BOOMING SECTOR AND DE-INDUSTRIALISATION IN A SMALL OPEN ECONOMY

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ABSTRACT

This paper presents a theoretical analysis of the "Dutch Disease": the phenomenon whereby a boom in one traded goods sector squeezes profitability in other traded goods sectors, both by directly bidding resources away from them and by placing upward pressure on the exchange rate. The effects of such a boom on resource allocation and income distribution are studied in a variant of the "Australian" model of a small open economy, under different assumptions about the degree of intersectoral factor mobility.

ACKNOWLEDGMENTS

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1. INTRODUCTION

This paper attempts to provide a systematic analysis of some aspects of structural change in an open economy. In particular, we are concerned with an increasingly common phenomenon in both developed and developing countries, sometimes referred to as the "Dutch Disease": the coexistence within the traded goods sector of progressing and declining, or booming and lagging, sub-sectors. In many cases – minerals in Australia, natural gas in the Netherlands, or oil in the United Kingdom, Norway and some members of OPEC – the booming sector is of an extractive kind, and it is the traditional manufacturing sector which is placed under pressure. Hence a major aim of this paper is to explore the nature of the resulting pressures towards "de-industrialisation".* However, our

* Of course, in many countries, including the United Kingdom, the effects of the booming sector are superimposed on a downward trend in the share of manufacturing in national output due to other reasons. Indeed, prior to the recent appreciation of sterling many British economists saw North Sea oil primarily as a potential source of tax revenue which might be used to cure de-industrialisation rather than as a factor contributing to it. (See the discussion in Blackaby (1978).) More recently, however, commentators such as Forsyth and Kay (1980) have adopted a general-equilibrium viewpoint closer to ours. See also various papers in Eltis and Sinclair (1981).

analysis is equally applicable to cases where the booming sector is not extractive (such as the displacement of older industry by technologically more advanced activities in Ireland, Japan or Switzerland). This is so because we are primarily concerned with the medium-run effects of asymmetric growth on resource allocation and income distribution, rather than with the longer-run issue of optimal depletion rates which has been the focus of recent work on the economics of exhaustible resources.* Moreover, in order to highlight the structural aspects of a boom we ignore monetary considerations and focus on its implications for real rather than nominal variables. We are thus able to draw on and extend the standard tools of international trade theory in order to throw light on the specific problem of a sectoral boom.

The structure of the paper is as follows. Section 2 introduces the basic framework, which is essentially a variant of the "dependent economy" model of Salter (1959), producing two traded goods and one non-traded good.** This section outlines the various models to be examined and introduces an important distinction between the two principal effects of a boom. The next three sections consider the effects of a boom in one of the traded goods sectors under different assumptions about the factor-market underpinnings of the model. Section 3 follows Jones (1971) and Snape (1977) in assuming that labour is the only mobile factor of production, while Sections 4 and 5 assume production structures more akin to that of the Heckscher-Ohlin model, allowing for different degrees of intersectoral capital mobility. Section 6 considers some extensions of the basic model, showing that the tools developed may also be applied to the effects of booms which arise from a variety of exogenous shocks in a small open economy,

* See Dasgupta and Heal (1978).

** In using this model to analyse the effects of a boom in one sector, we draw on and extend the analysis of the Australian case by Gregory (1976), Snape (1977) and Porter (1978); the general applicability of this study has been noted in Corden (1981b). In particular we build on the contribution of Snape, who presented the model described in Section 3 below and anticipated some of our results.

including a change in world prices. Finally, Section 7 summarises the paper's principal conclusions.*

2. THE EFFECTS OF A BOOM: AN OVERVIEW

In this section we set out the main assumptions underlying the analysis and introduce a basic decomposition of the effects of a boom. The framework we adopt is one of a small open economy producing two goods which are traded at exogenously given world prices, and a third non-traded good, the price of which moves flexibly to equalize domestic supply and demand. We label the two traded goods "energy", X_E, and "manufactured", X_M, and the non-traded good "services", X_S, although in terms of formal structure the models are consistent with many alternative interpretations. For the present we assume that all goods are used for final consumption only, postponing until Section 6 a consideration of the case where energy is used as an intermediate input by other sectors.

The questions we address concern the effects of a boom in the energy sector on the functional distribution of income, and on the size and profitability of the manufacturing sector. Although there are many reasons why a boom might occur, we concentrate for much of the paper on the case of a once-and-for-all Hicks-neutral improvement in technology. As we shall see in Section 6, other sources of booms will produce different effects, but the analysis we develop for the simple case is readily applicable to more complicated cases.**

* An Appendix to this paper sets out the model in algebraic form and derives the principal results.

** Of course, the discovery of new natural resources, typically as a result of previous investment in surveying and exploration activities, is not the same as a costless improvement in technology. Nevertheless, as noted in Section 1, the special issues raised by a natural resource discovery are not necessarily crucial from the point of view of medium-run allocation and distribution problems.

We make two other simplifying assumptions. Firstly, as already noted, the models are composed of real variables, and ignore monetary considerations: only relative prices (expressed in terms of the given prices of traded goods) are determined, and national output and expenditure are always equal, so that trade is always balanced overall. (Of course, trade in either one of the two traded goods need not balance, and indeed until Section 6 it is immaterial which of X_E or X_M is imported in the initial equilibrium.) Secondly, we assume that there are no distortions in commodity or factor markets: in particular, real wages are perfectly flexible, ensuring that full employment is maintained at all times. This assumption (which, as noted in Section 6, is easily relaxed) rules out the possibility of "immiserizing growth" for the economy as a whole. Hence the boom must raise potential national welfare, and we can focus on the distribution of the gains between different factors.

Our approach in this paper is to consider a sequence of real models characterised by different degrees of intersectoral factor mobility. We begin in Section 3 by assuming that each of the three sectors uses a single specific factor as well as a mobile factor which moves between sectors so as to equalize its return in all sectors. Following traditional usage, we refer to the mobile factor as labour and the specific factors as capital, but other interpretations are of course possible: for example, some categories of skilled labour may be quite immobile, especially in the short run, while the specific factor in the energy sector can be thought of as including natural resources as well as specific capital. This model has been implicit in much discussion of these issues and yields results which are intuitively plausible.

In Sections 4 and 5 we assume instead that more than one factor is intersectorally mobile, thus introducing production structures more akin to that of the standard Heckscher-Ohlin model. Even confining attention to the

Heckscher-Ohlin categories of capital and labour, there are a number of possible combinations of assumptions which might be considered, and we have chosen to concentrate on two which appear in our view to throw light on particular real-world cases. In Section 4 we examine the case where the energy sector stands on its own, using a specific factor and sharing only labour with the other two sectors, while both capital and labour are mobile between manufacturing and services.* Section 5 considers an alternative case where the two factors are mobile between all three sectors. Both models exhibit interesting properties, and give rise to some unexpected results.

Until Section 6 the terms of trade are assumed to be given, so that the relative price of the two traded goods, energy and manufactured goods, does not change. However, the *real exchange rate*, which we define as the relative price of non-traded to traded goods, can change, a rise in the relative price of the non-traded good (services) corresponding to a real appreciation. Throughout the paper we take manufacturing output as numeraire so that factor prices are measured in terms of manufactured goods. However, we are also concerned with changes in the real wage from the point of view of wage-earners: this depends on how the wage rate varies relative to the price of services as well as to the prices of traded goods.

A central feature of the analysis of all three models is a distinction between two effects of the boom, namely the *resource movement effect* and the *spending effect*. The boom in the energy sector raises the marginal products of the mobile factors employed there and so draws resources out of other sectors, giving rise to various adjustments in the rest of the economy, one mechanism of

* Logically there are three possible cases, in each of which one sector has a specific factor and shares only labour with the other two sectors, while both capital and labour are mobile between the remaining two sectors. The sector that stands on its own can be the booming sector itself, as in the present paper; it can be the non-traded goods sector, so that traded goods are grouped together; or it can be the manufacturing sector. Long (1981) explores the second case.

adjustment being the real exchange rate. This is the resource movement effect. If the energy sector uses relatively few resources that can be drawn from elsewhere in the economy this effect is negligible and the major impact of the boom comes (as it has in Britain) through the second, spending effect. The higher real income resulting from the boom leads to extra spending on services, which raises their price (i.e., the real exchange rate appreciates) and thus leads to further adjustments. Clearly the importance of this effect is positively related to the marginal propensity to consume services. In the model described in Section 3, with only labour mobile between all three sectors, both effects lead, as expected, to de-industrialisation, but this is not inevitable in the more Heckscher-Ohlin-type models of Sections 4 and 5.

3. THE EFFECTS OF THE BOOM WHEN LABOUR IS THE ONLY MOBILE FACTOR

3.1. Pre-Boom Equilibrium

We begin by describing the pre-boom equilibrium, which corresponds to points A and a in Figures 1 and 2, respectively. Figure 1 illustrates the labour market, with the wage rate (in terms of manufactured goods) measured on the vertical axis and the economy's total labour supply given by the horizontal axis $O_S O_T$. Labour occupied in the service sector is measured by the distance from O_S while distances from O_T measure labour employed in the two traded goods sectors. Given the assumptions of the model, the demand for labour in each sector is a decreasing function of the wage rate relative to the price of that sector's output. Thus L_M is the labour demand schedule for the manufacturing sector, and by laterally adding to this the initial labour demand schedule for the energy sector we obtain L_T, the pre-boom labour demand schedule for the two traded goods sectors combined. Similarly, L_S is the initial labour demand schedule for the service sector, drawn for the initial price of services. Initial

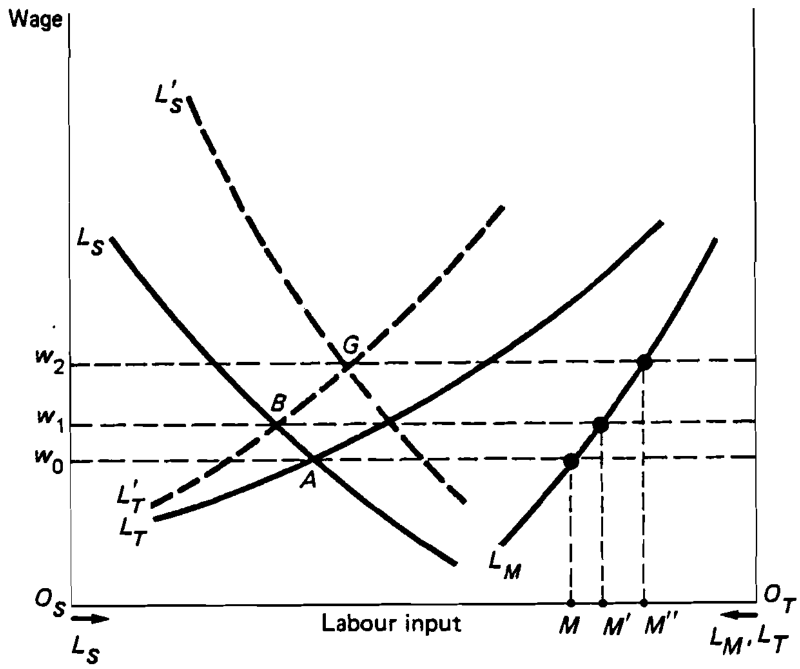

Figure 1. Impact of the boom on the labour market.

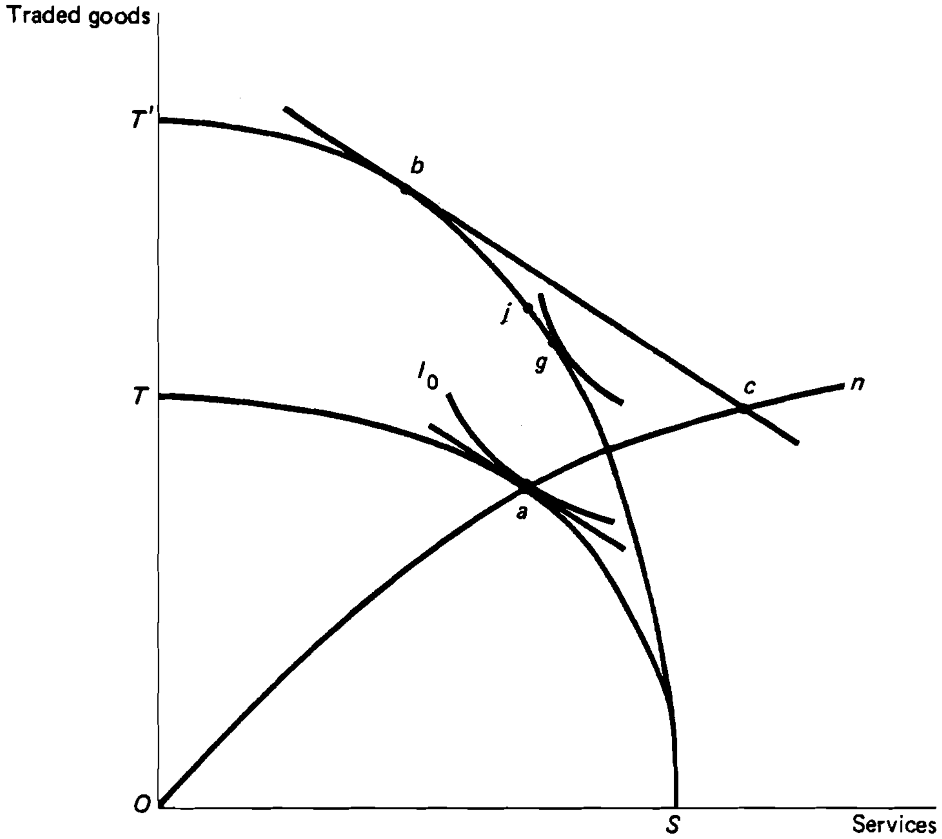

Figure 2. Impact of the boom on the commodity market.

full-employment equilibrium is at A, where L_T intersects L_S, and so the initial wage rate is w_0. However, Figure 1 does not provide a complete illustration of the initial equilibrium, since the profitability of producing services and hence the location of the L_S schedule depends on the initial price of services, which is not exogenous but is determined as part of the complete general equilibrium of the model.

To illustrate how the initial equilibrium price of services is determined, we turn to Figure 2, which is the familiar Salter diagram with traded goods on the vertical axis and services on the horizontal. Since the terms of trade are fixed, energy and manufacturing output can be aggregated into a single Hicksian composite traded good, X_T. The pre-boom production possibilities curve is TS and, in the absence of commodity or factor-market distortions, the production point must always lie on this curve. The initial equilibrium is at point a, where the production possibilities curve is tangential to the highest attainable indifference curve I_0. (Note that the latter curve is simply a shorthand way of summarising aggregate demands and need not have any welfare significance.) The initial price of services, i.e., the initial real exchange rate, is thus given by the slope of the common tangent to the two curves at a.

3.2. Effects of the Boom on Outputs

Consider now the effects of a boom in the form of Hicks-neutral technological progress in the energy sector. We tell this story in two steps. Firstly, we assume that the real exchange rate (the relative price of services) is held constant, so that the curve L_S in Figure 1 and the price ratio in Figure 2 stay unchanged. As a result the energy sector's labour demand schedule shifts upwards: the technological progress lowers unit labour costs in the energy sector and thus acts in exactly the same way as a price increase, raising profitability and the demand for labour at a given wage rate. This in turn causes the composite labour demand schedule L_T to shift upwards to L_T', and so a new equilibrium is attained at B, reflecting the resource movement effect of the boom. This effect, which raises the wage rate to w_1 at a constant real exchange rate, thus causes labour to move out of both manufacturing and service sectors. Since the output of the manufacturing sector therefore falls, from $O_T M$ to $O_T M'$, we may say that the resource movement effect gives rise to *direct de-industrialisation*.

Turning to Figure 2, the boom does not change the economy's maximum output of services, OS, but it raises the maximum output of traded goods from OT to OT'. The production possibilities curve therefore shifts out asymmetrically to $T'S$ and the resource movement effect is represented by the movement of the production point from a to b. At the initial real exchange rate the movement of resources from the service sector leads to a fall in the output of services and so point b lies to the left of point a.* Next we introduce the spending effect of the boom. At constant prices, demand moves along the income-consumption curve On to point c. There is now excess demand for services, both because of the spending effect and because of the reduction in the supply of services brought about by the resource movement effect. In this model, therefore, the boom necessarily gives rise to an *appreciation* of the real exchange rate: the price of services must rise to eliminate the excess demand, shifting demand away from services and tending to reverse the fall in that sector's output induced by the resource movement effect.

The final equilibrium is represented in Figure 2 by the point g at which an indifference curve is tangential to the new production possibilities curve, and so the new real exchange rate is indicated by the slope of the common tangent to the two curves at g. As drawn in Figure 2, this new equilibrium implies an

* The boom has thus given rise to "ultra-biased" growth, in the sense that it reduces the output of both other sectors at given commodity prices. Conditions under which this takes place have been explored in different models by Johnson (1955), Corden (1956), Findlay and Grubert (1959) and Neary (1981) among others.

increase in the output of services: point g lies to the right of a. However, it is essential to understand that there is no presumption that this outcome will ensue: everything hinges on the relative strengths of the two effects.* This may be seen by considering two extreme cases. Firstly, if the income-elasticity of demand for services were zero, there would be no spending effect and the output of services would have to fall. The income-consumption curve in this case would be a vertical line through a, intersecting $T'S$ at point j, and so the new equilibrium would have to lie somewhere between b and j. At the other extreme, if the energy sector did not use any labour, the curves L_T and L_M in Figure 1 would coincide and would be unaffected by the boom, so there would be no resource movement effect. In this case the effect of the boom would be to displace the production possibilities curve in Figure 2 vertically upwards. Point b would now lie vertically above a and so (assuming a positive income-elasticity of demand for services) the output of services would necessarily rise.

The same ambiguity of output response does not apply to manufacturing, however, as may be seen by returning to Figure 1. The service sector's labour demand schedule shifts upwards to L_S' because of the rise in the price of services and so the final equilibrium is at point G. As a result the wage level rises to w_2, which further reduces manufacturing output, from O_TM' to O_TM''. Hence the real appreciation caused by the boom (brought on both by the spending effect and by the reduction in the output of services induced by the resource movement effect) gives rise to *indirect de-industrialisation*, squeezing the output of manufacturing even further. The resource movement and spending effects thus combine to bring about a total reduction in manufacturing output from O_TM to O_TM''.

* Snape (1977) first showed that the output of non-traded goods may fall even though there is no real appreciation.

3.3. Effects of the Boom on Factor Incomes

To consider the effects of the boom on factor incomes, we may begin by summarising the changes in factor prices. Considering first the resource movement effect, its effects on factor prices are as indicated by the following chains of inequalities (where w denotes the wage rate, p_S the price of services and r_i the return to the specific factor in sector i, all measured in terms of manufacturing output, and a circumflex indicates a proportional rate of change):*

$$\hat{r}_E > \hat{w} > \hat{p}_S > 0 > \hat{r}_M \tag{1}$$

and:

$$\hat{p}_S > \hat{r}_S \quad 0 \tag{2}$$

The changes in factor prices attributable to the spending effect are as follows:

$$\hat{r}_S > \hat{p}_S > \hat{w} > 0 > \hat{r}_E, \hat{r}_M \tag{3}$$

Consider first the impact of the boom on the real wage. The resource movement effect on its own leads to a fall in the output of services, which is associated with a rise in the wage measured in terms of services. Since, as shown in Figure 1, the wage measured in terms of traded goods must rise as a result of the resource movement effect, the real wage – which takes account of changes in the prices of all goods consumed by wage-earners – must rise because of the resource movement effect. On the other hand, the spending effect on its own leads to a rise in the output of services and hence to a fall in the wage measured in terms of services. Since the wage in terms of traded goods must rise because of the spending effect (through the mechanism of a

* In general the inequalities which follow need not be strict. However, for expositional purposes it is convenient to ignore cases where they are not, which requires only that one of the spending or resource movement effects be non-zero.

real appreciation, as shown in Figure 1), the real wage may rise or fall because of the spending effect. Thus, when both effects are taken into account, the effect of the boom on the real wage is uncertain. A fall in the real wage is more likely the stronger the spending effect relative to the resource movement effect and the greater the share of services in wage-earners' consumption.

Turning next to the returns to the specific factors in the three sectors, the changes in each of the r_i may be interpreted as measures of the impact of the boom on the profitability of each sector. It is clear from (1) and (3) that profitability in the *manufacturing* sector must unambiguously fall. Profitability in the *service* sector would rise if there were only a spending effect, but once the resource movement effect is allowed for equation (2) shows that profitability in this sector could fall. This is because the rise in the wage rate relative to the price of services brought about by the resource movement effect squeezes profitability in that sector, and may do so sufficiently to reduce it in terms of traded goods. Of course, if the output of services rises, profitability in services measured in terms of all goods must rise. Finally, in the *energy* sector, profitability must rise because of the resource movement effect, but it must fall because of the spending effect. The factor specific to the energy sector fails to benefit from the spending effect, because the price of energy is fixed at the world level. It is thus possible for the benefits of the boom to be spread to other factors to such an extent that the owners of the factor specific to the booming sector actually lose.* This outcome requires a rather implausible set of parameter values, but is more likely the greater the rise in the wage rate, which means in turn the

* This apparent paradox may be understood by noting that it is a case of "immiserizing growth" accruing to the energy sector. The latter may be viewed (for this purpose only) as a "mini-economy" exporting energy and importing labour. This mini-economy faces a fixed price of energy but an upward-sloping supply schedule for labour, and since no "optimal tariff" is imposed on imports of labour we know from standard theory that immiserizing growth (which means in this context a fall in r_E) is possible. Of course, as already noted, immiserizing growth for the economy as a whole cannot take place in this model.

smaller the price-elasticity of demand for services and the larger its income-elasticity of demand.*

Finally, while it is clear that the return to the specific factor in manufacturing must fall in absolute terms, it is not necessarily the case that it must fall relative to the returns obtainable in other sectors. A key issue here is that of factor intensities in terms of value shares, for, if the share of labour in the value of manufacturing output is smaller than that in either of the other sectors, then a given rise in the wage rate reduces its profitability by less than it reduces that in the other sector. For example, if manufacturing is capital-intensive relative to services, and if the resource movement effect dominates the spending effect, the boom may raise profitability in manufacturing relative to services. If manufacturing is more capital-intensive than the energy sector and the spending effect dominates, it is actually possible that profitability in manufacturing could fall by less than in the booming sector (though, as noted already, this outcome requires an implausible combination of parameter values).**

These observations are relevant to the issue of whether the boom necessarily gives rise to de-industrialisation. As already pointed out, when this is defined as a fall in output and employment in manufacturing, there must be de-

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* As shown in the Appendix, the return to the specific factor in the energy sector falls if and only if the following expression is negative:

$$-\eta \xi_S \vartheta_{LE} \vartheta_E + \varphi_S (1 - \vartheta_{LE} \xi_E - \xi_S) + \varepsilon_S (1 - \vartheta_{LE} \xi_E)$$

where η and ε_S are the income and price elasticities of demand for services (the latter defined to be positive), ξ_j is the proportional contribution of sector j to the economy-wide elasticity of demand for labour, and φ_j, ϑ_j and ϑ_{ij} are the price-elasticity of supply, the share in national income and the share of factor i in the value of output of sector j, respectively. A number of sufficient conditions which rule out the paradox may easily be derived from this; for example, r_E must rise if the elasticity of substitution in the energy sector exceeds the marginal propensity to consume services.

** As shown in the Appendix, the condition for the return to the specific factor in manufacturing to fall by less than that to the specific factor in the energy sector is that the following expression be negative:

$$\eta \xi_S \vartheta_E (\vartheta_{LM} - \vartheta_{LE}) + \varphi_S (\vartheta_{KE} \xi_E + \vartheta_{KM} \xi_M) + \varepsilon_S \{\vartheta_{KE} \xi_E + \vartheta_{KM} (1 - \xi_E)\}$$

where the notation is the same as in the previous footnote. This expression can only be negative if $\vartheta_{LM} < \vartheta_{LE}$ i.e., the energy sector is labour-intensive relative to manufacturing.

industrialisation in this model provided there is any spending or resource movement effect. Furthermore, profitability in manufacturing must fall when measured in terms of traded goods and (when there is any real appreciation) even more when measured in terms of services. In addition, the balance of trade in manufacturing must deteriorate since output falls while home demand necessarily rises (provided that manufactured goods are normal in demand). However, as we have just seen, de-industrialisation in the sense of a decline in relative profitability need not take place if manufacturing is capital-intensive in value-share terms, so that it is less vulnerable than other sectors to the squeeze on profits induced by the rise in wages. Since it is relative rather than absolute levels of profitability which drive medium-run resource reallocation, we would therefore expect that the impact of the boom in reducing manufacturing output may in some cases be reversed rather than enhanced when capital begins to move between sectors in response to intersectoral differences in returns, and this indeed will turn out to be the case in the next two sections.

4. EFFECTS OF THE BOOM WHEN CAPITAL IS MOBILE BETWEEN TWO SECTORS

In assuming that only one factor was mobile between sectors, the analysis outlined in the previous section was firmly wedded to the short run. In the present section we turn to consider the effects of the boom over a somewhat longer time horizon, assuming that the manufacturing and service sectors draw on a common pool of mobile capital. However, we continue to assume (as before) that the energy sector uses a specific factor and shares only labour with the other two sectors.

In order to analyse this model, it is helpful to view the manufacturing and service sectors as a miniature Heckscher-Ohlin economy which faces a variable supply of labour equal to the total endowment of labour in the economy less the amount employed in the energy sector. Viewed in this light, the standard Stolper-Samuelson theorem implies a unique relationship between the equilibrium wage rate and the price of services (both, as always, measured in terms of traded goods), which depends only on the technology in the two mobile-capital sectors and so is unaffected by the boom. This relationship is drawn in the left-hand panel of Figure 3 as an upward-sloping curve, reflecting the assumption that manufacturing is capital-intensive relative to services.* In the right-hand panel are drawn the supply and demand schedules for services, but these are to be interpreted as general- rather than partial-equilibrium curves. Thus the supply curve X_S (which can be derived from a production possibilities curve such as TS in Figure 2) is the outcome of both the reallocation of resources between manufacturing and services and the movement of labour between these two sectors and the energy sector in response to a change in the relative price of services. This curve is upward-sloping, reflecting the fact that the supply response of the economy is normal.** Similarly the demand curve, D_S, is drawn on the assumption that expenditure is always equal to income, where the latter is determined by the production possibilities curve for any given price. The demand curve thus reflects a general-equilibrium relationship and so is not independent of the supply curve. The pre-boom equilibrium is represented in Figure 3 by points A and F.

As in the last section, we begin by considering the resource movement effect of the boom separately. Initially, therefore, we assume a zero income-elasticity of demand for services, which eliminates the spending effect and so

* The slope of the schedule in the left-hand panel of Figure 3 also reflects the property of the Heckscher-Ohlin model which Jones (1965) has called the "magnification effect": a rise in the relative price of services is associated with a greater than proportional increase in the relative return of the factor used intensively in that sector.

** At a given state of technology, an increase in the wage rate reduces the energy sector's demand for labour and hence *increases* the supply of labour available to the two mobile-capital sectors. The positive response of the output of services to a rise in their price is thus greater than if the supply of labour to the two sectors were fixed, reflecting the Le Chatelier-Samuelson principle. See Martin and Neary (1980) for an explicit derivation of the economy's supply response in such a model.

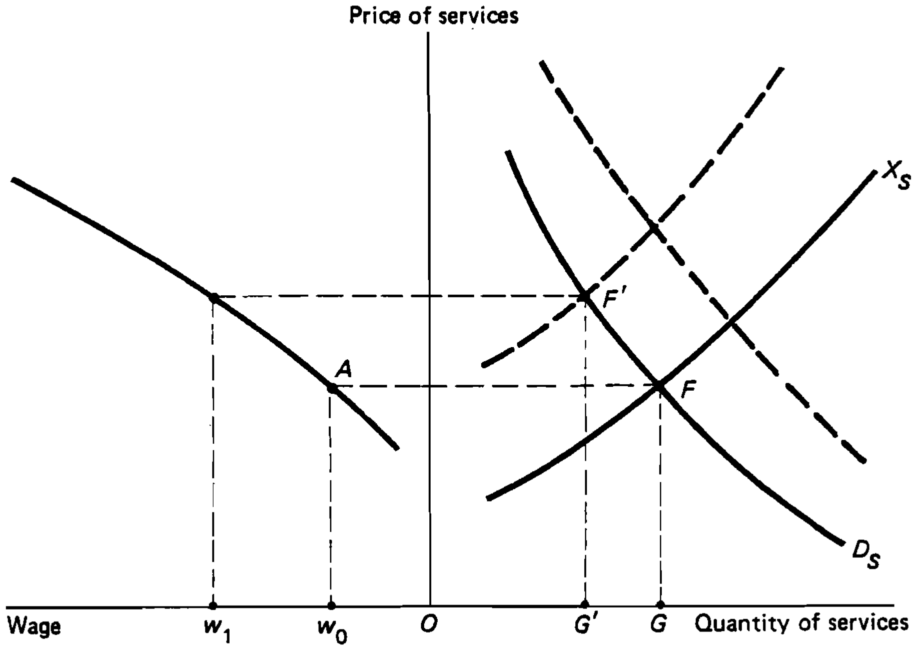

Figure 3. Effect of the boom when capital is mobile between two sectors.

ensures that the demand curve in Figure 3 does not shift. At the initial wage rate, the boom raises the energy sector's demand for labour and so reduces the amount available to the two mobile-capital sectors. The effects of this follow from a straightforward application of the Rybczynski theorem: at constant prices the output of the capital-intensive good rises and that of the labour-intensive good falls, as shown by the leftward shift of the service supply schedule in Figure 3. The service sector equilibrium moves from F to F'. Output falls from OG to OG', the wage rises from w_0 to w_1 and the price of services rises. However, in this model a fall in the output of services must be associated with an increase in the output of the manufacturing industry. Hence in this case the resource movement effect gives rise to *pro-industrialisation*!*

* This result follows from the fact, noted in Section 3, that if services are labour-intensive (in terms of value shares) relative to manufacturing, the resource movement effect raises the return to the specific factor in manufacturing relative to that in services. This generates an incentive for capital to move into manufacturing which leads, in the model of the present section, to a rise in the output of manufacturing. The "short-run capital specificity" hypothesis assumed here is surveyed in Neary (1978).

Suppose alternatively that manufacturing were labour-intensive relative to services. In this case the schedule in the left-hand panel of Figure 3 should be downward-sloping, since a rise in the relative price of services now reduces the real wage, while in the right-hand panel the boom shifts the supply curve to the right. As before the wage rate rises as a result of the resource movement effect, but this time the output of services rises and the price of services falls. Manufacturing output, which must change as before in the opposite direction to that of services, now falls, a "normal" case of de-industrialisation. The unexpected outcome in this case is that the real exchange rate *depreciates*.

Consider next the spending effect of the boom. It gives rise to an outward shift of the demand schedule in Figure 3, which unambiguously raises the output and price of services and thus squeezes manufacturing output, irrespective of the relative factor-intensities of the two sectors. However, the higher price of services is associated with a higher wage only if services are relatively labour-intensive, as in Figure 3.

All of these conclusions are summarised in Table 1. In general the results are quite similar to those reached in the previous section. In particular, when manufacturing is relatively capital-intensive the changes in prices are unambiguous and in the "expected" directions, and the same is true of the changes in outputs when manufacturing is relatively labour-intensive. However, in certain cases the two effects work in opposite directions, giving rise to the possibility of three counter-intuitive results: (1) When manufacturing is capital-intensive the resource movement effect of the boom causes manufacturing output to *increase*. As labour is drawn into the energy sector the capital-intensive part of the rest of the economy has to expand relative to the labour-intensive part, and because of the Rybczynski mechanism it has to expand absolutely. (2) When manufacturing is labour-intensive the resource movement effect causes the real exchange rate to ***depreciate***. As before, the relatively capital-intensive sector must expand, but this time it is the service sector, so that its increased supply leads to a fall in the price of services. (3) When manufacturing is labour-intensive the spending effect causes the wage to ***fall***, since the extra demand for services resulting from the extra spending raises the real return of the factor used intensively in the service sector and therefore lowers the real return of the other factor, which in this case is labour.

Table 1. Resource movement and spending effects when capital is mobile between manufacturing and service sectors: k_j = Capital-labour ratio in sector j; r_{MS} = Rental on capital used in manufacturing and service sectors.

<table>
<tr><th></th><th colspan="2">Resource movement effect</th><th colspan="2">Spending effect</th></tr>
<tr><td>$k_M > k_S$</td><td>$X_S \downarrow, X_M \uparrow, p_S \uparrow$</td><td rowspan="2">$w \uparrow, r_{MS} \downarrow$</td><td rowspan="2">$X_S \uparrow, X_M \uparrow, p_S \uparrow$</td><td>$w \uparrow, r_{MS} \downarrow$</td></tr>
<tr><td>$k_M < k_S$</td><td>$X_S \uparrow, X_M \downarrow, p_S \downarrow$</td><td>$w \downarrow, r_{MS} \uparrow$</td></tr>
</table>

5. EFFECTS OF THE BOOM WHEN CAPITAL IS MOBILE BETWEEN ALL THREE SECTORS

We turn next to consider the model in which both capital and labour are mobile between all three sectors. This model behaves somewhat differently from the two previously considered, since it exhibits the local factor-price equalization property: the number of sectors equals the number of endogenously determined prices (w, r and p_S), and so the latter are uniquely determined by technology and traded goods prices, independent of factor endowments and demand patterns. This is illustrated in Figure 4, which is adapted from Mussa (1979). Each of the curves in this diagram is a unit cost curve showing the different combinations of factor prices which are consistent with zero profits in the sector in question. Prior to the boom the curves for all three sectors intersect at A, whose co-ordinates are therefore the market-clearing factor prices in the initial equilibrium. Since the slope of the tangent to a unit cost curve equals the capital-labour ratio in the sector concerned, the equilibrium depicted at A is

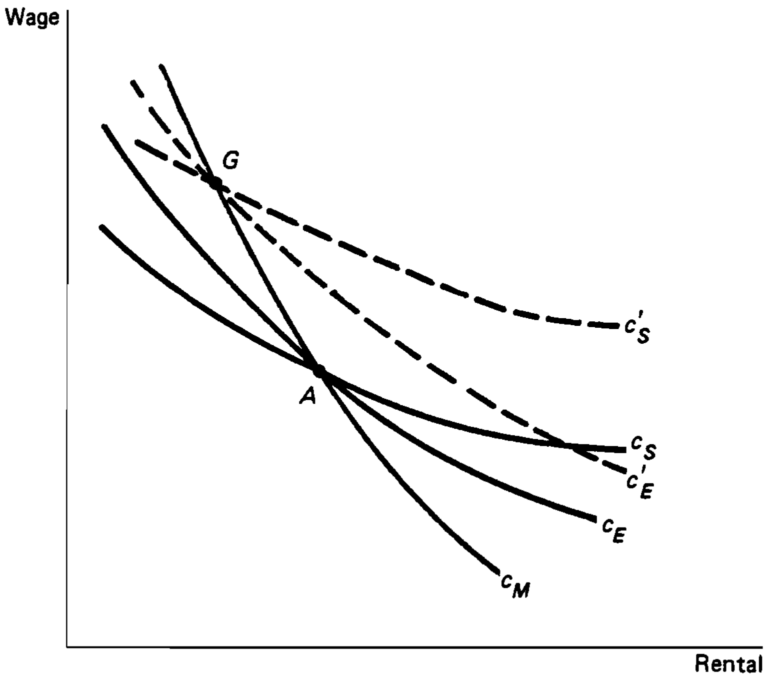

Figure 4. Effects of the boom on prices when capital is mobile between all three sectors.

one in which the energy sector is more capital-intensive than services but less so than manufacturing.

The effect of the boom is to shift the unit cost curve for the energy sector in Figure 4 outwards from c_E to c_E': Hicks-neutral technological progress is exactly analogous to a price increase in that it enables the sector to pay higher rewards to both factors while still covering its costs. Since the price of manufacturing and the state of technology in that sector are constant, the unit cost curve for that sector does not shift, and so the new post-boom equilibrium must be at point G: the expansion of the relatively labour-intensive sector pushes up the real wage. However, full factor-market equilibrium can only prevail if the service sector's unit cost curve also passes through G, and this requires an accommodating rise in the price of services (i.e., a real appreciation), shifting that sector's unit cost curve from c_S to c_S'.

Two conclusions follow from this analysis. Firstly, as far as prices (of both factors and commodities) are concerned, there is *no* spending effect in this model. Since prices are completely determined by the conditions for factor-market equilibrium (as illustrated in Figure 4), the changes in prices brought about by the boom are independent of the magnitude of the income-elasticity of demand for services. Secondly,the direction of these changes in prices (which depends solely on the resource movement effect) hinges on two key factor-intensity comparisons: that between the energy and manufacturing sectors determines the impact of the boom on factor prices, and that between the manufacturing and service sectors determines the change in the price of services which is required to accommodate the new factor prices. There are thus four possible cases, as shown in Table 2: real wages rise if and only if manufacturing is capital-intensive relative to the energy sector, while the price of services rises if and only if manufacturing is *extremal* in terms of factor intensities (i.e., if and only if its capital-labour ratio is either greater than or less than that in both other sectors).

Table 2. Effects of the boom on prices when capital is mobile between all three sectors.

	$k_M > k_S$	$k_M < k_S$
$k_M > k_E$	$p_S \uparrow$, $w \uparrow$ *	$p_S \downarrow$, $w \downarrow$
$k_M < k_E$	$p_S \downarrow$, $w \downarrow$	$p_S \uparrow$, $w \downarrow$

*This is the case illustrated in Figures 4 and 5.

This ambiguity of response persists when we come to consider the impact of the boom on manufacturing output, and is enhanced by the fact that output levels, unlike prices, are affected by a spending as well as a resource movement effect. Figure 5, which is based on Melvin (1968), illustrates these effects under the same assumptions as Figure 4: namely, that the capital-labour ratio in the energy sector is intermediate between those in the capital-intensive manufac-

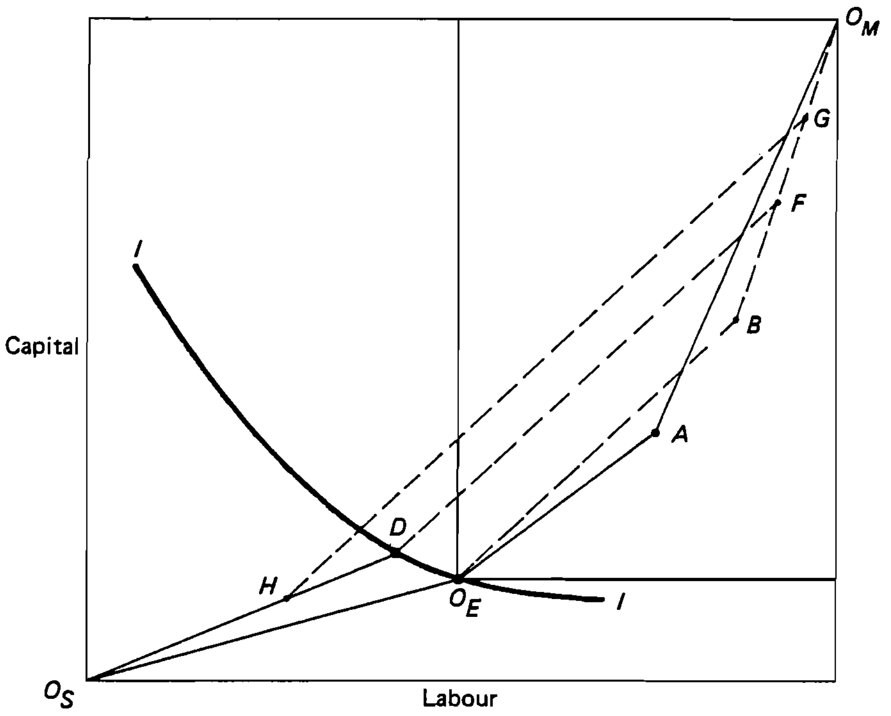

Figure 5. Factor-market effects of the boom when capital is mobile between all three sectors.

turing and labour-intensive service sectors. The diagram is a standard Edgeworth-Bowley production box, whose dimensions equal the economy's total endowment of capital and labour, and in which the service and manufacturing sectors' isoquants are measured from O_S and O_M, respectively. Demand conditions set the pre-boom output of services equal to that corresponding to the isoquant II, and factor-market equilibrium prevails when the energy and manufacturing sector isoquants have the same slope as II at O_E. Thus in the initial equilibrium the output levels of the service, energy and manufacturing sectors are indicated by the distances $O_S O_E$, $O_E A$ and $O_M A$, respectively.

We begin by considering the resource movement effect of the boom, proceeding as in Section 3 by initially holding the price of services constant. (Since both price and income effects on the demand for services are thus ruled out by assumption, the service production point must continue to lie along the II

isoquant for the present.) We already know from Figure 4 that, under our assumptions about the relative factor intensities of the three sectors, the wage rate is driven up by the boom, thus inducing substitution of capital for labour in all three sectors. If the service sector's production point were to remain at O_E, the shift towards greater capital intensity in energy and manufacturing would bring about a movement of the allocation of factors between those two sectors from A to a point such as B, with a consequent reduction in the output of manufactured goods from $O_M A$ to $O_M B$. However, if there is any flexibility in techniques in the service sector it also becomes more capital-intensive, its production point moving along II from O_E to a point such as D. Hence the output of the manufacturing sector is further reduced by the resource movement effect from $O_M B$ to $O_M F$: as in the models discussed in earlier sections, this effect unambiguously gives rise to direct de-industrialisation.

In addition we must take account of the fact that the output of services does not in general remain equal to the level corresponding to the isoquant II. Factor proportions in the service sector after the boom must correspond to the slope of the ray $O_S D$, but the scale of production must be sufficient to meet the demand expressed in the new equilibrium. This in turn depends on how the price of services and the level of national income have been affected by the boom, and, under the assumptions about relative factor intensities which underlie Figures 4 and 5, these have opposing effects: on the one hand, as we have already seen in Figure 4, the price of services rises, tending to reduce the demand for and thus the equilibrium output of services; on the other hand, the spending effect tends to raise demand, since services have been assumed to be a normal good. Figure 5 has been drawn assuming that the former price effect dominates, with the result that the output of services falls to $O_S H$. Thus the output of the manufacturing sector is further squeezed to $O_M G$.

There are six possible configurations of the relative factor intensities of the three sectors in this model, and each of the other five may be examined in a similar manner. In general, of the three distinct influences on the output of the manufacturing sector, only one, the direct de-industrialisation brought about by the resource movement effect, tends to reduce manufacturing output in all cases. This comes about because it raises the return of the factor used intensively by the energy sector relative to the manufacturing sector and so forces the latter to contract. By contrast, each of the other two influences may or may not give rise to de-industrialisation. Consider first the change in the demand for services brought about by the resource movement effect working through their price. The impact of this effect depends on the relative factor intensities of all three sectors, because these determine both the direction of change in the price of services (as shown in Table 2) and the relationship between the resulting change in the output of services and the associated change in the output of manufactured goods. This effect tends to raise manufacturing output if and only if the capital-labour ratio in services is intermediate between those in the other two sectors (which is not the case in Figure 5). Finally, the spending effect of the boom always tends to raise the output of services, but the effect of this on manufacturing output depends once again on relative factor intensities, tending to raise it if and only if the capital-labour ratio in the energy sector is intermediate between those in the other two sectors (as in Figure 5).

Drawing all these results together, we may conclude that in this model there is a weak presumption in favour of de-industrialisation for two reasons: firstly, because one of the three effects (the direct impact on outputs of the resource movement effect) always tends to reduce manufacturing output, and secondly, because whatever the pattern of relative factor intensities at least two of the three effects tend in that direction. However, in four of the six possible configurations of relative factor intensities either the price change induced by the resource movement effect or the spending effect tends to raise manufacturing output and so the actual outcome cannot be predicted without a detailed analysis. Only when the capital-labour ratio in manufacturing is intermediate between those in the other two sectors is de-industrialisation the assured outcome.

6. OTHER SOURCES OF A BOOM

We have concentrated so far on one particular source of a boom in the energy sector, an exogenous Hicks-neutral technological improvement, but the analysis, and especially the distinction between spending and resource movement effects, may fruitfully be applied to other sources of structural change. To illustrate this, we may begin by considering two relatively trivial applications.* Firstly, if the source of the boom is not technological change but an exogenous inflow of foreign capital into the energy sector, then the resource movement effects are qualitatively identical to those considered earlier. However, the spending effect of the boom is diluted to the extent that the additional rental income accruing to the energy sector is repatriated. At the opposite extreme, if the boom is due to technological improvement as before, but there is initial unemployment due to downward rigidity of real wages, the spending effect operates in the usual manner but there is now no resource movement effect: the expanding energy sector can draw on the pool of unemployed labour without taking resources away from other sectors.

* Neither of these applications is valid in the model discussed in Section 5, since with complete intersectoral mobility of capital it does not make sense to speak of a capital inflow into one sector only, and a binding minimum real wage is inconsistent with both traded goods being produced in the pre-boom equilibrium when world prices for traded goods are fixed at arbitrary levels.

In the remainder of this section we consider three other applications which raise slightly more complex issues.

6.1. Non-Neutral Technological Progress

Whether or not technological progress is unbiased in the Hicks-neutral sense, it unambiguously raises real national income, and so the spending effect operates in a manner similar to that examined in earlier sections. However, the same is not true of the resource movement effect. When capital is assumed to be specific to the energy sector, it is possible for technological progress to be sufficiently labour-saving that it could *reduce* rather than increase that sector's demand for labour at the initial wage.* The various resource movement effects then go into reverse. As in the model discussed in Section 5, the sign of the resource movement effect may be reversed, thus tending to encourage pro-industrialisation, if the technological progress is biased in such a way that it enables the energy sector to economise on the factor which it uses intensively relative to manufacturing.**

6.2. A Rise in Energy Prices

As noted earlier, Hicks-neutral technological progress has exactly the same effects on the level of profitability and the factor demands of the energy sector as an equivalent increase in energy prices. Hence the resource movement effects of a rise in energy prices are exactly as considered in earlier sections. However, the same is not true of the spending effect, since a change in energy prices affects national income in a different way from an improvement in

* As shown by Neary (1981), a necessary condition for this outcome is that the price-elasticity of supply in the energy sector be less than one.

** This follows from a straightforward application of the analysis of Findlay and Grubert (1959). For example, in the case depicted in Figures 4 and 5, manufacturing must expand to absorb the excess supply of labour which results from labour-saving technological progress in energy at constant factor prices. The mechanism of adjustment is a *fall* in the wage relative to the return to capital.

technology, and also has a substitution effect on the demand for services. The substitution effect works in the expected direction (tending to raise demand for services) provided that energy and services are net substitutes in consumption, while the sign of the spending effect depends on whether energy is an export or an import good. For example, if energy is a net import, a rise in its world price amounts to a worsening of the home country's terms of trade, so reversing the spending effect examined in earlier sections. For the prospective British situation, with oil a net export, the spending effect is positive and (assuming plausibly that energy and services are net substitutes) the model outlined in this paper can be used to analyse the effects of a world oil price rise.

6.3. A Rise in Energy Prices when Energy is an Intermediate Input*

The analysis just given of the effects of a rise in energy prices corresponded to the case in which there is a domestic energy-producing sector and energy is used for final consumption only. However, if energy is also used as an intermediate input, a rise in its price will have additional effects. Fortunately, these effects may easily be studied using the tools developed earlier, once it is recognised that, by reducing profitability in energy-using sectors, a rise in energy prices is exactly analogous in its effects to an exogenous deterioration in technology, i.e., to technological *regress.*** Thus the reduction in profitability reduces the demand for factors of production by energy-using sectors, giving rise to a negative resource movement effect. Moreover, by lowering national income it induces a negative spending effect, thus tending to depress the relative price of services; i.e., giving rise to a real depreciation rather than a real

* Bruno and Sachs (1979) present an analysis of an energy price rise which resembles ours in a number of respects.

** The analogy between technological regress and an input price increase has been drawn by Malinvaud (1977). If more than one factor is mobile, the analogy becomes strained unless energy is separable in production from labour and capital. However, the analytic problems to which non-separability gives rise are well-known from the literature on effective protection and need not detain us here.

appreciation. It is clear that the effects of this exogenous shock raise no new analytic issues, although the combined outcome of the expansionary effects of the energy boom itself and the reverse effects resulting from its impact on energy-using sectors depends to an even greater extent than before on the relative magnitudes of different parameters. As far as the central issue of de-industrialisation is concerned, however, there is no ambiguity: the reduced profitability brought about by the rise in input prices reinforces the effects already considered in tending to depress manufacturing output and employment.

7. SUMMARY AND CONCLUSION

This paper has analysed the effects on resource allocation, factoral income distribution and the real exchange rate of a boom in one part of a country's traded goods sector. In the simplest of the models considered, which assumed that only labour was mobile between sectors, de-industrialisation (a decline in the non-booming part of the traded goods sector, assumed here to be manufacturing) was shown to follow in most of the usual senses of the term, including a fall in manufacturing output and employment, a worsening in the balance of trade in manufacturing and a fall in the real return to factors specific to the manufacturing sector (though not necessarily in their return relative to those of factors specific to other sectors). Furthermore, it was shown in this model that the boom gives rise to a real appreciation, i.e., a rise in the relative price of non-traded relative to traded goods. (This outcome is sometimes blamed as an independent cause of de-industrialisation, although our analysis shows that it should more properly be seen as a symptom of the economy's adjustment to the new post-boom equilibrium.) However, in later models which allowed for inter-sectoral mobility of more than one factor, it was shown that some of these outcomes could be reversed.

The analysis has been conducted subject to many limiting assumptions, including a concern with real and not nominal magnitudes, maintenance of balance-of-trade equilibrium, absence of international capital mobility and (except in Section 6) continual full employment. However, the analysis we have presented, and in particular the key distinction between the *resource movement effect* and the *spending effect* of the boom, would remain important ingredients in a more complete analysis of the issues arising from the "Dutch Disease", or of the policy implications of natural resource development. Among other important omissions from our analysis, we note particularly that we have assumed that the income gains from the boom are spent by the factors that directly gain real incomes. Since typically a large part of the rents accruing to specific factors in the booming sector are paid in taxes, the manner in which the government spends its extra revenues is, of course, a crucial element in determining the magnitude and direction of the spending effect. We have also not touched on the issue of whether a deliberate policy of preventing a real appreciation – i.e., a policy of *exchange- rate protection* designed to protect the traded goods sectors – should be pursued.* In addition, it should be noted that the manufacturing sector of a country may in reality include some non-traded goods sectors, so that the decline of the sector as a whole because of a resource boom is by no means inevitable.** Finally, the various effects we have considered must be superimposed on a background of general growth, including technological progress elsewhere, and "decline" should only be interpreted as a fall in the size of

* Such a policy would have to be accompanied by an appropriate fiscal accommodation. See Corden (1981a, 1981b). In Corden (1981a) the relationship between real wage rigidity and exchange-rate protection is explored. Furthermore the spending effect of a sectoral boom in the presence of nominal wage and money supply rigidities is analysed. Naturally it becomes possible for total employment to vary, and the nominal exchange rate becomes determinate.

** The same outcome follows if manufacturing is assumed to be a traded good but it faces a downward-sloping world demand schedule. This is the assumption made by Buiter and Purvis (1982), although since their model does not have a resource movement effect and they consider only two sectors, the real appreciation following a domestic resource discovery does not affect the steady-state output of the "manufacturing" sector in their model.

a sector relative to the outcome in the absence of a sectoral boom.

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APPENDIX

A.1. Preliminaries: The Markets for Labour and Services

In all three models labour is assumed to be fully employed at all times. Following Jones (1965), this may be written as follows, where a_{ij} denotes the quantity of factor i used per unit of output in sector j:

$$a_{LE}X_E + a_{LM}X_M + a_{LS}X_S = L \tag{A.1}$$

In addition it is assumed that the market for services is always cleared. The demand for services may be written in differential form as a function of changes in the price of services, p_s, and in the level of real income, y:

$$\hat{X}_S = -\varepsilon_S\hat{p}_S + \eta\hat{y} \tag{A.2}$$

We use a circumflex to denote a proportional rate of change (e.g., $\hat{y} \equiv d \ln y$); ε_S and η are the compensated internal-price elasticity and the income elasticity of demand, respectively. Except in Section 6 of this paper, the only source of change in real income is technological improvement in the energy sector. Hence:

$$\hat{y} = \vartheta_E\pi \tag{A.3}$$

where ϑ_E is the share of the energy sector in national income and π is the Hicksian measure of the extent of technological improvement (and thus a measure of the proportional increase in energy output, holding the employment of all factors in that sector constant). Equating demand and supply of services, (A.2) and (A.3) therefore yield:

$$\hat{X}_S = -\varepsilon_S\hat{p}_S + \eta\vartheta_E\pi \tag{A.4}$$

A.2. The Model with Labour as the only Mobile Factor

In the model described in Section 3 of the text, (A.1) is supplemented by full-employment equations for each of the three sector-specific stocks of "capital":

$$a_{Kj} X_j \;=\; K_j \qquad j \;=\; E, M, S \tag{A.5}$$

Using (A.5) to eliminate output levels from (A.1) and totally differentiating the latter (bearing in mind that the endowments of all factors are fixed) yields:

$$\lambda_{LE}(\hat{a}_{LE} - \hat{a}_{KE}) + \lambda_{LM}(\hat{a}_{LM} - \hat{a}_{KM}) + \lambda_{LS}(\hat{a}_{LS} - \hat{a}_{KS}) \;=\; 0 \tag{A.6}$$

where λ_{ij} is the proportion of factor i used in sector j. The expressions in brackets in (A.6) may be related to the change in the real wage experienced by each sector by invoking the definition of the elasticity of substitution between labour and capital:

$$\hat{a}_{Lj} - \hat{a}_{Kj} \;=\; -\sigma_j(\hat{w} - \hat{r}_j) \qquad j = E, M, S \tag{A.7}$$

and the price-equal-to-unit-cost equations:

$$\hat{p}_E \;=\; \vartheta_{LE}\,\hat{w} + \vartheta_{KE}\,\hat{r}_E - \pi \tag{A.8}$$

$$0 \;=\; \vartheta_{LM}\,\hat{w} + \vartheta_{KM}\,\hat{r}_M \tag{A.9}$$

$$\hat{p}_S \;=\; \vartheta_{LS}\,\hat{w} + \vartheta_{KS}\,\hat{r}_S \tag{A.10}$$

(where ϑ_{ij} is the share of factor i in the value of output in sector j and $\hat{p}_M$ is zero by choice of numeraire). Substituting all these equations into (A.6) with p_E assumed constant and simplifying yields:

$$\hat{w} = \xi_E \pi + \xi_S \hat{p}_S \tag{A.11}$$

where ξ_j is the proportional contribution of sector j to Δ, the wage elasticity of the aggregate demand for labour:

$$\xi_j \;\equiv\; \frac{1}{\Delta}\lambda_{Lj}\,\frac{\sigma_j}{\vartheta_{Kj}} \qquad j = E, M, S \tag{A.12}$$

$$\Delta \;\equiv\; \lambda_{LE}\,\frac{\sigma_E}{\vartheta_{KE}} + \lambda_{LM}\,\frac{\sigma_M}{\vartheta_{KM}} + \lambda_{LS}\,\frac{\sigma_S}{\vartheta_{KS}}$$

Turning to the market for services, their supply in this model depends only on the real wage facing entrepreneurs in this sector:

$$\hat{X}_S = \varphi_S(\hat{p}_S - \hat{w}) \tag{A.13}$$

where φ_S, the price elasticity of supply, equals $\sigma_S \vartheta_{LS} / \vartheta_{KS}$. Equating demand and supply of services, (A.4) and (A.13) therefore yield:

$$(\varphi_S + \varepsilon_S)\hat{p}_S = \varphi_S \hat{w} + \eta \vartheta_E \pi \tag{A.14}$$

Equations (A.11) and (A.14) may now be solved jointly for the effects of the boom on p_S and w:

$$A\hat{p}_S = (\eta \vartheta_E + \varphi_S \xi_E)\pi > 0 \tag{A.15}$$

$$A\hat{w} = [\eta \xi_S \vartheta_E + (\varphi_S + \varepsilon_S)\xi_E]\pi > 0 \tag{A.16}$$

where

$$A \equiv \varphi_S(1 - \xi_S) + \varepsilon_S > 0 \tag{A.17}$$

The expression $(\varphi_S + \varepsilon_S)$ is the compensated elasticity of excess supply of services at a given wage rate, while A is the same elasticity when the change in w induced by a change in p_S is taken into account. Clearly both of these elasticities of excess supply must be positive.

Some other comparative-static effects may now be derived. Firstly, the change in the real (product) wage in the service sector (which determines the change in that sector's output and employment levels) is given by:

$$A(\hat{w} - \hat{p}_S) = [-\eta \vartheta_E(1 - \xi_S) + \xi_E \varepsilon_S]\pi \tag{A.18}$$

Next, if α_S is the share of services in the goods consumed by wage-earners, then the change in the real wage from their standpoint is:

$$A(\hat{w} - \alpha_S \hat{p}_S) = [\eta \vartheta_E(\xi_S - \alpha_S) + \xi_E \{ \varphi_S(1 - \alpha_S) + \varepsilon_S \}]\pi \tag{A.19}$$

Finally, (A.15) and (A.16) may be combined with (A.8), (A.9) and (A.10) to determine the changes in the rentals on specific capital in each sector:

$$\vartheta_{KE} A \hat{r}_E = [-\eta \xi_S \vartheta_{LE} \vartheta_E + \varphi_S (1 - \vartheta_{LE} \xi_E - \xi_S) + \varepsilon_S (1 - \vartheta_{LE} \xi_E)]\pi \qquad (A.20)$$

$$\vartheta_{KM} A \hat{r}_M = -\vartheta_{LM} [\eta \xi_S \vartheta_E + \xi_E (\varphi_S + \varepsilon_S)]\pi < 0 \qquad (A.21)$$

$$\vartheta_{KS} A \hat{r}_S = [\eta (1 - \vartheta_{LS} \xi_S) \vartheta_E + \xi_E (\vartheta_{KS} \varphi_S - \vartheta_{LS} \varepsilon_S)]\pi \qquad (A.22)$$

Also of interest is the change in the rental in the energy sector relative to the price of services:

$$\vartheta_{KE} A (\hat{r}_E - \hat{p}_S) = [-\eta \vartheta_E (\xi_S \vartheta_{LE} + \vartheta_{KE}) + \varphi_S \xi_M + \varepsilon_S (1 - \vartheta_{LE} \xi_E)]\pi \qquad (A.23)$$

and the change in the rental differential between the manufacturing and energy sectors:

$$\vartheta_{KE} \vartheta_{KM} (\hat{r}_E - \hat{r}_M) = \vartheta_{KM} \pi + (\vartheta_{LM} - \vartheta_{LE}) \hat{w} \qquad (A.24)$$

Substituting from (A.16) for $\hat{w}$ this becomes:

$$\begin{aligned} \vartheta_{KE} \vartheta_{KM} A (\hat{r}_E - \hat{r}_M) = {} & [\eta \xi_S \vartheta_E (\vartheta_{LM} - \vartheta_{LE}) + \varphi_S (\vartheta_{KE} \xi_E + \vartheta_{KM} \xi_M) \\ & + \xi_S \{ \vartheta_{KE} \xi_E + \vartheta_{KM} (1 - \xi_E) \}]\pi \end{aligned} \qquad (A.25)$$

All these results may be related to the discussion in the text by noting that η determines the magnitude of the spending effect and ξ_E that of the resource-movement effect. If both of these parameters are zero then the increase in r_E is proportional to π and no other domestic variables are affected by the boom.

A.3. The Model with Capital Mobile between Two Sectors

In the model discussed in Section 4 of the text, with capital mobile between the manufacturing and service sectors, the rentals in these two sectors (r_M and r_S) must be equal. Writing r_{MS} for the common value of the rentals, equations (A.9) and (A.10) may be manipulated to obtain a relationship between the wage rate and the price of services (both, it will be recalled, measured in terms of manufacturing):

$$|\vartheta| \hat{w} = -\vartheta_{KM} \hat{p}_S \tag{A.26}$$

where:

$$|\vartheta| \equiv \vartheta_{LM} - \vartheta_{LS} = \vartheta_{KS} - \vartheta_{KM} \tag{A.27}$$

is the determinant of the matrix of factor shares in the manufacturing and service sectors, and is positive if and only if manufacturing is more labour-intensive than services. Equation (A.26) is illustrated in the left-hand panel of Figure 3. Note that, from the Stolper-Samuelson theorem, the change in p_S determines the direction of change in the real wage, however defined:

$$|\vartheta| (\hat{w} - \hat{p}_S) = -\vartheta_{KS} \hat{p}_S \tag{A.28}$$

Turning to factor allocations and output levels, equation (A.5) continues to hold for the energy sector in this model but for the other two sectors it is replaced by (A.29):

$$a_{KM} X_M + a_{KS} X_S = K_{MS} \tag{A.29}$$

The total stock of capital available to the two sectors, K_{MS}, is given, but the amount of labour available is not, since it equals the economy's endowment of labour less the amount employed in the energy sector. To reflect this it is convenient to rewrite (A.1) as follows:

$$a_{LM} X_M + a_{LS} X_S = L_{MS} \tag{A.30}$$

where:

$$L_{MS} = L - L_E \tag{A.31}$$

But L_E in turn depends only on the wage rate and on the level of technology in the energy sector (since p_E is held constant):

$$\hat{L}_E = \frac{\sigma_E}{\vartheta_{KE}} (\pi - \hat{w}) \tag{A.32}$$

(This result may be obtained by combining (A.8) with equations (A.5) and (A.7) for the energy sector.) Differentiating (A.31) and substituting from (A.32) therefore yields the labour supply function faced by the two mobile-capital sectors:

$$\hat{L}_{MS} = E_{Lw}(\hat{w} - \pi) \tag{A.33}$$

where the labour supply elasticity is non-negative and is defined as:

$$E_{Lw} = \frac{\lambda_{LE}}{1 - \lambda_{LE}} \frac{\sigma_E}{\vartheta_{KE}} \tag{A.34}$$

We may note that when this elasticity is zero there is no resource movement effect in this model.

Equations (A.29) and (A.30) combined with (A.33) define a standard Heckscher-Ohlin economy with a variable supply of labour. Using the approach of Jones (1965) and Martin and Neary (1980), the model may be solved for the general-equilibrium service sector supply function (which is illustrated in the right-hand panel of Figure 3):

$$\hat{X}_S = \bar{E}_S \hat{p}_S + \frac{\lambda_{KM}}{|\lambda|} E_{Lw} \pi \tag{A.35}$$

where:

$$|\lambda| \equiv \lambda_{LM} - \lambda_{LS} \tag{A.36}$$

is the determinant of the matrix of factor allocations to the manufacturing and service sectors, and is positive if and only if manufacturing is relatively labour-intensive. (Since there are no factor-market distortions by assumption, $|\lambda|$ and

$|\vartheta|$ must have the same sign.) The term $\bar{E}_S$ is the general-equilibrium price-elasticity of supply of services taking into account the variability of labour supply. It is related to (and, by the Le Chatelier-Samuelson principle, larger than) the corresponding fixed labour supply elasticity, E_S, as follows:

$$\bar{E}_S \equiv E_S + \frac{\lambda_{KM}\vartheta_{KM}}{|\lambda|\,|\vartheta|}E_{Lw} \tag{A.37}$$

where E_S itself is a complicated function of the elasticities of substitution and other parameters of the manufacturing and service sectors.

Equating demand and supply of services, (A.4) and (A.35), we may solve for the effect of the boom on the price of services:

$$B\,\hat{p}_S = \left[\eta\vartheta_E - \frac{\lambda_{KM}}{|\lambda|}\,E_{Lw}\right] \tag{A.38}$$

where:

$$B \equiv \bar{E}_S + \varepsilon_S \tag{A.39}$$

is the general-equilibrium elasticity of excess supply of services and is necessarily positive. Equation (A.38) may be substituted into (A.35) to find the change in the output of services. However, we are more interested in the change in the output of the manufacturing sector, which by a series of derivations similar to those which led to (A.35) may be shown to equal:

$$\hat{X}_M = -\bar{E}_M\,\hat{p}_S - \frac{\lambda_{KS}}{|\lambda|}\,E_{Lw}\,\pi \tag{A.40}$$

where $\bar{E}_M$ is defined analogously to $\bar{E}_S$ and is positive. Substituting from (A.38) for $\hat{p}_S$ (and making use of the fact that $\lambda_{KM}\bar{E}_M = \lambda_{KS}\bar{E}_S$) yields the required result:

$$B\,\hat{X}_M = -\left[\eta\vartheta_E\bar{E}_M + \varepsilon_S\,\frac{\lambda_{KS}}{|\lambda|}\,E_{Lw}\right]\pi \tag{A.41}$$

A.4. The Model with Complete Capital Mobility

In the model discussed in Section 5, the rentals on capital are equalized between all three sectors. Labelling the common rental r, equations (A.8) and (A.9) may be solved for the effect of the boom on the wage rate:

$$|\vartheta_E| \ \hat{w} = \vartheta_{KM}\pi \tag{A.42}$$

where:

$$|\vartheta_E| \equiv \vartheta_{LE} - \vartheta_{LM} \tag{A.43}$$

is the determinant of the matrix of factor shares in the energy and manufacturing sectors, and is positive if and only if the energy sector is relatively labour-intensive. Combining (A.42) with (A.10) we may also solve for the change in p_S:

$$\hat{p}_S = -\frac{|\vartheta|}{|\vartheta_E|}\pi \tag{A.44}$$

Equations (A.42) and (A.44) underlie the results presented in Table 2.

Turning to the effects of the boom on outputs in this model, the change in the output of services is easily obtained by substituting from (A.44) into (A.4):

$$\hat{X}_s = \left[\varepsilon_s \frac{|\vartheta|}{|\vartheta_E|} + \eta\vartheta_E\right]\pi \tag{A.45}$$

This shows that the spending effect necessarily raises the output of services, while the resource movement effect raises it provided that manufacturing is not extremal in terms of relative factor intensities.

In order to determine the effect of the boom on manufacturing output, we use the full-employment constraint for labour (A.1) and the corresponding equation for capital:

$$a_{KE}X_E + a_{KM}X_M + a_{KS}X_S = K \tag{A.46}$$

Differentiating (A.1) and (A.46) and relating the changes in input-output coefficients to changes in the wage-rental ratio following Jones (1965) yields the following equations:

$$\lambda_{LE}\hat{X}_E + \lambda_{LM}\hat{X}_M + \lambda_{LS}\hat{X}_S = \delta_L(\hat{w} - \hat{r}) \tag{A.47}$$

$$\lambda_{KE}\hat{X}_E + \lambda_{KM}\hat{X}_M + \lambda_{KS}\hat{X}_S = -\delta_K(\hat{w} - \hat{r}) \tag{A.48}$$

The parameters δ_L and δ_K give the elasticity of demand for labour and capital at given output levels in response to a change in the wage-rental ratio; these parameters are positive and their magnitude depends on the ease of substitutability of capital for labour in all three sectors. Eliminating $\hat{X}_E$ from (A.47) and (A.48) and using (A.8) and (A.9) to eliminate the change in the wage-rental ratio yields the following:

$$\hat{X}_M = \frac{|\lambda_S|}{|\lambda_E|}\hat{X}_S - \frac{\delta}{|\lambda_E|\,|\vartheta_E|}\pi \tag{A.49}$$

Consider the second term in (A.49). The numerator is a weighted sum of δ_L and δ_K and is necessarily positive:

$$\delta \equiv \lambda_{KE}\,\delta_L + \lambda_{LE}\,\delta_K \tag{A.50}$$

The denominator is the product of $|\vartheta_E|$ (defined in (A.43)) and $|\lambda_E|$, which is the determinant of the matrix of factor allocations to the energy and manufacturing sectors:

$$|\lambda_E| \equiv \lambda_{LE}\,\lambda_{KM} - \lambda_{LM}\,\lambda_{KE} \tag{A.51}$$

This determinant is positive if and only if energy is labour-intensive relative to manufacturing and so it has the same sign as $|\vartheta_E|$. The second term in (A.49) is thus unambiguously negative, reflecting the direct de-industrialization brought about by the resource movement effect of the boom. This corresponds to the movement of the manufacturing production point from A to F in Figure 5.

Now consider the first term in (A.49), whose magnitude depends on the change in service output brought about by the boom. Substituting for this change from (A.45), the change in manufacturing output may alternatively be written as follows:

$$\hat{X}_M = \frac{1}{|\lambda_E|\,|\vartheta_E|}\left[\eta\vartheta_E\,|\lambda_S|\,|\vartheta_E| + \varepsilon_S\,|\lambda_S|\,|\vartheta| - \delta\right]\pi \qquad \text{(A.52)}$$

As already noted, the denominator of (A.52) is positive. However, the coefficients of η (which determines the sign of the spending effect) and of ε_S (which determines the sign of that part of the resource movement effect working through the price of services) may be positive or negative depending on the relative factor intensities of all three sectors. These operate both through the determinants $|\vartheta|$ and $|\vartheta_E|$ already defined and through the determinant $|\lambda_S|$, which is defined in a similar manner to $|\lambda_E|$:

$$|\lambda_S| \equiv \lambda_{LS}\lambda_{KE} - \lambda_{LE}\lambda_{KS} \qquad \text{(A.53)}$$

This is positive if and only if services are labour-intensive relative to energy. The resulting possibilities are given in Table A.1 and are summarised at the end of Section 5.

Table A.1. Effects of the boom when capital is mobile between all three sectors.

Relative factor intensities	Effect of boom on			
			X_M*	
	w	P_S	Spending effect	Resource movement effect (indirect)
$k_M > k_S > k_E$	+	+	-	+
$k_M > k_E > k_S$**	+	+	+	-
$k_S > k_E > k_M$	-	+	+	-
$k_S > k_M > k_E$	+	-	-	-
$k_E > k_M > k_S$	-	-	-	-
$k_E > k_S > k_M$	-	+	-	+

* The two effects on the output of X_M shown in this table are in addition to the direct de-industrialization brought about by the resource movement effect.

** This is the case illustrated in Figures 4 and 5.