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9 Real Adjustment and Exchange Rate Dynamics

J. Peter Neary and Douglas D. Purvis

The 1970s witnessed numerous events which called into question much of the "accepted wisdom" of macroeconomics as it was perceived at the start of the decade. Stagflation and the resistance of inflation to contractionary policy constituted a major challenge to closed economy macroeconomists. For those analysts who focus on open-economy macroeconomics, two further phenomena can be added to the list of problems.

First, there was a frequent occurrence of sector-specific disturbances or shocks which buffeted many economies and set in motion a variety of perplexing dynamic responses. Most prominent, of course, were disturbances in the petroleum sector; macroeconomic difficulties were frequently encountered in adjusting to oil price increases of foreign origin and, perhaps surprisingly, in adjusting to discoveries of new domestic sources of petroleum products.

Second, the volatility of exchange rates following the adoption of a system of flexible exchange rates in the early 1970s has been far greater than expected by most economists who advocated such a system. Of course such variability does not present a prima facie argument that the system failed; indeed, it is possible to argue that the flexibility represented by such variability in the face of an uncertain and unstable international economic environment represents a virtue of the system, not a fault. Nevertheless, such variability does raise a number of interesting

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questions. To the extent that exchange rate fluctuations are caused by external factors, do they lead to inappropriate domestic resource allocation by temporarily altering relative prices? To what extent are such exchange rate movements a response to exogenous domestic disturbances, and to what extent are they a concommitant part of the domestic response to external shocks?

This paper presents a model designed to capture the two possibilities raised by the last question. However, as by-products, the model also casts light on the nature of macroeconomic responses to sectoral shocks and provides a basis for initiating investigation of the resource allocation effects of exchange rate variability.

A currently popular analysis of the role of domestic disturbances in generating exchange rate variability is the "overshooting" result of Dornbusch (1976). By postulating sticky goods prices, Dornbusch shows that the exchange rate, which is viewed as being perfectly flexible, responds to a domestic monetary disturbance by more in the short run when goods prices remain at their initial value than in the long run when all variables are allowed to adjust to their new equilibrium values. Dornbusch enhances this scenario with a version of the efficient markets hypothesis which views participants in the foreign exchange market setting the initial value of the exchange rate following the monetary disturbance at a level consistent with the expected change in the exchange rate required to equate domestic and foreign yields.[1] The appeal of the model draws in part from its simple explanation of the variance of the exchange rate exceeding that of underlying fundamentals (i.e., the money supply) and of its characterization of a dynamic path involving negatively correlated domestic price and exchange rate changes, in contrast to the prediction based on purchasing power parity that such movements will be positively correlated.

The model presented in this paper also generates exchange rate dynamics as a result of a rigidity in the economy. However, in contrast, our model does not rest on a rigidity in nominal prices but instead focuses on the dynamic adjustment elicited by sluggish reallocation of capital in response to change in relative returns. This adjustment, which we refer to as "Marshallian" dynamics, gives rise to a framework in which resource allocation and exchange rate movements are interrelated. It is also possible that in the short run the exchange rate overshoots its new long-run equilibrium level; in this case dynamic paths of nominal variables in response to a *real* shock are qualitatively equivalent to those in the Dornbusch model in response to a *monetary* shock.

1. This might be termed "rationalized expectations." Domestic monetary policy determines the domestic interest rate which in turn, given uncovered interest parity, dictates the expected rate of change of the exchange rate. The actual current exchange rate then changes to "rationalize" those expectations.

The plan of the paper is as follows. In section 9.1 we outline our real model of sectoral resource allocation, and in section 9.2 we derive the basic overshooting result in terms of the "real" exchange rate. In section 9.3 we expand the model to incorporate a macroeconomic structure to allow for the determination of the nominal exchange rate given an exogenous value of the domestic money supply; the response of the nominal exchange rate to monetary and real shocks is then examined. Section 9.4 presents the conclusions and draws some comparisons between Marshallian and macroeconomic sources of exchange rate dynamics.

9.1 A Model of Sectoral Shifts and Resource Allocation

In this section we introduce the basic consumption and production relationships which constitute the real part of our model, and then examine the model's properties in terms of short- and long-run equilibrium and dynamic adjustment. The particular specification we have chosen is designed to permit, in as simple a manner as possible, an analysis of the two features mentioned in the introduction. The model is multisectoral to allow both for sectoral shocks and for reallocation of resources in response to other disturbances.

A key feature of the model is that prices adjust instantaneously to clear markets, yet we distinguish between situations of short-run equilibrium, contingent on predetermined values of some variables, and long-run or full equilibrium. The distinction arises due to the multisectoral framework combined with the assumption that factor reallocation, in particular changes in sectoral capital stocks, is costly and hence takes time.

There are three sectors in the model: two traded goods, benzine and manufactures; and one nontraded good, services. The first two are produced and consumed domestically; both have perfect substitutes available in infinitely elastic supply in world markets, so their foreign currency prices, and hence their relative price, can be taken as given. The price of services adjusts instantaneously to equate the domestic demand and supply for services.

Since the economy is "small" in traded goods markets, demand repercussions of various shocks impinge only on the services sector. Hence most of our focus is on the structure of production. In one traded goods sector capital is combined with a sector-specific factor, or natural resource, to produce benzine. In the other, capital and labor are used in combination to produce manufactured goods. In the nontraded goods sector, services are produced using only labor.[2]

2. In Neary and Purvis (1982), where we also employ this real structure, we relate it to alternative models used in the analysis of the "Dutch Disease," e.g., Buiter and Purvis (1983) and Corden and Neary (1981).

Factors differ not only with respect to where they are used, but also with respect to how quickly they can move between uses. Labor is assumed to be mobile between the sectors in which it is used—services and manufacturing—with the wage rate adjusting to clear the labor market. Capital, however, is "bolted down" and hence sector-specific in the short run; only with time can the capital stock in the sectors in which it is used—manufacturing and benzine—adjust in response to changing factor rewards. Note that there is no *direct* factor market link between the benzine and services sectors, but that over time there is an *indirect* link operating through the manufacturing sector.[3] This plays an important role in the behavior of the model.

9.1.1 The Market for Services

The domestic demand for services depends on all prices and on domestic real income.[4]

(1) $$c_S = -\epsilon_S p_S + \epsilon_B p_B + \epsilon_M p_M + \eta y.$$

The only source of changes in national income which we consider is a discovery of the resource or "specific factor" used in the production of benzine, denoted by v, so we can write real income as

(2) $$y = \theta_V v,$$

where θ_V is the share of the specific factor in national income.[5] Letting e be the nominal exchange rate (i.e., the domestic price of foreign currency), we define the real exchange rate, π, as

(3) $$\pi \equiv e - p_S.$$

By appropriate choice of units we can set the levels of the foreign currency prices of manufactures and benzine equal to unity, so their domestic prices are given simply by the nominal exchange rate (i.e., $p_B = p_M = e$). Noting that the compensated price elasticities in (1) must be related by $\epsilon_B + \epsilon_M = \epsilon_S$, and using (2) and (3), we can rewrite (1) as

(4) $$c_S = \epsilon_S \pi + \eta\theta_V v.$$

Equation (4) shows that the domestic demand for services is an increasing function of the real exchange rate and of the availability of the natural resource.

3. Note also that output of benzine is a predetermined variable while output of manufacturing and services can adjust on impact since the allocation of labor can respond instantaneously.

4. Unless otherwise noted, all variables are in logarithmic form and all coefficients are positive. In principle, the compensated elasticities ϵ_B and ϵ_M can be positive or negative; we assume in what follows that all commodities are net substitutes, so ϵ_B and ϵ_M are positive.

5. Changes in the terms of trade can of course also create income effects. Elsewhere (Neary and Purvis 1982) we have analyzed the consequences of such disturbances in the presence of domestic price rigidities.

As noted earlier, we postulate that the production of services involves only labor, a useful simplification which reflects the relative labor intensity of service sectors in most economics. This allows us, by appropriate choice of units, to identify the demand for services with the demand for labor in the services sector, $c_S = \ell_S$, and the price of services with the wage rate, $p_S = w$. Recalling that $p_M = e$, we can therefore reinterpret the real exchange rate as the inverse of the real wage in the manufacturing sector.

$$\pi = -(w - p_M). \tag{3'}$$

Equation (4) thus shows that the demand for labor in services depends negatively on the manufacturing real wage and positively on the stock of the natural resource.

9.1.2 Short-Run Equilibrium in the Market for Labor

Labor, it will be recalled, is assumed to be fully employed at all times, with the total stock of labor allocated between the manufacturing and services sectors. The demand for labor in manufacturing, ℓ_M, depends on the (predetermined) capital stock in that sector, k_M, and on the manufacturing real wage rate:

$$\ell_M = k_M - \gamma_M(w - p_M),$$

where γ_M is the real wage elasticity of the demand for labor in manufacturing. Using equation (3′) we can rewrite this as

$$\ell_M = k_M + \gamma_M \pi. \tag{5}$$

For given values of v, p_M, and k_M, equilibrium in the labor market arises when π adjusts so that (4) and (5) together satisfy the full employment condition:

$$\lambda_{LS}\ell_S + \lambda_{LM}\ell_M = 0, \tag{6}$$

where the λ's are the fractions of the labor force employed in the respective sectors.

This equilibrium is illustrated in figure 9.1, where the horizontal axis equals the economy's endowment of labor measured in natural units. The demand for labor in services, equation (4), is depicted by the negatively sloped line C_S, drawn for a given value of v. The demand for labor in manufacturing, equation (5), is depicted by L_M drawn with respect to the right-hand axis as a negative function of the real wage. Equilibrium is at E_0 where the wage is such that the demand for labor in the two sectors just exhausts the total available supply of labor, L.[6]

6. In this paper labor is treated as being in perfectly inelastic supply; elsewhere (in Neary and Purvis 1982) we treat the full employment level of employment as the "natural" level about which actual employment can fluctuate.

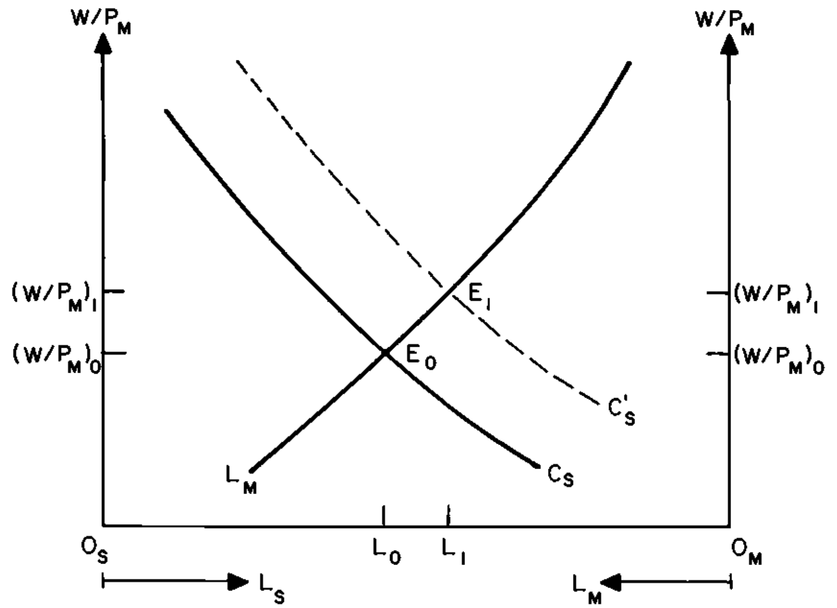

Fig. 9.1 The market for labor.

9.1.3 Short-Run Response to a Resource Boom

The effects of a resource boom in the sense of an exogenous increase in the availability of the natural resource can now readily be determined. The income effect arising from an increase in v leads to an increased demand for services and hence to an increased demand for labor in the services sector. In figure 9.1 the increase in v causes the C_S curve to shift up and to the right to the dashed line C_S'. As can be seen from equation (5), the boom has no effects on the demand for labor in manufacturing, so the new equilibrium obtains at E_1 with an increased wage and a shift of L_0L_1 units of labor from manufacturing to services. Hence, on impact the resource boom causes an increase in national income but a reduction in the output of the manufacturing sector.

The equilibrium illustrated in figure 9.1 is contingent on the predetermined stock of capital in the manufacturing sector. But the boom, by drawing labor into the service sector and away from manufacturing, causes a decline in the return to capital in manufacturing and thereby creates incentives for disinvestment in manufacturing. As that disinvestment proceeds, there will be further changes in the equilibrium wage rate and allocation of labor depicted in figure 9.1. To set the stage for the dynamic analysis that follows, it is useful to examine how a change in the manufacturing capital stock influences the short-run equilibrium.

9.1.4 Capital Stock Adjustment and Domestic Equilibrium

By equation (5) a decrease in k_M reduces the demand for labor in manufacturing; this leads to a decrease in the equilibrium wage or, equivalently, an increase in the real exchange rate. Formally, substituting the two labor demands (4) and (5) into the full employment condition (6) yields the labor market equilibrium relationship:

$$(7) \qquad \epsilon\pi + \lambda_L k_M + \eta_V v = 0; \ \epsilon \equiv \epsilon_S + \lambda_L \gamma_M \text{ and } \lambda_L \equiv \lambda_{LM}/\lambda_{LS},$$

where ϵ is the aggregate real wage elasticity of demand for labor and λ_L measures the labor intensity of manufacturing relative to services.

This is depicted in figure 9.2 by the labor market equilibrium locus *LL*; its negative slope indicates that both a real depreciation (i.e., an increase in π) and an increase in the manufacturing capital stock lead to an increased demand for labor. Accordingly, above and to the right of *LL* there is excess demand for labor, and conversely below and to the left.[7]

Further, as shown in figure 9.1, an increase in v also creates an excess demand for labor and hence leads to a leftward shift in *LL* to the dashed line *L'L'* shown in figure 9.2. This leftward shift arises as a result of the increased expenditure on services; following Corden and Neary (1982) we refer to it as the *spending* effect of the resource discovery.

The impact effect of the boom can also be shown in figure 9.2: since the manufacturing capital stock is predetermined, the economy remains on the vertical dotted line $k_M{}^0$, and the new equilibrium is at E_1. The real wage increase shown in figure 9.1 is identical to the real appreciation of $\pi_0\pi_1$ involved in moving from E_0 to E_1 in figure 9.2. From equation (7) we calculate the short-run response of the real exchange rate, given the initial value of k_M, as:[8]

$$(8) \qquad \pi_1 = -(\eta\theta_V/\epsilon)v.$$

In summary, the impact effects of the resource boom are as follows. The increase in national income raises the demand for services, causing a shift of labor out of the manufacturing sector into services and a rise in the real wage (i.e., a real appreciation). The reduction in the manufacturing labor force causes a fall in the return earned by capital in that sector; this,

7. *LL* can equivalently be thought of as the locus of points which correspond to equilibrium in the services sector, $c_S = x_S$, where x_S is the supply of services derived by using (5) in the full-employment condition (6) to yield

$$x_S \equiv \ell_S = -\lambda_L k_M - \lambda_L \gamma_M \pi.$$

Equating this to c_S given in (4) yields (7). The simplifying assumption that only labor is used in services, which allows us to illustrate the model in $\pi - k_M$ space has been adopted from Kouri (1979).

8. In what follows, the initial equilibrium will be denoted by a subscript zero, the new short-run equilibrium by a subscript one, and the new long-run equilibrium by an asterisk. The latter two are expressed as deviations from the former, or, equivalently, all variables are normalized so that their values at the initial equilibrium are zero.

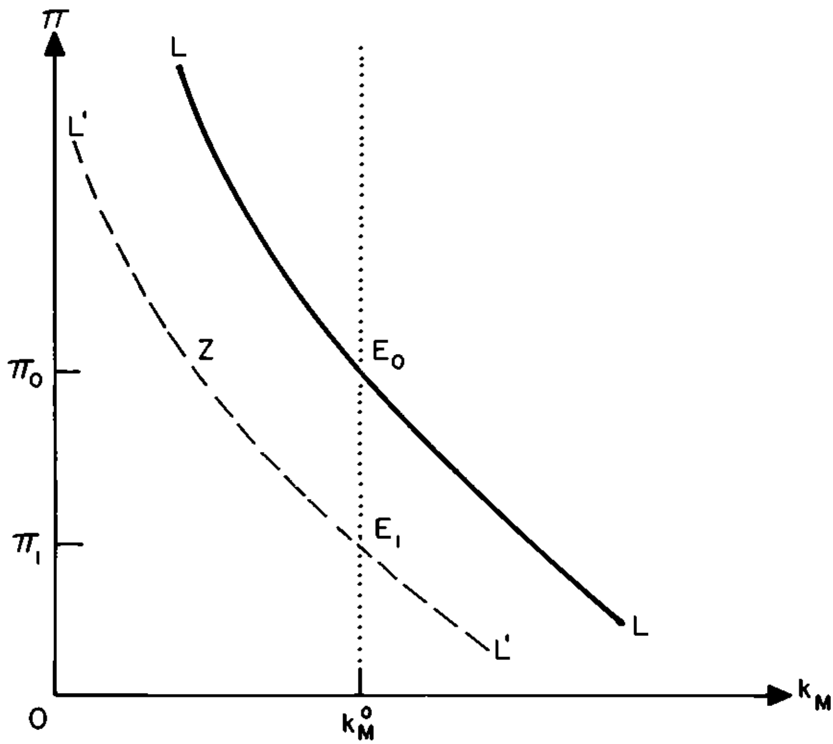

Fig. 9.2 Labor market equilibrium and the manufacturing capital stock.

of course, is the opposite of the change in the return to capital in the benzine sector since the initial disturbance being considered is an increase in the factor used in conjunction with capital in producing benzine. We turn next to consider the medium-run evolution of the model as the sectoral capital stocks respond to these changes in returns.

9.2 The Allocation of Capital and Long-Run Equilibrium

In this section we examine the dynamic adjustment that occurs in response to the quasi-rents generated by the short-run effects in the labor market described above. We consider two alternative models of long-run capital stock adjustment. In model 1, physical capital is internationally mobile, and so the total stock of capital located in the home country is variable. In model 2, following the Heckscher-Ohlin tradition, the total stock of capital in the economy is fixed. In both models the long-run equilibrium allocation of capital between sectors requires that the return to capital in the two sectors be equalized; in model 1 the common rental also equals that available in world markets, r^f.

In either model, the relationship between the return to capital in manufacturing and the real exchange rate follows from the requirement that price equals unit cost in that sector:

$$p_M = \theta_{LM} w + \theta_{KM} r_M ,$$

where the θ's are the distributive factor shares in manufacturing. Using the association of the real exchange rate with the inverse of the manufacturing real wage, we can therefore write:[9]

$$(9) \qquad r_M - p_M = \theta_L \pi; \qquad \theta_L \equiv \theta_{LM} / \theta_{KM} .$$

Equation (9) states that a real depreciation, by lowering the manufacturing real wage, leads to an increase in the return to capital in manufacturing. In model 1 international capital mobility, by fixing the long-run return to capital, also fixes the long-run real exchange rate. In model 2, the long-run real exchange rate must be determined endogenously along with the return to capital. We now examine each of these models in turn.

9.2.1 Model 1: International Capital Mobility; Exogenous Returns and Endogenous Total Capital Stock

This model is particularly simple for the purpose of studying real exchange rate dynamics. In the long run both r_M and r_B must equal $(r^f + e)$, hence if the initial equilibrium E_0 in figure 9.2 were a position of long-run equilibrium, then the new long-run equilibrium is at Z. We can specify a capital-stock adjustment equation for the manufacturing sector of the form:[10]

$$(10) \qquad \dot{k}_M = \phi(r_M - p_M - r^f) .$$

In terms of figure 9.2, we see that $\dot{k}_M$ is negative at E_1. There is an initial jump real appreciation followed by continuous depreciation until the real exchange rate has returned to its initial value.

But while the resource boom leaves the long-run exchange rate unchanged, it causes a permanent reduction in manufacturing sector output; the higher domestic income commands that more resources (i.e., labor) be allocated to the services sector. Production of manufactures falls; increased domestic consumption of manufactures is effected via increased imports, paid for by increased exports of benzine. The decline in manufacturing output, rather than constituting a macroeconomic problem, simply reflects the appropriate resource allocation response to a change in comparative advantage caused by the resource discovery.

9. Recall that both p_M and p_B equal e, which is assumed to be fixed.

10. As Mussa (1978) argues, an ad hoc specification such as (10) tends to overstate speeds of adjustment by implicitly assuming that current yields will persist indefinitely.

In contrast to the response of the manufacturing capital stock, the stock of capital in the benzine sector rises. What happens to the total demand for capital in the long run? The demand for capital in the benzine sector is given by:

$$(11) \qquad k_B = v - \gamma_B(r_B - p_B),$$

where γ_B is the real-rental elasticity of demand for capital in benzine. Equation (11) is depicted in figure 9.3, where the horizontal axis measures the initial total stock of capital in natural units by the negatively sloped solid line K_B, drawn for given values of v and p_B. As can be seen in equation (11) the resource discovery causes a proportionate increase in the demand for capital in the benzine sector; in terms of figure 9.3, K_B shifts up and to the right to the dashed line K_B'.

Using the labor market equilibrium condition (10), the demand for capital in manufacturing can be written as the reduced form:

$$(12) \qquad k_M = -\lambda_L^{-1}[(\epsilon/\theta_L)(r_M - p_M) + \eta\theta_V v].$$

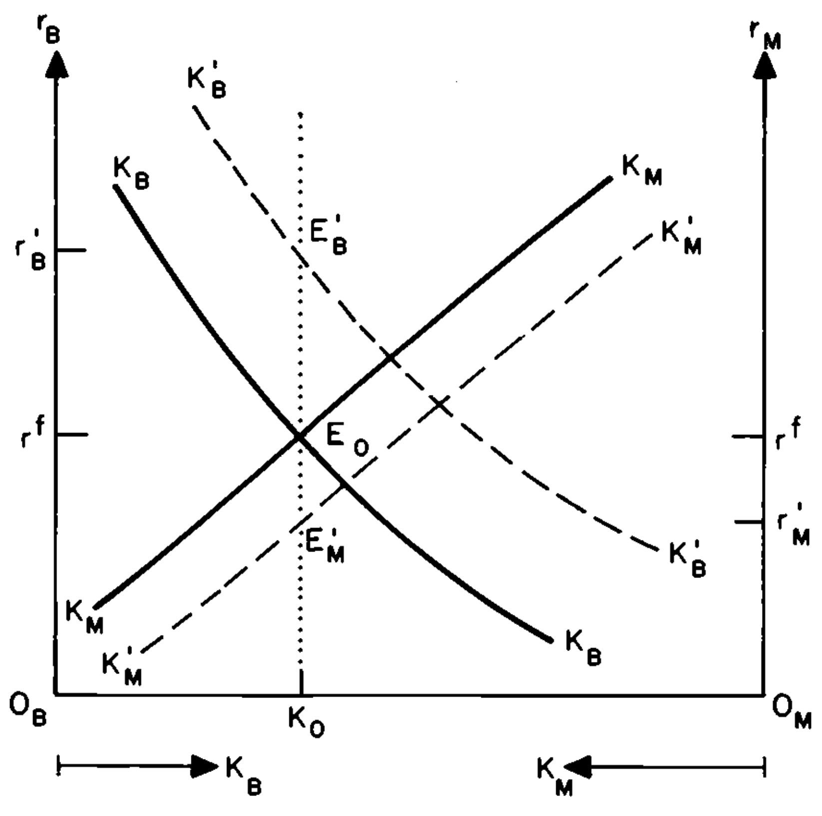

Fig. 9.3 Impact of a resource boom on the returns to capital.

This is shown in figure 9.3 as the solid line, K_M, drawn, for given v and e, as negatively sloped with respect to the right-hand vertical axis. The resource boom, operating through the spending effect, causes K_M to shift down to the dashed line K_M'.[11] The impact effects on the rates of return are also shown in figure 9.3 where at the initial capital stocks r_M falls to r_M' and r_B rises to r_B'.

There is an ambiguous effect of a resource boom on the total demand for capital, k:

$$k \equiv \lambda_{KB} k_B + \lambda_{KM} k_M, \tag{13}$$

where the λ's are the fractions of the total capital stock allocated to the respective sectors. Figure 9.3 depicts the case where k rises at the given initial value of $r_B = r_M = r^f$; however that need not be the case, as is apparent from substituting (11) and (12) into (13):

$$k = \lambda_{KB} v - \lambda_L^{-1} \lambda_{KM}(\epsilon\pi + \eta\theta_V v). \tag{14}$$

The condition for k to rise in the long run (when π returns to its long-run value) is therefore:

$$\eta\theta_V < \lambda_L / \lambda_K; \qquad \lambda_K \equiv \lambda_{KM} / \lambda_{KB}, \tag{15}$$

where λ_K measures the capital intensity of manufacturing relative to benzine. If the manufacturing sector is small in its use of capital or large in its use of labor, or if the income effects on the service sector are small, this condition will be satisfied.

9.2.2 Model 2: Intersectoral Capital Mobility; Exogenous Total Capital Stock and Endogenous Returns

The alternative model pursued in this subsection is in the tradition of the Heckscher-Ohlin model in its specific factor variant (see, e.g., Jones 1971; Mayer 1974; Mussa 1974, 1978; and Neary 1978). The long-run equilibrium allocation of the given capital stock occurs when the returns to capital are equalized. Hence we now specify the dynamic adjustment as

$$\dot{k}_M = \phi(r_M - r_B). \tag{16}$$

Note that this completely characterizes the dynamic adjustment since, with k given, changes in k_M just reflect opposite changes in k_B.

11. Note that the shift in the K_B schedule is permanent and independent of further domestic demand repercussions. However, the adjustment process will generate income effects which will operate through the services sector to have further repercussions on the demand for manufacturing capital. The adjustment of the sectoral capital stocks will raise real national income. We abstract from these in what follows; this can be interpreted as assuming that those income effects are anticipated and hence capitalized into the initial real income response $\theta_V v$. Other possible income effects will depend in part on domestic savings behavior, since with capital mobility the usual distinction between gross domestic product—production located in the economy—and gross national product—production owned by the economy—arises. In what follows, these income effects are also ignored.

Use (9) to substitute for r_M in (16), and invert the k_B demand function (11) to get r_B:

$$r_B = e + \gamma_B^{-1}(v - k_B).$$

Substitute for k_B from equation (13)—choosing units so that the exogenous value of k is zero—and substitute the resulting expression for r_B into (16) to write the adjustment equation as:

$$\dot{k}_M = \phi[\theta_L \pi - \gamma_B^{-1}(\lambda_K k_M + v)]. \tag{17}$$

Equilibrium in the capital market arises when $\dot{k}_M = 0$, or

$$\theta_L \pi = \gamma_B^{-1}(\lambda_K k_M + v). \tag{18}$$

Hence for a given value of v, the real exchange rate and the manufacturing capital stock must be positively related, as shown by the solid line KK in figure 9.4. It is positively sloped because a real depreciation is associated with a lower real manufacturing wage and hence with an increase in the sustainable return to capital in manufacturing; for equilibrium, the

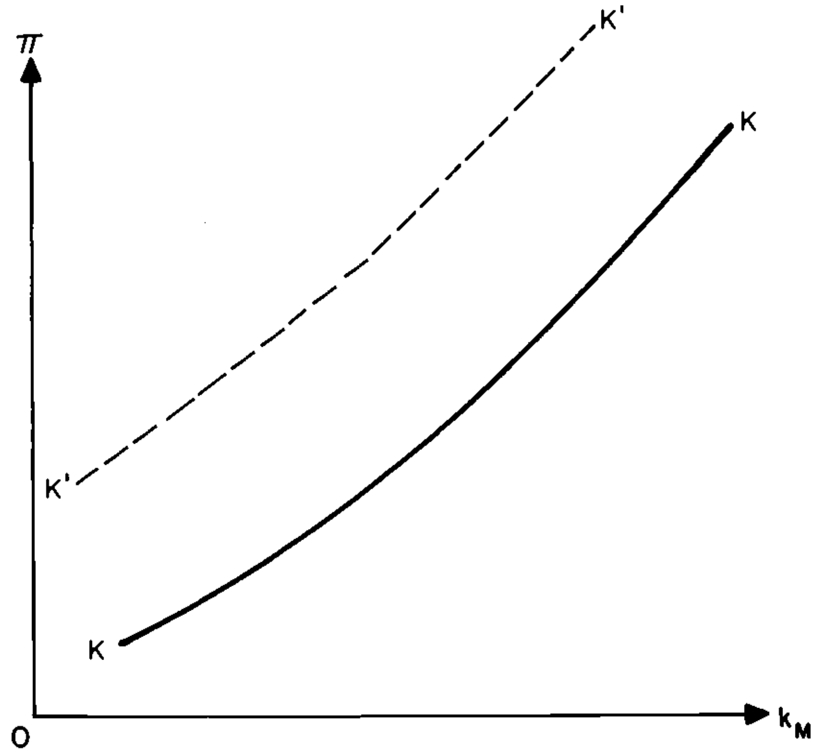

Fig. 9.4 Response of the allocation of a fixed total stock of capital to a resource boom.

real return to capital in benzine must also rise which necessitates a fall in k_B and, hence, a rise in k_M. Above and to the left of KK there is too little capital allocated to manufacturing, below and to the right there is too much.

An increase in v, as noted earlier and as can be seen directly from equation (12), reduces the demand for k_M. Either k_M must fall or π must rise; hence the equilibrium locus shifts up and to the left following a resource boom. Again following Corden and Neary (1982), we refer to this as the *resource-movement* effect of the resource discovery.

9.2.3 Long-Run Equilibrium

Long-run equilibrium obtains when the conditions for both capital-market equilibrium (18) and labor-market equilibrium (7) are satisfied, as illustrated at E_0 in figure 9.5. Letting stars indicate the new long-run equilibrium values (recalling that we set the initial equilibrium values of both k_M and π equal to zero), the response to a resource boom is as follows:

(19)
$$k_M{}^* = -(b_1/a)v,$$
$$\pi^* = (b_2/a)v,$$

where
$$a \equiv \lambda_L\theta_L\gamma_B + \lambda_K\epsilon > 0,$$
$$b_1 \equiv \eta\theta_V\theta_L\gamma_B + \epsilon > 0,$$
$$b_2 \equiv (\lambda_L - \lambda_K\eta\theta_V) \gtreqless 0.$$

A resource boom leads in the long run to a fall in the manufacturing capital stock, as both the spending effect (the leftward shift of $L'L'$ to LL) and the resource movement effect (the leftward shift of $K'K'$ to KK) operate in this direction. However, the long-run effect on the real exchange rate is ambiguous. The spending effect tends to cause a real appreciation by stimulating the demand for services and hence raising their negative price; the resource-movement effect tends to cause a real depreciation by pushing labor out of manufacturing into services, thus stimulating the supply of services and lowering their relative price.

In figure 9.5 the new long-run equilibrium at Z depicts what we consider to be the more plausible case—that the resource boom causes a long-run real appreciation. Note that the condition for π to fall ($b_2 < 0$) is identical to the condition that k fall in equation (15).[12] If the manufacturing sector is small in its use of capital so that the expulsion of labor to the services sector is small, real appreciation will ensue.

Manufacturing output also falls unambiguously in model 2. The capital stock in that sector falls, but there is the possibility, associated with real depreciation, that labor input per unit of capital rises. That rise, however,

12. It also is easily shown that if b_2 is negative so that the long-run effect is a fall in the real exchange rate, that fall is less than the short-run effect given by (8).

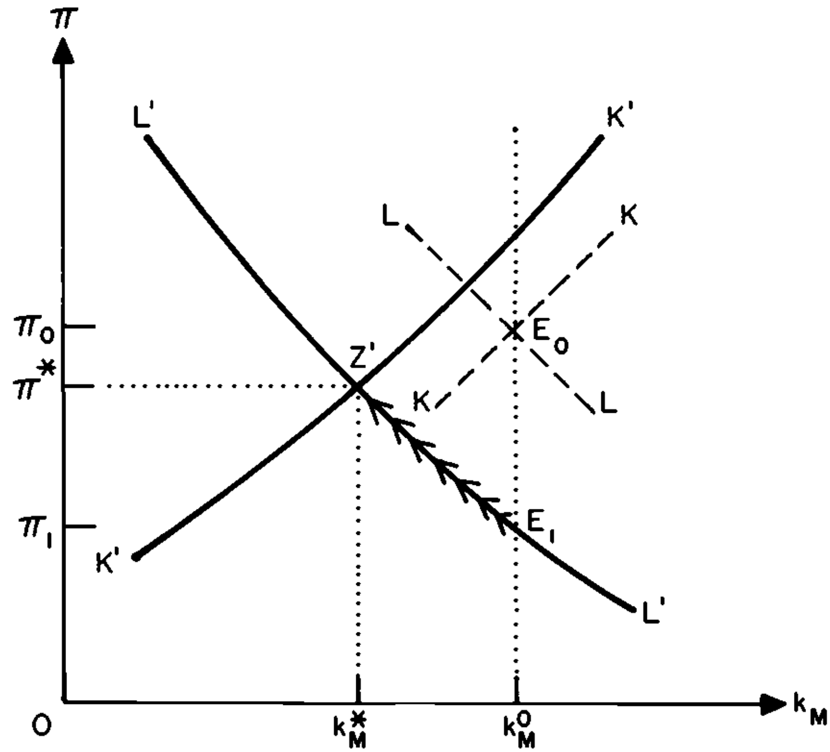

Fig. 9.5 Equilibrium effects of a resource boom.

cannot be large enough to lead to a net increase in manufacturing output. Using the labor demand condition (5) and the labor market equilibrium condition (8), the logarithm of manufacturing output can be written as:

$$x_M = \epsilon^{-1}[(\epsilon - \lambda_L\theta_{LM}\gamma_M)k_M - (\eta\theta_V\lambda_{LM}\gamma_M)v].$$

Using the definition of ϵ, the coefficient of k_M is seen to be positive. Hence the level of manufacturing output falls by more the greater the outflow of capital into the benzine sector: the direct output-reducing effect of this outflow is more than sufficient to offset any reduction in costs brought about by a real depreciation.

9.2.4 Short-Run Dynamics

Using the long-run solutions (19), the dynamic adjustment equation (17) can be rewritten as

$$(17') \qquad \dot{k}_M = \phi_1(k_M{}^* - k_M); \qquad \phi_1 \equiv (a/\gamma_B\epsilon)\phi.$$

The dynamics can now be illustrated in figure 9.5 where on impact, with k_M fixed, the economy moves from the initial equilibrium E_0 to E_1.

Since the labor market clears continually, and by (17′) k_M declines steadily to $k_M{}^*$, the economy follows the path E_1Z' marked by the arrows along $L'L'$. In the short run the real exchange rate overshoots its long-run value.[13] This overshooting is the result of Marshallian dynamics: it is worth repeating that it is overshooting the *real* exchange rate, in response to *real* shocks, and caused by *real* inertia.

9.3 Real Shocks and the Nominal Exchange Rate

In this section we combine the real model of resource allocation and output of the previous sections with a simple monetary model of nominal exchange rate determination in order to examine the effect of a resource boom on the nominal exchange rate. The nominal money stock is treated as exogenously determined; we continue to assume that relative prices adjust instantaneously to clear markets so that there is no role for monetary policy. As before, the dynamics of the model arise from the adjustment of sectoral capital stocks in response to perceived changes in returns.

International financial markets are treated as being closely integrated. Domestic and foreign interest-bearing assets are assumed to be perfect substitutes, so domestic and foreign nominal interest rates are linked by the uncovered interest rate parity (IRP) condition, $i = i^f + x$, where x is the expected rate of change of the nominal exchange rate. We restrict our attention to equilibrium dynamic paths so we impose long-run perfect foresight on the model. With x equal to the actual change in the exchange rate, we write the IRP condition as:

(20) $$i = i^f + \dot{e}.$$

According to equation (20), the domestic interest rate can exceed the foreign interest rate only if there is a (fully anticipated) depreciation of the domestic currency to offset the nominal yield differential. Alternatively, depreciation of the domestic currency is only consistent with asset-market equilibrium if holders of domestic assets are compensated by a yield premium.

The demand for domestic money balances in real terms depends on real income and the nominal interest rate,

(21) $$m - p = \alpha y - \delta^{-1} i.$$

The domestic price index, p, is given by

(22) $$p = \beta p_S + (1 - \beta)e,$$

where β is the expenditure share of nontraded goods.

13. If π rises in the long run, then, rather than overshooting, the short-run response is in the wrong direction.

9.3.1 Monetary Equilibrium

Using the definition of the real exchange rate (3), the price index can be rewritten as $p = e - \beta\pi$; using the definition of real income (2) the money market equilibrium condition becomes

$$m - e = \alpha\theta_V v - \delta^{-1} i - \beta\pi. \tag{23}$$

This is depicted in figure 9.6 as the positively sloped locus MM drawn for given values of π, v, and m; its upward slope reflects the fact that an increase in e creates an excess demand for money by reducing the supply of real balances, while an increase in i creates an excess supply by reducing demand. Above and to the left of MM there is excess supply of money balances; below and to the right there is excess demand. A resource boom shifts the MM curve left *for given* π; but since π itself adjusts in response to a resource boom, a full analysis of the effects on e is deferred.

For simplicity, we abstract from domestic or foreign inflation so in long-run equilibrium the exchange rate must be constant. Imposing $\dot{e} = 0$

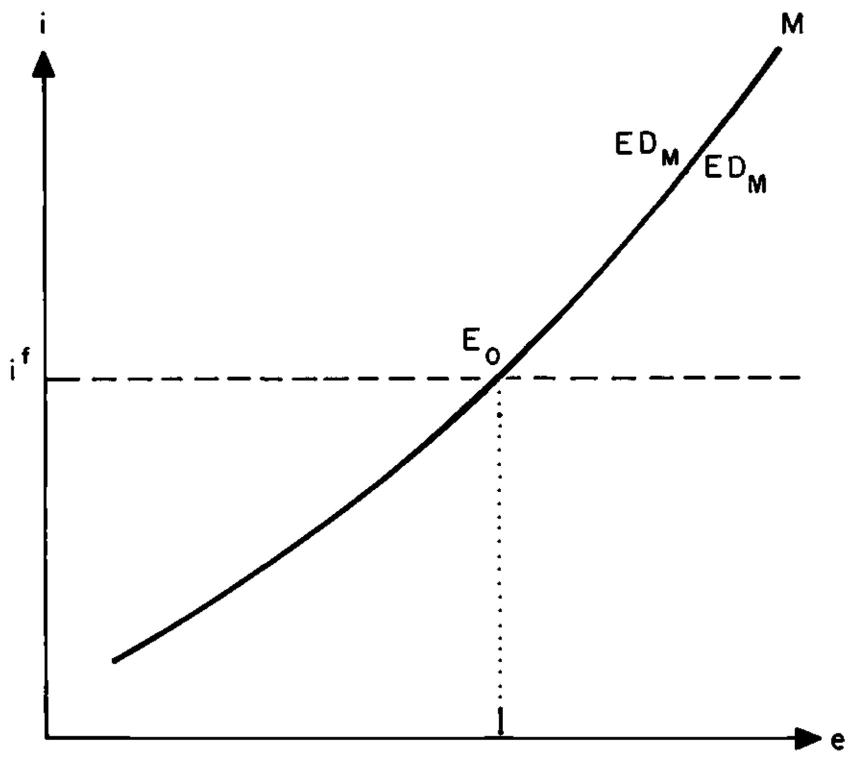

Fig. 9.6 Monetary equilibrium and the nominal exchange rate.

in (20) and substituting into (23), we can solve for the long-run nominal exchange rate:

$$e^* = m + \delta^{-1} i^f + \beta\pi^* - \alpha\theta_V v, \tag{24}$$

where we also have set the real exchange rate at its long-run value. Note that for a given real exchange rate there is an additional force, $-\alpha\theta_V$ (which we term the liquidity effect), working toward nominal appreciation in response to a resource boom: the effect of the resource boom on real income increases the demand for money and hence tends to cause e to fall. Thus a long-run real appreciation in response to a resource boom is sufficient (but not necessary) to also ensure a nominal appreciation.

The determination of the long-run nominal exchange rate is illustrated in figure 9.6. Given the determination of the real exchange rate as described in the previous sections, monetary equilibrium determines the nominal prices of traded goods, e, and of nontraded goods, $p_S = e - \pi$. Money is neutral, as can be seen by the unitary coefficient of m in equation (24). Further, that neutrality obtains even in the short run; an increase in the money supply causes no change in the real exchange rate and so leads to an immediate equiproportionate change in e and p_s. This, of course, is because the only dynamics in the system result from the need to reallocate capital, and monetary policy creates no incentives to do so even in the short run.[14]

9.3.2 Real Shocks and Monetary Dynamics

Real shocks such as a resource boom will give rise to dynamics in $e - i$ space which reflect those in $k_M - \pi$ space illustrated in figure 9.5. Using equation (23) to eliminate i from equation (20), the evolution of the exchange rate can be written as follows:

$$\dot{e} = \delta(e + \alpha\theta_V v - m - \beta\pi) - i^f. \tag{25}$$

Using the long-run solutions in (19) and (24) this can be written as

$$\dot{e} = \delta(e - e^*) + \delta\beta(\pi^* - \pi).$$

Using the fact that $\pi^* = -(b_1/b_2)k_M{}^*$, we rewrite this in what will prove to be the more convenient form

$$\dot{e} = \delta(e - e^*) + (\delta\beta\lambda_L/\epsilon)(k_M - k_M{}^*). \tag{26}$$

The complete dynamic system is therefore obtained by writing equations (17′) and (26) in matrix form:

$$\begin{bmatrix} \dot{k}_M \\ \dot{e} \end{bmatrix} = \begin{bmatrix} -\phi_1 & 0 \\ \delta\beta\lambda_L/\epsilon & \delta \end{bmatrix} \begin{bmatrix} k_M - k_M{}^* \\ e - e^* \end{bmatrix}. \tag{27}$$

14. In Neary and Purvis (1982) we explore the dynamics which arise when both the capital stock and the price of services adjust sluggishly.

Denote the transition matrix as A; since the determinant of A (equal to $-\delta\phi_1$) is negative, the system exhibits generalized saddle-path stability, as illustrated in figure 9.7. The nominal exchange rate, e, is a jump variable that for stability takes on an initial value to place the economy on the stable arm. It is straightforward in this system to generate an explicit solution for e, using a method outlined by Dixit (1980).

The system described by equation (27) has two characteristic roots: $\mu_1 = -\phi_1 < 0$ and $\mu_2 = \delta > 0$. Choosing the stable arm amounts to suppressing the unstable root, δ. As Dixit shows, this can be done by choosing the initial value of the jump variable proportional to the value of the predetermined variable ($k_M{}^0$), where the factor of proportionality is derived from the left eigenvector corresponding to the unstable root. Formally, the deviations of e and k_M from their new equilibrium values are related throughout the adjustment period by:

$$(e - e^*) = q(k_M - k_M{}^*), \tag{28}$$

where q is chosen by solving the matrix equation:

$$[q \quad -1][-A + \delta I] = [0 \quad 0]. \tag{29}$$

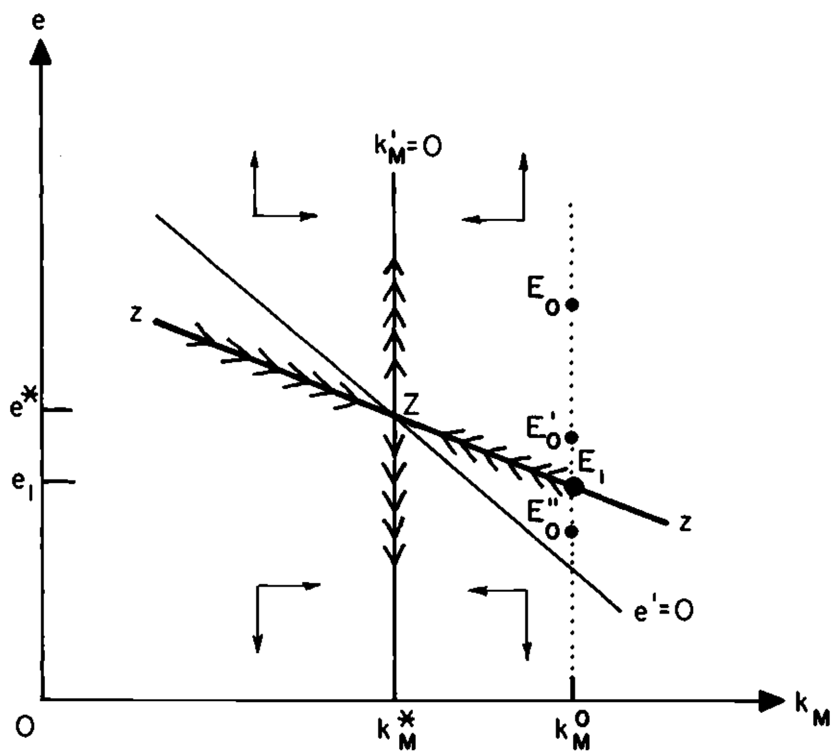

Fig. 9.7 Dynamic adjustment of manufacturing capital stock and the nominal exchange rate.

Straightforward calculation yields

(30) $$q = -\delta\beta\lambda_L/\epsilon(\phi_1 + \delta) < 0.$$

The stable arm, zz, is therefore negatively sloped but flatter than the $\dot{e} = 0$ locus, as shown in figure 9.7. From any of the possible initial equilibrium positions (E_0, E_0', or E_0''), on impact the system moves to point E_1 from which it converges monotonically to Z.

To find the initial value of e required for stability following a disturbance which changes the long-run equilibrium to (k_M, e^*), substitute into equation (28) for q, e^*, and k_M^* to yield:[15]

(31) $$e_1 = e_0 + \sigma v,$$

where e_0, the initial equilibrium value of the exchange rate, equals $m + \delta^{-1}i^f + qk_M^0$, and where σ, the short-run elasticity of the nominal exchange rate with respect to the natural resource, is given by:

(32) $$\sigma \equiv a^{-1}(qb_1 + \beta b_2) - \alpha\theta_V \gtreqless 0.$$

The sign of σ obviously determines whether e rises or falls on impact. If σ is negative, e falls on impact and the initial equilibrium must be at either E_0 or E_0' in figure 9.7. If σ is positive, e rises on impact and the initial equilibrium must be at E_0''. In equation (32) the term in brackets is negative, and hence σ is negative, provided (b_2/a), the long-run response of the real exchange rate, is not large positive. If b_2 is negative (i.e., if the resource boom generates a long-run real appreciation) then σ is negative and on impact e falls.[16] In the international capital mobility case, recall that $\pi^* = \pi_0$; b_2 is effectively zero and hence the nominal exchange rate must fall in the short run.

The long-run response of the nominal exchange rate is given by:

(33) $$e^* = e_0 + \sigma' v,$$

where σ', the long-run elasticity, is given by

(34) $$\sigma' = \beta b_2/a - \alpha\theta_V \gtreqless 0.$$

It is clear that since $\sigma' = \sigma - qb_1a^{-1} > \sigma$, on impact the exchange rate is below its long-run value.[17] There are three possible cases.

(1) If $\beta b_2 < a\alpha\theta_V$, then σ and σ' are both negative. This includes both

15. Substitution of (31) into (23) thus gives the short-run value of the domestic interest rate, i.

16. These results illustrate how the structural characteristics of an economy may influence the response of nominal variables to exogenous shocks, a point also made by Jones and Purvis (1983).

17. Equation (34) can be rewritten as

$$e^* = e_1 - (qb_1/a)v > e_1,$$

which establishes that the exchange rate *on impact* is below its long-run value, as dictated by the negative slope of the saddle-path zz.

model 1 (the international capital mobility case) where b_2 is zero, and the more plausible outcome in model 2 (the intersectoral capital mobility case) where b_2 is negative and there is long-run real appreciation. The short-run elasticity of the nominal exchange rate is larger than the long-run elasticity in absolute value; there is short-run overshooting, and the initial equilibrium must have been like E_0 in figure 9.7.

(2) If $a\alpha\theta_V < \beta b_2 < a\alpha\theta_V - qb_1$, then σ is negative but σ' is positive. The exchange rate falls on impact but ultimately rises, as would occur from an initial equilibrium like E_0'.

(3) If $\beta b_2 > a\alpha\theta_V - qb_1$, then σ and σ' are both positive; the exchange rate rises on impact and continues to rise during the dynamic adjustment, as would occur from an initial equilibrium like E_0''.

In order to examine the dynamics in $e - i$ space, substitute equation (30) into (26), which yields

$$\dot{e} = \phi_1(e^* - e). \tag{35}$$

This shows that under rational expectations the speed of adjustment of the capital stock toward its steady-state value determines the speed of adjustment of the exchange rate toward its equilibrium value. This follows from the fact that the system is recursive since the transition matrix in equation (27) is triangular.

The dynamics of the monetary variables can now be illustrated in figure 9.8. On impact the economy moves to E_1 while the new long-run equilibrium is at Z; E_0, E_0' and E_0'' correspond to the three possible initial equilibria discussed above in connection with figure 9.7.

As in figure 9.6, money market equilibrium for given π and v is depicted by a positively sloped line. Immediately following a resource boom we know from section 9.2 that the real exchange rate is below its long-run equilibrium value, and hence from equation (23) that the money market equilibrium locus cuts i^f to the left of the new long-run equilibrium, as shown by $M'M'$ in figure 9.8.

The negatively sloped AA curve is derived by substituting the equilibrium exchange rate adjustment equation (35) into the asset arbitrage condition (20) to get

$$i + \phi_1 e = i^f + \phi_1 e^*. \tag{36}$$

Note that AA always passes through the long-run equilibrium position; a boom shifts it right or left depending on the long-run effect on e.

The initial equilibrium could be any one of E_0, E_0', or E_0''. The resource boom shifts the long-run equilibrium to Z with $e = e^*$. On impact the boom raises the domestic interest rate above i^f and causes the nominal exchange rate to jump to e_1 less than e, as can be seen by the fact that MM shifts to the dashed line $M'M'$. If the initial equilibrium is E_0, with e^* less than e_0, this corresponds to the first possibility indicated above; there is

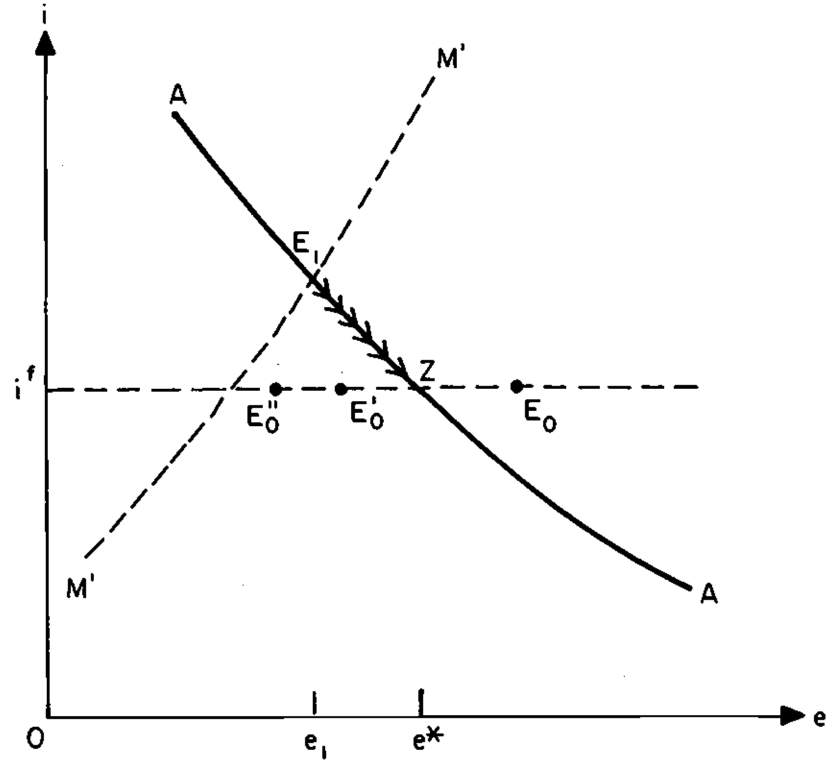

Fig. 9.8 Monetary dynamics in response to a resource boom.

overshooting of the nominal exchange rate. If the real exchange rate rises by enough to offset the liquidity effect (which works in favor of a nominal appreciation), the initial equilibrium is E_0''—the last of the three possibilities—and the nominal exchange rate rises both on impact and in the long run; further, the short-run response of the nominal exchange rate is smaller than the long-run response. If the real exchange rate rises but not by enough to offset the liquidity effect—the middle possibility—then e falls on impact but rises in the long run, as from an initial equilibrium E_0'.

9.4 Conclusions

This paper has stressed the implications for the dynamics of the real and nominal exchange rates of a Marshallian distinction between short- and long-run supply responses in the face of an exogenous disturbance. Marshall's partial-equilibrium analysis stressed the overshooting of a relative price due to short-run factor fixity. Our analysis derives this result in a general equilibrium context, although in that context it is possible that the long-run price response is perverse and so, rather than overshooting, the short-run relative price response is actually in the "wrong direction."

We then extend the framework to incorporate the behavior of money prices in the face of these changing relative prices. The model focuses on monetary equilibrium combined with rational speculation; the dynamic behavior of the nominal exchange rate exhibits a straightforward dependence on that of the real exchange rate.[18] But the latter is independent of monetary equilibrium and, in particular, of any speculative behavior; any influence of speculators on the nominal exchange rate gives rise to identical movements in the equilibrium price of services. It is interesting to note that in our model the dynamics of the nominal exchange rate in response to a real shock are qualitatively equivalent to those generated by Dornbusch's analysis (1976), built on the assumption of domestic price rigidity and focusing on the role of monetary disturbances.

One obvious weakness of the current analysis is the asymmetric nature of expectations formation. Agents are "rational forecasters" when formulating money demands but not when making investment or resource extraction decisions. A useful extension would thus be to incorporate "rational accumulators" into the analysis, drawing on Mussa (1978), van Wijnbergen (1981), or Hayashi (1982) as extended to the open economy by Bruno and Sachs (1981). We have also abstracted throughout from the wealth dynamics inherent in the current account imbalances that will arise in the adjustment in section 9.3; analyzing the feedback onto exchange rate dynamics is another obvious extension.

Our emphasis has been on the real effects of real disturbances where the dynamics of the system stem from real criteria. While we have shown that these dynamics will also have implications for the behavior of the nominal exchange rate, in our model nominal disturbances which influence the nominal exchange rate would not have any effects on resource allocation or other real variables. This asymmetry would vanish if a nominal rigidity were included in the specification. These issues are explored in Neary and Purvis (1982).

18. As Jeffrey Sachs has pointed out, a solution for $e(t)$ in terms of the time paths of exogenous variables and of the real exchange rate can be found by explicitly solving the differential equation (25) to yield

$$e(t) = \int_t^\infty [\delta(m + \beta\pi - \alpha\theta_{Y}) + i']\exp(-\rho\tau)d\tau.$$

Hence the path of $e(t)$, given the constancy of the exogenous variables, is fully described by that of $\pi(t)$.

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Comment Kent P. Kimbrough

As one would have expected, Peter Neary and Douglas Purvis have presented a most interesting and stimulating paper—a paper that is as elegant a piece of economic model building as it is rich in its implications. This richness is apparent when one reflects on the fact that their paper outlines a framework that can be used to examine the short-run, dynamic, and long-run response of:

(i) the allocation of labor,
(ii) the allocation of capital,
(iii) the real exchange rate (and the real wage),
(iv) the return to capital, and
(v) the nominal exchange rate

to various real and monetary shocks. Neary and Purvis choose to use their model to examine the effects of a resource boom in one sector of the economy, but the model is particularly well suited for studying the impact of almost any real shock. They could just as easily have employed their model to discuss the effects of:

(i) tariffs and other types of commercial policies,
(ii) terms of trade changes,
(iii) domestic taxes and subsidies,
(iv) international transfer payments,
(v) technological changes,
(vi) changes in factor endowments, or
(vii) any other real shock commonly studied in the pure theory of international trade.

In my comments on this paper I shall mention three possible generalizations, either in interpretation or in substance, then turn to two issues concerning the production structure of the model, and finally I shall address the issues raised by Neary and Purvis in the introduction to their paper.

My first comment concerning generalization has to do with interpretation. From the perspective of the monetary or asset market approach to the exchange rate, Neary and Purvis have made an especially useful contribution—they have highlighted the many channels through which real disturbances influence the equilibrium exchange rate. Another in-

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teresting result is provided by the structure of the model itself. As Neary and Purvis point out, their model dichotomizes. That is, the real equilibrium can be solved for independently of the monetary equilibrium. The solutions for the real variables can then be used to solve for the equilibrium values of the nominal variables, including the exchange rate. Therefore, given the structure of the model, a monetary or asset-market approach "naturally" suggests itself as a way of organizing one's thoughts about the exchange rate.

The second generalization also has to do with interpretation; it concerns the exchange rate overshooting result derived by Neary and Purvis. Their framework has overshooting arising in response to real rather than monetary shocks, while in the Dornbusch (1976) framework overshooting occurs in response to monetary rather than real shocks. The difference in the two frameworks is that in Neary and Purvis dynamics arise as a result of the slow adjustment of a real variable (the intersectoral allocation of the capital stock), while in Dornbusch the dynamics are a result of the slow adjustment of a nominal variable (the money prices of goods). Neary and Purvis mention this, but I would have preferred the point to have been made a bit more forcefully as I feel they have discovered a general result. That is, when real variables are slow to adjust, real shocks will be accompanied by overshooting; while when nominal variables are slow to adjust, monetary shocks will be accompanied by overshooting.

The third generalization I wish to suggest is more substantive in nature. An important feature of the model is that it accounts for the link between exchange rate movements and deviations from purchasing power parity as reflected in movements of the real exchange rate. This result falls out of the model as a result of the simultaneous response of the real and the nominal exchange rates to various shocks rather than being imposed on the model via the assumption of sticky prices as in Dornbusch (1976). However, as the model is presented by Neary and Purvis, income and expenditure are always equal. This can be seen from their equation (1) where income, rather than expenditure, enters the demand function for services. The failure to distinguish between income and expenditure is unfortunate because it rules out any discussion of the role of the current account in the adjustment process. This is particularly unfortunate in the version of the model with international capital mobility because, were it not for the failure to distinguish between income and expenditure, that version of the model would be capable of bringing out a general point that seems to be "in the air," but has yet to be put forth in a unified framework. The point is that there is a dynamic link between exchange rate movements, deviations from purchasing power parity, and the current account; and that link is the consequence of transfer criteria in the goods and assets markets. Current account imbalances are similar in their effects on goods markets to international transfer payments and thus lead to changes in relative prices. These relative price movements are reflected in a link between deviations from purchasing power parity and the current account. The financial counterpart of a current account imbalance is a reallocation of wealth between countries. This reallocation of wealth constitutes a transfer in the asset market, and the exchange rate, which is the relative price of two assets, must adjust to maintain asset-market equilibrium as dictated by a transfer criterion analogous to that in the goods market. It is thus an asset-market transfer criterion that accounts for the dynamic link between the exchange rate and the current account (see Kouri and de Macedo 1978 and Kimbrough 1981 on this issue). Depending on parameter values, the model is rich enough to encompass almost any possible dynamic link between the current account, the exchange rate, and deviations from purchasing power parity, including the stylized relation which associates a current account surplus (deficit) with a currency that is appreciating at a rate faster (slower) than trend and is, from the perspective of purchasing power parity, undervalued (overvalued).

Two other issues I wish to raise at this point concern the production structure of the model. First, the assumptions concerning the use of the factors of production in the three sectors implies that manufactured goods are a substitute in production for benzine and services, while the latter are complements in production. This somewhat restricts the generality of the model, but on the plus side the assumptions serve to cut down on the number of production links in the model and this greatly simplifies the analysis. In addition, these assumptions do seem to capture certain stylized facts concerning production in the countries which Neary and Purvis probably had in mind when writing the paper.

The second point concerning the production structure has to do with the treatment of the natural resource which is used in the benzine sector. Neary and Purvis do not discuss the issue of the price of the natural resource, because it is not traded (presumably because of the existence of prohibitive tariffs or transport costs). However, many important natural resources, including the petroleum that is used to produce benzine, are traded internationally. The authors should discuss the implications of such trade for the results presented in their paper. For example, if a small country discovers petroleum, will it produce more benzine or will it simple export the newly discovered petroleum either directly or indirectly via a reduction in its oil imports? In light of this, would the capital stock still need to be reallocated? The answer to this last question would seem to be "yes" because of the change in the real exchange rate resulting from what Corden and Neary (1982) have called the "spending effect." This seems to indicate that the assumption that the natural resource used in the benzine sector is nontraded is not as restrictive as it first appears.

My final remarks concern the issues raised by the authors in the introduction to their paper. They cite two phenomena that characterized the 1970s: First, the frequent occurrence of sector-specific shocks, the most prominent of which were shocks in the petroleum sector. Second, the extreme variability of exchange rates following the adoption of managed floating. Neary and Purvis have clearly done a superb job of addressing the first issue by tracing through in detail the impact of a sector-specific shock in the form of a resource boom (North Sea oil?). They have also discussed how such sector-specific shocks may have contributed to exchange rate variability, and, in doing this, have added to the growing list of factors which may contribute to exchange rate overshooting. We now know that exchange rate overshooting may occur as a result of the gradual adjustment of the capital shock that takes place in response to changes in its relative return.

However, the authors also raise the following question:

> Do exchange rate fluctuations lead to inappropriate domestic resource allocation by temporarily altering relative prices?

Setting aside the issue of what is meant by inappropriate, it is clear that Neary and Purvis do not provide a satisfactory answer to this question (although in their defense it must be mentioned that they claim to only be providing "a basis for initiating investigation" of this question). To see this, note the following: (i) Sections 9.1 and 9.2 of the paper, which derive the results for the real variables of the model, are done without reference to the nominal exchange rate. Hence the variability of the nominal exchange rate has no effect on resource allocation. (ii) As the authors note, purely monetary shocks have no impact on resource allocation even in the short run. Since monetary shocks influence the exchange rate, it is possible for a highly variable monetary policy to lead to a highly variable exchange rate without affecting the allocation of resources.

These results follow from the assumptions that all prices are perfectly flexible and that expectations are characterized by perfect foresight. These assumptions are sufficient to rule out any scope for monetary shocks, and hence exchange rate variability, to exert real effects. For this reason, the model seems ill suited for addressing the question of the impact of exchange rate variability on resource allocation, although, as Neary and Purvis so elegantly show, the two may be associated without any feedback from the former to the latter.

There are two ways the model could be altered to allow for exchange rate variability to influence the allocation of resources. First, sticky prices could be introduced into the model in one way or another (see Neary and Purvis 1982). Second, a stochastic framework could be adopted and some short-run confusion about the source of the shocks affecting the economy could be introduced. Both approaches would surely be fruitful. In what remains I shall focus on the latter approach.

Introducing some short-run confusion about the source of shocks into the model would seem to allow for a much more thorough analysis of the relationship between exchange rate variability and resource allocation, as it would allow feedback in both directions rather than one as in the current framework. It would seem natural here to introduce an upward sloping supply of labor and to focus on the allocation of time between work and leisure. This would introduce the issue of the connection between exchange rate variability and the business cycle into the model. One might also wish to consider the role of the exchange rate as a provider of contemporaneous economy-wide information, as suggested in Barro (1980). These modifications would necessarily complicate the model, so that it would have to be trimmed down in some way to be at all manageable. I would suggest a two-sector version of the specific-capital model.

From this vantage point, the paper that has been presented by Neary and Purvis makes the following contribution: The paper focuses on the intersectoral allocation of resources *given* the level of economic activity, and examines the effects of the reallocation of resources for the variability of exchange rates. The other question of interest is the impact of exchange rate variability on the level of economic activity (i.e., the business cycle). If one views business cycles as arising from a lack of complete contemporaneous information on the part of rational agents, then to the extent that capital stock reallocation takes longer than the time it takes agents to know the true source of the shocks affecting the economy, this paper can be viewed as analyzing the long-run relation between resource allocation and exchange rate variability. This is certainly a significant step toward providing an answer to a fundamental question concerning the functioning of a system of managed floating.

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Comment Jeffrey Sachs

J. Peter Neary and Douglas Purvis offer a lucid analysis of the price and output effects of a wealth increase in a small open economy. Their specific focus is on the "Dutch disease," in which a natural resource discovery boosts nontraded goods production at the expense of tradeables. This effect has generated considerable interest in recent years, for it has been identified as a culprit in the slowdown in manufacturing sector growth in the United Kingdom and elsewhere. The Neary-Purvis (N-P) model neatly describes the sectoral effects of a resource boom and shows how real exchange rate movements following a boom may be mimicked by nominal exchange rate movements in a floating rate regime. The strength of the paper lies in its treatment of the short-run versus long-run sectoral effects of the boom. Its specific treatment of the dynamics, however, neglects some important adjustment problems that are likely to arise following a resource shock.

The authors emphasize three implications of a resource boom for adjustment in the other two sectors (services, S, and tradables, T): (1) an expansion of S at the expense of T that is *larger* in the long run than short run; (2) a fall in the relative price of T (i.e., a real exchange rate appreciation) that is *smaller* in the long run than short run; and (3) a nominal exchange rate appreciation that tracks the movements in the real exchange rate (at least in the absence of other monetary developments). Figure 9C.1 illustrates the first and second effects. An oil boom raises demand for services in both the short run and long run (the demand shift will probably be more complicated than a one-time change, but the diagram follows the N-P assumption). The shift is depicted as the movement from D^S to $\hat{D}^S$. The short-run supply schedule is denoted by S^S, and the long-run schedules for N-P models 1 and 2 by S_1^L and S_2^L, respectively. In either variant, the long-run supply schedule is more elastic than the short-run schedule, so that the long-run quantity effects (at B_1 or B_2) are larger, and price effects are smaller than in the short run (at A).

The "overshooting" of the real exchange rate is a robust feature of the N-P model. The fact that $(P_S/P_T)^A$ is greater than $(P_S/P_T)^{B_1}$ or $(P_S/P_T)^{B_2}$ depends simply on the greater elasticity of the long-run supply curve, and not on the specific formulation of dynamics in the paper. Indeed the N-P model (variant 2) achieves the result through a very *unimportant* channel: the direct competition of the resource sector and tradeable sector for a fixed domestic capital stock. The physical capital used in the resource sector is (generally) a traded good itself, so that capital expenditure in natural resources can rise without depriving tradeables of capital inputs. Nor is there likely to be much direct competition for savings for new

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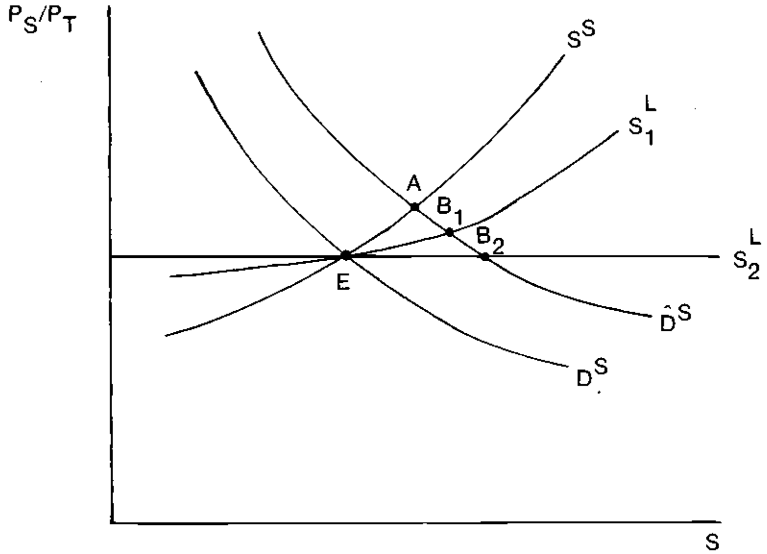

D^S is the demand curve for services ($\hat{D}^S$ after shift in demand)

S^S is the short-run supply curve for services,

S_1^L is the long-run supply curve for model 1, and

S_2^L is the long-run supply curve for model 2.

$P_S/P_T = 1/\pi$, where π is the real exchange rate.

Fig. C9.1 Demand shift for S in the short run and long run.

investment in the two sectors, since such accumulation can be financed from abroad, as noted below. A more realistic channel for long-run dynamics can simply arise from the use of capital in the S sector (with investment in S subject to convex costs of adjustment).

In models like that of N-P. with market-clearing prices and a fixed money stock, the nominal exchange rate will closely follow movements in the real exchange rate. With $\pi = e - p_S$; $p = e - \beta_S \pi$; $m - p = -i/\delta$; and $\dot{e} = i - i^f$ (see [20]–[22]), it is easy to check that $\dot{e} = \delta(e - m - \beta_S \pi) - i^f$. The solution to this first-order differential equation is:[1]

$$(1) \qquad e(t) = \int_0^\infty \exp[-\delta(\tau - t)](\delta m + \delta \beta_S \pi + i^f)d\tau.$$

From (1) it may be verified directly that if π falls on impact (i.e., a real exchange rate appreciation) and then partially recovers, e will follow a similar, though damped, path.

In practice, an oil boom may affect e through future m as much as through future π. The recent strength of the pound sterling probably reflects, among other factors, the widespread expectation of smaller fiscal deficits and lower inflationary finance in future years, as huge North Sea oil revenues flow into the United Kingdom Treasury coffers. It is important to note that the nominal appreciation of the pound has had profound macroeconomic effects, given the rigidities in nominal wages and prices in the United Kingdom economy. Of course, these implications cannot be addressed in a flexible price market-clearing framework.

While the N-P results are generally persuasive, the dynamic analysis is rather casually handled and therefore misses a number of important phenomena. To mention a few problems: (1) households simply consume current income, rather than optimizing, in any way, over time; (2) while there is an international capital market, there is no focus on national borrowing or lending in light of an oil boom (the current account is either balanced or ignored); (3) induced changes in national income along the adjustment path (e.g., through capital accumulation, exchange rate changes, etc.) are all ignored; (4) no allowance is made for depletion of the resource base; and (5) entrepreneurial investment decisions are based on static expectations of profitability.

Bruno (1982) and Bruno and Sachs (1982) have avoided these simplifying assumptions, in the first case by using a two-period model and in the second case by implementing a numerical simulation. These studies and empirical observations suggest that the issue of foreign borrowing, in particular, is at the heart of the adjustment problem. The discovery of a natural resource base generates important incentives for current account imbalances, and the allocational effects of the shock depend on how much foreign borrowing is encouraged or restricted by the central authorities. On impact, a resource boom leads to a large current account deficit for two reasons: consumption rises in anticipation of future income not yet on stream (e.g., if the resource base must be developed); and investment financed from abroad will rise to exploit the new resource. Thus, after the discovery of Norway's huge oil reserves, that country's current

1. This solution is derived by ruling out speculative bubbles in e, by imposing the boundary condition that $\exp(-\delta t)e(t) \to 0$ as $t \to \infty$.

account deficit rose by about 10 percent of GNP in the mid-1970s. After the investment boom subsides and resource production begins, the nation's optimal current account position will most likely involve a shift to surplus to generate wealth in anticipation of the future depletion of the resource. The extent of the surplus importantly conditions the size of the long-run growth of the service sector.[2]

References

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2. If the current account is kept in balance and the resource find is fully depleted, the original sectoral distribution of output will be reestablished; with current account surpluses along the adjustment path, the service sector will remain expanded in the long run.