetary expansion occurs, the foreign interest rate increases to a level above the domestic rate, but below its long-run equilibrium. Thereafter, I* increases steadily towards its equilibrium. The reason is that the increase in foreign output at time T, stimulated by the domestic monetary expansion, increases the demand for money balances abroad. Since the foreign nominal money balances remain fixed and prices and the exchange rate move continuously at time T, the real stock of foreign money balances remains fixed at time T. Thus in order for foreign money market equilibrium to hold, the foreign nominal interest rate must rise in order to offset the increased money demand resulting from the higher level of income. With the continuous appreciation of the domestic currency following the monetary expansion, the fact that I^* must lie above I during the subsequent transition back to equilibrium is an immediate consequence of the interest rate parity condition.

Finally, we may note that it is possible to analyze the effects of the monetary disturbance upon other variables such as the real exchange rate $E + P^* - P$, the domestic and foreign CPI, C, C^*, as well as the domestic and foreign real exchange rates, $I - \dot{C}$, $I^* - \dot{C}^*$. Their responses as essentially composites of those we have been discussing.

Taking an overview of Figure 2, it is seen that the anticipation of a future domestic monetary expansion has markedly different effects on the two economies, particularly during the initial phases. Domestically, it generates an increase in output, together with rising prices, although the boom is reversed after the expansion occurs. Abroad, it initially generates a recession with falling prices, although this too is reversed after the expansion.

6. DOMESTIC FISCAL EXPANSION

We turn now to a consideration of a unit increase in domestic government expenditure, i.e., $dG = 1$. The corresponding changes in the equilibrium exchange rate and price levels are

$$d\bar{E} = \frac{1-2\delta}{2d_3} < 0$$

$$d\bar{P} = \frac{\alpha_2}{2d_2} + \frac{1-\delta}{2d_3} > 0$$

$$d\bar{P}^* = \frac{\alpha_2}{2d_2} - \frac{(1-\delta)}{2d_3}$$

where we shall assume $d\bar{P}^* > 0$.

A. Unanticipated Fiscal Expansion

The solutions for the relevant variables are given in (A.4), with the time paths being illustrated in Figure 3.

The increase in demand resulting from the increase in government expenditure leads to an increase in the relative price of the domestic good. With the prices of domestic and foreign goods fixed instantaneously, this is brought about by an appreciation of the domestic currency.[12/] At the same time, the fiscal expansion leads to an increase in domestic output, thereby causing the rate of inflation of domestic output to increase. With the domestic nominal money supply fixed, the initial appreciation of the domestic currency causes the real domestic money supply to increase, while the expansion in output stimulates the demand for real money balances. The response of the domestic interest rate depends upon which of these two effects dominates. We have illustrated the more usual one, where the latter is dominant, in which case the domestic interest rate rises.

The initial appreciation of the domestic currency is only a partial one. Thereafter, it continues to appreciate gradually towards its new equilibrium level. As a result of this, the fall in the relative price of foreign goods continues, causing the demand for domestic goods to decline. This in turn moderates the rate of inflation of domestic goods. The combination of the appreciating domestic currency and the rising real money supply together with the falling output causes the domestic interest rate to continue rising.

The impact of the domestic fiscal expansion on the foreign economy is slightly less clear cut, although the effects are probably as indicated.[13/] The initial depreciation of the foreign currency stimulates the demand for the foreign good and its output. At the same time the upward pressure on interest rates (without the accompanying increase in government expenditure abroad) has a contractionary effect abroad. We assume that on balance the expansionary effect dominates and foreign output rises, although by a lesser amount than does the domestic. As a consequence, the inflation rate abroad rises, although again less than in the domestic economy. The combination of the depreciating foreign currency and increase in foreign output drives the foreign interest rate up.

The continued depreciation of the foreign currency following its initial depreciation causes real money balances abroad to continue declining. This is contractionary, so that output begins to fall steadily. While the depreciating foreign currency puts upward pressure on the foreign price level, these contractionary effects cause the foreign inflation rate to decline, with the price of foreign output ultimately levelling off at its new equilibrium level, which as we have noted is below that in the domestic economy. Finally, the rising domestic interest rate and the depreciating foreign currency means that the foreign interest rate must keep rising, remaining above the domestic rate during the transition.

B. Announced Fiscal Expansion

The solution for an announced fiscal expansion is given in (A.5), with the time paths being illustrated in Figure 4.

The anticipation of the future fiscal expansion and the long-run appreciation of the domestic currency leads to an immediate partial appreciation. With sluggish output prices, this leads to an immediate increase in the relative price of the domestic good, causing the demand for domestic output, and hence domestic output itself to decline. This fall in activity causes the price of domestic output to begin falling. The appreciation of the domestic currency, given the fixed nominal money supply, raises the domestic real money supply, while the fall in output leads to a decline in real money demand. For domestic money market equilibrium to prevail, the domestic nominal interest rate must fall.

The domestic currency continues to appreciate following the announcement. This further reduces demand for the domestic good, thereby continuing to reduce domestic output and the domestic rate of inflation. The combination of the continuously appreciating exchange rate, falling domestic price level, together with falling real output, generates a continuously downward pressure on thedomestic nominal interest rate.

This pattern continues until time T, when the anticipated fiscal expansion occurs. This expansion stimulates domestic output to a level above its long-run equilibrium. The deflation is reversed and the price of domestic output begins to start rising. This in turn means that the real stock of domestic money starts to fall, thereby providing an offsetting contractionary effect to output, which then gradually falls to its equilibrium level. As this occurs, the inflation rate is moderated and the price of domestic output gradually approaches its new, higher, equilibrium level. The expansion in output at time T, generated by the additional government expenditure also increases the demand for money. With real money balances fixed at that point, this causes the domestic interest rate to undergo a discrete jump at time T after which it continues to rise towards its new equilibrium level. The fiscal expansion at time T impacts most directly on domestic output. As a consequence, the domestic demand for money rises relative to the foreign demand. Given that the respective real money stocks in the two economies are given at time T (since they adjust continuously at that time), this means that the domestic interest rate must rise more than the foreign, so that the real rate of appreciation of the domestic currency is reduced at time T. Thereafter, the domestic currency continues appreciating, gradually approaching its new equilibrium level.

We turn now to the foreign economy. As in the case of an anticipated monetary expansion, the aggregate world economy remains stationary until time T, when the fiscal expansion actually takes place. Since the appreciation of the domestic currency during the initial phase $0 < t \leq T$ is ipso facto a depreciation of the foreign currency, during this period the foreign economy behaves as an exact mirror image of the domestic. Again this is an immediate consequence of the symmetry being assumed.

Thus during the period following the announcement, but prior to the fiscal expansion, the initial fall in domestic output, together with the subsequent continuous fall, is matched by an equivalent initial increase and continued rise abroad, stemming from the depreciation of the foreign currency. The rising foreign output causes the price of foreign output to begin rising at an increasing rate. The initial depreciation of the foreign currency, together with the increase in foreign output forces an immediate increase in the foreign interest rate, which continues to rise during the initial phase.

At the time of the fiscal expansion, the increase in domestic activity thus stimulated, generates some spillover effects onto demand and output in the foreign economy. Output abroad therefore undergoes a modest increase at time T. increasing the foreign rate of inflation at that time. With the foreign money supply fixed throughout, the increase in the real demand for money abroad resulting from the increase in output causes the foreign interest rate to rise at that point. The rising foreign price level causes the relative price of foreign goods to increase, causing foreign output to fall, thereby moderating the inflation. The fiscal expansion in the domestic economy drives up the long-run world rate of interest and the foreign rate continues to converge to this new equilibrium level.

7. CONCLUDING REMARKS

In this paper we have analyzed the effects of anticipated and unanticipated domestic monetary and fiscal expansions on both the domestic and foreign economies. The analysis is based on symmetric behavior, enabling it to be carried out in terms of sums and differences of the two economies. The properties of the dynamic time paths following these disturbances have been discussed in the text and the details need not be repeated here. However, one striking aspect which is worth highlighting is that the domestic and foreign economies are affected in precisely offsetting ways during the initial phase of the adjustment, following the announcement of the future policy change. This behavior is a direct consequence of symmetry underlying the analysis.

The analysis has considered the effects stemming from unilateral policy actions by the domestic government on the level of economic performance at home and abroad. By symmetry, analogous policy changes abroad will have similar effects on the domestic economy. It is easy to establish that if both governments undertake parallel expansions simultaneously, of either monetary or fiscal type, so either $dM = dM^*$ or $dG = dG^*$, that the exchange rate will remain fixed.[14/] As a consequence, neither economy responds to the announcement of a future policy change of this type. Instead, the adjustment begins only when the policy change is actually implemented.

Finally, we may note that the framework we have adopted in this paper is well suited to considering questions of strategic behavior by domestic and foreign governments with respect to monetary and fiscal policy. We plan to pursue this topical issue in subsequent work.

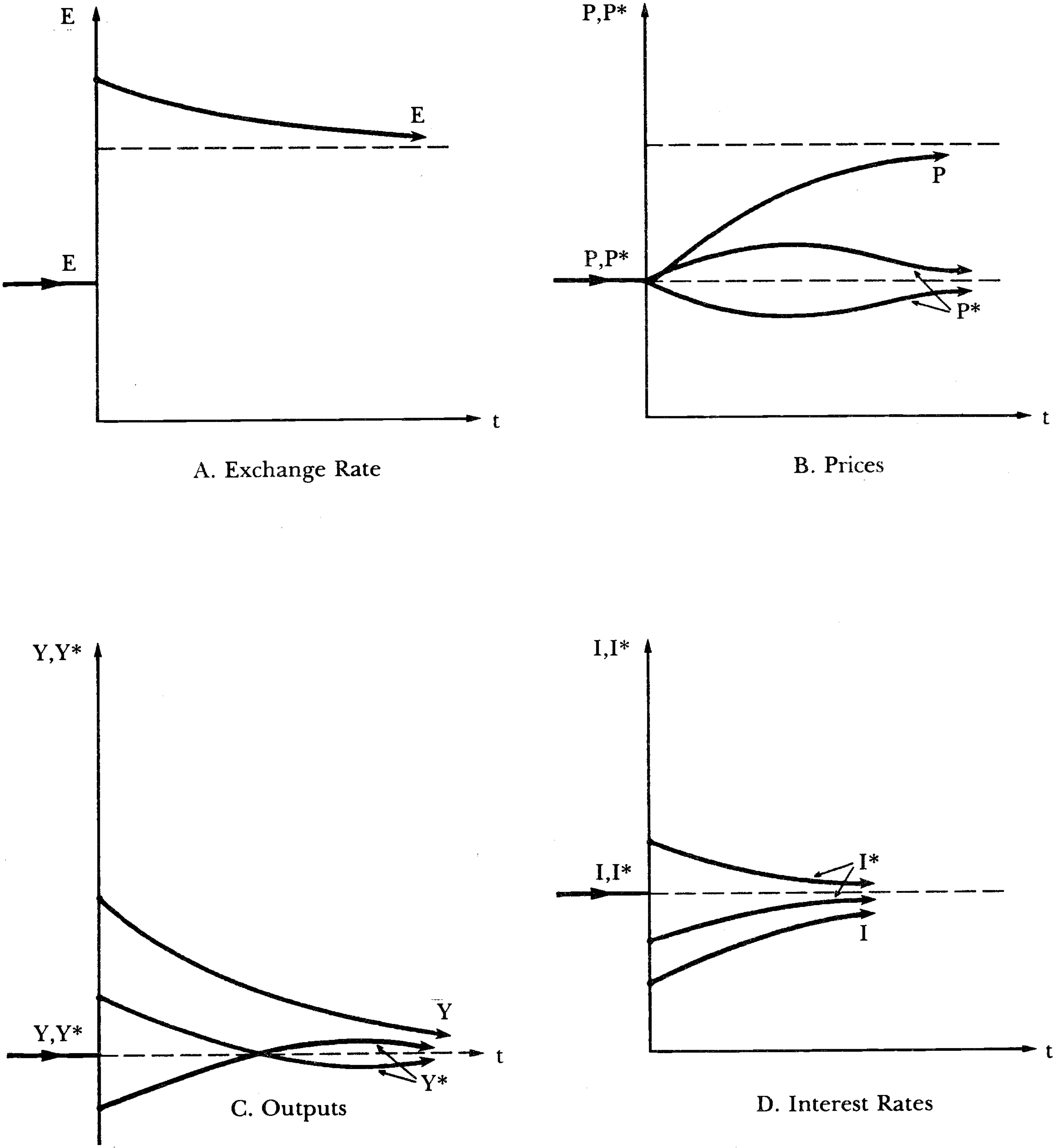

Figure 1
Unanticipated Monetary Expansion

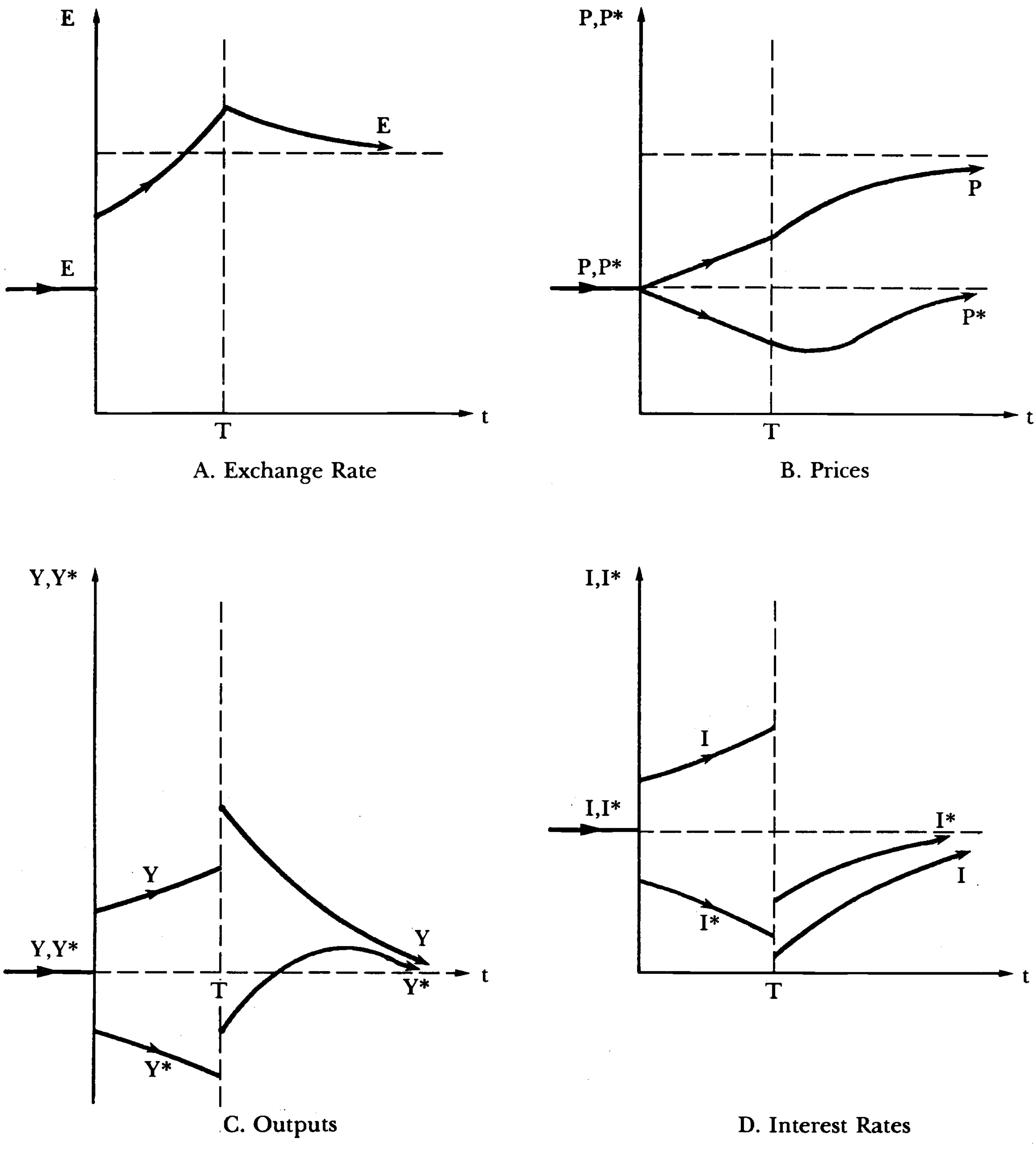

Figure 2
Announced Monetary Expansion

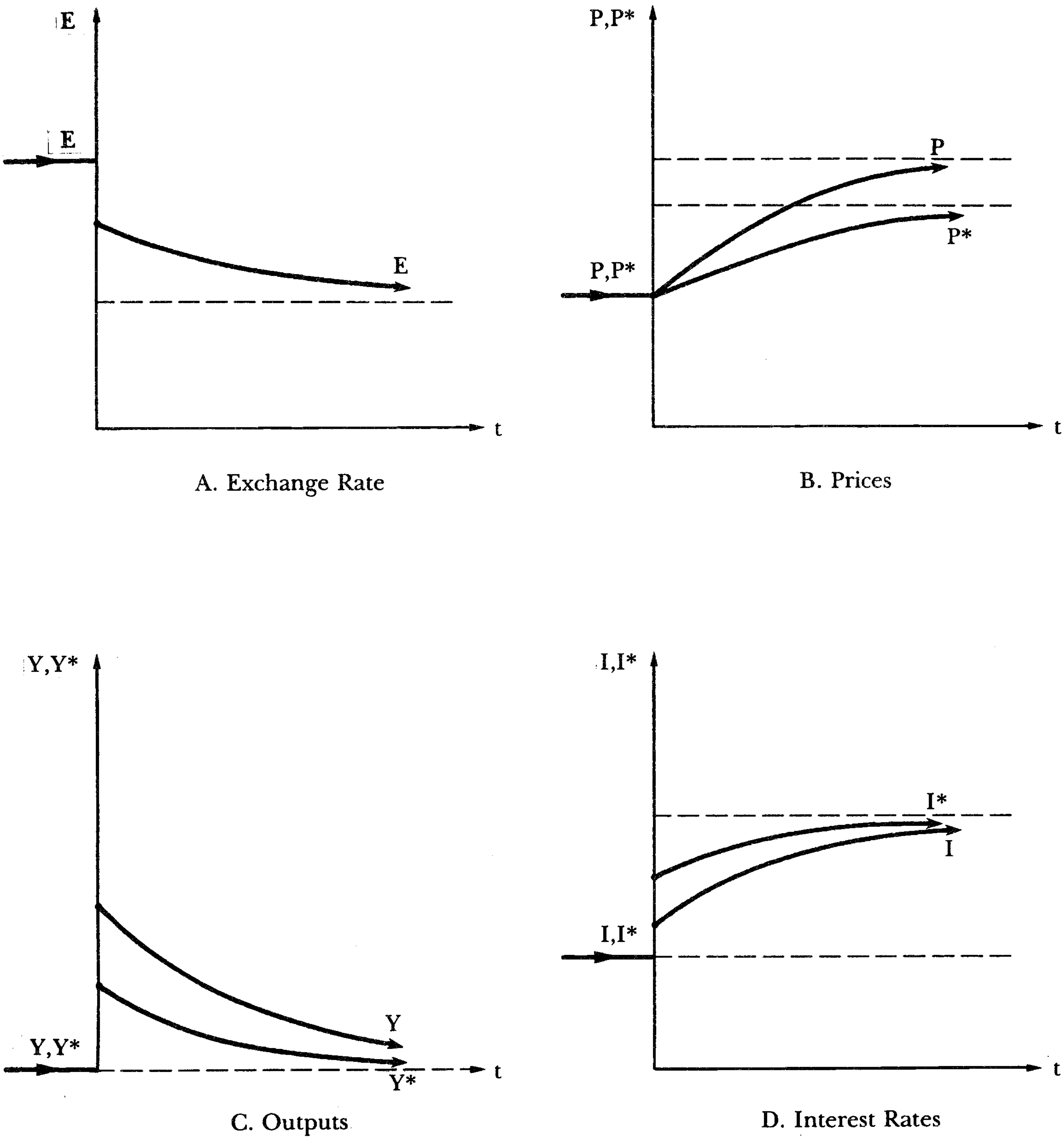

Figure 3
Unanticipated Fiscal Expansion

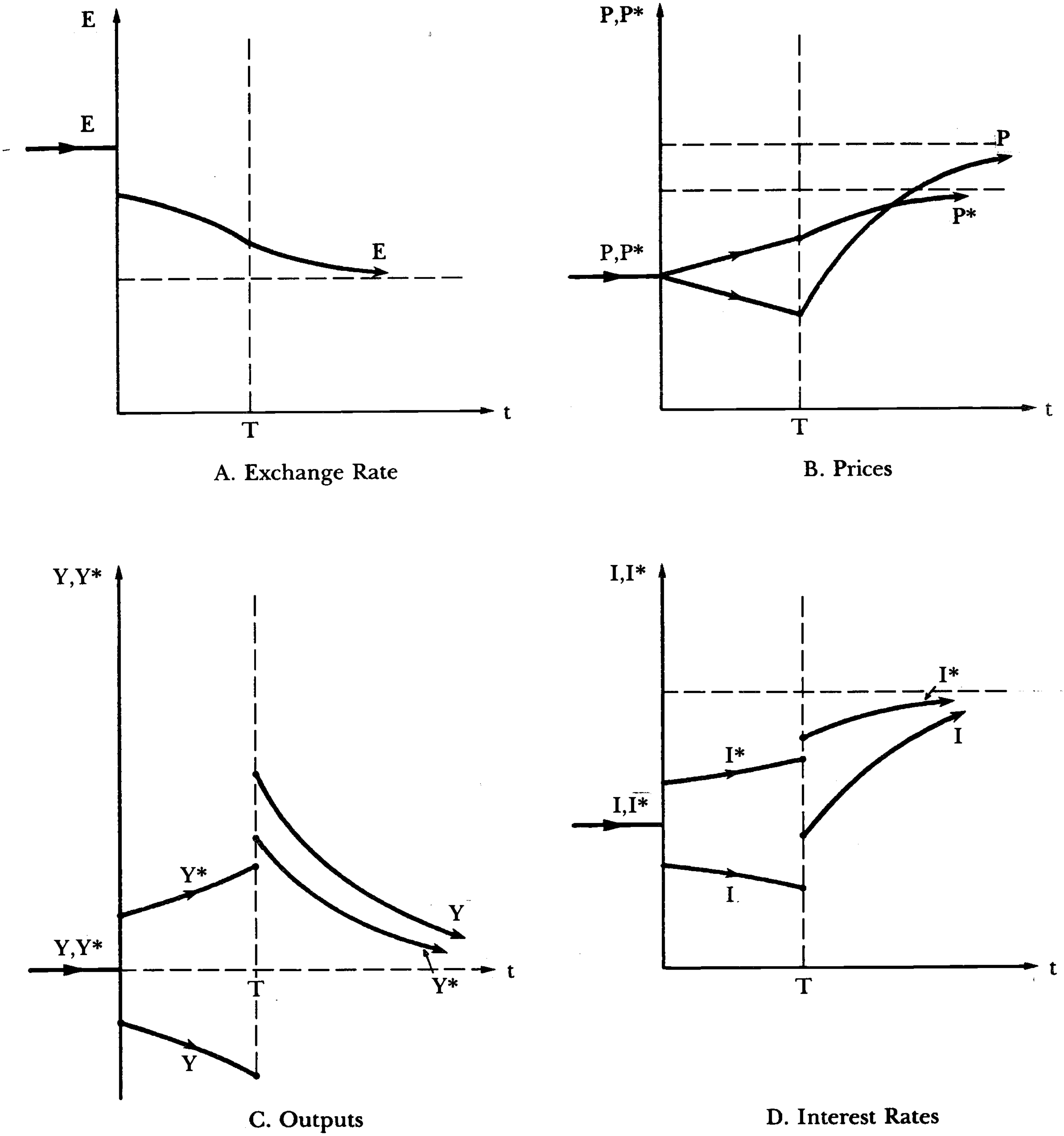

Figure 4
Announced Fiscal Expansion

APPENDIX

This appendix presents the formal solutions for the system in the case of the specific disturbances analyzed in the text.

A. Unanticipated Monetary Expansion

The arbitrary constants in the solution for the case of an unanticipated monetary expansion are obtained by setting T = 0, $d\bar{E} = d\bar{P} = 1$, $d\bar{P}^* = 0$ in (17a)-(17c). The relevant constant is $A_2' = -1$. Substituting into (19), the solutions for P, P*, E, are given by (for $t \geq 0$).

$$P = \bar{P}_2 - \frac{1}{2} e^{\lambda_1 t} - \frac{1}{2} e^{\lambda_2 t} \qquad \text{(A.1a)}$$

$$P^* = \bar{P}_2^* - \frac{1}{2} e^{\lambda_1 t} + \frac{1}{2} e^{\lambda_2 t} \qquad \text{(A.1b)}$$

$$E = \bar{E}_2 - \frac{h_{12}}{\lambda_2 - h_{11}} e^{\lambda_2 t} \qquad \text{(A.1c)}$$

From these equations and the basic model we obtain

$$Y = -\frac{\lambda_1}{2\gamma} e^{\lambda_1 t} - \frac{\lambda_2}{2\gamma} e^{\lambda_2 t} \qquad \text{(A.1d)}$$

$$Y^* = -\frac{\lambda_1}{2\gamma} e^{\lambda_1 t} + \frac{\lambda_2}{2\gamma} e^{\lambda_2 t} \qquad \text{(A.1e)}$$

$$I = \bar{I} - \frac{(1-d_1-d_2\gamma)}{2D} e^{\lambda_1 t} - \frac{h_{12}\lambda_2}{2(\lambda_2 - h_{11})} e^{\lambda_2 t} \qquad \text{(A.1f)}$$

$$I^* = \bar{I} - \frac{(1-d_1-d_2\gamma)}{2D} e^{\lambda_1 t} + \frac{h_{12}\lambda_2}{2(\lambda_2 - h_{11})} e^{\lambda_2 t} \qquad \text{(A.1g)}$$

B. Announced Monetary Expansion

The solutions for the arbitrary constants in the case of an announced monetary expansion are

$$-A_2 = A_3 = \left(\frac{h_{22} + h_{21} - \lambda_2}{\lambda_3 - \lambda_2}\right) e^{-\lambda_3 T} \tag{A.2a}$$

$$A_2' = \left(\frac{h_{22} + h_{21} - \lambda_3}{\lambda_3 - \lambda_2}\right) e^{-\lambda_2 T} - \left(\frac{h_{22} + h_{21} - \lambda_2}{\lambda_3 - \lambda_2}\right) e^{-\lambda_3 T} \tag{A.2b}$$

where $\lambda_2 < 0$, $\lambda_3 > 0$, are the solutions to the characteristic equation

$$\lambda^2 - (h_{11} + h_{22})\lambda + (h_{11}h_{22} - h_{12}h_{21}) = 0$$

Using elementary properties of the roots to the quadratic equation it is easy to show that given $h_{11} > 0$, $h_{22} < 0$, $h_{12} > 0$, $h_{21} > 0$, then $A_3 > 0$.

The solution to the relevant variables is

$0 \leq t < T$

$$P = \bar{P}_1 + \frac{1}{2} A_3(e^{\lambda_3 t} - e^{\lambda_2 t}) \tag{A.3a}$$

$$P^* = \bar{P}_1^* - \frac{1}{2} A_3(e^{\lambda_3 t} - e^{\lambda_2 t}) \tag{A.3b}$$

$$E = \bar{E}_1 + h_{12} A_3\left[\frac{e^{\lambda_3 t}}{\lambda_3 - h_{11}} - \frac{e^{\lambda_2 t}}{\lambda_2 - h_{11}}\right] \tag{A.3c}$$

$$Y = \frac{1}{2} A_3(\lambda_3 e^{\lambda_3 t} - \lambda_2 e^{\lambda_2 t}) \tag{A.3d}$$

$$Y^* = -\frac{1}{2} A_3(\lambda_3 e^{\lambda_3 t} - \lambda_2 e^{\lambda_2 t}) \tag{A.3e}$$

$$I = \bar{I}_1 + \frac{1}{2} h_{12} A_3\left(\frac{\lambda_3 e^{\lambda_3 t}}{\lambda_3 - h_{11}} - \frac{\lambda_2 e^{\lambda_2 t}}{\lambda_2 - h_{11}}\right) \tag{A.3f}$$

$$I^* = \bar{I}_1 - \frac{1}{2} h_{12} A_3\left(\frac{\lambda_3 e^{\lambda_3 t}}{\lambda_3 - h_{11}} - \frac{\lambda_2 e^{\lambda_2 t}}{\lambda_2 - h_{11}}\right) \tag{A.3g}$$

where A_3 is given by (A.2a) above.

$t \geq T$

$$P = \overline{P}_2 - \frac{1}{2} e^{\lambda_1(t-T)} + \frac{1}{2} A_2' e^{\lambda_2 t} \quad \text{(A.3a')}$$

$$P^* = \overline{P}_2^* - \frac{1}{2} e^{\lambda_1(t-T)} - \frac{1}{2} A_2' e^{\lambda_2 t} \quad \text{(A.3b')}$$

$$E = \overline{E}_2 + \frac{h_{12} A_2'}{\lambda_2 - h_{11}} e^{\lambda_2 t} \quad \text{(A.3c')}$$

$$Y = -\frac{1}{2} \lambda_1 e^{\lambda_1(t-T)} + \frac{1}{2} A_2' \lambda_2 e^{\lambda_2 t} \quad \text{(A.3d')}$$

$$Y^* = -\frac{1}{2} \lambda_1 e^{\lambda_1(t-T)} - \frac{1}{2} A_2' \lambda_2 e^{\lambda_2 t} \quad \text{(A.3e')}$$

$$I = \overline{I} - \frac{(1-d_1-d_2\gamma)}{2D} e^{\lambda_1(t-T)} + \frac{1}{2} \frac{h_{12} A_2' \lambda_2}{\lambda_2 - h_{11}} e^{\lambda_2 t} \quad \text{(A.3f')}$$

$$I^* = \overline{I}^* - \frac{(1-d_1-d_2\ )}{2D} e^{\lambda_1(t-T)} - \frac{1}{2} \frac{h_{12} A_2' \lambda_2}{\lambda_2 - h_{11}} e^{\lambda_2 t} \quad \text{(A.3g')}$$

where A_2' is given by (A.2b) above.

C. <u>Unanticipated Fiscal Expansion</u>

The arbitrary constants in this case are botained by setting $T = 0$, $d\overline{E} = (1-2\delta)/2d_3$, $d\overline{P} = \alpha_2/2d_2 + (1-\delta)/2d_3$, $d\overline{P}^* = \alpha_2/2d_2 - (1-\delta)/2d_3$ in (17a)-(17c). This implies $A_2' = -(1-\delta)/d_3$ and substituting into (19) the solution for P, P*, E and other variables are

$$P = \overline{P}_2 - \frac{\alpha_2}{2d_2} e^{\lambda_1 t} - \frac{(1-\delta)}{2d_3} e^{\lambda_2 t} \quad \text{(A.4a)}$$

$$P^* = \bar{P}^*_2 - \frac{\alpha_2}{2d_2} e^{\lambda_1 t} + \frac{(1-\delta)}{2d_3} e^{\lambda_2 t} \tag{A.4b}$$

$$E = \bar{E}_2 - \frac{h_{12}(1-\delta)}{(\lambda_2-h_{11})d_3} e^{\lambda_2 t} \tag{A.4c}$$

$$Y = \frac{-\alpha_2 \lambda_1}{2d_2} e^{\lambda_1 t} - \frac{(1-\delta)\lambda_2}{2d_3} e^{\lambda_2 t} \tag{A.4d}$$

$$Y^* = \frac{-\alpha_2 \lambda_1}{2d_2} e^{\lambda_1 t} + \frac{(1-\delta)\lambda_2}{2d_3} e^{\lambda_2 t} \tag{A.4e}$$

$$I = \bar{I} - \frac{(1-d_1-d_2\gamma)\alpha_2}{2D\ d_2} e^{\lambda_1 t} - \frac{h_{12}\ \lambda_2(1-\delta)}{2(\lambda_2-h_{11})d_3} e^{\lambda_2 t} \tag{A.4f}$$

$$I^* = \bar{I}^* - \frac{(1-d_1-d_2\gamma)\alpha_2}{2D\ d_2} e^{\lambda_1 t} + \frac{h_{12}\ \lambda_2(1-\delta)}{2(\lambda_2-h_{11})d_3} e^{\lambda_2 t} \tag{A.4g}$$

B. Announced Fiscal Expansion

The solutions for the arbitrary constants are

$$-A_2 = A_3 = -\left[\frac{2(1-\delta)(\lambda_3-h_{11}) + (1-2\delta)h_{21}}{2d_3(\lambda_2-\lambda_3)}\right] e^{-\lambda_3 T} \tag{A.5a}$$

$$A_2' = \left[\frac{2(1-\delta)(\lambda_3-h_{11}) + (1-2\delta)h_{21}}{2d_3(\lambda_2-\lambda_3)}\right] e^{-\lambda_3 T} - \left[\frac{2(1-\delta)(\lambda_2-h_{11}) + (1-2\delta)h_{21}}{2d_3(\lambda_2-\lambda_3)}\right] e^{-\lambda_2 T} \tag{A.5b}$$

$0 \leq t < T$

The solution to the system is again given by (A.3a)-(A.3g), with the constant A_3 now given by (A.5a).

$t \geq T$

$$P = \bar{P}_2 - \frac{\alpha_2}{2d_2} e^{\lambda_1 (t-T)} + \frac{1}{2} A_2' e^{\lambda_2 t} \tag{A.6a}$$

$$P^* = \bar{P}_2^* - \frac{\alpha_2}{2d_2} e^{\lambda_1(t-T)} - \frac{1}{2} A_2' e^{\lambda_2 t} \tag{A.6b}$$

$$E = \bar{E}_2 + \frac{h_{12} A_2'}{\lambda_2 - h_{11}} e^{\lambda_2 t} \tag{A.6c}$$

$$Y = - \frac{\alpha_2 \lambda_1}{2d_2} e^{\lambda_1(t-T)} + \frac{1}{2} A_2' \lambda_2 e^{\lambda_2 t} \tag{A.6d}$$

$$Y^* = - \frac{\alpha_2 \lambda_1}{2d_2} e^{\lambda_1(t-T)} - \frac{1}{2} A_2' \lambda_2 e^{\lambda_2 t} \tag{A.6e}$$

$$I = \bar{I}_2 - \frac{(1-d_1-d_2\gamma)\alpha_2}{2D\ d_2} e^{\lambda_1(t-T)} + \frac{h_{12} A_2' \lambda_2}{2(\lambda_2 - h_{11})} e^{\lambda_2 t} \tag{A.6f}$$

$$I^* = \bar{I}_2^* - \frac{(1-d_1-d_2\gamma)\alpha_2}{2D\ d_2} e^{\lambda_1(t-T)} - \frac{h_{12} A_2' \lambda_2}{2(\lambda_2 - h_{11})} e^{\lambda_2 t} \tag{A.6g}$$

where A_2' is now given by (A.5b).

FOOTNOTES

1/ See, e.g., the comprehensive survey of exchange rate dynamics by Obstfeld and Stockman (1984). Several of the early Mundell-Fleming type models do of course analyze monetary and fiscal policy for two countries, but in a static context. In addition, some of the more recent work on transmission mechanisms uses two country models, although these too are typically static, or perhaps assume some kind of backward-looking dynamics, see, e.g., Hamada and Sakurai (1978), Corden and Turnovsky (1983).

2/ See, e.g., Canzoneri and Gray (forthcoming), Miller and Salmon (1985), Oudiz and Sachs (1985).

3/ We assume that a unit increase in foreign output has a less than equivalent increase on the demand for the domestic good, i.e., $d_1 < 1$.

4/ Like most of the literature, we assume that the residents of each country do not hold the money of the other country. We may also note that the analysis remains unchanged if the money demand functions are modified to

$$M - C = \alpha_1[P + Y - C] - \alpha_2 I$$

and analogously for the foreign demand function, with $\alpha_1 < 1$.

5/ In signing h_{11}, h_{22} we are assuming $\delta > 1/2$. In addition to establish $\Delta > 0$, use is being made of the assumption $1 - d_1 - \gamma d_2 > 0$.

6/ $h_{12} > 0$ implies the following upper bound on α_1.

$$\alpha_1 < (2\delta-1)[(1+d_1) + d_2\gamma(1-2\delta)]/2d_3$$

7/ The numerator of the expression of h_{21} is

$$4\gamma d_2\delta^2 - 6\gamma d_2\delta + 2\gamma(d_2 + d_3\alpha_2)$$

This will be positive everywhere in the range $0 < \delta < 1$ and hence $h_{21} > 0$ if and only if

$$d_3 > d_2/8\alpha_2$$

8/ I am grateful to a referee for drawing this to my attention. From (1e) we see that $Y^* = \bar{Y}$ at

$$t^* = \frac{\ln(\lambda_1/\lambda_2)}{\lambda_2 - \lambda_1}$$

With both $\lambda_1 < 0$, $\lambda_2 < 0$, this quantity is necessarily positive.

9/ In the case that $h_{12} < 0$, the exchange rate does not overshoot, so that $\dot{E} > 0$, throughout the adjustment. The interest parity condition then implies $I > I^*$.

10/ The time path for I* may or may not overshoot its long run adjustment, during the transition. We have drawn monotonic adjustment paths.

11/ This occurs at the point where the foreign price level begins to rise. If the spillover of the domestic monetary expansion is sufficiently great to cause the foreign price level to begin rising immediately at time T, then Y* will be driven above its equilibrium level at that time.

12/ If $\delta = 1$, as in the Dornbusch model, then the exchange rate completes its adjustment instantaneously in response to an unanticipated fiscal expansion.

13/ If $\delta \gtrsim 1$, for example the adjustment will be as illustrated.

14/ In either of these cases it follows from (10c)-(10e) that the long-run exchange rate remains fixed, while the price of domestic and foreign goods increase proportionately. It then follows from (17a)-(17c) that $A_2 = A_3 = A_2' = 0$, so that the exchange rate remains fixed at all times. Since anticipations of future policy changes impinge on the current system through the exchange rate, it follows that these are non-operative in the case of such balanced policy changes.

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