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NATURAL RESOURCES AND THE MACROECONOMY:

A THEORETICAL FRAMEWORK

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I. INTRODUCTION

Recent years have seen a great deal of attention devoted to the allegedly harmful consequences of natural resource discoveries. Whether it is natural gas in the Netherlands, oil in the UK, Norway and Mexico, or minerals in Australia, such discoveries have been accused of causing structural problems almost as severe as the absence of indigenous resources has undoubtedly caused in less fortunate countries. These problems have even been given a name - the "Dutch Disease" - which prompted The Economist to comment that "to refer to a vast, valuable energy resource as the source of a disease is surely rather ungrateful."

Academic researchers have not been slow to subject these problems to scrutiny, and a sizeable literature has now developed dealing with various aspects of the Dutch Disease. At the level of analysis, existing models from the theories of international trade, open-economy macroeconomics and natural resource depletion have been extended to study the intersectoral shifts induced by a resource boom and to examine the possible rationales for government intervention. At a more applied level, a great many case studies have examined the steps in adjustment to the exploitation of oil, gas or coal discoveries in individual countries. However, these two strands of literature have been inadequately integrated until now. The objective of the CEPR research project Natural Resources and the Macroeconomy is to attempt to bridge the gap between theory and applications, and in this opening paper we set the scene for later empirical analyses by reviewing the theoretical models which have been used to analyse different aspects of the Dutch Disease.[1]

The large-scale exploitation of natural resource discoveries is a real rather than a monetary shock to an economy, since its primary impact falls on the level of real income and on the intersectoral allocation of factors of production. Hence, it is natural to begin analysing the consequences of such discoveries with a real model which abstracts from monetary considerations. Further simplification is possible if we focus initially on the static effects of a resource boom. This is done in Section II, which uses a simple static

framework to examine the consequences of a boom for relative prices, the size of the exposed traded sector and the level of unemployment. Next, Section III introduces a two-period model, and examines the effects of a boom on the intertemporal allocation of resources. Monetary issues are then considered in Section IV, which also looks at the implications of alternative macroeconomic policy responses and exchange rate regimes. Finally, Section V concludes by attempting to summarise the implications of the different models considered for some of the most frequently asked questions about natural resource discoveries.

Two further general points should be made before we proceed. The first is that, although the initiating disturbance in all the models we consider is the discovery and exploitation of natural resources, we ignore the issues of optimal and competitive depletion rates which have been the focus of much recent work on the economics of exhaustible resources.[2] Rather than dealing with these longer-run issues, most of the literature we survey has concentrated on the short- and medium-run effects of asymmetric growth which takes place at an exogenous rate. It has thus taken the time path of extraction and revenues as given, and throughout the paper we follow it in this respect.

A second issue which should be clarified at the outset relates to the use of the term "Dutch Disease" to describe the phenomena with which we are concerned. In fact, there is no presumption that the consequences of a natural resource discovery are harmful. On the contrary, its initial impact is beneficial and amounts to a Pareto improvement for the economy as a whole. Of course, legitimate grounds for concern may arise over the distribution of the gains, over the issue of whether transitional assistance should be offered to declining sectors and over the issue of the appropriate response to various market failures which may impede the smooth adjustment of the economy to its new equilibrium. However, as we shall have occasion to point out on a number of occasions, the case for treatment of the disease must be considered on its merits in each individual application.[3]

II. THE STATIC EFFECTS OF A RESOURCE BOOM

The simplest general-equilibrium model within which the static effects of the Dutch Disease can be analysed is one which distinguishes between two sectors, one producing a single non-traded good whose price is determined endogenously by the interaction of domestic supply and demand and the other producing a composite traded good whose price is fixed exogenously. We shall denote the output levels of these two sectors by x_n and x_m ("M" for "manufacturing") respectively. In this model the natural resources sector is purely of the "enclave" type, and does not directly compete with other sectors for factors of production. As a consequence, the resource boom operates in exactly the same manner as an exogenous transfer: it affects the domestic economy solely through a "spending effect", whose consequences are examined in Section II.A. Section II.B moves on to consider the case where the expansion of the booming sector has a direct impact on domestic factor markets, and as a result the boom has an additional "resource movement effect." [4] Finally, Section II.C considers the case where domestic wages and prices do not adjust instantaneously to the boom, and shows that unemployment may result depending (among other things) on the degree of wage indexation.

A. The Spending Effect of a Boom

Equilibrium in this model can be characterised solely in terms of the market-clearing condition for the non-traded good. In obvious notation, this may be written as:

$$x_n(q) = c_n(q,y). \tag{2.1}$$

Here, x_n and c_n denote domestic production and consumption of the non-traded good respectively, and equilibrium in the market is brought about by adjustment of the relative price of non-traded to traded goods, q . This price is thus a key variable in this economy; its inverse, the relative price of traded to non-traded goods, is often referred to as the real exchange rate. While output of the non-traded good depends solely on the real exchange rate, demand depends also on the level of real income (measured in terms of

traded goods), denoted by y . This is fixed exogenously by the assumption of full employment, except that the effect of the boom is to increase it in a once-off fashion. The resulting excess demand for the non-traded good raises q , an outcome which we will refer to as a "real appreciation."

The implications of this disturbance for the pattern of output in the economy may be illustrated using the Salter (1959) diagram in Fig. 1.1. Non-traded goods output is measured along the horizontal axis and traded goods output (including both manufacturing and booming sector output) along the vertical axis. The curve TN is the economy's initial production possibilities frontier, depending on domestic technology and factor endowments. Before the boom, equilibrium is determined by the intersection of this curve with the highest attainable social indifference curve, I_0 , at point A.[5] Since the boom is equivalent to a transfer, its effect is to shift the production possibilities curve vertically upwards to T'N'N as shown. The initial real exchange rate equals the slope of the common tangent to the two curves at point A. If this were to remain unchanged, the production point would shift vertically upwards to point B: domestic output of both manufactures and non-traded goods remains unchanged but total domestic availability of traded goods is augmented by the extent of the additional resource output. With production and therefore domestic real income determined at B, desired consumption must lie along the price line tangential to B. Moreover, since relative prices are unchanged, it must take place at the point C where the price line intersects the income-consumption curve through A, OAE. (We assume that both goods are normal in demand, so that this curve is upward-sloping.) The resulting excess demand for non-tradeables drives up their relative price until the new equilibrium at a point such as D is attained. The characteristics of this new equilibrium are obvious: domestic welfare has risen, but at the expense of a reallocation of production - the output of the non-traded good has risen whereas that of manufacturing has fallen. The spending effect of the boom thus unambiguously gives rise to both deindustrialisation and a real appreciation.

B. The Resource Movement Effect of a Boom

Our next task is to examine how these results are altered if the booming sector is not an enclave but requires a significant input of productive factors which must be bid away from other sectors in the economy. The answer to this question depends to a considerable extent on the detailed production structure of the economy, and a great many different specifications have been considered in the literature.[6] The simplest of these, and probably the most appropriate to a relatively short time horizon, is the so-called "specific-factors" model,[7] which assumes that each sector uses a single specific factor as well as drawing on a pool of intersectorally mobile labour. Under this specification, the output of each sector depends on the real product wage it faces. Hence, equation (2.1) must be replaced by the following:

$$x_n(q/w) = c_n(q,y). \quad (2.2)$$

where w is the wage rate, measured in terms of traded goods. This model has two endogenous variables, q and w , and the additional equilibrium condition comes from the requirement that the labour market clear:

$$e_n(q/w) + e_m(w) + e_b(w,b) = L. \quad (2.3)$$

Here, L is the total available labour supply, assumed to be fixed, while e_i is the labour demand function from sector i . In the two traded good sectors, producing manufacturing and booming sector output respectively, these depend negatively on w , while in the non-traded good sector it depends positively on q/w . In addition, the boom itself exerts a direct influence on the demand for labour by the booming sector, represented by the inclusion of the parameter b in that sector's labour demand function.

The determination of equilibrium in this model may be illustrated by locating the two equations (2.2) and (2.3) in (w,q) space, as illustrated in Fig. 1.2. The non-traded goods market equilibrium locus, corresponding to (2.2), must be upward-sloping, since either an increase in q or a decrease in w induces excess supply of the non-traded good. More-

over, it must be more steeply sloped than a ray from the origin, since an equiproportionate increase in w and q leaves supply unchanged but discourages consumption so leading to excess supply. Similarly, the labour-market equilibrium locus, corresponding to (2.3), must also be upward-sloping, with either an increase in w or a decrease in q giving rise to unemployment. However, this curve must be less steeply sloped than a ray from the origin, since an equiproportionate increase in both variables leaves the non-traded sector's demand for labour unchanged but depresses that from the other two sectors, so giving rise to unemployment. The initial equilibrium is therefore as depicted by point a in Fig. 1.2, at the intersection of the non-traded goods market equilibrium locus NN and the labour market equilibrium locus, LL .

The effects of the resource boom are now easily illustrated. From Section 2.A we know that the spending effect generates excess demand for non-tradeables, which must displace the NN locus rightwards to $N'N'$ as shown. If there were no resource movement effect, the new equilibrium would be at point d , corresponding to point D in Fig. 1.1. In addition, the resource movement effect displaces the LL locus: the increased demand for labour from the booming sector generates excess demand for labour at the initial point a , requiring either a rise in w or a fall in q if equilibrium is to be restored. The labour market equilibrium locus therefore shifts upwards to $L'L'$ as shown, and so the final equilibrium is at point f . It is clear that, under the assumptions of the specific-factors model, the resource movement effect reinforces the spending effect as far as changes in q and w are concerned. This means that the two principal conclusions of the last subsection are unchanged: deindustrialisation (since output and employment in manufacturing depend inversely on w) and a real appreciation (a rise in q) must follow the boom. The implications for the output of the non-traded good are ambiguous, however. This depends directly on the ratio q/w , and it is clear from the diagram that this may rise or fall, depending on which of the two effects dominates.

C. The Effects of Wage and Price Rigidities

So far, we have assumed that the wage rate and the price of the non-traded good are perfectly flexible, so that the economy moves smoothly and instantaneously to the new equilibrium. If this is not the case, then in the short run agents on the long side of either market will be rationed, in the manner familiar from the "disequilibrium" or "fix-price" macroeconomic literature.[8] It might be thought that the only disequilibrium regime which resource discoveries can induce is one of labour shortage, since we have seen in the last section that the wage rate may be expected to rise. However, as we shall see, this turns out to hinge crucially on the wage setting mechanism.

For simplicity, we return to the case where the boom has a spending effect only. (The added complications from a resource movement effect will be noted briefly where appropriate.) To examine the consequences of wage-price rigidities, we first show how different exogenous values of the wage and the price of the non-traded good give rise to different disequilibrium regimes. We do this by dividing (w, q) space into different disequilibrium regions. This is done in Fig. 1.3, where the dashed curves represent the notional equilibrium loci from Fig. 1.2, where these differ from the effective equilibrium loci.

Consider first the labour market equilibrium locus. Since labour supply is exogenous, the notional locus is unaffected if households are rationed in the non-traded good market. (We assume throughout that no agents are ever rationed in the market for traded goods.) Since the booming sector does not use labour (given the assumption that there is no resource movement effect), equation (2.3) need be only slightly modified as follows:

$$e_n(q/w) + e_m(w) = L. \tag{2.4}$$

This curve is labelled LL, and extends to the left of point a in Fig. 2.3. To the right of that point, however, there is excess supply of the non-traded good. Domestic producers are rationed therefore, and scale down their labour demand in the face of the sales constraint they face. The labour market equilibrium locus in this region is therefore given not by (2.4) but by the following:

$$\tilde{e}_n [c_n(q,y)] + e_m(w) = L. \quad (2.5)$$

The key feature of this effective locus is that, because employment in the non-traded good sector is now demand -determined, it depends negatively rather than positively on the relative price of the non-traded good, q . The locus is therefore downward- rather than upward-sloping in (w,q) space, and is denoted by the line LN in Fig. 1.3.

Consider next the equilibrium locus for the non-traded good market. We may confine attention to the case where unemployment prevails, since under excess demand for labour the effective non-traded good market equilibrium locus coincides with the LN curve just derived.[9] With unemployment, the locus is formally identical to (2.2), except that the level of income is no longer at its full employment level but is determined endogenously:

$$y = qx_n(q,w) + x_m(w) + v, \quad (2.6)$$

where v is the value of the natural resource discovery. This locus is labelled NN in Fig. 1.3. It may be checked that it is upward-sloping and more steeply sloped than the corresponding notional locus.

As a result of taking account of the spillovers between markets arising from wage and price rigidities, the diagram is partitioned into three regions, each corresponding to a different disequilibrium regime. Following Malinvaud (1977), these are labelled C for Classical unemployment, K for Keynesian unemployment and R for repressed inflation. The next step is to investigate the effects of the resource discovery on the loci. Since we have excluded a resource movement effect, it is clear from equation (2.4) that the LL locus is not affected. However, the same is not true of the NN and LN loci. The spending effect of the boom leads to a greater demand for the non-traded good and, in Fig. 1.4, the Walrasian equilibrium shifts to point d. This is of course exactly the same equilibrium as that illustrated in Fig. 1.2. However, the new feature is that the economy does not immediately jump to d but instead remains in the short run at point a. Relative to the new equilibrium, this point is on the LL locus but to the left of the new N'N' and

L'N' loci. Hence, the initial effect of the resource boom is to leave the labour market in equilibrium and to induce excess demand for the non-traded good.

The principal question of interest is how the economy will move from a to d, and, in particular, whether any unemployment will emerge during the adjustment period. Without specifying the dynamics of adjustment in detail, we may presume that the price of the non-traded good will rise in response to excess demand. However, the behaviour of the wage rate is more complex and depends on the wage indexation rule which is adopted. Following van Wijnbergen (1984b) we make the standard augmented Phillips curve assumption that real consumption wages can only be reduced by temporary unemployment. The crucial issue is therefore whether the real consumption wage at d is higher or lower than it is at a.

To answer this question, we add a further locus to the diagram, the Wage Indexation locus, labelled WI. Its slope is greater the larger the share of the non-traded good in the consumption basket of wage-earners. This may be seen most easily by assuming that the real consumption wage may be identified with the utility level of wage-earners, and by invoking their expenditure function:

$$w = E(p, q, u) \quad (2.7)$$

(p denotes the price of traded goods, which is fixed throughout.) Equation (2.7) for the initial level of utility defines the WI locus. Fig. 1.4 illustrates the case where it is more steeply sloped than the LL locus so that the movement from a to d requires a fall in the real consumption wage and transitional unemployment must result. It may be checked that this requires that the non-traded sector be "more important" in demand than supply, in the sense that the share of its output in the consumption of wage-earners must exceed its contribution to a weighted average of the supply elasticities of the two sectors.[10] Conversely, if the non-traded good sector is less important in demand than in supply in this sense, the boom will raise the real consumption wage over time, and the economy enters a period of generalised labour shortage as it moves into the R region.

These results seem to accord well with some of the stylised facts of how different countries have responded to natural resource discoveries and increases in the prices of resources. Thus, the countries of the Persian Gulf, many of which import virtually all their consumption goods, experienced excess demand for labour after the oil price shocks. On the other hand, Latin American oil producers, with a long history of prohibitive tariff barriers making many of their consumer goods virtually non-traded, saw no employment benefits and in some cases (such as Mexico and Venezuela) increases in unemployment after the oil boom. Finally, it may be added that the addition of a resource movement effect makes it more likely that labour shortage rather than unemployment will emerge, since, as already shown in Fig. 1.2, this provides a boost to the wage rate additional to that induced by the spending effect.

III. INTERTEMPORAL ADJUSTMENT AND PUBLIC POLICY

It was argued in the Introduction that many aspects of the Dutch Disease can be satisfactorily examined in a static context. However, this is obviously not true of all. For example, issues arising from the finiteness of oil reserves or from the presence of learning-by-doing externalities in manufacturing require a dynamic perspective, and so it is necessary to develop a framework within which they can be analysed. In Section III.A we outline the basic model of a two-period open economy producing traded and non-traded goods which is assumed to enjoy a resource discovery. We assume that there are no market imperfections or externalities, postponing consideration of these issues until Sections III.B and III.C.

A. Intertemporal Adjustment with no Market Imperfections

We begin with the supply side of the economy. In the first period, technology and factor endowments are given and competition ensures that all factors are fully employed. In addition, we ignore for the present any supply-side or resource-movement effect of the oil discovery. The value of national output at domestic prices is therefore a function

only of the relative price of the non-traded good, q . However, for later use it is convenient to make explicit the domestic price of manufactures, p , so that the value of national output is therefore written as $r(p,q)$. [11] While the capital stock in the first period is given by past decisions (and so there is no need to specify it in the function r), next period's capital stock is the outcome of current investment decisions. For simplicity, we assume that investment consists of manufactured goods only. The value of national output in the second period is therefore a function of the amount of capital invested in the current period, K , as well as of the future prices of the manufactured and non-traded goods, P and Q , respectively. We write this function as $R(P,Q,K)$.

The use of the revenue functions $r(p,q)$ and $R(P,Q,K)$ implies that factors of production are allocated efficiently within each period. But with no production externalities or wage-price rigidities, and with perfect foresight on the part of producers, factors will also be allocated efficiently between the two periods. The subsequent analysis is greatly simplified if we use this fact to define an intertemporal revenue function, which equals the present value of current and future national output:

$$\hat{R}(p,q,P,Q,D) = \text{Max}_K [r(p,q) - pK + DR(P,Q,K)], \quad (3.1)$$

where D is the discount factor, equal to $1/(1+r^*)$, r^* being the exogenously given world rate of interest. It may be checked that the derivatives of \hat{R} with respect to q and Q give the competitive non-traded good supply functions for the two periods:

$$\hat{R}_q(p,q,P,Q,D) = r_q(p,q) = x_n(p,q); \quad (3.2)$$

$$\hat{R}_Q(p,q,P,Q,D) = DR_Q[Q,K(P,Q,D)] = DX_n(P,Q,D). \quad (3.3)$$

Note that in deriving (3.3) we have made use of the fact that the first-order condition for maximisation of (3.1) defines the optimal level of investment, K , as a function of p , P , Q and D :

$$DR_K(P,Q,K) = p. \quad (3.4)$$

Apart from permitting a more compact presentation of the model, the intertemporal revenue function yields an easy proof of the fact that optimal capital accumulation raises the own-price responsiveness of non-traded goods in the second period; i.e.: [12]

$$\frac{dX_n(P,Q,D)}{dQ} > \frac{dX_n(P,Q,K)}{dQ}. \quad (3.6)$$

This result (which is independent of the relative factor intensities of the traded and non-traded good sectors) will prove useful below.

Turning next to demand, we follow Razin and Svensson (1983) and van Wijnbergen (1984a) in characterising this by a homogeneously separable expenditure function:

$$\hat{E}[m(p,q), DM(P,Q), \hat{U}] = \underset{z,Z}{\text{Min}} [mz + MZ: \hat{U}(z,Z) \geq \hat{U}]. \quad (3.7)$$

The terms z and Z denote period-specific sub-utility functions in the current and future periods respectively, and the functions m and M are per-unit utility expenditure functions for the two periods. Because of the assumption of homogeneous separability between periods, these functions may be interpreted as measuring the price level in each period. Differentiating (3.7) with respect to q and Q gives the demand (or consumption) functions for the non-traded goods in the two periods:

$$\hat{E}_q = \hat{E}_m m_q = c_n. \quad (3.8)$$

$$\hat{E}_Q = D\hat{E}_m M_Q = DC_n \quad (3.9)$$

We may now characterise an equilibrium of this model in terms of the market-clearing conditions for the non-traded good in the two periods:

$$x_n(p,q) = c_n [m(p,q), DM(P,Q), \hat{U}], \quad (3.10)$$

$$X_n(P,Q,D) = C_n [m(p,q), DM(P,Q), \hat{U}]. \quad (3.11)$$

In both of these equations, the value of the household sector's lifetime utility is given by the intertemporal budget constraint, which requires the present value of expenditure to equal the present value of national output plus the oil wealth, \hat{V} :

$$\dot{E} [m(p,q), DM(P,Q), \bar{U}] = \dot{R}(p,q,P,Q,D) + \dot{V}. \quad (3.12)$$

Because capital markets are assumed to be perfect (until Section III.C), the total differential of (3.12) takes a very simple form:

$$d\bar{U} = d\dot{V} / \dot{E}_{\bar{U}}. \quad (3.13)$$

i.e., the change in lifetime utility as a result of the oil discovery equals the spending effect of the discovery (equal to the change in the present value of total income) multiplied by the marginal utility of income.

The determination of the equilibrium prices of the non-traded good in the two periods by equations (3.10) and (3.11) is conveniently illustrated in Fig. 1.5. Both of the loci corresponding to the two equations must be upward-sloping. For example, a rise in q leads to excess supply of the non-traded good in the current period both because consumption falls and production rises; whereas a rise in Q has no effect on current production but encourages substitution towards consumption of both goods in the current period, and so generates excess demand for the current non-traded good.[13] In addition, the dominance of own over cross substitution effects ensures that the equilibrium locus for the current non-traded good market (labelled N_1) must be more steeply sloped than that for the future non-traded good market (labelled N_2), as shown.

The effects of a resource discovery are now easily derived. The effect on national welfare is given by equation (3.13) and is clearly positive. The resulting spending effect leads to excess demand for the non-traded good in both periods at initial prices, causing the two equilibrium loci to shift as shown. The outcome is a new equilibrium represented by point B. It is characterised by a real appreciation in both periods (i.e., a rise in the equilibrium values of both q and Q), and, with a normal price-output response, this increases the output of the non-traded good and reduces that of the traded good in both periods. Thus, the implications of the simple static model of Section 2.A - deindustrialisation coupled with a real appreciation - continue to hold in our two-period extension.

One special case which is of some interest is where tastes and technology are identical in the two periods. With perfect foresight and perfect capital markets, the discovery has the same effect on demand in the two periods, and the only difference between periods follows from the fact that the capital stock can be optimally adjusted in the second period but not in the first. However, as already noted (see equation (3.6)), this leads to a larger supply response of the non-traded good in the second period, and so to a future appreciation which is smaller than that in the current period. In this case, therefore, the oil discovery leads to overshooting of the real exchange rate, in the manner to which Neary and Purvis (1983) have drawn attention. This case is illustrated in Fig. 1.5: point B lies below the ray OA, implying a larger rise in the real exchange rate in the short run than in the long run.

Before leaving the undistorted case, we may note three additional points. Firstly, a resource-movement effect of the discovery may easily be incorporated into the model by adding shift parameters to the period-specific revenue functions r and R . In this way it is possible to analyse the effects both of a permanent discovery (implying an equivalent shift in both functions) and a temporary one (implying a shift in r only). The implications of these extensions of the model are relatively straightforward. (See van Wijnbergen (1985).)

Secondly, these results are completely independent of the time pattern of the oil revenues because of the assumption that capital markets are perfect. Even if the natural resource is fully exhausted in the first period, there will be no depreciation in the second, post-oil, period (relative to the real exchange rate which would have prevailed in that period if the boom had not taken place). Of course, this feature of the model depends crucially on the perfect capital market assumption and assumes that any excess of current revenues over the permanent income equivalent is used to accumulate foreign assets.

Finally, it should be stressed that, under the assumptions made so far, the real appreciation is an efficient response to the increase in oil revenues and is in no sense a

symptom of "disease." On the contrary, the appreciation is essential to effect the allocation of factors of production out of the traded goods sector into the non-traded good sector which is necessary to accommodate the natural resource boom. It is only a disease requiring treatment in the form of government intervention if there is some market failure preventing the appropriate adjustment or if there is some existing immovable distortion which is exacerbated by the natural resource boom. In the remainder of this section we turn to consider some problems of this kind which may justify offsetting government intervention.

B. Learning-by-Doing in Traded Goods Production

A common concern of policy-makers in the presence of sudden increases in revenues from natural resource exploitation is that allowing the industrial sector to decline will prevent it benefitting from technological progress as a result of learning by doing. In this section we present a simple model which formalises this idea.[14] We assume that technological progress takes place only in manufacturing and that it is external to the firm. In these circumstances, there is a case for subsidising manufacturing whether or not it is threatened with being squeezed by another booming sector; the key issue rather is whether the boom justifies an increase in the optimal subsidy.

To capture the phenomenon of learning-by-doing externalities in manufacturing, we amend the second-period revenue function of the last sub-section to include the first-period output of manufacturing as one of its arguments. We also simplify by ignoring investment. Hence the value of national output in the second period is given by the following:

$$R = R(P, Q, x_m), \quad R_m > 0, \quad R_{mP} > 0, \quad R_{mQ} < 0, \quad (3.14)$$

where $R_m = dR/dx_m$, etc. and the signs of the cross derivatives indicate that the externality benefits future manufacturing production. For analytical convenience we assume that the externality operates in a linear fashion, so that $R_{mm} = 0$. In turn, the output of manufacturing in the first period is itself given by:

$$x_m = r_p(p, q). \quad (3.15)$$

The subsidy to manufacturing output in the first period is denoted by s and is assumed to be financed by lump-sum taxation of consumers. The household sector's intertemporal budget constraint (3.12) must therefore be replaced by the following:

$$\dot{E}[m(p, q), DM(P, Q), \dot{U}] = r(p+s, q) + DR[P, Q, x_m] + \dot{V} - sx_m \quad (3.16)$$

To determine the optimal subsidy, we differentiate equation (3.16) totally, holding \dot{V} constant. This yields, after some simplifications:

$$d\dot{U} = (DR_m - s) dx_m / \dot{E}_{\dot{U}} \quad (3.17)$$

Hence the optimal subsidy is given by the following:

$$s^* = DR_m \quad (3.18)$$

This formula has a nice intuitive interpretation. Private producers will produce the socially optimal level of manufactured goods in the first period if they receive a subsidy equal to the marginal benefits generated by the learning-by-doing externality (R_m) discounted back to the present by the discount factor, D .

Before the oil discovery takes place, we may view the model as a simultaneous system in which the market-clearing prices of the non-traded good in each period, q and Q , and the optimal subsidy level s^* are jointly determined. The three equations necessary to determine the values of these variables are the expression for the optimal subsidy, (3.18) and the market-clearing conditions for the non-traded good in each period, given by (3.10) and (3.11) with slight modifications. Strictly speaking, an algebraic analysis is required to solve this system. However, Fig. 1.6 allows us to deduce the effects of a resource boom on the optimal subsidy in a simpler manner.[15] The curve in the left-hand quadrant labelled OS illustrates the relationship between the optimal subsidy and the real exchange rate in period 2 implied by equation (3.18).[16] This curve is downward-sloping since a higher value of Q reduces the value of future benefits of the subsidy ($R_{mQ} < 0$) and so

reduces the optimal level of the subsidy. The curves in the right-hand quadrant have the same interpretation as those in Fig. 1.5, and the first-period equilibrium locus N_1 is unchanged. However, the second-period locus N_2 may be upward-sloping (as in Fig. 1.5) or downward-sloping (as illustrated), since its slope depends on two competing influences.[17] On the one hand, as in Section III.A, a higher value of q leads to excess supply of the non-traded good in period 1 and, since the goods in the two periods are necessarily substitutes in consumption, a rise in the future price Q works to restore equilibrium. This effect tends to lead to an upward-sloping locus. On the other hand, a higher value of q today tends to draw resources out of manufacturing today, leading to lower productivity in that sector tomorrow because of less learning-by-doing experience. This in turn will lead to a shift of resources out of manufacturing tomorrow, necessitating a lower value of Q .

The N_2 curve in Fig. 1.6 is drawn with a negative slope, implying that the learning-by-doing effect outweighs the intertemporal substitution effect. As a result, the effect of the boom on the future market-clearing value of Q is ambiguous. By the usual spending effect mechanism, the boom shifts N_1 rightwards and N_2 upwards as shown. Since the OS curve is not itself affected by the boom, the direction of change in the optimal subsidy therefore depends solely in the change in Q : if, as in the case illustrated in Fig. 1.6, a future real depreciation (i.e., a fall in Q) is anticipated, then the optimal level of current subsidy to manufacturing should increase. In this case, therefore, the term "Dutch Disease" is indeed appropriate, in the sense that increased government intervention is justified by the natural resources boom.

C. Imperfect Capital Markets

A key assumption of the analysis so far is that of perfect capital markets. On the consumption side, this implies that the private household sector is free to reallocate its spending between periods, so that the time profile of consumption is independent of the timing of the resource revenues. On the production side, it implies in addition that factors of production are allocated efficiently between as well as within the two periods.

Since space precludes a consideration of all the issues which relaxing this assumption raises, we concentrate on the case where households do not have access to perfect capital markets. In addition, we simplify the model of Section III.A by assuming that investment does not take place.

With households precluded from smoothing their income stream across periods, the single intertemporal budget constraint (3.12) must be replaced by two separate budget constraints, one for each period. (In effect, the prohibition of borrowing or lending amounts to fixing the current account exogenously at zero.) Suppose for concreteness that all the resource revenues accrue to households in the first period only. In the standard case of Section III.A, with no investment and no learning-by-doing externalities in manufacturing, the budget constraints therefore become:

$$e(p,q,z) = r(p,q) + v, \tag{3.19}$$

and

$$E(P,Q,Z) = R(P,Q). \tag{3.20}$$

Here, e and E are period-specific expenditure functions and z and Z are period-specific sub-utility functions.[18] Clearly, the diagrammatic analysis of this case is extremely simple. Instead of the configuration shown in Fig. 1.5, the N_1 curve is vertical, the N_2 curve is horizontal and only the former is shifted by the boom. In this case, therefore, the absence of any links between periods (either in the form of saving, investment or learning by doing) means that the real exchange rate adjusts fully in the period when the revenue from natural resource exploitation becomes available and subsequently returns to the level it would have reached in any case.

Of greater interest is the case where the learning-by-doing externality of Section III.B coexists with imperfect capital markets. The budget constraints for the two periods now become:

$$e(p,q,z) = r(p+s,q) + v - sx_m \tag{3.21}$$

and

$$E(P,Q,Z) - R(P,Q,x_m) \quad (3.22)$$

In this case, the optimal subsidy may be derived by maximising the direct utility function \hat{U} which depends directly on z and Z . It can be shown that this leads to the following expression for the optimal subsidy:[19]

$$s^* = LR_m, \quad L = \frac{m \, d\hat{U} / dz}{M \, d\hat{U} / dZ} \quad (3.23)$$

Here, L is the ratio of the marginal utility of expenditure tomorrow to the marginal utility of expenditure today. In a perfect capital market L would equal the world discount factor D but with capital market imperfections that equality need not obtain. This formula should be compared with (3.18) in the last section: to induce private producers to produce the socially optimal level of manufactured goods in period 1, they should receive a subsidy equal to the marginal benefits generated by the learning-by-doing externality DR_m , corrected for any wedge between L and D caused by capital market imperfections. If there is no such wedge the formula simplifies to $s^* = DR_m$ as in equation (3.18). The presence of L in (3.23) indicates that there is an intertemporal trade-off involved in s^* ; an increase in s will lead to a decline in welfare today because of the increased static price distortion it causes today; but to an increase in welfare tomorrow because of the dynamic benefits associated with the larger future outward shift of the production function in manufacturing. If at the margin expenditure tomorrow generates less additional welfare than expenditure today because capital market imperfections prevent intertemporal arbitrage ($L < D$), a smaller subsidy is called for than would otherwise be the case.

Now what happens when first period oil revenues go up? We will use a diagrammatical representation of the equation system to help in the analysis. N_1 in Fig. 1.7 represents the first period goods market schedule in (q,s) space where s denotes the actual subsidy level (by assumption s equals s^* , the optimal level, before the increase in oil revenues). z has been substituted out using (3.21). The N_1 schedule slopes upwards: a high-

er subsidy to manufacturing production draws resources out of the non-traded sector, reducing its output; a return to equilibrium requires a higher value of q . [20] Moreover, higher oil revenues in period 1 will be spent partially on non-traded goods in period one, shifting the schedule upwards (to N'_1 in Fig. 1.7).

The N_2 schedule represents non-traded goods market equilibrium in period 2. Except that Z has been substituted out using (3.22), this is the same N_2 schedule as in Fig. 1.6. Because of our assumption of an exogenous current account, the only intertemporal channel is that arising from learning-by-doing externalities. As we saw in Section III.B, this means that N_2 must have a negative slope. An increase in first period oil revenues will not directly affect N_2 under our exogenous current account assumption.

Finally the OS schedule represents equation (3.23) in (s^*, Q) space, where s^* is the optimal subsidy level. A higher value of Q in the second period implies a lower value of second period manufacturing output; therefore, given everything else, the value of the extra future productivity benefits of an additional unit of first-period manufacturing production declines and so does the optimal subsidy level: OS has a negative slope. First period increases in oil revenues shift OS out under our exogenous current account assumption; more expenditure today for given expenditure tomorrow increases L , the ratio of the marginal utility of expenditure tomorrow to that of expenditure today, because of the concavity of $U(Z, z)$. Since s^* equals LR_m , the OS schedule must shift out.

We now have all the building blocks in place to work through the effects of more oil today on the optimal subsidy to manufacturing. As argued above, higher oil revenues today will at least partially be spent on non-traded goods today, shifting the N_1 curve upwards and leading to a first period real appreciation for standard Dutch Disease reasons. The resulting decline in manufacturing production will lead to a decline in second period productivity in that sector as technological progress slows down. The resulting resource shifts into the non-traded sector will lead to a real depreciation in period 2 (i.e., a fall in Q).

For a given location of the OS schedule this in itself would be enough to increase the optimal subsidy level: the negatively sloped OS schedule tells us that a lower second period exchange rate (and so a higher value of manufacturing output in period 2) calls for higher first period subsidies: the post-oil-increase optimal subsidy s_1^* exceeds the pre-oil-increase one s_0^* . Moreover, we have already seen that higher oil revenues today will increase L , the social discount factor, shifting out the OS schedule. This leads to a further increase in the optimal subsidy to s_2^* . [21]

We therefore have a clear cut result: if the current account cannot be or is not used to smooth expenditure, subsidies to the non-oil traded goods sector should be increased if that sector shows the potential of significant learning-by-doing induced increases in productivity external to the firm. In this sense the Dutch Disease is indeed a disease.

IV. THE MONETARY CONSEQUENCES OF A RESOURCE DISCOVERY

So far, we have considered only the aspects of the Dutch Disease which concern the allocation of real resources. However, especially in the short run, many of the important policy issues which arise in this context involve monetary considerations. In this section we turn to consider some of these issues, assuming for simplicity that the real side of the economy is characterised by the static model of Section II. In Section IV.A we assume that both the wage and the price of non-traded goods are flexible, while in Section IV.B we consider the consequences of wage and price rigidities, thus presenting an analysis which complements in many respects the disequilibrium analysis of Section II.C above.

A. Monetary Adjustment with Flexible Wages and Prices

Since the real side of the model is essentially identical to that in Section II, the market-clearing condition for non-traded goods is little changed from equation (2.1). However, some amendments are necessary. Firstly, since we are now concerned with the price level as well as with relative prices, we make explicit the nominal prices of traded and non-traded goods. We denote these by e and q respectively: since the domestic price

of traded goods is linked directly to their world price, we may set world prices equal to unity and identify e with the nominal exchange rate (the domestic currency price of a unit of foreign exchange). We also allow for a real-balance effect on spending. Letting the parameter b represent the resource movement effect, the non-traded good market equilibrium condition may therefore be written as:

$$x_n(q/e, b) = c_n(q, e, y, M/P). \quad (4.1)$$

P is the domestic price level, which is homogeneous of degree one in the prices of traded and non-traded goods:

$$P = P(q, e). \quad (4.2)$$

Equation (4.1) is represented by the line NN in Fig. 1.8. Obviously, a rise in q induces an excess supply of the non-traded good while an increase in e gives rise to excess demand. Moreover, with a fixed nominal money supply, an equiproportionate increase in q and e leads to excess supply of the non-traded good by reducing the value of real money balances and so depressing spending. The non-traded good market equilibrium locus is therefore upward-sloping and less steeply sloped than a ray from the origin, as shown.

The determination of equilibrium is completed by adding the equilibrium conditions for the monetary sector. In this sub-section we simplify by assuming that money is the only asset and that velocity is constant. Hence, the requirement that the domestic money supply be willingly held is expressed by equating demand and supply:

$$M/P = Ay. \quad (4.3)$$

Note that we assume that the resource boom affects money demand directly through its effect on y : this gives rise to what we call the liquidity effect of the boom (although the mechanism involved may just as well be thought of as emanating from a wealth effect). Equation (4.3) is represented by the locus MM in Fig. 1.8: from (4.2), an increase in either nominal price raises the domestic price level P and so gives rise to excess demand for money by reducing the real value of the given supply. This locus is therefore

downward sloping as shown. If the exchange rate is flexible (and assuming that the domestic money market always clears), equilibrium must lie along this locus at all times. A rise in q must be accompanied by a fall in e if the domestic money supply is to be willingly held when the level of income is given at its full employment level. Alternatively, under a fixed exchange rate, equilibrium in the short run may be at (for example) a point above MM , reflecting a shortfall of actual holdings of real money balances below desired holdings. This disequilibrium must be offset by a build-up of foreign exchange reserves to augment the domestic money supply. Hence, all points above MM correspond to situations of balance of trade surplus and points below MM correspond to a deficit.

With the initial pre-boom equilibrium determined at point A , where the MM and NN loci intersect, we are now in a position to consider the consequences of a natural resource discovery. As far as the NN locus is concerned, we know already that both the spending and resource movement effects lead to excess demand for the non-traded good at initial prices. Hence, this locus shifts upwards to $N'N'$. The rise in real income also raises money demand and, if the domestic money supply is not changed, the price level must fall to restore money market equilibrium. The resulting liquidity effect therefore shifts the MM locus inwards to $M'M'$. Precisely what happens now depends on the exchange rate regime pursued by the authorities and we consider in turn the two extreme cases of floating and fixed exchange rate regimes.

If the nominal exchange rate is allowed to float freely, the new equilibrium must be at point C , where $M'M'$ and $N'N'$ intersect. The fact that a real appreciation has taken place is reflected in the greater slope of the ray OC relative to the ray OA . Under floating exchange rates, the mechanism whereby this comes about is through a nominal appreciation, so that the domestic prices of traded goods unambiguously fall. By contrast, the domestic nominal price of the non-traded good may either rise or fall, although we postpone considering the possible implications of this until the next sub-section.

What happens if the nominal exchange rate is not free to change but instead remains equal to its initial value e_0 ? On impact, with a constant nominal money supply, the shifts in the two equilibrium loci are as just described. Hence, the nominal price of the non-traded good rises to eliminate the incipient excess demand and equilibrium moves in the short run to point J. The change in the relative price of the non-traded good, and hence the degree to which the real side of the economy adjusts, is less than that required for long-run equilibrium, since the spending effect is dampened by the leakage into hoarding which is reflected in a balance-of-payments surplus. Since desired money balances are now greater than actual, the equilibrium at J cannot be permanently sustained. Over time therefore, the trade surplus leads to a build-up of foreign-exchange reserves, and so, provided the authorities do not attempt to sterilise this inflow, the domestic money supply gradually increases. This causes both the M'M' and the N'N' loci to drift upwards, and so the equilibrium point moves upwards from point J as indicated by the arrows. Since the long-run equilibrium is independent of nominal variables, and in particular is independent of the exchange-rate regime pursued, this process can only end when the post-boom equilibrium real exchange rate represented by the slope of the line OC is attained. This occurs at point D, where the two loci once again intersect, the surplus is eliminated and the economy reaches its new long-run equilibrium.

The implications of this comparison between exchange rate regimes are clear: a fixed exchange rate delays the real effects of the boom and gives rise to inflationary rather than deflationary pressures. The required increase in the relative price of the non-traded good is brought about by a rise in their nominal price rather than by a fall in the nominal prices of traded goods. This may to some extent suggest that a strategy of permitting some nominal appreciation may be desirable, since experience in many countries suggests that the domestic inflation induced by a boom under fixed exchange rates may pose political problems which are just as severe as those arising from the required change in the structure of the economy.

Of course, the assumption made so far - that the domestic monetary authorities adopt a neutral stance - has been made for analytic convenience only, and the consequences of alternative assumptions can easily be examined in the diagram. For example, if the authorities are committed to a fixed nominal exchange rate but are concerned about its inflationary consequences, they may attempt to sterilise the inflow of foreign exchange reserves. This amounts to what Corden (1981) has called a policy of "exchange-rate protection": the central bank acts to suppress the real appreciation, so protecting the traded goods sectors and mitigating the extent of deindustrialisation. The cost of such a policy does not arise from a divergence between home and foreign relative prices (as with orthodox tariff protection). Rather, to the extent that the policy is successful, it arises from a continuing shortfall of aggregate consumption below the new level of national income, which is reflected in an ongoing balance of payments surplus.

B. Sticky Prices and the Adjustment Problem

So far in this section we have assumed that prices and wages adjust instantaneously, so as to ensure the continual clearing of domestic goods and factor markets. We have already seen in Section II.C that real wage stickiness can impede the adjustment process, irrespective of monetary conditions. We therefore concentrate in what follows on nominal rigidities. If we confine attention to rigidities in the domestic price of the non-traded good, then the discussion of Fig. 1.8 has already drawn attention to the fact that, under fixed exchange rates, the effect of the boom is to put upward pressure on q . Shortages in the home market may result in the short run therefore, especially if the authorities attempt to enforce price controls. Probably of greater policy concern, however, is the fact that the boom may require a fall in the domestic price of the non-traded good if the exchange rate is flexible. If the price of the non-traded good is sticky, then in this case the boom can paradoxically lead to domestic excess supply.

Fig. 1.9 illustrates this possibility. The shifts in the MM and NN schedules are similar to those in Fig. 1.8 except that now it is assumed that the adjustment to the new

long-run equilibrium under flexible exchange rates requires a fall in q ; in other words, the shift in the MM schedule as a result of the liquidity effect is assumed to dominate that in the NN schedule as a result of the spending and resource movement effects. Since in the short run the price of the non-traded good is sticky, the domestic price of tradeables, that is to say, the nominal exchange rate, must bear all the brunt of adjusting to ensure that the money market clears at the new higher level of real income. In other words, the nominal exchange rate overshoots its new long-run equilibrium value as a result of the boom. Immediately after the boom, therefore, the equilibrium jumps from A to B which lies on the post-boom money market equilibrium locus, $M'M'$. At this point, there is excess supply of the non-traded good, which, over time, drives down its price. The economy therefore gradually moves towards the new long-run equilibrium as shown by the arrows. The consequences for the real economy of moving along this path are clear: because both the real and the nominal exchange rates overshoot their final equilibrium values, manufacturing profitability and output fall even more in the short run than in the long run. Since this emanates from a "distortion" represented by the sticky price of the non-traded good, we may conclude that in this case, flexible exchange rates exacerbate the Dutch Disease.

Finally, it may be noted that the overshooting result we have derived here continues to hold when we adopt a more sophisticated approach to modelling financial markets. For example, allowing for perfect international capital mobility, so that home and foreign bonds are perfect substitutes, does not significantly affect the analysis. It also continues to hold when exchange rate expectations are assumed to be formed rationally, although the degree of exchange rate overshooting in that case is somewhat less.[22] We may therefore conclude that the result appears to be relatively robust.[23]

V. CONCLUSION

In this paper we have examined the effects of natural resource discoveries in a variety of theoretical models representative of those in the now extensive literature on the Dutch Disease. Each model has been deliberately simplified as far as possible in order to focus on one or two particular issues. Rather than summarising each of the models in turn, we conclude by considering their implications for some of the practical policy questions which typically arise in discussions of the effects of natural resource discoveries.

1. Is deindustrialisation inevitable?

Deindustrialisation, in the sense of a decline in output and employment in the exposed manufacturing sector, is indeed a feature exhibited by all of the models we have considered. However, it is important not to be misled by labels. The key feature of the sectors which may be expected to decline are that they are exposed to foreign competition and have little or no ability to set their own prices. Thus, export-oriented agricultural or even service sectors may be squeezed; and, conversely, industries which cater for the home market as a result of trade protection or which possess monopolistic price-setting powers in their export markets may benefit from the rise in home demand. Moreover, it should be stressed that deindustrialisation is in general a symptom of the economy's adjustment to its new equilibrium. It certainly does not provide prima facie grounds for diagnosing a "disease" which requires corrective action. (See point 4. below.)

2. Is a real appreciation inevitable?

The models we have considered are also unanimous in predicting that a resource boom will give rise to a real appreciation, in the sense of an increase in the relative price of non-traded to traded goods. Once again, it is important not to be misled by labels, since a nominal appreciation (i.e., a rise in the external value of the home currency) is neither necessary nor sufficient for a real appreciation. Moreover, to date no

convincing model has been constructed which predicts that a resource boom will generate both pro-industrialisation and a real depreciation.[24]

3. Can a resource discovery generate unemployment?

Obviously, a necessary condition for this is that there be some degree of wage rigidity. In addition, two other issues are crucial. The first is the weight of non-traded goods in the consumption basket of wage-earners. If this is sufficiently large (in a sense made precise in Section II.C), then real wage stickiness will give rise to transitional unemployment following a resource boom. A second issue is the degree of monetary accomodation. Even if wages are merely sticky in nominal rather than real terms, unemployment may still ensue in certain cases, if the monetary authorities fail to provide adequate liquidity. (See Section IV.B.)

4. Is intervention at the industrial or sectoral level justified?

This might alternatively be expressed as "Does the Dutch Disease call for a cure?" As has been repeatedly stressed, the fact that resource exploitation is likely to lead to deindustrialisation and a real appreciation does not in itself provide any justification for offsetting intervention. On the contrary, these responses represent general equilibrium adjustments of the economy which are necessary if the economy is to enjoy the fruits of its increased wealth. Of course, on both allocative and distributional grounds, transitional adjustment assistance to the declining sectors may be justified. However, permanent subsidies are only justified if there is some market failure which implies a divergence between private and social valuations. Moreover, if such a market failure is present, then intervention is likely to be justified whether or not the economy enjoys a resource boom. In such cases, the relevant question is therefore whether the boom raises or lowers the optimal level of subsidy and, as we have seen (in Section III), this is more likely to be the case if capital market imperfections prevent intertemporal smoothing of consumption.

5. What is the appropriate stance of macroeconomic policy?

The conduct of macroeconomic policy is one of the most controversial issues in economics as a whole and raises questions which go far beyond the issue of natural resource discoveries. Insofar as general conclusions can be drawn, there seems to be a clear presumption that maintaining a fixed exchange rate is likely to require an increase in the domestic price level in order to effect the necessary changes in relative prices. (Section IV.A) On the other hand, it is also possible that a policy of floating exchange rates without moderate monetary accomodation may lead the boom to subject the economy to a deflationary shock, with unfavourable consequences for output and employment in the short run. (Section IV.B)

6. What happens when the oil runs out?

The finite nature of reserves does not of itself pose additional problems if capital markets are sufficiently flexible and private agents are sufficiently well informed that they can carry out the necessary intertemporal smoothing of consumption without assistance. Of course, if industry is subject to significant learning by doing the "re-entry" problem when the resource revenue comes to an end may be considerable. In the case considered in Section III, this was seen to justify subsidies to manufacturing, and in certain circumstances the optimal degree of subsidisation may rise as a result of the natural resource boom.

It should be added that even the stable of models we have considered is highly incomplete. Many other issues need to be taken into account to enhance our understanding of the process of structural change resulting from natural resource discoveries and no doubt further theoretical work will emerge to fill this gap. However, probably the greatest need in the present state of our knowledge is not for further theoretical elaboration but for detailed consideration of individual country experiences with resource exploitation with a view to ascertaining the usefulness of the theoretical models already developed. It is with this process that many of the other contributions to this conference will be concerned.

FOOTNOTES

- [1] For other surveys of the theoretical literature, see Corden (1984), Neary (1984) and van Wijnbergen (1985). The present chapter draws in part on the latter two papers.
- [2] See Dasgupta and Heal (1978).
- [3] For these reasons, we are attracted by the more neutral French term for these phenomena: "Syndrome Hollandais."
- [4] The terms "resource-movement effect" and "spending effect" of a natural resource discovery were introduced by Corden and Neary (1982).
- [5] For convenience, we use social indifference curves as a shorthand way of summarising aggregate demands, and ignore the well-known difficulty that changes in income distribution are likely to shift them, except under restrictive assumptions.
- [6] Examples include Snape (1977), Corden and Neary (1982), Long (1983) and Cassing and Warr (1985). A general production structure allowing for any number of goods and factors is outlined in the appendix to Neary (1984).
- [7] See Jones (1971).
- [8] See Barro and Grossman (1971) and Malinvaud (1977). The present application draws on Neary (1980) and van Wijnbergen (1984b).
- [9] This follows from the assumptions that all of the output of the non-traded good sector is used for current consumption and that some of the labour market rationing falls on firms in that sector. If either of these assumptions does not hold, the two loci do not coincide and the region between them corresponds to a regime of "underconsumption" or simultaneous excess demand for labour and excess supply of the non-traded good. Since points below and to the right of A are irrelevant to the effects of natural resource exploitation we do not consider these issues further. For a fuller discussion, see Neary (1980) and van Wijnbergen (1984b).
- [10] This result is derived in Neary (1984) and van Wijnbergen (1984b).

[11] We follow the convention throughout of using lower-case notation for period 1, upper-case notation for period 2 and a superimposed bar to denote variables which refer to both periods.

[12] This is an example of the Le Chatelier principle and is proved by totally differentiating (3.3):

$$\hat{R}_Q Q. = D[R_Q Q. - R_Q K. R_K K.^{-1} R_K Q.] > DR_Q Q. \quad (3.5)$$

The non-traded good is relatively capital-intensive in the second period if $R_Q K.$ is positive, but (since this equals $R_K Q.$) the inequality holds irrespective of the sign of this term.

[13] Homogeneous separability of \hat{E} guarantees that the non-traded good in the current and future periods are net substitutes: $\hat{E}_q Q. = D\hat{E}_{mM_q^m M_Q} > 0.$

[14] This section is based on van Wijnbergen (1984a).

[15] Details are given in van Wijnbergen (1984a).

[16] This equation is independent of the first-period relative price, q , because of the assumption that period 1 manufacturing output affects period 2 national income in a linear fashion: $r_{mm} = 0.$

[17] Note, however, that it must always be flatter than N_1 in stable configurations, at least in the neighbourhood of equilibrium.

[18] The manner in which this specification is consistent with homothetic separability of the utility function \bar{U} is spelt out in van Wijnbergen (1984a).

[19] For details, see van Wijnbergen (1984a).

[20] The N_1 schedule also depends on Q , so that complete graphical analysis is not possible. A similar remark applies to N_2 , which depends on s as well as s^* . The algebraic analysis in van Wijnbergen (1984a) takes account of these interactions and shows that the diagrammatic analysis gives the correct conclusions.



- [21] Finally, when the actual subsidy s is set at its new optimal level, the N_2 curve will also shift, leading to a series of second round effects. It can be shown that these will not reverse the result of an increase in s^* following an increase in first period oil revenues.
- [22] See Eastwood and Venables (1982), Buiters and Purvis (1984), Neary (1984) and Neary and van Wijnbergen (1984).
- [23] The Dutch Disease has also been examined in models which allow for imperfect asset substitutability or controls on capital markets by Giavazzi, Sheen and Wyplosz (1984) and Pesaran (1984).
- [24] It should be noted that quite plausible theoretical examples of a resource discovery which gives rise to "proindustrialisation" or to a real depreciation have been uncovered. (See Corden and Neary (1982).) However, these typically assume more than one intersectorally mobile factor (and so are less appropriate to a short-run horizon) and require that the resource movement effect dominate the spending effect.

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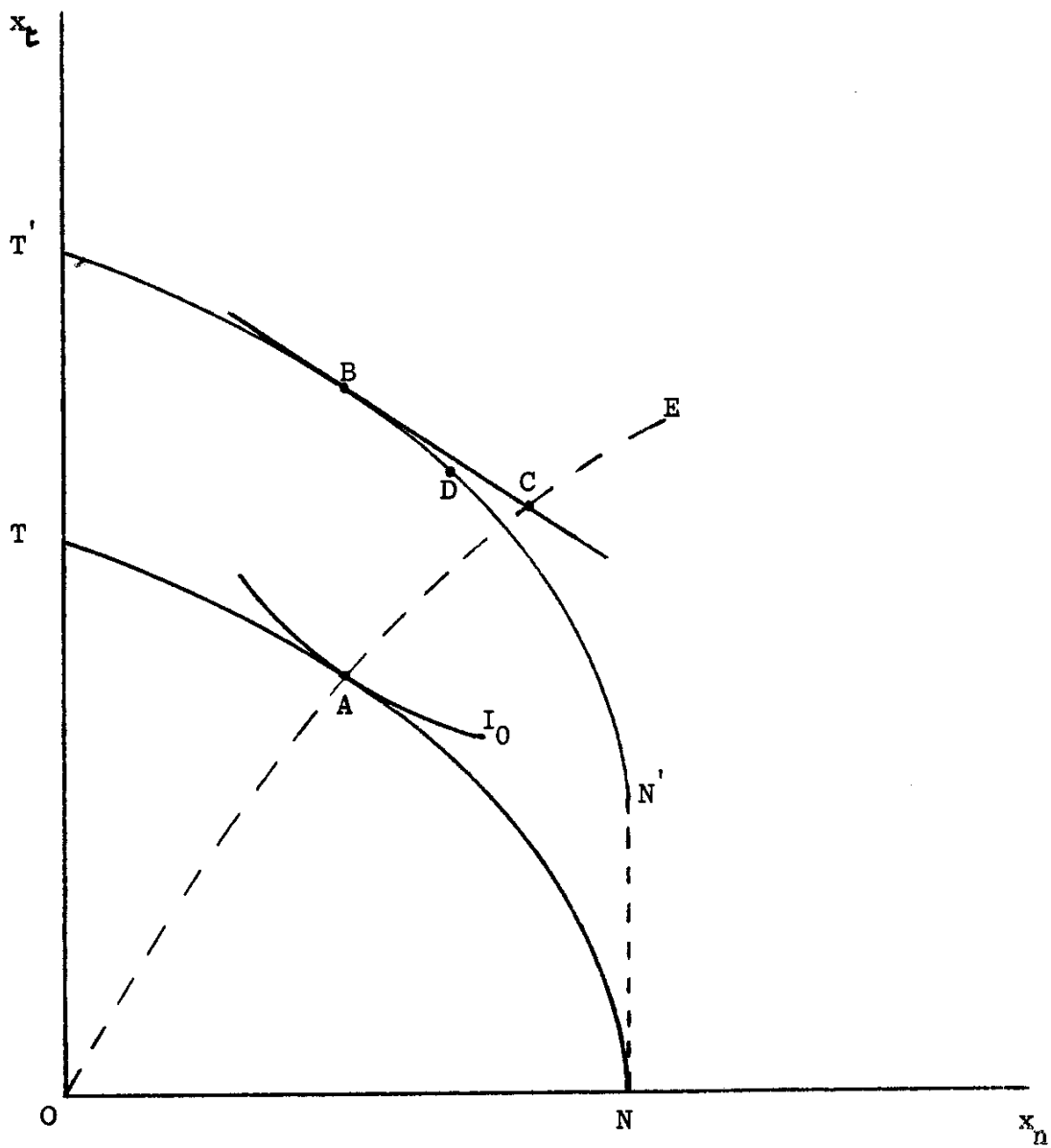


Fig. 1.1 : The spending effect of a resource boom

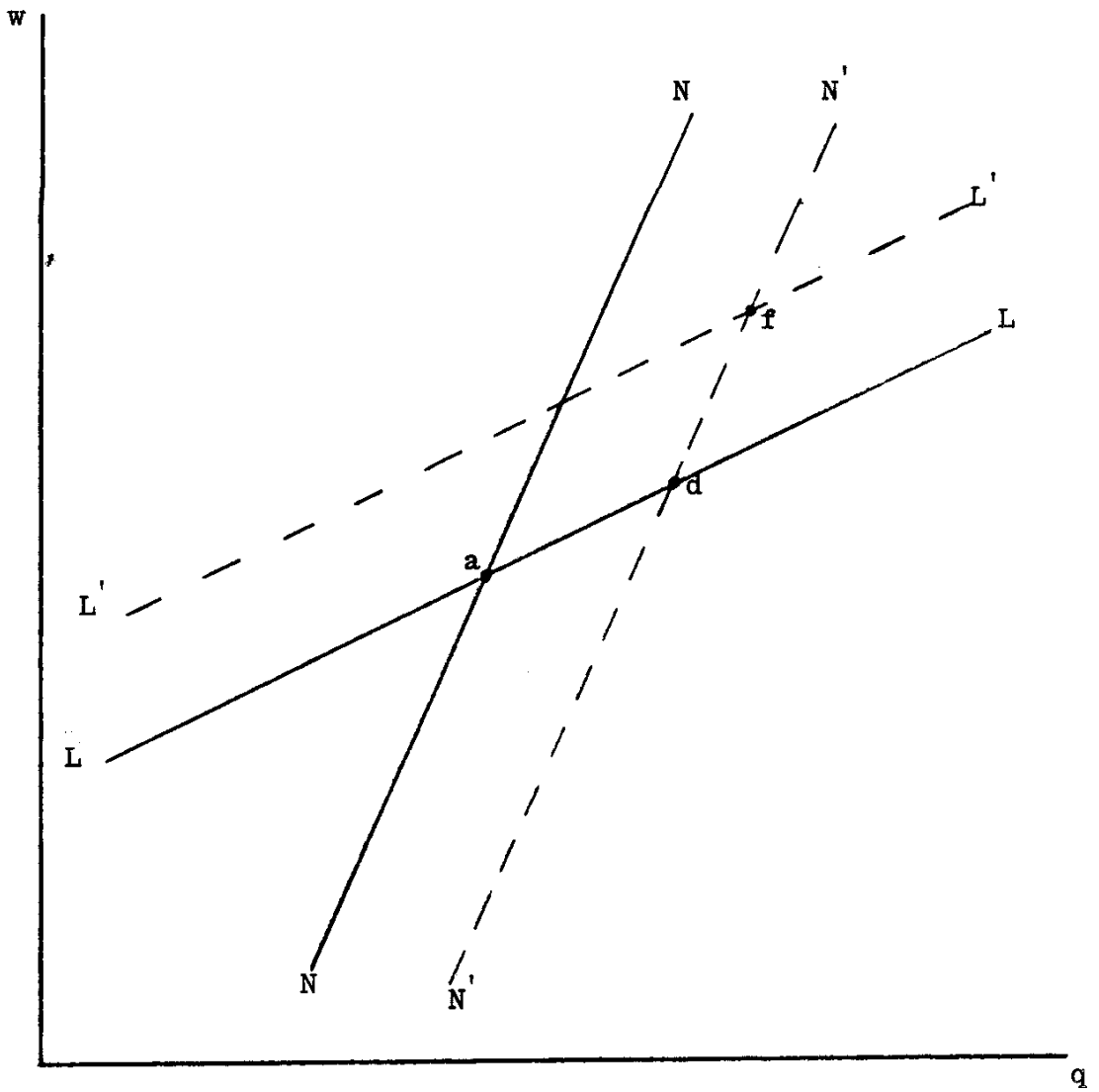


Fig. 1.2 : Spending and resource movement effects of a boom

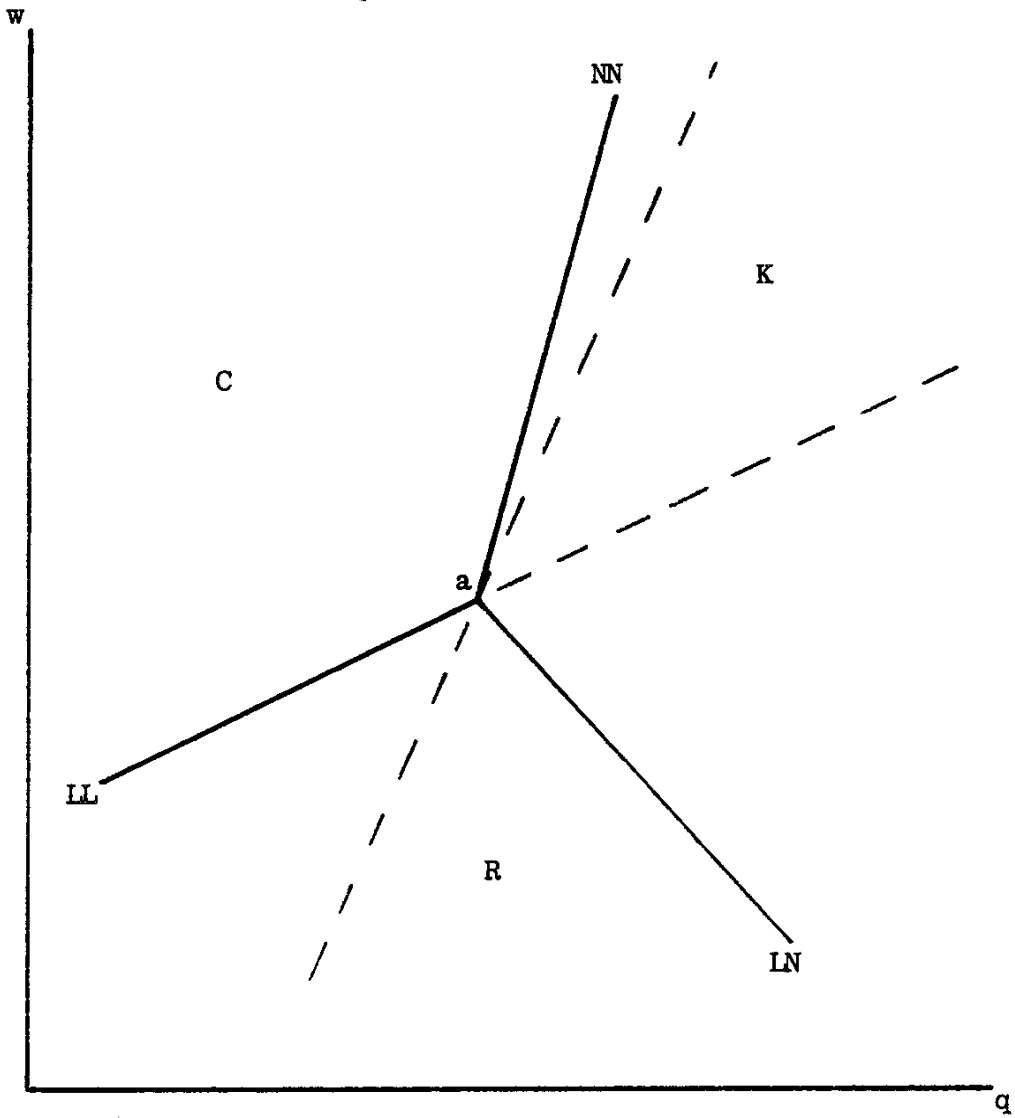


Fig. 1.3 : Disequilibrium regimes with wage and price rigidities

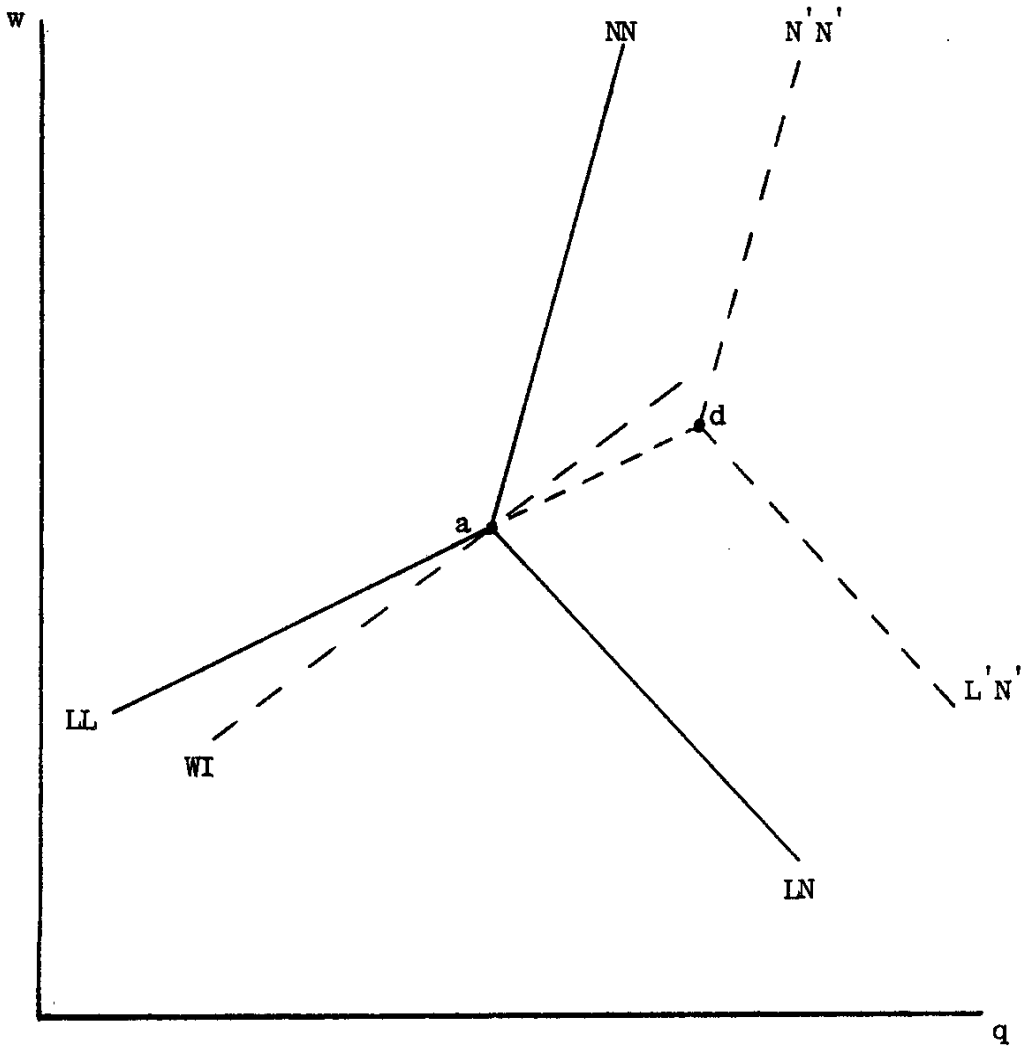


Fig. 1.4 : Effects of a boom with wage and price rigidities

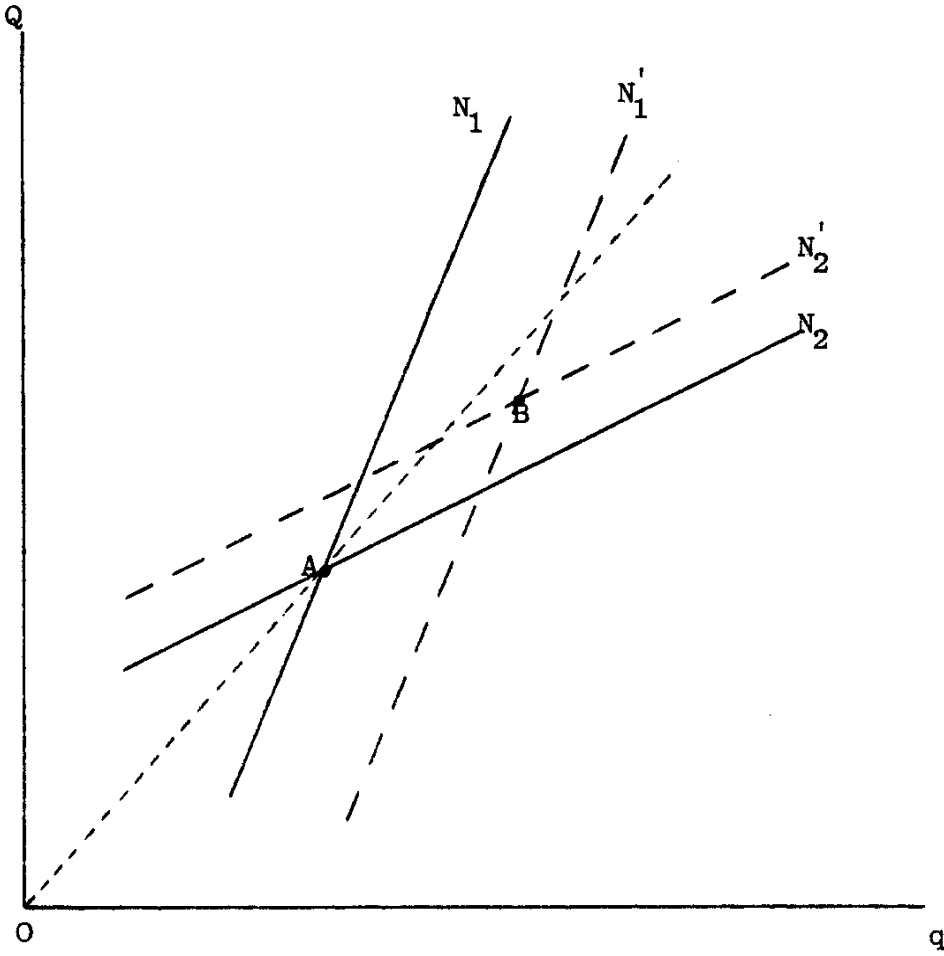


Fig. 1.5 : Effects of a boom on current and future real exchange rates

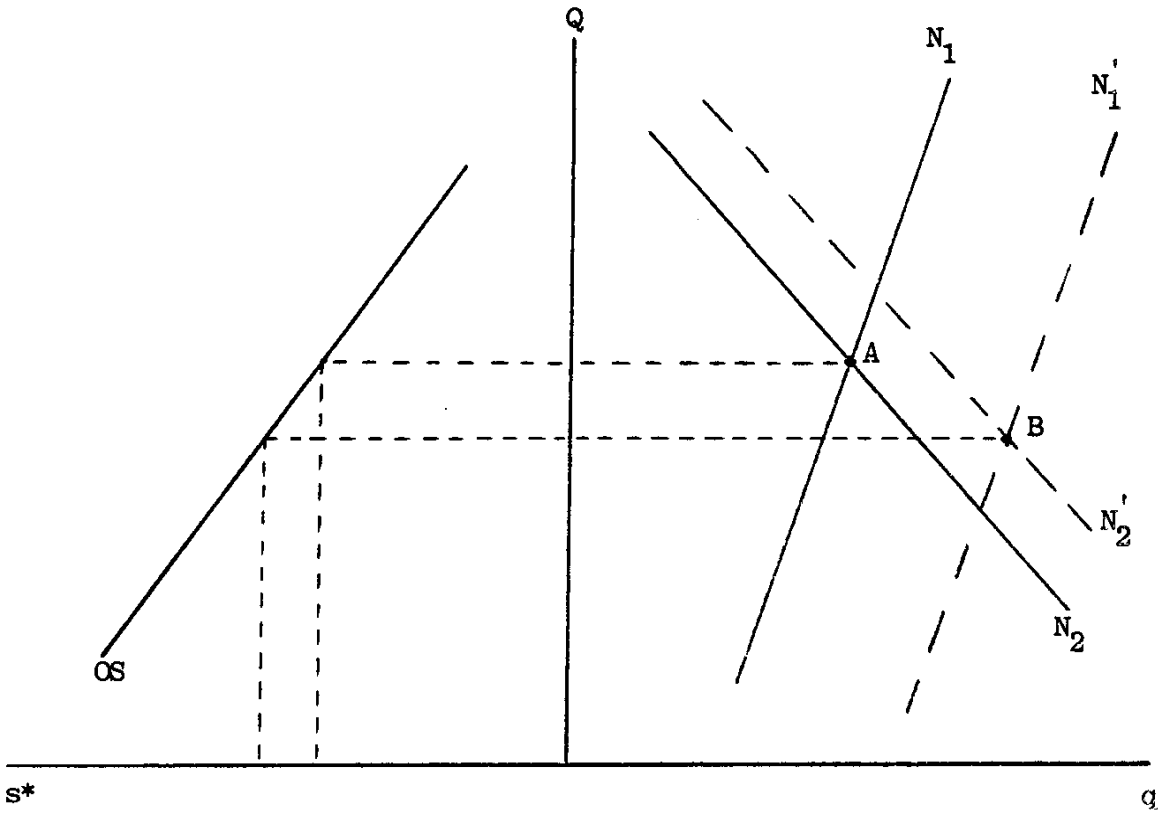


Fig. 1.6 : Determination of the optimal subsidy when manufacturing benefits from learning by doing

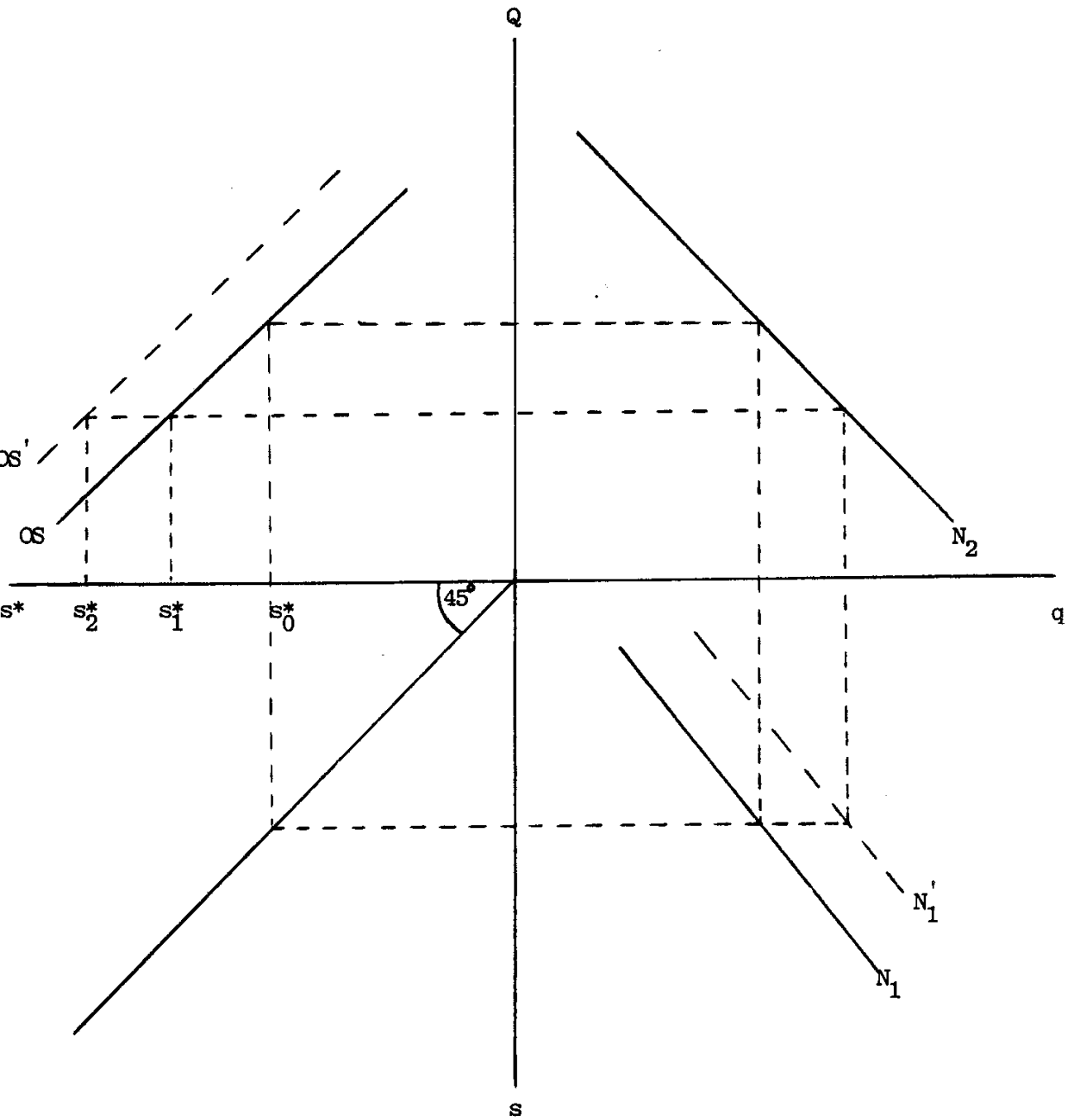


Fig. 1.7 : Determination of the optimal subsidy to manufacturing with imperfect capital markets

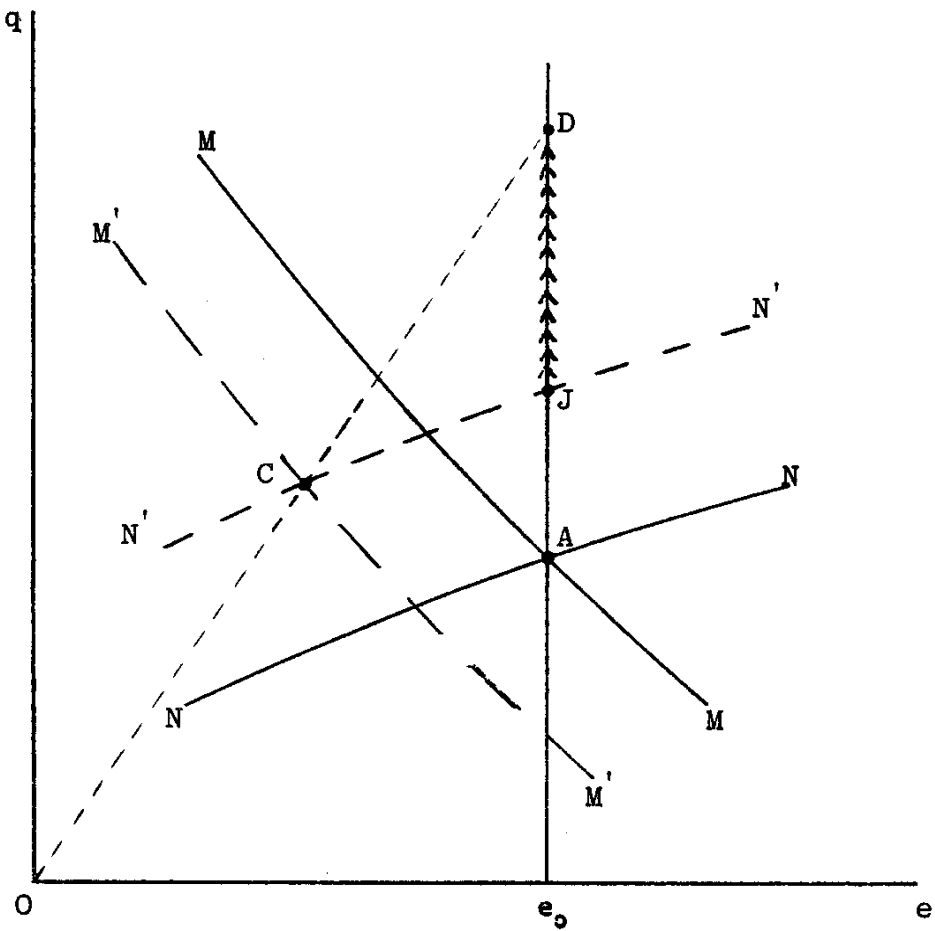


Fig. 1.8 : Real and monetary effects of a boom under fixed and floating exchange rates

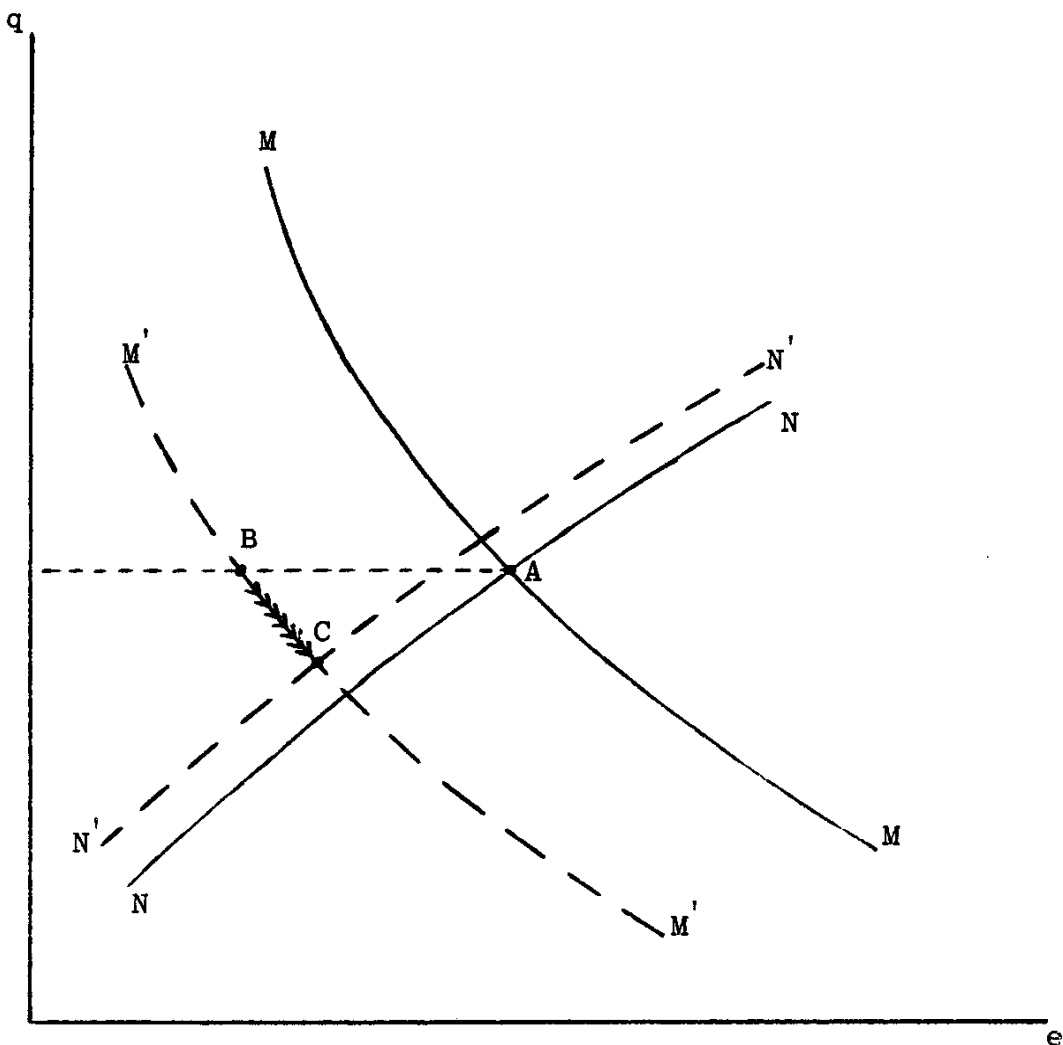


Fig. 1.9 : With sticky prices, a resource boom may lead to exchange rate overshooting and transitional unemployment