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BOOMING SECTOR AND DE-INDUSTRIALISATION IN A SMALL OPEN ECONOMY*

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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 the paper is to explore the nature of the resulting pressures towards 'de-industrialisation'.[1] However, our 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. (See Dasgupta and Heal, 1978.) 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 plan of the paper is as follows. Section I 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.[2] 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

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[1] 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).

[2] 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), whose general applicability has been noted in Corden (1981 *b*). In particular we build on the contribution of Snape, who presents the same model as in Section II below and anticipates some of our results.

of a boom in one of the traded goods sectors under different assumptions about the factor-market underpinnings of the model. Section V discusses 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, including a change in world prices. Finally, Section VI summarises the paper's principal conclusions, while the Appendix sets out the model in algebraic form and gives the derivation of the principal results.

I. 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 equalise domestic supply and demand. We label the two traded goods 'energy', X_E, and 'manufactures', 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 V 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 V, other sources of a boom will have different effects, but the analysis we develop for the simple case is readily applicable to more complicated cases.[1]

We make two other simplifying assumptions. First, as already noted, the models are purely real ones, 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 V 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 V, is easily relaxed) rules out the possibility of 'immiserising 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 the paper is to consider a sequence of real models characterised by different degrees of intersectoral factor mobility. We begin in Section II,

[1] 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 the introduction, 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.

following Jones (1971) and Snape (1977), by assuming that each of the three sectors uses a single specific factor as well as a factor which is perfectly mobile between 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 skill categories of 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 III and IV 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 III 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.[1] Section IV 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 V the terms of trade are assumed to be given, so that the relative price of the two traded goods, energy and manufactures, 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 manufacturing goods. However, we are also concerned with changes in the real wage from the point of view of wage-earners, which depend 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 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 instead (as it has in Britain) through the spending effect. The higher real income resulting from the boom leads to extra spending on services which raises their price (i.e. causes a real appreciation) and thus leads to further adjustments. Clearly the importance

[1] 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 good sector, so that traded goods are grouped together; or it can be manufacturing. Long (1981) explores the second case.

of this effect is positively related to the marginal propensity to consume services. In the model of Section II, 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 III and IV.

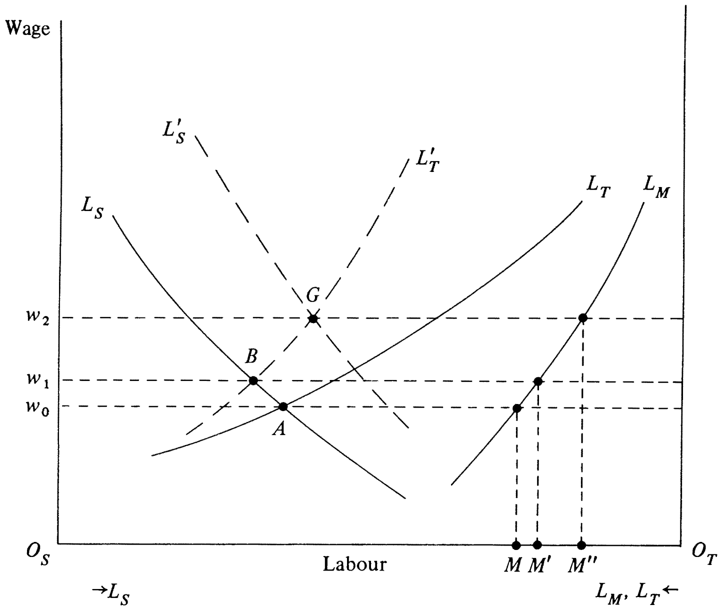

Fig. 1. Effect of the boom on the labour market.

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

(a) *Pre-Boom Equilibrium*

We begin by describing the pre-boom equilibrium, which corresponds to points A and a in Figs. 1 and 2 respectively. Fig. 1 illustrates the labour market, with the wage rate (in terms of manufactures) measured on the vertical axis and the economy's total labour supply given by the horizontal axis $O_S O_T$. Labour input into services is measured by the distance from O_S while distances from O_T measure labour input into 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 services sector, drawn for the initial price of services. Initial full-employment equilibrium is at A, where L_T intersects L_S, and so the initial wage rate is w_0. However, Fig. 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 Fig. 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*

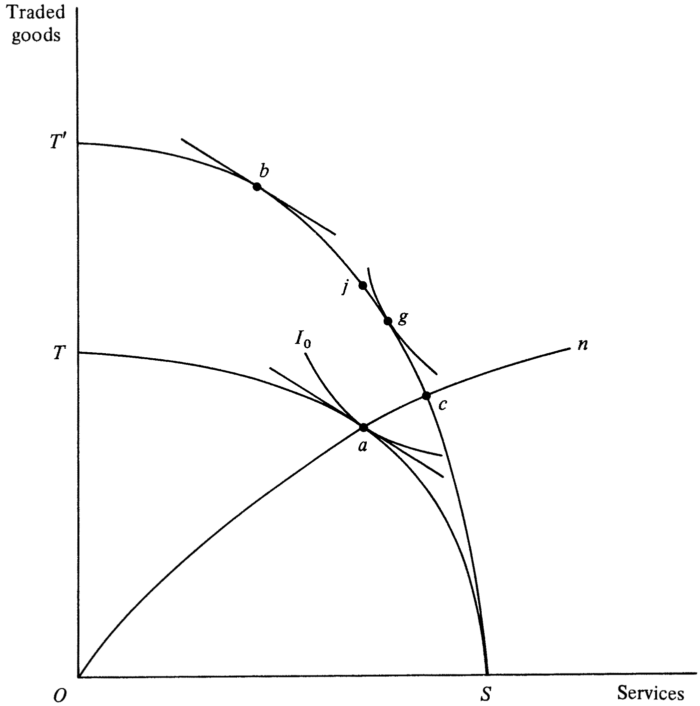

Fig. 2. Effect of the boom on the commodity market.

and, in the absence of commodity or factor-market distortions, the initial equilibrium is at point *a*, where the production possibilities curve is tangential to the highest attainable indifference curve I_0. (We use indifference curves as a shorthand way of summarising aggregate demands, and ignore the well-known fact that changes in income distribution cause them to shift, except under highly restrictive assumptions.) 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*.

(*b*) *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. Following the distinction introduced in the last section, we look separately at the resource movement effect and the spending effect in turn. In the case of the resource movement effect we conduct a two-stage analysis: first the real exchange rate (the relative price of services) is held constant, and then it is allowed to vary to restore equilibrium in the market for services. Thus, at the first stage, the curve L_S in Fig. 1 and the price ratio in Fig. 2 are unchanged.

Beginning then with the resource movement effect, the energy sector's labour demand schedule shifts upwards by an amount proportional to the extent of the technological progress: the latter acts in exactly the same way as a price increase, raising profitability and the demand for labour in the energy sector 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 at B is attained. This effect, which raises the wage rate to w_1 at a constant real exchange rate, thus causes labour to move out of both the manufacturing and services sectors. Since employment in manufacturing 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 Fig. 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 at a constant real exchange rate is represented by the movement of the production point from a to b. The movement of labour out of the services sector leads to a fall in the output of services and so point b lies to the left of point a.[1]

For the present we wish to abstract from the spending effect, so we assume that the income–elasticity of demand for services is zero, which implies that the income–consumption curve in Fig. 2 is a vertical line through a, intersecting $T'S$ at j. Hence at the initial real exchange rate the resource movement effect leads to excess demand for services. There must therefore be a *real appreciation* to restore equilibrium: the price of services must rise to eliminate the excess demand, switching demand away from services and dampening the fall in that sector's output induced by the resource movement effect. However, the fall in the services sector's output cannot be reversed: in Fig. 2 the equilibrium following this adjustment must be at some point on $T'S$ between b and j, implying that the output of services is lower than in the initial equilibrium as a result of the resource movement effect.

Next, consider the spending effect on its own. In order to abstract from the resource movement effect we now assume that the energy sector does not use any labour. Hence at the initial real exchange rate the boom has no effect in Fig. 1 (since the curves L_T and L_M coincide) while in Fig. 2 the boom displaces the production possibilities curve vertically upwards, point b lying vertically above point a. Provided the demand for services rises with income (i.e. services are normal in the aggregate), demand at the initial real exchange rate moves along an income–consumption curve such as On, which intersects $T'S$ at point c. Once again, there is excess demand for services at the initial real exchange rate and so a real appreciation must occur. But this time the new equilibrium must lie somewhere between j and c, so that the output of services rises compared with the initial situation.

[1] 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.

When the two effects are combined we see that both contribute to a real appreciation: the final equilibrium at point g in Fig. 2 has a higher relative price of services than the initial equilibrium at a. However, the resource movement effect tends to lower the output of services whereas the spending effect tends to raise it, and there is no presumption as to which will dominate. (The exact condition is given by equation (A 18) in the Appendix.)[1] Fig. 2 illustrates the case where the spending effect is stronger and so point g lies to the right of j.

The same ambiguity of output response does not apply to manufacturing however, as may be seen by returning to Fig. 1. The services 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 rises further to w_2, which reduces manufacturing employment from $O_T M'$ to $O_T M''$. Thus the boom gives rise to both direct de-industrialisation, reflected in the fall in manufacturing output from $O_T M$ to $O_T M'$, and now *indirect de-industrialisation*, reflected in the additional fall to $O_T M''$. The former is caused by the resource movement effect alone, while the latter is caused by the real appreciation which results both from the reduced output of services (at the initial real exchange rate) due to the resource movement effect, and from the increased demand for services due to the spending effect. Clearly, since manufacturing employment unambiguously falls, the same must also be true of that sector's output.

(c) *Effects of the Boom on Factor Incomes*

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 Fig. 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 real appreciation, as shown in Fig. 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 is the spending effect relative to the resource movement effect and the greater the share of services in wage-earner's consumption. (See equation (A 19) in the Appendix.)

Turning next to the returns to the specific factors in the three sectors, the changes in each of these may be interpreted as measures of the impact of the boom on the profitability of each sector. It is clear that profitability in *manufacturing* must unambigously fall. Profitability in the *services* sector would rise if there were only a spending effect, but once the resource movement effect is allowed for 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 move-

[1] Snape (1977) first showed that the output of non-traded goods may fall even though there must be a real appreciation.

ment 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.[1] 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 smaller is the compensated price-elasticity of demand for services and the larger is its income-elasticity of demand. (See equation (A 20) in the Appendix.)

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. While, 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: see equation (A 25) in the Appendix).

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-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 manufactures are normal goods). 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

[1] This apparent paradox may be understood by noting that it is a case of 'immiserising 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 immiserising growth (which means in this context a fall in r_E) is possible. Of course, as already noted, immiserising growth for the economy as a whole cannot take place in this model.

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 turns out to be a possibility in the models of the next two sections.

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

In assuming that only one factor was mobile between sectors, the analysis of 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 services 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 labour only with the other two sectors.

In order to analyse this model, it is helpful to view the manufacturing and services sectors as comprising 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. Since this miniature economy exhibits all the conditions for the Stolper–Samuelson theorem, including constant returns to scale and non-specialisation, there is 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 Fig. 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 $T'S$ in Fig. 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 pre-boom equilibrium is represented in Fig. 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 ensures that the demand curve in Fig. 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 services supply schedule in Fig. 3 from X_S to X'_S. The services sector equilibrium moves from F to F'. Output falls from OG to $O'G$, 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 manufacturing. Hence in this case the resource movement effect gives rise to *pro-industrialisation*![1]

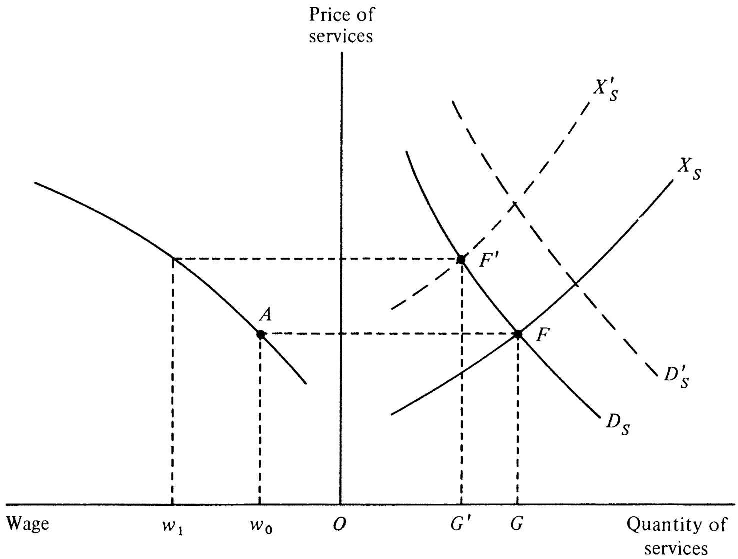

Fig. 3. Effects of the boom when capital is mobile between manufacturing and services.

Suppose alternatively that manufacturing is labour-intensive relative to services. In this case the schedule in the left-hand panel of Fig. 3 is downward-sloping, since a higher relative price of services is now associated with a lower 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 falls: there is a *real depreciation.*

Consider next the spending effect of the boom. It gives rise to an outward shift of the demand schedule in Fig. 3 from D_S to D'_S, 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 Fig. 3.

All these conclusions are summarised in Table 1. In general the results are

[1] This result follows from the fact, noted in Section II, 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).

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 the three counter-intuitive results just mentioned.

Table 1

Resource Movement and Spending Effects When Capital is Mobile Between Manufacturing and Services

	Resource movement effect		Spending effect	
$k_M > k_S$	$X_S\downarrow, X_M\uparrow, p_S\uparrow$	$w\uparrow, r_{MS}\downarrow$	$X_S\uparrow, X_M\downarrow, p_S\uparrow$	$w\uparrow, r_{MS}\downarrow$
$k_M < k_S$	$X_S\uparrow, X_M\downarrow, p_S\downarrow$			$w\downarrow, r_{MS}\uparrow$

k_i = Capital-labour ratio in sector i.
r_{MS} = Rental on capital used in manufacturing and services.

IV. 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, with constant returns to scale and provided all three goods are produced before and after the boom, it exhibits the local factor–price equalisation property: the number of sectors equals the number of endogenously determined prices (the wage rate, the rental and the price of services), and so the latter are uniquely determined by technology and traded goods prices, independent of factor endowments and demand patterns. This is illustrated in Fig. 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 one in which the manufacturing sector is more capital-intensive than services but less so than energy: probably the case which is closest to reality for the UK economy.

The impact effect of the boom in Fig. 4 is to shift the unit cost curve for the energy sector outwards from c_E to c_E' since the sector can now pay higher rewards to both factors while still covering its costs. (The curve shifts outwards by a uniform proportionate amount because the technological progress is Hicks-neutral, which in this respect is exactly analogous to an energy price increase.) 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 capital-intensive sector pushes down the real wage. However full factor–market equilibrium can only prevail if the services sector's unit cost curve also passes through G, and for this to come about an accommodating fall in the price of services (i.e. a real depreciation) is required, shifting that sector's unit cost curve from c_S to c'_S.

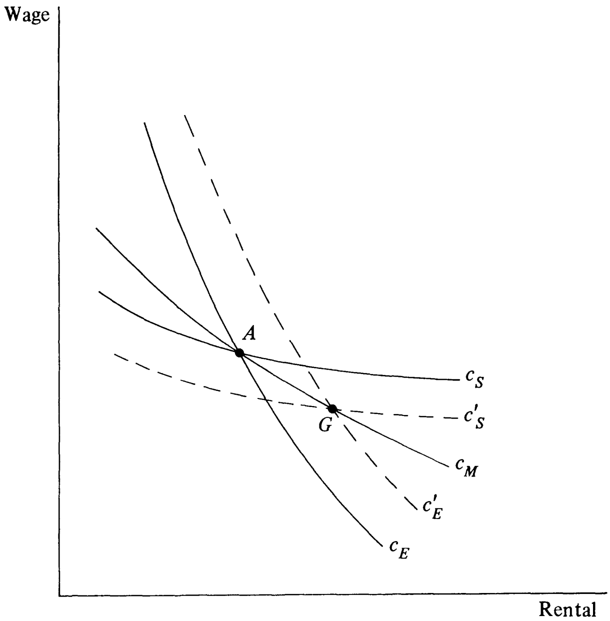

Fig. 4. Effects of the boom on prices when capital is mobile between all three sectors.

Table 2

Effects of the Boom on Prices When Capital is Mobile Between All Three Sectors

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

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

Two conclusions follow from this analysis. First, 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 Fig. 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 services sectors determines the change in the price of services which is required to accommodate the new factor prices. These 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).

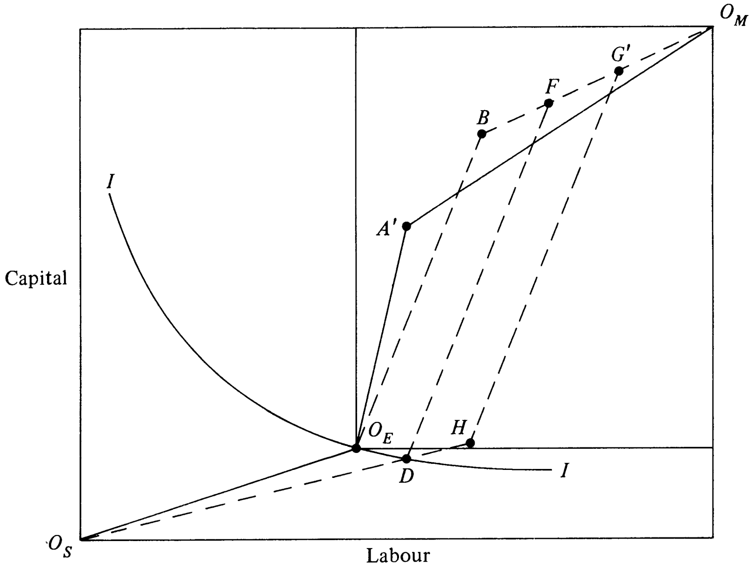

Fig. 5. Factor-market effects of the boom when capital is mobile between all three sectors.

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. Fig. 5, which is based on Melvin (1968), illustrates these effects for the same case as Fig. 4: namely, the capital–labour ratio in the manufacturing sector is intermediate between those in the capital-intensive energy and labour-intensive services 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 services and manufacturing sectors' isoquants are measured from O_S and O_M respectively. The pre-boom equilibrium output of services corresponds to the isoquant *II*, and factor-market equilibrium prevails when the energy and manufacturing sector isoquants at point A' have the same slope as *II* at O_E. Thus in the initial equilibrium the levels of factor usage in the services, 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 II 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 services production point must continue to lie along the *II* isoquant for the present.) We know already from Fig. 4 that, under our assumptions about the relative factor intensities of the three sectors, the real wage is reduced by the boom, thus inducing substitution of labour for capital in all three sectors. If the services sector's production point were to remain at O_E, the shift towards lower capital intensity in energy and manufacturing would bring about a reallocation of factors between those two sectors from A' to a point such as B, with a consequent reduction in the output of manufacturing. However, if there is any flexibility in techniques in the services sector it also becomes more labour-intensive, its production point moving along II from O_E to a point such as D. Hence the level of factor usage in manufacturing is further reduced from $O_M B$ to $O_M F$: as in the models of earlier sections, therefore, the resource movement 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 services sector after the boom must correspond to the slope of the ray $O_S D$, but the scale of production must be such as to meet the demand which is forthcoming 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 Figs. 4 and 5, these work in the same direction. The demand for and thus the equilibrium output of services rises both because their relative price falls (as we have already seen in Fig. 4) and because national income rises. Assuming that the final services production point is H, the output of manufacturing is further squeezed to the level corresponding to the distance $O_M G'$.

In total 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 manufacturing, only one, the direct de-industrialisation brought about by the resource movement effect, tends to reduce the output of manufacturing 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 a contraction of the latter. 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 manufacturing. 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 Fig 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 (which is not the case in Fig. 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: first, 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 spending effect or the price change induced by the resource movement effect tends to raise manufacturing output and so the actual outcome cannot be predicted without a detailed knowledge of parameter values. Only when the capital–labour ratio in manufacturing is intermediate between those in the other two sectors is de-industrialisation the assured outcome.

V. 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 begin by considering two relatively straightforward applications.[1] First, 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, to the extent that the additional rental income accruing to the energy sector is repatriated the spending effect of the boom is diluted. Secondly, if the boom is due to technological improvement as before, but there is initial unemployment due to downward rigidity of real wages, the manufacturing sector is effectively insulated from the effects of the boom, since the expanding energy sector can draw on the pool of unemployed labour without bidding resources away from other sectors. (Of course, this conclusion would have to be modified if we introduced monetary considerations, since de-industrialisation could still come about in this case as a result of a nominal appreciation: see Neary (1982).)

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

(a) *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.[2] The various resource movement effects then go into reverse. As for the model of Section IV, in which energy uses both capital and

[1] Neither of these applications are valid in the model of Section IV, 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.

[2] 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.

labour, the sign of the resource movement effect may be reversed, so 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.[1]

(*b*) *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 the latter 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 differently from an improvement in 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 energy and services are net substitutes in consumption (i.e. provided their compensated cross-price elasticity of demand is positive); 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 likely to remain a net export for some time, the spending effect is on balance probably positive and so (assuming plausibly that energy and services are net substitutes) the effects of a world oil price rise are similar to those of an oil discovery.

(*c*) *A Rise in Energy Prices When Energy is an Intermediate Input*[2]

The analysis just given of the effects of a rise in energy prices applied to the case where 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*.[3] In particular, the reduction in profitability reduces the demand for factors of production by energy-using sectors, giving rise to a negative resource movement effect. 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 contractionary effects resulting from its impact

[1] This follows from a straightforward application of the analysis of Findlay and Grubert (1959): For example, in the case depicted in Figs. 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.

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

[3] 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.

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 provided manufacturing is intensive in its use of energy: the reduced profitability brought about by the rise in input prices reinforces the effects already considered in tending to depress manufacturing output and employment.

VI. 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 of 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 though, as our analysis shows, it should more properly be seen as a symptom of the economy's adjustment towards the new post-boom equilibrium.) However, in later models, which allowed for intersectoral mobility of more than one factor, it was shown that some of these outcomes could be reversed.

The analysis of the paper has been conducted subject to many limiting assumptions, including a concern with real and not nominal magnitudes, absence of international capital mobility and (except in Section V) 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 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. In reality, however, since a large part of the rents accruing to specific factors in the booming sector are typically paid in taxes, the manner in which the government spends its extra revenues is 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.[1] In addition, it should be noted that

[1] Such a policy would have to be accompanied by an appropriate monetary or fiscal accommodation. See Corden (1981 *a*, *b*) and Neary (1982). In Corden (1981 *a*) 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 manufacturing sector of a country may include some non-traded as well as traded goods sectors, so that the decline of the sector as a whole because of a resource boom is by no means inevitable.[1] 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 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:

$$a_{LE}X_E + a_{LM}X_M + a_{LS}X_S = L. \quad \text{(A 1)}$$

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

$$\hat{C}_S = -\epsilon_S\hat{p}_S + \eta\hat{y}. \quad \text{(A 2)}$$

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 own-price elasticity and the income elasticity of demand respectively. Except in Section V of the paper, the only source of a change in real income is the technological improvement in the energy sector. Hence:

$$\hat{y} = \theta_E\pi, \quad \text{(A 3)}$$

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 so measures the proportional increase in energy output holding constant the employment of all factors in that sector). Substituting (A 3) into (A 2), the demand for services may thus be written as follows:

$$\hat{C}_S = -\epsilon_S\hat{p}_S + \eta\theta_E\pi. \quad \text{(A 4)}$$

A 2. *The Model with Labour as the Only Mobile Factor*

In the model of Section II of the text, (A 1) is supplemented by full-employment equations for each of the three sector-specific stocks of 'capital':

$$a_{Kj}X_j = K_j \quad (j = E, M, S). \quad \text{(A 5)}$$

[1] 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.

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

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

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

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

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

$$\hat{p}_E = \theta_{LE}\hat{w}+\theta_{KE}\hat{r}_E-\pi, \qquad (A\,8)$$

$$0 = \theta_{LM}\hat{w}+\theta_{KM}\hat{r}_M, \qquad (A\,9)$$

$$\hat{p}_S = \theta_{LS}\hat{w}+\theta_{KS}\hat{r}_S, \qquad (A\,10)$$

(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 until Section V and simplifying yields:

$$\hat{w} = \xi_E\pi+\xi_S\hat{p}_S, \qquad (A\,11)$$

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

$$\xi_j \equiv \frac{1}{\Delta}\lambda_{Lj}\frac{\sigma_j}{\theta_{Kj}} \quad (j = E, M, S), \qquad (A\,12)$$

$$\Delta \equiv \lambda_{LE}\frac{\sigma_E}{\theta_{KE}}+\lambda_{LM}\frac{\sigma_M}{\theta_{KM}}+\lambda_{LS}\frac{\sigma_S}{\theta_{KS}}.$$

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

$$\hat{X}_S = \phi_S(\hat{p}_S-\hat{w}) \qquad (A\,13)$$

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

$$(\phi_S+\epsilon_S)\,\hat{p}_S = \phi_S\hat{w}+\eta\theta_E\pi. \qquad (A\,14)$$

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

$$A\hat{p}_S = (\eta\theta_E+\phi_S\xi_E)\,\pi > 0, \qquad (A\,15)$$

$$A\hat{w} = [\eta\xi_S\theta_E+(\phi_S+\epsilon_S)\,\xi_E]\,\pi > 0, \qquad (A\,16)$$

where

$$A \equiv \phi_S(1-\xi_S)+\epsilon_S > 0. \qquad (A\,17)$$

The expression $(\phi_S+\epsilon_S)$ 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. First, the change in the real (product) wage in the services sector (which determines the change in that sector's output and employment levels) is given by:

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

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

$$A(\hat{w}-\alpha_S\hat{p}_S) = \{\eta\theta_E(\xi_S-\alpha_S)+\xi_E[\phi_S(1-\alpha_S)+\epsilon_S]\}\,\pi. \tag{A 19}$$

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:

$$\theta_{KE}A\hat{r}_E = [-\eta\xi_S\theta_{LE}\theta_E+\phi_S(1-\theta_{LE}\xi_E-\xi_S)+\epsilon_S(1-\theta_{LE}\xi_E)]\,\pi, \tag{A 20}$$

$$\theta_{KM}A\hat{r}_M = -\theta_{LM}[\eta\xi_S\theta_E+\xi_E(\phi_S+\epsilon_S)]\,\pi < 0, \tag{A 21}$$

$$\theta_{KS}A\hat{r}_S = [\eta(1-\theta_{LS}\xi_S)\theta_E+\xi_E(\theta_{KS}\phi_S-\theta_{LS}\epsilon_S)]\,\pi. \tag{A 22}$$

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

$$\theta_{KE}A(\hat{r}_E-\hat{p}_S) = [-\eta\theta_E(\xi_S\theta_{LE}+\theta_{KE})+\phi_S\xi_M+\epsilon_S(1-\theta_{LE}\xi_E)]\,\pi \tag{A 23}$$

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

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

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

$$\theta_{KE}\theta_{KM}A(\hat{r}_E-\hat{r}_M) = \{\eta\xi_S\theta_E(\theta_{LM}-\theta_{LE})+\phi_S(\theta_{KE}\xi_E+\theta_{KM}\xi_M) + \xi_S[\theta_{KE}\xi_E+\theta_{KM}(1-\xi_E)]\}\,\pi. \tag{A 25}$$

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 of Section III 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 manufactures):

$$|\theta|\,\hat{w} = -\theta_{KM}\hat{p}_S, \tag{A 26}$$

where $|\theta|$ is the determinant of the matrix of factor shares in the manufacturing and services sectors, and is positive if and only if manufacturing is more labour-intensive than services:

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

Equation (A 26) is illustrated in the left-hand panel of Fig. 3. Note that, from the Stolper–Samuelson theorem, the change in p_S determines the direction of change in the real wage, however defined:

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

Turning to factor allocations and output levels, in this model equation (A 5) continues to hold for the energy sector 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 in use 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):

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

(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 facing 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:

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

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 facing 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 services sector supply function (which is illustrated in the right-hand panel of Fig. 3):

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

where $|\lambda|$ 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:

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

(Since there are no factor–market distortions by assumption, $|\lambda|$ and $|\theta|$ must have the same sign.) The term $\bar{E}_S$ is the general-equilibrium price-elasticity of supply of services taking account of 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:

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

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:

$$B\hat{p}_S = \left(\eta\theta_E - \frac{\lambda_{KM}}{|\lambda|} E_{Lw}\right)\pi, \tag{A 38}$$

where:

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

is the general-equilibrium elasticity of excess supply of services and is necessarily positive. Equation (A 38) may be substituted in (A 35) to find the change in the output of services. However, we are more interested in the change in the output of manufacturing, 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:

$$B\hat{X}_M = -\left(\eta\theta_E\bar{E}_M + \epsilon_S\frac{\lambda_{KS}}{|\lambda|} E_{Lw}\right)\pi. \tag{A 41}$$

A 4. The Model with Complete Capital Mobility

In the model of Section IV the rentals on capital are equalised between all three sectors. The common rental, denoted by r, may therefore be eliminated from equations (A 8) and (A 9) to obtain the effect of the boom on the wage rate:

$$|\theta_E|\,\hat{w} = \theta_{KM}\pi, \tag{A 42}$$

where $|\theta_E|$ 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:

$$|\theta_E| \equiv \theta_{LE} - \theta_{LM}. \tag{A 43}$$

Combining (A 42) with (A 10) we may solve also for the change in p_S:

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

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

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):

$$\hat{X}_S = \left(\epsilon_S\frac{|\theta|}{|\theta_E|} + \eta\theta_E\right)\pi. \tag{A 45}$$

This shows that the spending effect necessarily raises the output of services, whereas the resource movement effect raises it provided 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 constraints: (A 1) for labour and the corresponding equation for capital:

$$a_{KE} X_E + a_{KM} X_M + a_{KS} X_S = K. \qquad (A\,46)$$

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

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

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

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:

$$\hat{X}_M = \frac{|\lambda_S|}{|\lambda_E|} \hat{X}_S - \frac{\delta}{|\lambda_E|\,|\theta_E|} \pi. \qquad (A\,49)$$

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

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

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

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

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

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

$$\hat{X}_M = \frac{1}{|\lambda_E|\,|\theta_E|} (\eta \theta_E |\lambda_S|\,|\theta_E| + \epsilon_S |\lambda_S|\,|\theta| - \delta)\, \pi. \qquad (A\,52)$$

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 $|\theta|$ and $|\theta_E|$ already defined and through the determinant $|\lambda_S|$, which is defined in a similar manner to $|\lambda_E|$:

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

This is positive if and only if services are labour-intensive relative to energy. The resulting possibilities are summarised at the end of Section IV in the text.

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