9 International Capital Mobility and the Coordination of Monetary Rules

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International capital mobility is cited frequently by economists as a serious constraint on domestic monetary policy. Since highly mobile capital forces a close linkage among interest rates in different countries, it appears that any one country's interest rate cannot be manipulated independently in order to achieve an efficient domestic macroeconomic performance. Although the classic Mundell-Fleming models with flexible exchange rates show that perfect capital mobility need not reduce the effectiveness of monetary policy, recent research on exchange rate overshooting, on the direct inflationary effects of exchange rate depreciation, and on the beggar-thy-neighbor contractionary repercussions of domestic monetary expansion seems to have reinforced the conventional reasoning that macroeconomic goals are difficult to achieve under such circumstances. In reviewing the literature, Tobin (1978) concluded that capital mobility is such a hindrance to efficient macroeconomic performance that we should "throw some sand in the wheels of our excessively efficient international money markets." By making the international capital market less efficient, domestic macroeconomic performance might become more efficient.

The purpose of this chapter is to develop a quantitative framework for evaluating macroeconomic policy rules in a world of flexible exchange rates and perfect capital mobility. We begin by defining a criterion for measuring macroeconomic performance. In early fixed-price demand-oriented models, the natural criterion for macroeconomic performance was real output stability; policy would be effective or ineffective depending on whether it could be used to stimulate, and thereby stabilize, real output. However, the resurgence of aggregate supply issues and renewed emphasis on the simultaneous determination of prices and output have created the need for a broader measure of macroeconomic performance, one that includes both price and output stability. The static Phillips curve policy trade-off—in which macroeconomic performance can be measured in terms of the level of inflation and output—could serve as such a measure of macroeconomic efficiency were it not for widely documented shifts of this trade-off. An alternative performance measure, in which macroeconomic performance is measured in terms of fluctuations in inflation and output, is used in this chapter.[1]

The framework for policy evaluation involves the application of this performance measure to a two-country model in which financial capital is perfectly mobile, exchange rates are flexible, and expectations are rational. Aggregate supply is modeled using a staggered price setting approach in which there are recurrent supply or price shocks in each country. We assume that all shocks to the model are due to such price shocks, abstracting entirely from demand shocks. It is assumed that the two countries are linked by aggregate spending spillovers, relative price effects, and markup pricing arrangements. Each country is assumed to follow a monetary policy rule that can be characterized by how strongly the money supply responds to price shocks. The model is solved and analyzed through deterministic and stochastic simulation techniques that enforce the rational expectations restrictions. Using these techniques we evaluate how the choice of a monetary policy rule in one country affects the macroeconomic performance of the other country. This provides a way to assess the importance of capital mobility for macroeconomic interdependence.

The results of this evaluation suggest that international capital mobility is not necessarily an impediment to efficient domestic macroeconomic performance. For certain values of the parameters of our model and for certain monetary policy rules, changes in the expected appreciation or depreciation of the exchange rate along with differentials between real interest rates in the two countries can permit macroeconomic performance in one country to be relatively independent of the policy rule chosen by the other country. The results do not hold universally, however. Interdependence can become stronger with alternative parameter or policy configurations. Our results therefore suggest a need for econometric work to determine the size of certain crucial parameters.

In section 1 we review the aggregate supply side of the model and show how policy can be evaluated in terms of output and price variability using a rudimentary quantity theory model of aggregate demand. In section 2 we discuss a more detailed model of aggregate demand, which includes interest rate effects, and we examine monetary policy in a closed economy version of this model. In order to achieve macroeconomic efficiency in the closed economy, policymakers must offset the effects of fluctuations in the expected inflation rate. It is shown that a real interest rate rule automatically provides this offset. Section 3 describes the full two-country model and examines the interaction between the macroeconomic policies of each country.

1. Aggregate Supply

The aggregate supply side of the model is derived from staggered wage-setting assumptions as modified to incorporate the price linkages important in open economy applications.[2] The staggered wage setting approach has the advantage of incorporating forward-looking (rational expectations) behavior while allowing for realistic short-run rigidities that lead to a trade-off between output and price stability. These rigidities also guarantee the effectiveness of monetary policy in stabilizing real output, despite the existence of rational expectations. Nevertheless an increase in the rate of money growth is neutral over the long run, increasing the rate of inflation but not output; that is, the long-run Phillips curve is vertical.

In general we assume that wages are set for n periods and that $1/n$ of all workers have their wages determined at the start of each period. The equations of the supply side for a single open economy (the home economy) can then be written:

$$x_t = \frac{\delta}{n}\sum_{i=0}^{n-1} \hat{w}_{t+i} + \frac{1-\delta}{n}\sum_{i=0}^{n-1} \hat{p}_{t+i} + \frac{\gamma}{n}\sum_{i=0}^{n-1} \hat{y}_{t+i} + \varepsilon_t, \tag{1}$$

$$w_t = \frac{1}{n}\sum_{i=0}^{n-1} x_{t-i}, \tag{2}$$

$$p_t = \theta w_t + (1-\theta)(e_t + p_t^*), \tag{3}$$

where p_t is the log of the price level, y_t is the log of real GNP relative to trend, w_t is the log of the average wage, x_t is the log of the contract wage set in period t to last three periods, e_t is the log of the exchange rate, and ε_t is a supply shock. The hats on the variables indicate expectations based on information available through period t. The asterisks identify variables external to the home country (the rest of the world). For example, p_t^* in equation (3) is the average price level in the rest of the world.

Equation (1) is the wage determination equation; it reflects the tendency for contract wages to be bid up if aggregate wages or prices are expected to rise or if aggregate demand, as represented by y_t, is expected to rise.[3] The distributed leads in equation (1) extend for n periods because contracts last n periods. The weights on these distributed leads are equal because workers are assumed to average future price, wage, and demand conditions over the n future periods of the contract. Parameter δ represents the relative importance of prices versus wages. In order to preserve the long-run neutrality of money growth, the weights on prices and wages together must sum to one, as indicated in the notation of equation (1). Parameter γ measures the sensitivity of wage adjustment to demand pressures. Equation (2) defines the aggregate wage in terms of contract wages negotiated in the current and previous periods.

Equation (3) is the price equation; it states that prices are set as a markup on wage costs, w_t, and the costs of imported inputs denominated in domestic currency units, $(e_t + p_t^*)$. The effects of exchange rates and foreign prices on domestic price determination, as represented in (3), are an important feature of the supply side of the model. It is through this channel that foreign price shocks or exchange rate depreciations (increases in e) have inflationary consequences. An alternative way to model such external price linkages would be to assume that wages are directly indexed to consumer prices that include the domestic price of imported goods. This alternative would give somewhat different dynamic responses of wages and prices to foreign price shocks or exchange rate changes. However, except for the extreme case of perfect, instantaneous indexing, the effects on the output-inflation trade-off would be similar to those obtained in this chapter.

At this point it is useful to review briefly how this aggregate supply framework (with the closed economy assumption $\theta = 1$) can be joined with a rudimentary treatment of aggregate demand to generate a macropolicy trade-off between output and price stability.[4] Consider the simple quantity equation $y_t + p_t = m_t$, where m_t is the log of the money supply, and suppose that monetary policy is driven by the rule $m_t = \alpha p_t$, in which α is the accommodation parameter. An aggregate demand relationship between p_t and y_t can be derived by substituting the money supply rule into the quantity equation, resulting in $y_t = -(1 - \alpha)p_t$. Substituting this aggregate demand relationship into (1) and substituting equations (2) and (3) into (1) results in a two-sided difference equation in x_t, involving both leads and lags. The leads from this equation can be eliminated to generate a stochastic difference equation in x_t. The shock ε_t is the disturbance in this relation. From (3), one can then obtain an autoregressive moving average, ARMA $(n - 1, n - 1)$, representation for p_t in which the parameters depend on the policy parameter α and the structural parameters δ

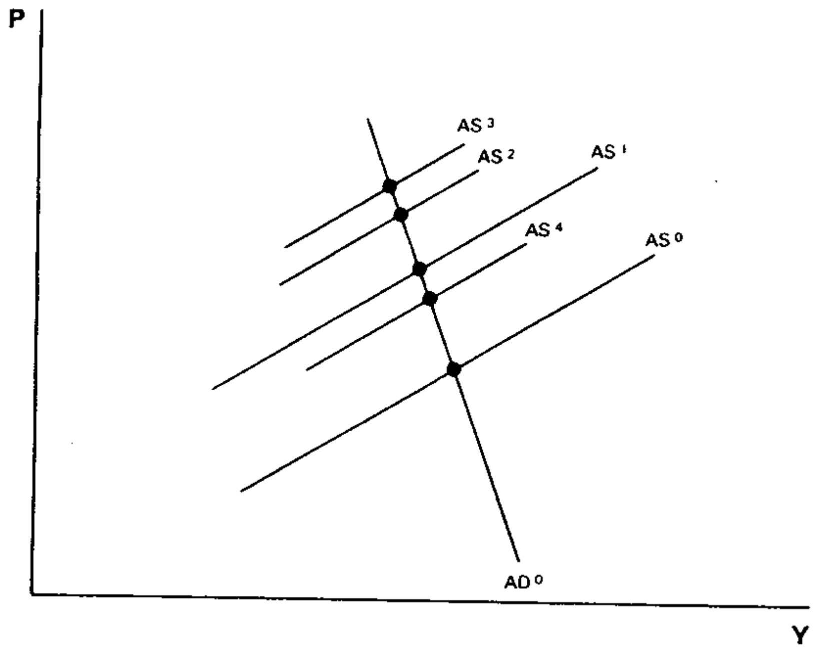

Figure 9.1
Steep aggregate demand curve

and γ. The behavior of y_t follows directly from the aggregate demand relation. The variances of both p_t and y_t can then be calculated from these relationships. The properties of the variances are such that the variance of p_t increases and the variance of y_t decreases as α rises. This traces out a trade-off curve; a more accommodative policy (higher α) results in more output stability and less price stability.

The mechanics of this trade-off and its dependence on α can be explained graphically. Figure 9.1 illustrates an aggregate supply curve corresponding to the difference equation for p_t. The supply curve shifts with lagged movements in p and the shock term ε_t. The α parameter determines the slope of the aggregate demand curve, also shown in figure 9.1.

The slope of this curve determines how large the output effects of a supply shock will be. A steep aggregate demand curve (α near 1) results in very small output fluctuations, given the size of supply shocks. However, α close to 1 also causes a given shock to the aggregate supply curve to persist for a long time. A flat aggregate demand curve, as illustrated in figure 9.2, increases output fluctuations while reducing price fluctuations.

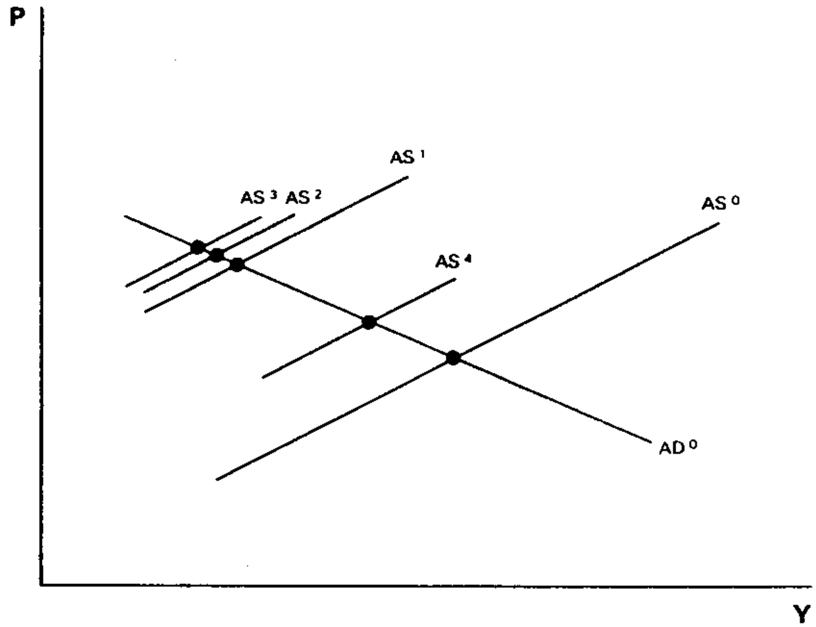

Figure 9.2
Flat aggregate demand curve

2. Aggregate Demand, Interest Rates, and Policy Rules

A more explicit model of aggregate demand than the simple quantity equation is necessary in order to capture the impact of capital mobility on the output-price stability trade-off. Our approach to the demand side is conventional and corresponds closely with that of the Mundell-Fleming models. We distinguish between the effects of the real and the nominal interest rate. The real interest rate is assumed to affect expenditures on investment and consumer durable goods, while the nominal interest rate is assumed to affect the demand for money. Inflationary expectations, which determine the differential between the real and the nominal rate of interest, are formed rationally. We also allow nominal interest rates to differ at home and abroad to allow for the expected rate of exchange rate appreciation, a modification of the Mundell-Fleming model explored by Dornbusch (1976) and others.

The aggregate demand equations for the home country can be written as:

$$y_t = -dr_t + f(e_t + p_t^* - p_t) + gy_t^* \tag{4}$$

$$m_t - p_t = -bi_t + ay_t \tag{5}$$

$$r_t = i_t - \hat{\pi}_t \tag{6}$$

where $\pi_t = p_{t+1} - p_t$ is the rate of inflation, r_t is the real interest rate, i_t is the nominal interest rate, and m_t is the log of the money supply. Equation (4) is an "IS"-type equation in which total demand depends on the real interest rate, terms of trade, and foreign demand (parameters d, f, g, b, and a are positive). Inclusion of the terms of trade in this way permits short-run deviations from purchasing power parity. The elasticity is positive because exports are stimulated and imports are reduced by a higher relative price of foreign goods. Equation (5) is the money demand equation, and equation (6) defines the real rate of interest. Because our analysis will not consider demand side shocks, we have omitted shift terms from these equations. All variables are measured as proportional deviations from secular trend and therefore have a zero mean.

In a simple quantity model of aggregate demand, the natural way to write the monetary reaction function is in terms of the money supply, as was done in section 1. There are obvious alternatives to money supply rules when interest rates play an explicit role in demand determination. Interest rate rules in particular, either a nominal interest rate rule:

$$i_t = \alpha_i p_t, \tag{7}$$

or a real interest rate rule,

$$r_t = \alpha_r p_t, \tag{8}$$

are possible characterizations of monetary policy. Note that (7) and (8) as well as the money supply rule ($m_t = \alpha p_t$) considered in the previous section can be interpreted as prices rule such as those recently discussed as alternatives to monetarist policies. They state that the interest rate should be increased whenever prices rise above target. In this model the price target is normalized to zero.

Before turning to the case of a two-country model with capital mobility, it is useful to consider the analysis of a closed economy.[5] To close the economy we set $f = g = 0$ and $\theta = 1$. A reduced form aggregate demand curve (in $p - y$ space) can be derived by substituting the interest rate and money response rules into (4) and (5). This results in the following alternative aggregate demand equations:

$$y_t = -d\alpha_i p_t + d\hat{\pi}_t, \tag{9}$$

$$y_t = -d\alpha_r p_t, \tag{10}$$

$$y_t = -h(1 - \alpha)p_t + hb\hat{\pi}_t, \tag{11}$$

for the nominal interest rate rule, real interest rate rule, and money rule, respectively, where $h = (a + b/d)^{-1}$.

As is clear from these equations, the rules differ in two ways: in how they effect the slope of the aggregate demand curve and in how they offset the effect of the expected inflation rate on aggregate demand. Both the nominal interest rate rule and the money rule result in aggregate demand equations in which the expected inflation rate has an impact. This is a disadvantage of these rules since it results in another source of instability. This instability could be avoided by using a money supply rule in which the money supply responded to changes in the expected inflation rate. In other words the money supply rule could be written as $m_t = \alpha p_t + \beta\hat{\pi}_t$. If the response of the money supply to expected inflation were exactly equal to the interest rate coefficient in the money demand equation—that is, if $\beta = -b$—then the effect of a change in the expected rate of inflation would be perfectly offset. The primary advantage of the real interest rate rule is that it automatically offsets the effects of shifts in expected inflation on aggregate demand.

The dynamic response of the economy to supply shocks with and without the inflation offset appears in figures 9.3 and 9.4. (The parameters used to generate this and following simulations are reported in table 9.1.) The disturbance generating these responses is a one-period shock to the contract wage equation. As a result of this shock, output declines and prices increase over the short run before returning to their initial levels. The mechanics of wage contracting lead to a maximum decline in real output during the third period following the disturbance, simultaneous with the peak in the real interest rate. The inflation offset reduces the magnitude of these output and interest rate effects while increasing price and nominal interest rate adjustments. In figure 9.4 the behavior of the money supply illustrates the intervention necessary in order to offset changes in inflationary expectations.

The importance of offsetting variations in the expected inflation rate can be illustrated graphically. Suppose that a monetarist policy is adopted

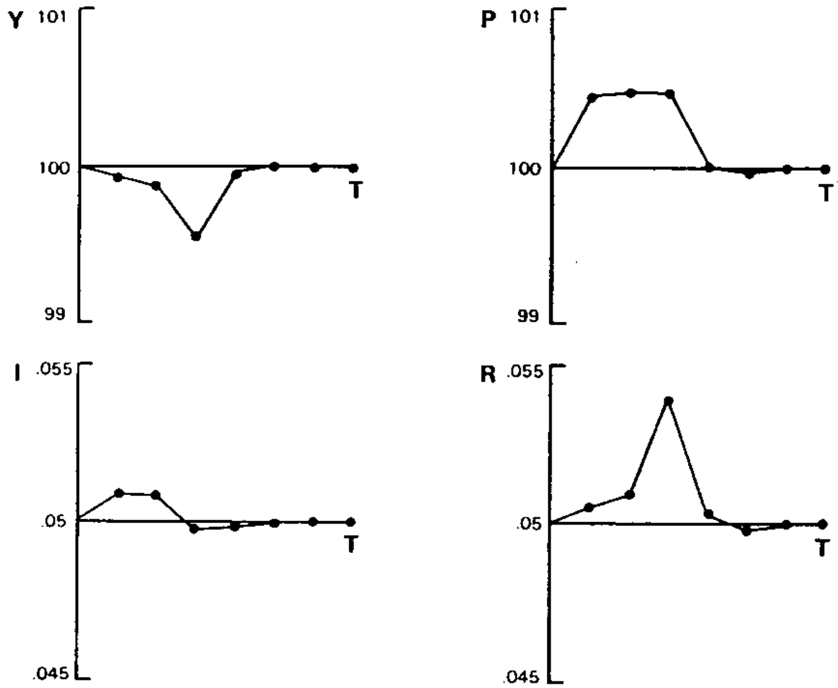

Figure 9.3
Price shock without inflation offset

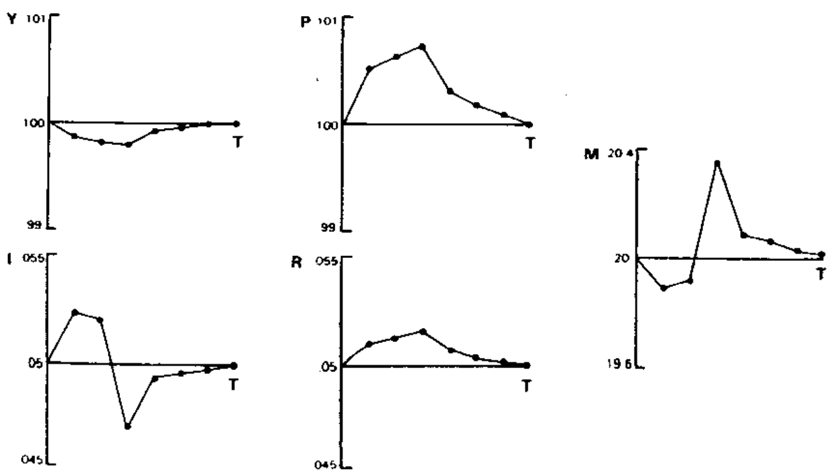

Figure 9.4

Table 9.1
Parameter values used in model simulations

Parameter	Value
δ	0.5
γ	1.0
θ	0.8 (0.7)
n	3.0
d	1.2
f	0.1 (0.3)
g	0.1 (0.3)
b	4.0
a	1.0

Note: The home and foreign economies are equal in size and are symmetrically parameterized. The alternative parameter values shown in parentheses are used in the moderate interaction simulations of the two-country model reported in section 3. Parameter d is the semielasticity of aggregate demand with respect to the real rate of return. At the equilibrium level of the real rate, the interest elasticity of aggregate demand is approximately equal to -0.06. Parameter b is the semielasticity of money demand with respect to the nominal rate of return. At the equilibrium level of this rate, the interest elasticity of aggregate demand equals -0.2. This is a rough average of the estimates reported by Goldfeld (1973) and Simpson et al. (1979).

with $\alpha = 0$ and without any attempt to offset expected inflation. If a supply shock shifts the aggregate supply curve upward, as shown in figure 9.5, then output initially will fall and prices will rise. Because the price effects take time to work through the system of staggered contracts (in the diagram it is assumed that contracts last three periods, $n = 3$), there is a period of time in which the expected rate of inflation rises. Without a policy offset to this increase, the aggregate demand curve will shift to the right, partially reducing the contractionary effect of the shock. Because the price level eventually returns to its previous level (or trend path), subsequently there is a period of declining inflationary expectations. This decline results in an increase in the real rate of interest and causes the aggregate demand curve to shift back to the left. The shift to the left in turn causes a large decline in output before the economy returns to full employment. The responses of prices and output are shown by the intersections of the various supply and demand diagrams in figure 9.5. The dynamic response patterns corresponding to those price-output intersections in figure 9.5 are shown in figure 9.3. Note that there is a large increase in the real rate of interest in period 3, the same period in which the price level peaks and price declines are anticipated in future periods.

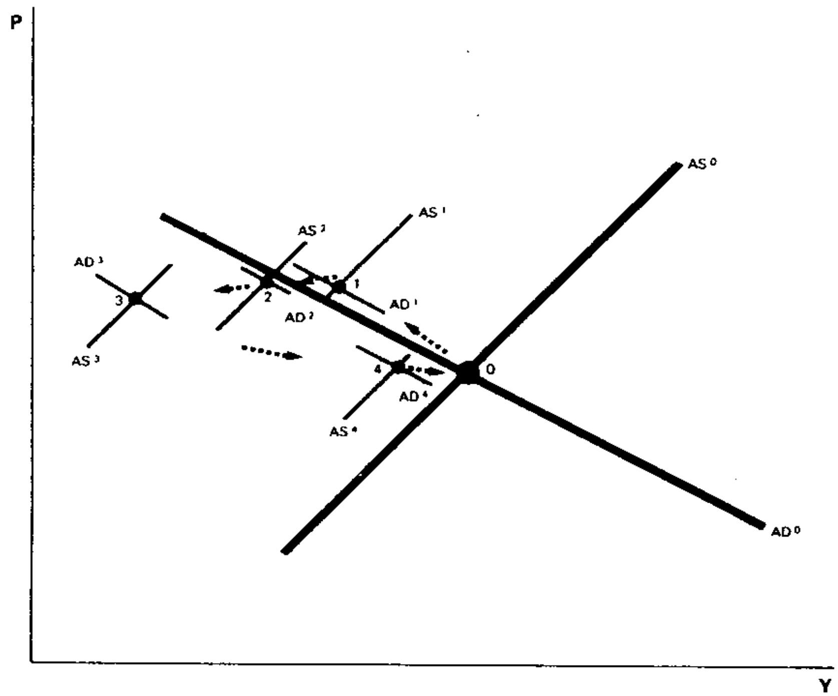

Figure 9.5
Price shock without inflation offset

This rise in real interest rates causes output to fall sharply in the same period, as is shown in the diagram.[6]

The pattern of nominal and real interest rate movements is much different when there is an attempt to offset the effects of the expected inflation rate on aggregate demand. In figure 9.6 we show the impact of the same aggregate supply shock when the money stock is increased or decreased to offset perfectly the effect of shifts in the expected inflation rate on aggregate demand. In this simulation $\beta = -b$. The dynamic response patterns for this alternative policy rule are shown in figure 9.4. Note the smooth patterns of real interest rate movements compared with the wide swings in figure 9.3. For this smooth movement in real interest rates, there is a corresponding irregular pattern for nominal rates. Recall that the aggregate supply shock first increases and subsequently decreases the expected rate of inflation. If real interest rates are to move smoothly,

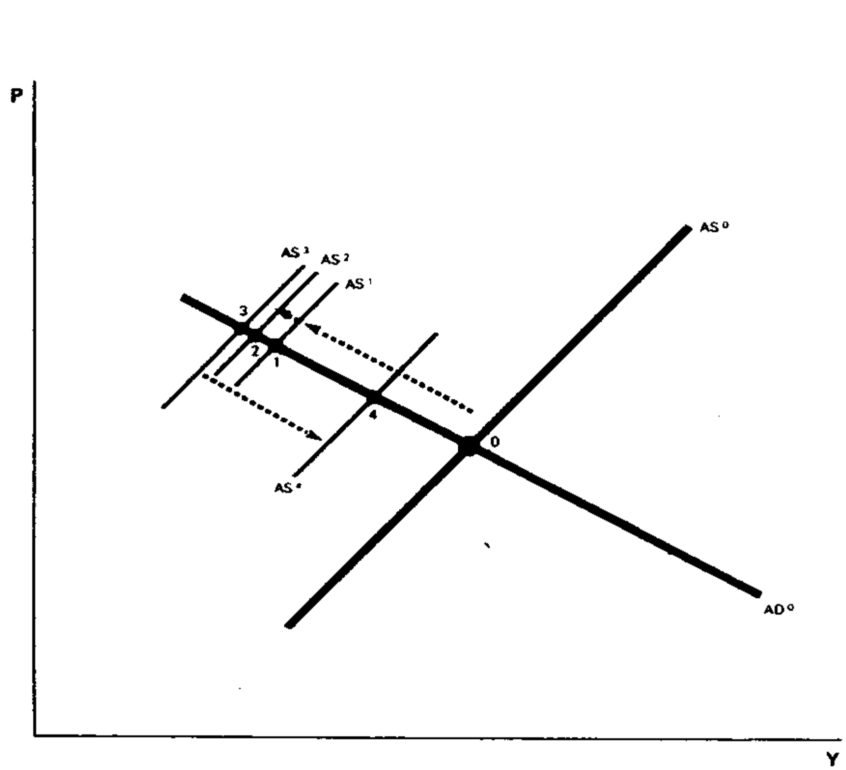

Figure 9.6
Price shock with inflation offset

then there must be an increase in nominal rates in the first few periods after a supply shock, followed by a fall in nominal rates below normal before returning to their original level. The pattern of the money supply is also irregular. The money supply is reduced below normal in the first few periods and subsequently rises above normal.

In terms of failing to offset the expected rate of inflation, nominal interest rate targeting is always worse than money stock targeting. With an interest rate target, the expected inflation-induced shifts in the IS curve translate into larger output fluctuations than with a money supply target. Using the algebra of equations (9) and (11), this can be seen by comparing the coefficients of expected inflation ($d > hb$).

As one should expect in a situation without demand shocks, there are certain equivalence relationships between the various types of price rules. The response of a money supply rule to prices will have exactly the same effects as an interest rate rule (ignoring the problem of offsetting expected inflation) if $\alpha_r = (h/d)(1 - \alpha)$. For example, a monetarist rule ($\alpha = 0$) results in a positively responding interest rate rule with a response coefficient equal to h/d. An interest rate rule that is completely nonresponsive ($\alpha_r = 0$) corresponds to a fully accommodative money supply rule ($\alpha = 1$).

A nominal GNP rule could also be contemplated within this framework. A nominal GNP rule takes the form $y_t + p_t = \alpha_n p_t$ where α_n is the response of nominal GNP to price disturbances. Although nominal GNP rules are usually discussed as if nominal GNP (or its growth rate) were unresponsive to prices ($\alpha_n = 0$), this results in very nonaccommodative policy. Clearly a given nominal GNP rule is equivalent to a real interest rate rule if $\alpha_r = (\alpha_n - 1)/d$.[7]

The previous analysis indicates that real interest rate rules (or more generally monetary rules that offset the effects of expected inflation on aggregate demand) ought to work better than money stock or nominal interest rate rules. In order to illustrate this, we have computed combinations in output and price stability for the closed economy version of the model using stochastic simulation techniques. These output-price stability points are computed under the assumption that independent and identically distributed random variables ε_t continually shock equation (3). By stochastically simulating the model for alternative values of the policy rules, the average fluctuations of output and prices can be computed for these different rules—measured in terms of the standard deviations of output and prices.

The results of this exercise are shown in figure 9.7. The triangles indicate output-price stability points corresponding to different monetary policy rules. All of the points indicated by triangles correspond to policies in which changes in the expected rate of inflation are offset. Points on the upper left-hand segment of the diagram correspond to accommodative policies—that is, policies in which the real interest rate rises only slightly in response to price movements above normal. Points on the lower right-hand segment of the diagram correspond to less accommodative policies. For these points real interest rates are increased by a larger amount in response to price shocks. The scatter of the points is due to the uncertainty associated with the stochastic simulations and could be eliminated by increasing the size of the samples.[8] Despite the scatter a downward sloping trade-off is evident. Note that the fixed money supply rule and the interest rate rule are well inside the scatter, supporting our earlier argument that

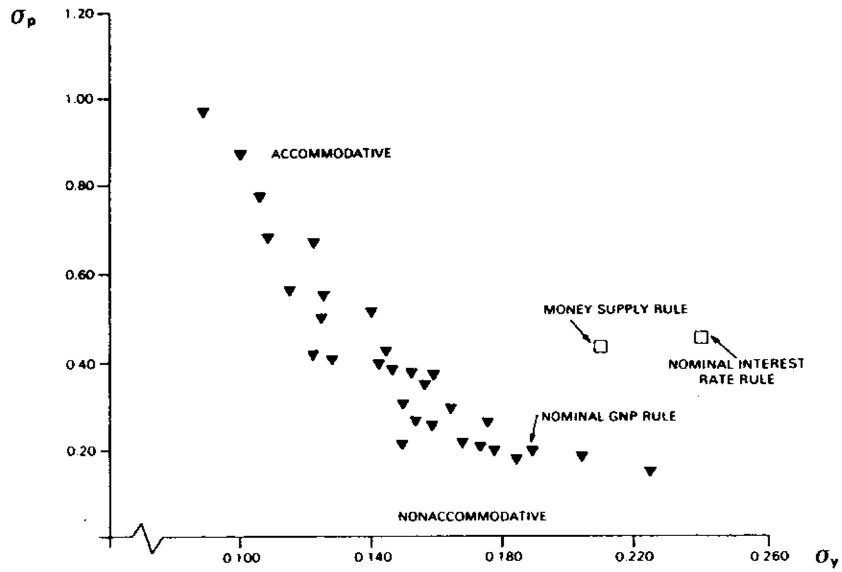

Figure 9.7
Price versus output stability in a closed economy with price shocks

Before proceeding with the two-country analysis, it is useful to consider the dynamic response of the closed economy to a classic macroeconomic policy shock: an unanticipated permanent increase in the level of the money supply. The macroeconomic responses to a 1 percent increase in money are shown in figure 9.8. There is a positive real output effect that diminishes exponentially to zero in the long run. Prices rise slowly at first but eventually by the same amount as the increase in money. Both the real and the nominal interest rate eventually decline, but the decline in the nominal rate is comparatively small. The nominal interest rate returns to the initial level more quickly than the real rate. Throughout the simulation the expected rate of inflation holds the real interest rate below the nominal rate, making the impact of monetary policy on real interest rates larger than its impact on the nominal rate. The plots in figure 9.8 pertain to the closed economy parameter values listed in table 9.1. For other parameter values we have experimented with (a small γ, for example), the nominal interest rate falls by a larger amount. The decline in the real rate is always larger than the decline in the nominal rate, however.

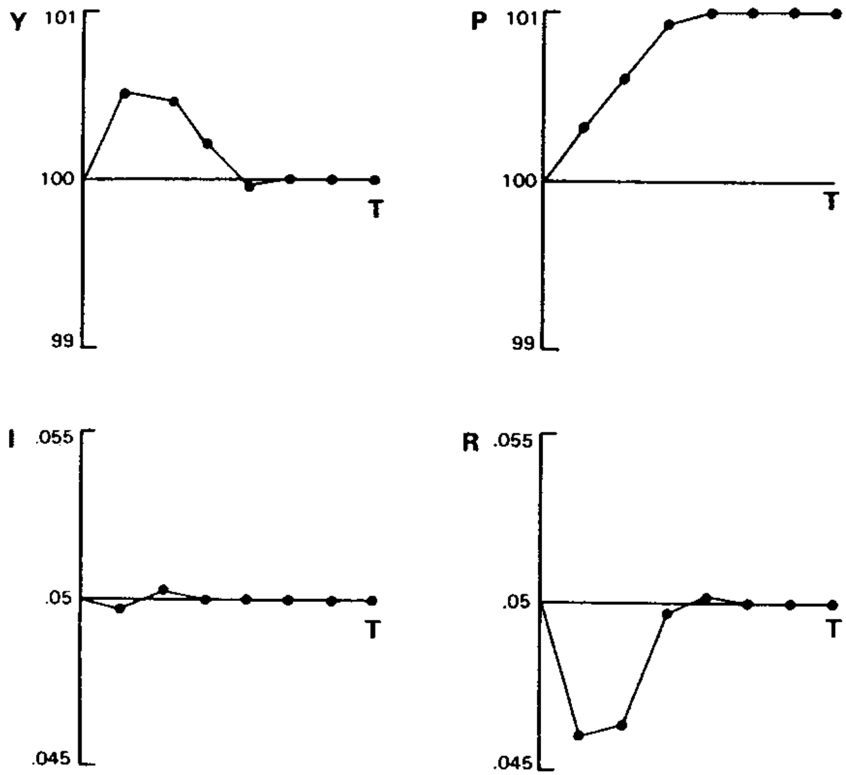

Figure 9.8
Money shock in closed economy

3. Monetary Policy in a Two-Country Model with Capital Mobility

We now consider the effects of capital mobility on macroeconomic performance in a two-country flexible exchange rate world. We have already summarized in equations (1) through (6) the basic elements of aggregate supply and aggregate demand for a single open economy. (We now emphasize that $\theta \neq 1$ and that neither f nor g equals zero.) To close the system we need to add a corresponding model for the rest of the world and to provide a link between capital markets in the home country and the rest of the world. We assume that international capital mobility can be approximated by the assumption of perfect capital mobility—that is, perfect substitutability between domestic and foreign interest earning assets plus instantaneous adjustment of capital flows. Algebraically the perfect capital mobility assumption can be written as:

$$i_t = i_t^* + \hat{e}_{t+1} - e_t. \tag{12}$$

In other words the domestic interest rate is equal to the rest of the world interest rate plus the expected rate of depreciation of the home currency.

The aggregate demand and aggregate supply equations for the rest of the world are given by:

$$x_t^* = \frac{\delta^*}{n}\sum_{i=0}^{n-1} \hat{w}_{t+i}^* + \frac{1-\delta^*}{n}\sum_{i=0}^{n-1} \hat{p}_{t+i}^* + \frac{\gamma^*}{n}\sum_{i=0}^{n-1} \hat{y}_{t+i}^* + \varepsilon_t^*, \tag{13}$$

$$w_t^* = \frac{1}{n}\sum_{i=0}^{n-1} x_{t-i}^*, \tag{14}$$

$$p_t^* = \theta^* w_t^* + (1-\theta^*)(p_t - e_t), \tag{15}$$

$$y_t^* = -d^* r_t^* - f^*(p_t^* + e_t - p_t) + g^* y_t, \tag{16}$$

$$m_t^* - p_t^* = -b^* i_t^* + a^* y_t^*. \tag{17}$$

$$r_t^* = i_t^* - \hat{\pi}_t^*. \tag{18}$$

The rest of the world equations (13) through (18), when combined with the capital mobility equation (12) and home country equations (1) through (6), form the complete model. How the model is solved depends on the exchange rate regime. With flexible exchange rates each country's money supply (m and m^*) can be set either exogenously or by a policy rule. With fixed exchange rates the money supply in only one country can be set, either exogenously or by a policy rule, while the other country's money supply is determined by the fixed exchange rate objective. No sterilization, in the usual sense of the word, is possible with perfect capital mobility. We will focus on flexible exchange rates.[9]

The dynamic response of the flexible exchange rate model to an unanticipated permanent increase in the home country money supply is shown in figure 9.9. These responses are calculated using the parameter values in table 9.1 that suggest a low degree of interaction between the two countries. The effects on prices and output in the home country are much like those in the closed economy model shown in figure 9.8. The increase in prices is slightly more rapid and the effect on output slightly smaller. Both real and nominal interest rates decline, with the real interest rate

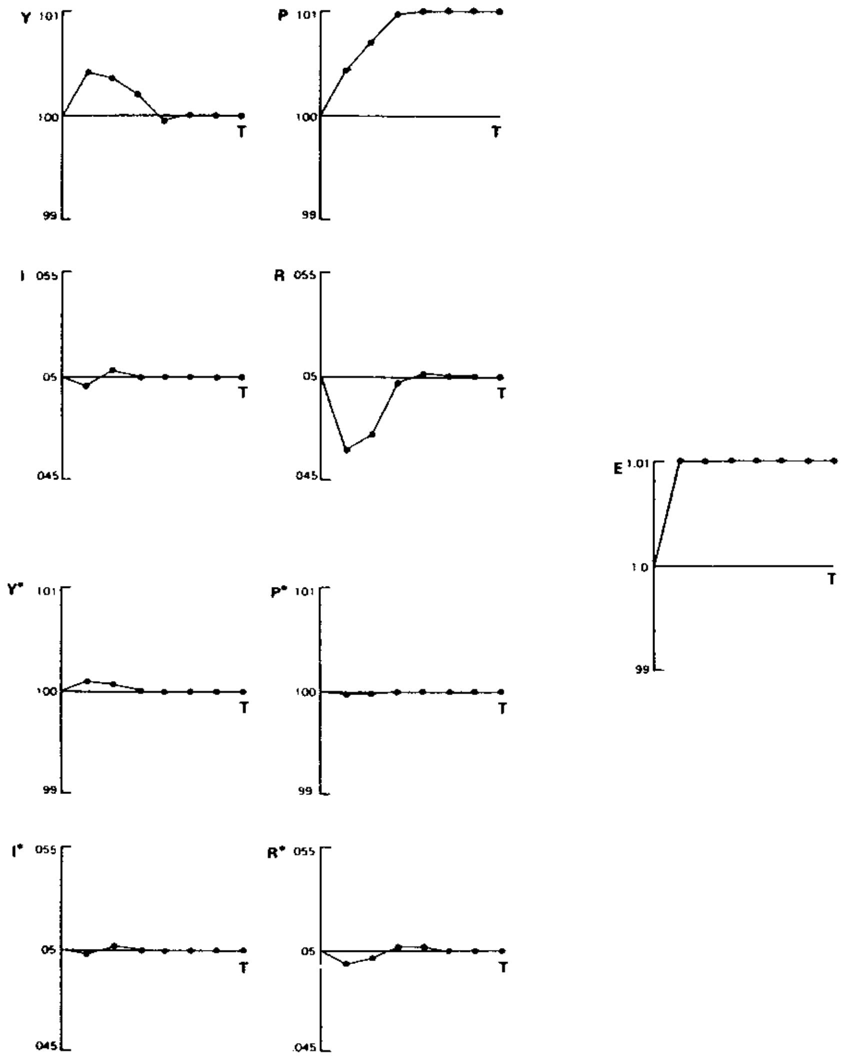

Figure 9.9
Money shock in two-country model

declining more than the nominal interest rate. The exchange rate in the home country depreciates in the first period by the same percentage as the increase in the home money supply. Hence, to a first approximation, the exchange rate immediately jumps to its new long-run equilibrium value. There is some overshooting, analogous to that studied by Dornbusch (1976), but this is very small in comparison with the size of the jump to the region of the new equilibrium rate. Despite perfect capital mobility, monetary policy in the home economy of this two-country model has many similarities with monetary policy in the closed economy model. A decline in real interest rates temporarily stimulates output and leads to a rise in prices. In addition the exchange rate depreciates, raising the real exchange rate to stimulate demand further and adding to the rise in the domestic price level.

The impact of the increase in the home money supply on foreign output is positive but fairly small. This contrasts with the Mundell-Fleming result that an expansionary monetary policy at home causes contraction in demand in the rest of the world due to the appreciation of the exchange rate.[10] According to this model the impact effects of monetary policy have the same sign at home and abroad. The reason is found in the price linkage or markup equations. The appreciation of the exchange rate in the rest of the world tends to reduce the foreign price level through its effect on import costs. This lower price level translates into an increase in real money balances in the rest of the world, despite the fixed nominal money supply. This increase in real money balances can stimulate demand and can offset the negative effects of the appreciation, unlike the Mundell-Fleming model where the fixed price level prevents the real money stock from increasing.

Given our focus on capital mobility, it is interesting to study the impact of the home monetary expansion on foreign interest rates. Because the exchange rate jumps almost exactly to the new long-run equilibrium value and then stays with very little overshooting at that value, there is only a very small expected appreciation of the home currency after the first period. Hence domestic and foreign nominal interest rates cannot diverge from each other by much. But recall that the nominal interest rate in the home country declined by only a small amount. Most of the stimulative effects of the monetary expansion came from the decline in real interest rates as caused by the increase in the expected inflation rate. Because monetary policy works in this model primarily by reducing the real interest rate and because it is nominal rather than real interest rates that are linked in this model by capital flows, it is possible for monetary policy to have powerful domestic effects.

We now go on to examine the output-price stability trade-off and how the world economy responds to supply shocks under alternative policy rules. From the analysis of section 2 it is clear that macroeconomic inefficiencies will result from a monetary policy rule that does not offset the impact of changes in the expected inflation rate on aggregate demand. So that we can assess whether capital mobility impinges on macroeconomic efficiency, we therefore focus on monetary rules for which such an inflation offset automatically occurs. Equivalently we limit our analysis to real interest rate rules. Since there are now two countries, we need to specify two such interest rate rules. Let these be:

$$r_t = \alpha_r p_t, \tag{19}$$

$$r_t^* = \alpha_r^* p_t^*. \tag{20}$$

The dynamic response of the model to a supply shock in the home country when $\alpha_r = \alpha_r^* = 0.2$ is shown in the charts in figure 9.10. What is perhaps most striking about this simulation is the small effect of the supply shock on the rest of the world. The rise in prices caused by the supply shock brings forth an increase in real interest rates in the home country, as called for in (19), but almost no change in the interest rate in the rest of the world. Unlike the case of an unanticipated increase in the money supply, the exchange rate is expected to change by significant amounts following a supply shock. These expected movements in the exchange rate permit a divergence between nominal interest rates in the two countries. In the early periods of the simulation, the exchange rate depreciates and is expected to depreciate, permitting the interest rate to rise at home relative to abroad. This rise is necessary if real interest rates are to rise. Later the exchange rate appreciates back to the long-run equilibrium value, and the nominal interest rate falls at home relative to abroad (as it should, because by this time the decline in the expected rate of inflation has its own negative effects on real interest rates).

These results suggest that the output-price performance generated by such supply shocks might be surprisingly unaffected by policy choice abroad despite perfect capital mobility. To test this proposition, we stochastically simulate the two-country model under parameterizations of

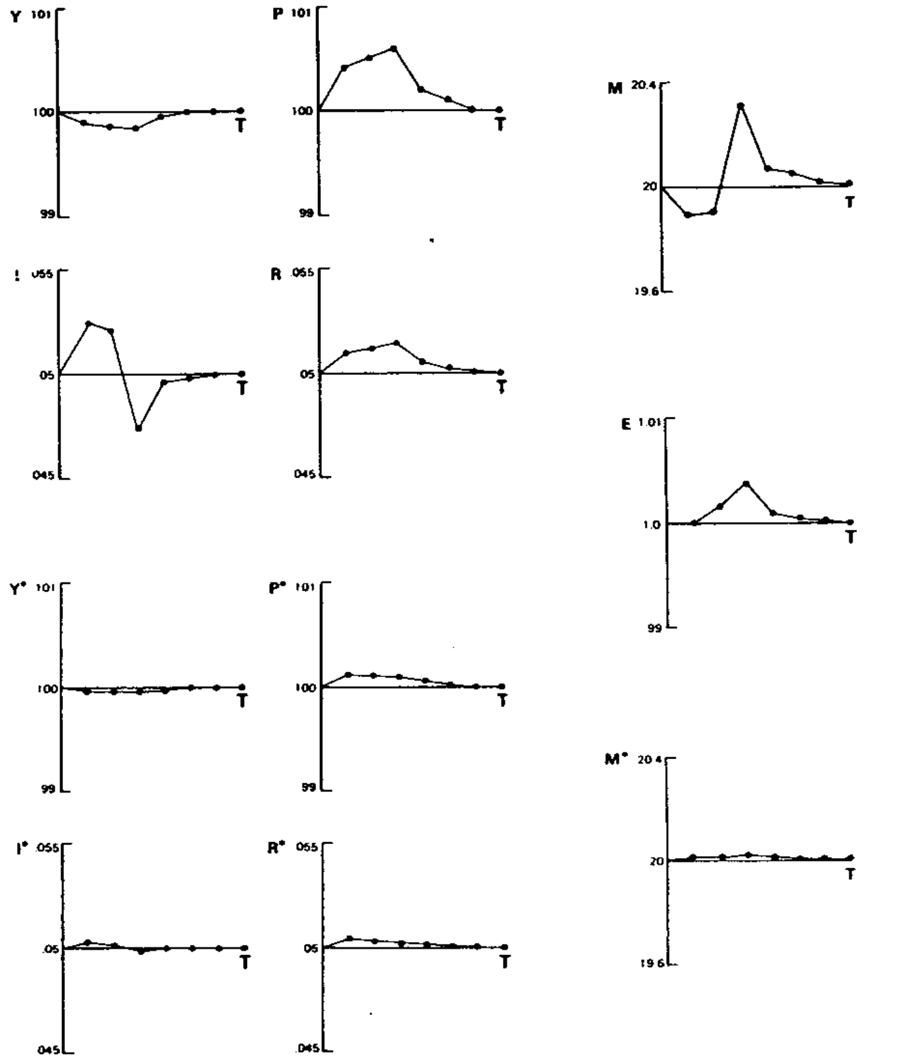

Figure 9.10
Price shock (with offset) in two-country model

equations (19) and (20) corresponding to different values of α_r and α_r^*. These calculations are made under the assumption that supply shocks continually occur in both countries, that these shocks are unanticipated and temporary, and that they are uncorrelated between the countries. In other words, ε_t and ε_t^* are serially and contemporaneously uncorrelated random variables. Only a limited number of policy rule parameterizations have been examined in order to save on computation costs.[11] Variances calculated for α and α_r^* equal to 0.2 and 0.6 are reported in figures 9.11 and 9.12. In figure 9.11 we have computed the variances of output and prices assuming a low degree of direct interaction between the countries. In figure 9.12 the interaction is moderate.[12]

Figures 9.11 and 9.12 indicate in what sense there is relatively little interaction between the policy rules in the two countries. For example, as the home country moves from a relatively nonaccommodative interest rate rule to a more accommodative interest rate rule, its output variability declines and its price variability increases. But the effect of this move on the other country's variability measure is very small. There is some indication that the rest of the world benefits from a more accommodative policy at home (its performance improves), but the effect is second order.

This relative independence is illustrated by figure 9.13, in which the standard deviations of output and prices under the moderate interaction parameterization are plotted for α_r ranging from 0.05 (accommodative) to 0.90 (nonaccommodative). These stability pairs are plotted first under the assumption that foreign policy is nonaccommodative ($\alpha_r^* = 0.6$) and second under the assumption that foreign policy is relatively accommodative ($\alpha_r^* = 0.2$). Figure 9.13 suggests a slight positive feedback between the policy choices of these two nations. When the home nation is interested in pursuing an accommodative domestic policy, it can achieve more efficient macroeconomic performance if the foreign nation also adopts an accommodative policy. And when domestic policymakers prefer a nonaccommodative response rule, macroeconomic performance is enhanced if a similar policy is chosen abroad. The results reported in figure 9.13 indicate, however, that the magnitude of this interaction is small.

4. Concluding Remarks

Our purpose has been to develop and test a quantitative framework for evaluating macroeconomic performance in a world of perfect capital

	$\alpha_r^* = 0.6$	$\alpha_r^* = 0.2$
$\alpha_r = 0.6$	0.188 0.147 0.188 0.147	0.423 0.111 0.181 0.144
$\alpha_r = 0.2$	0.181 0.144 0.423 0.111	0.425 0.112 0.425 0.112

Key:

σ_p^* σ_y^* σ_p σ_y

Figure 9.11
Two-country trade-offs: Low interaction——*Note:* The equal size, identical structure, and symmetric parameterization of the two countries ensure that this trade-off matrix is symmetric. This symmetry is taken into account in reporting the results for the two countries. The average of the standard deviations for the two countries is reported for similar policies.

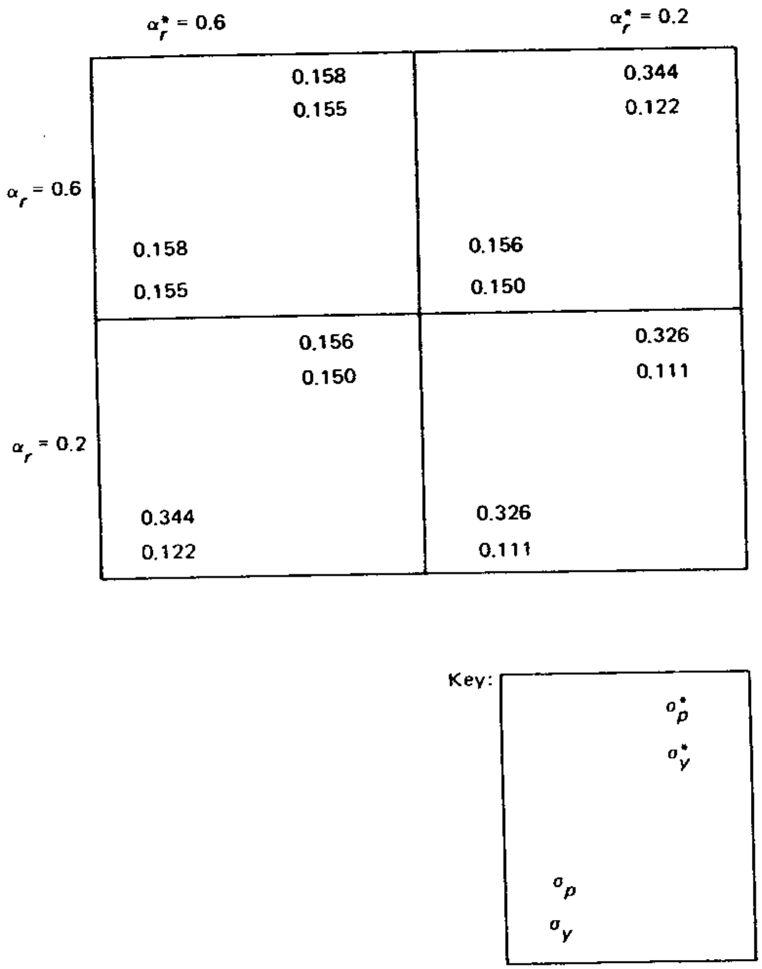

Figure 9.12
Two-country trade-offs: Moderate interaction—*Note*: The same reporting conventions are followed as in figure 9.11.

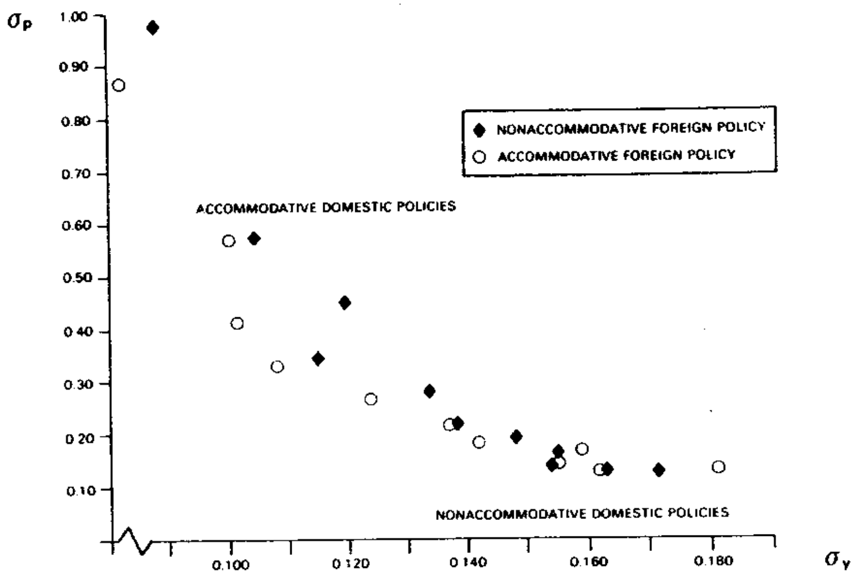

Figure 9.13
Price versus output stability in two-country model with price shocks

mobility. The framework is based on a simulation procedure for a two-country rational expectations model with price (or supply) shocks.

The simulation results suggest that if exchange rates are flexible, capital mobility does not necessarily place constraints on domestic macroeconomic performance and does not necessarily prevent individual countries from choosing their own monetary rules without interfering with other countries in significant ways. This conclusion is dependent on the particular model structure and parameter configuration we chose to investigate. Further research is required to determine the robustness of such results to widely different parameter and model configurations and to obtain econometric estimates of the crucial parameters in different countries.[13]

Notes

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1. See Taylor (1980), for example.

2. Bhandari (1982), Calvo (1983), Dornbusch (1982), Rehm (1982), and Taylor (1982) have used staggered wage-setting models of aggregate supply in an open economy framework. See Mussa (1982) and Liederman (1982) for alternative sticky-price approaches to aggregate supply in open economy models.

3. Because prices are partly influenced by foreign import prices, it is important to include both wages and prices in the contract determination equation in order to capture all of the dynamic effects of a foreign price disturbance.

4. This paragraph and the next provide a brief overview of the results in Taylor (1980).

5. Rehm (1982) has provided an extensive set of deterministic simulations to illustrate the dynamic properties of a closed economy model like this one and has also examined the case of a small, open economy. Calvo (1983) has studied a small, open economy model using continuous time techniques.

6. The dynamic response patterns shown in figure 9.3 were computed numerically for the parameter values shown in table 9.1 using the extended path algorithm described in Fair and Taylor (1983). The patterns show the response of the closed economy model to a one-unit shock to ε_t in the first period of the simulations. This corresponds to a temporary unanticipated contract wage shock, which we refer to simply as a supply shock in the text.

7. The simulation results reported in the text take advantage of this correspondence among response rules. The interest rate and nominal GNP response rule simulations are generated using a money response rule parameterized to yield the appropriate aggregate demand relations.

8. The stochastic simulation results are based on single runs of 500 periods for each parameter configuration. In order to ensure stationarity, the standard deviations are computed using the last 450 observations of each of these runs.

9. This model also could be used to investigate the choice of exchange rate regimes (fixed versus flexible) using the same stochastic simulation approach. See Carlozzi (1982) for this type of application using a different model.

10. See Dornbusch (1980: 201) for a discussion.

11. Johnson (1982) has computed two-country output-inflation trade-offs of this type in a model without capital mobility and with explicit exchange rate management and has explored alternative equilibrium concepts in the choice of rules in the two countries.

12. The parameter values for the low and moderate interaction simulations of the two-country model are reported in table 9.1.

13. Structural estimates can be obtained using the econometric procedures employed by Rehm (1982) to estimate small open economy models for Germany and the U.S.

References

Bhandari, J. S. 1982. "Staggered Wage Setting and Exchange Rate Policy in an Economy with Capital Assets." *Journal of International Money and Finance* 1: 175-192.

Calvo, G. A. 1983. "Staggered Contracts and Exchange Rate Policy." In J. Frenkel, ed., *Exchange Rates and International Macroeconomics*. University of Chicago Press for National Bureau of Economic Research.

Carlozzi, N. 1982. "Economic Disturbances and Exchange Regime Choice." Working Paper 82-8, Federal Reserve Bank of Philadelphia.

Dornbusch, R. 1976. "Expectations and Exchange Rate Dynamics." *Journal of Political Economy* 84:1161–1176.

Dornbusch, R. 1980. *Open Economy Macroeconomics*. New York: Basic Books.

Dornbusch, R. 1982. "PPP Exchange Rate Rules and Macroeconomic Stability," *Journal of Political Economy* 90:158–165.

Fair, R., and Taylor, J. B. 1983. "Solution and Maximum Likelihood Estimation of Dynamic Nonlinear Rational Expectations Models." *Econometrica* 51:1169–1185.

Goldfeld, Stephen M. 1973. "The Demand for Money Revisited." *Brookings Papers on Economic Activity* 3:577–638.

Fleming, M. J. 1962. "Domestic Financial Policies under Fixed and under Floating Exchange Rates." *International Monetary Fund Staff Papers* 9:369–379.

Johnson, R. A. 1982. "Monetary Stabilization and Interdependence in a Two-Country Model." Unpublished paper. Princeton University.

Liederman, L. 1982. "Monetary Accommodation and the Variability of Output Prices, and Exchange Rates." *Carnegie Rochester Conference Series on Public Policy* 16:47–86.

Mundell R. 1961. "Flexible Exchange Rates and Employment Policy." *Canadian Journal of Economics and Political Science* 27:509–517.

Mundell, R. 1963. "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates." *Canadian Journal of Economics and Political Science* 29:475–487.

Mussa, M. 1982. "A Model of Exchange Rate Dynamics." *Journal of Political Economy* 90:74–104.

Rehm, D. E. 1982. "Staggered Contracts, Capital Flows and Macroeconomic Stability in the Open Economy." Ph.D. dissertation, Columbia University.

Simpson, Thomas D., et al. 1979. "A Proposal for Redefining the Monetary Aggregates." *Federal Reserve Bulletin* 65:13–42.

Taylor, John B. 1980. "Aggregate Dynamics and Staggered Contracts." *Journal of Political Economy* 88:1–23.

Taylor, John B. 1982. "Macroeconomic Tradeoffs in an International Economy with Rational Expectations." In W. Hildenbrand, ed., *Advances in Economic Theory*. Cambridge: At the Press.

Tobin, J. 1978. "A Proposal for International Monetary Reform." *Eastern Economic Journal* 4:153–159.