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No single production structure has become dominant in models of the pure theory of international trade, even those characterized by perfect competition. Most models are represented by Ricardian, Heckscher-Ohlin, or Specific-Factors structures, or variants and combinations of these, with the selection often dictated by the problem being investigated. However, it is well known that if a country is freed from the bonds of autarky and allowed to engage in trade in goods or factors, a certain degree of specialization is encouraged so that the production structure with trade can differ significantly from that postulated in autarky. In that sense production structures are endogenously affected by trade.

Several examples in which trade alters production structure come readily to mind. Intermediate goods that are used specifically in each of two individual sectors may be exchanged for each other with trade; as Sanyal and Jones (1982) pointed out, such trade tends to convert a 3×2 specific-factors framework into a 2×2 Heckscher-Ohlin one.[1] Similarly, a two-country Heckscher-Ohlin trade model adopts many of the Ricardian characteristics should international movement of capital be allowed (see Jones and Ruffin (1975)). Perhaps the most frequently cited example is one involving time rather than trade, *viz* the interpretation of the Heckscher-Ohlin model as a long-run variant of the specific factors model, with time allowing the transformation (or replacement) of one type of sector-specific capital with another (see Neary (1978)). (Alternatively, the transformation of a specific-factors model into a Heckscher-Ohlin structure results if the "mobile" factor is itself produced by the specific factors.)[2]

All these examples involve trade or transformation at the input level. In this paper we analyze how trade in final commodities in a country with many productive

[1]To repeat Doug Purvis's remark about this model, "Heckscher-Ohlin does not explain trade, trade explains Heckscher-Ohlin."

[2]This is the "Produced Mobile Factor" structure discussed in Jones and Marjit (1991). Somewhat related is recent work by Ali Khan (1991), in which separate ethnic groups (specific factors) are joined by mobile capital, either to produce rural outputs in isolation or to join forces with each other in an urban environment to produce a separate urban product.

factors causes one of two production structures to emerge. On the one hand is the familiar $(n+1)$-factor, n-commodity version of the specific-factor model (Jones, 1975), and on the other is a generalization to many commodities of a model proposed by Gruen and Corden (1970), in which one industry is tied to a production "nugget" by the common use of a single factor (labor), whereas the "nugget" contains two industries in a standard 2×2 Heckscher-Ohlin structure. In what follows we focus on the manner in which external shocks to such an economy, in the form of changes in the terms of trade (or technical progress or endowment discoveries), get spread from industry to industry. A particular phenomenon of interest to trade theorists has been labelled the "Dutch Disease", whereby a shock favorable to one trading sector spells trouble for other sectors, usually through passing on cost increases to these sectors. Our multi-commodity framework facilitates such an investigation and reveals that such shocks may require some industries to be completely wiped out and encourage new industries to emerge — industries which have experienced no external change in market conditions. As well, we investigate how the existence or creation of industries which are shielded from the direct competition of trade can crowd out industries which otherwise could compete successfully in the world market, or how non-traded industries modify the pattern of the Dutch Disease phenomenon. Once non-traded goods are introduced, our structure can be used to examine the frequently-held view that a country's terms of trade and real exchange rate go hand in hand.

1 Production Structure in Autarky

The country's economic activity in autarky is broken down into N productive sectors. Each sector, i, is characterized by the existence of a number of industries which employ labor and a type of capital, K^i, fixed in total amount but used only by the industries in sector i. Labor is homogeneous, fixed in total amount, and available on the same terms to all sectors of the economy. Thus one factor (labor) trades in a national market while all types of capital are limited by sector. If local demand maintains production even at high prices in autarky, a competitive equilibrium in each sector is of the type illustrated by the set of unit-value isoquants in Figure 1. These unit-value isoquants are all tangent to a line whose slope indicates the ratio of wages to rentals on the type of capital specific to that sector. Thus each sector of the economy is characterized by the two-factor, many-commodity version of the Heckscher-Ohlin model in which the non- traded status of all commodities in autarky ensures that commodity prices adjust to reflect unit costs. Sector j is composed of n_j industries, and the total number of commodities produced, $\sum_{j=1}^{N} n_j$, substantially exceeds the number of productive factors, $(N+1)$.

2 Free Trade in All Commodities

If all commodities in all sectors are freely traded at a given set of world prices — the economy being deemed to be too small to affect these prices — a considerable degree of specialization takes place in each sector. The analysis of this phenomenon

within each sector follows closely that given in Jones (1974), except that the supply of labor provided each sector is to be determined endogenously. Figure 2 illustrates a set of unit-value isoquants for a 4-industry sector (i) facing given world prices. Technology at home is not assumed to be reflected in world prices, and this helps explain the existence of commodities such as industry 4 in sector i. The country has inefficient technology in this industry, and cannot effectively compete at these prices regardless of the quantity of labor employed in this sector. A further reflection of the independence of home technology is the assumption that no more than two industries have unit-value isoquants tangent to a common line.

The unit-value isoquants depicted in Figure 2 reflect a combination of the country's technology and world prices. Further information about factor supplies is required to determine which commodity or pair of commodities the country produces in this sector. If a ray whose slope represents the capital/labor ratio available in sector i is drawn in Figure 2, the composition of output is determined. Thus for ray k^i the country would produce commodities 1 and 2, with the wage/rent ratio reflected in the common tangent line and industries 3 and 4 ruled out at these factor prices since unit costs would exceed given world prices. The convex hull of unit-value isoquants in Figure 2 represents a Hicksian composite traded-commodity isoquant for sector i, and which particular industries survive in a competitive equilibrium depends upon how much labor this sector can attract.

The demand for labor in sector i is a function of the wage rate, given specific factor K^i and prevailing world prices. Figure 3 illustrates this demand curve. High wage rates imply that only industry 1, the most capital-intensive industry in sector i, would survive. The wage rate and given price for x_1^i would determine the rental on K^i and techniques. As w falls, the first industry adopts more labor-intensive techniques (and thus increases its demand for labor) until the next industry in ranking according to capital-intensity has its costs lowered to the level of world price. The flat at this wage rate in Figure 3 shows that x_2^i output can expand, with x_1^i output contracting, without requiring any change in factor prices or techniques. However, such a compositional shift raises the demand for labor from this sector until specialization in the second industry is complete. Further lowering of the wage rate encourages more labor-intensive techniques. The demand for labor schedule from sector i in Figure 3 thus consists of downward-sloping portions along which only one commodity is produced and flat stretches along which sector i produces two commodities. Which pattern emerges depends on the equilibrium wage rate and this, in turn, reflects the overall supply of labor to the economy.

Figure 4 illustrates the demand for labor in the entire economy, and its shape and position depends on the technology and prices in all industries and the array of specific capital endowments, K^i. We assume the absence of "ties" — each horizontal step in Figure 4 corresponds to some sector exhibiting a single pair of industries which could be simultaneously operated at the appropriate wage (and world prices). The given supply of labor may intersect the demand curve along a downward-sloping portion, in which case each sector devotes all its specific capital to a single industry. Alternatively, the supply curve may intersect at a flat (as shown), in which case one sector of the economy has a Heckscher-Ohlin "nugget" comprising two commodities using a common pair of factors (labor and the type of capital specific to that sector),

with all other sectors specialized.

Two alternative outcomes characterize the possible equilibrium. One of these corresponds to the $(N + 1) \times N$ specific-factor model. Free trade induces each sector to focus on a single producing industry, utilizing a type of capital used in no other activity (at the equilibrium wage) and mobile labor. In the other alternative there exists a single sector displaying a Heckscher-Ohlin 2×2 "nugget".[3] Our assumption that the country's technology is independent of world prices rules out as purely accidental the possibility of two or more sectors displaying such a nugget at the same wage rate or the existence of more than two commodities in any single nugget. Such a structure is reminiscent of the three-factor, three-commodity model analyzed by Gruen and Corden (1970):[4] An economy (say, Australia) produces two commodities in one sector (wool and grain, each using land and labor), and as well a single commodity (textiles) in an alternative sector, requiring capital and labor as inputs. Such a structure was imposed arbitrarily in their model. Here it emerges endogenously (extended to encompass many sectors of the "textile" variety but only a single 2×2 nugget) as a consequence of the forces of free trade.

3 Small Shocks in World Prices

The pattern of response in local income distribution and outputs to a change in world prices depends sensitively on which of these alternative production structures emerges with free trade. The response depends as well on the size of the shock. A "small" shock is one which, by definition, does not disturb the qualitative pattern of production in the economy.

Review, first, the familiar pattern of factor-price and output response in the absence of any sector displaying a "nugget" in free-trade equilibrium. A small increase in any commodity price has no effect on the distribution of income if this commodity is not locally produced. Indeed, it lowers all factors' real income by an amount proportional to that factor's consumption of the commodity. Should that commodity be produced, however, the community as a whole would gain if production is sufficiently large to support exports. As to local income distribution, the real return to the type of capital found in that sector unambiguously rises, the wage rate is driven up, but by less, relatively, than the price of the commodity, while the return to capital in all other sectors falls. The familiar result on output patterns also emerges: the industry whose price has risen expands with industries in all other sectors contracting.

In the alternative Gruen/Corden setting, in which some sector displays a 2×2 nugget, production patterns and income distribution depend upon whether the industry experiencing the price rise lies in the nugget or in some other sector, assuming the commodity is produced somewhere in the economy. If the commodity lies within the nugget, the response depends in typical Heckscher-Ohlin fashion upon the relative factor intensity ranking of industries found in the nugget. Suppose the favored

[3]For earlier uses of this concept see Marjit (1990).

[4]Deardorff (1984) discusses in detail Krueger's (1977) model, which is similar in structure to that of Gruen and Corden.

industry is labor-intensive. The wage rate unambiguously rises, the return to capital in that sector falls, and the wage increase spreads to all other sectors of the economy to force decreases in the returns to capital everywhere. Thus the income distribution response for this particular price rise is precisely that of the strong Stolper/Samuelson variety in this $(N+1) \times (N+1)$ model. As for outputs, within the favored sector the labor-intensive industry expands at the expense of the more capital-intensive industry. Such a change in outputs is supported from two sources. For any given allocation of labor among sectors there emerges the familiar movement along a transformation curve for the two industries in the nugget. In addition, the increase in the wage rate causes all other sectors of the economy to release labor to the favored sector, encouraging a further expansion of the labor-intensive commodity in the nugget and a contraction of the capital-intensive industry (a la Rybczynski). The pattern of output changes is similar to that of the specific-factors model described earlier.

A rise in the world price of the more capital-intensive of the two commodities produced in the nugget can be expected to alter these findings. Most directly, within the nugget it is the return to capital which is unambiguously raised and the wage rate which falls. This wage drop spreads throughout other sectors, in which commodity prices have not changed, to cause an increase in the rate of return to all other sector-specific capitals. (These returns may or may not rise by relatively more than the price of the capital-intensive good in the nugget). The pattern of income distribution is now that modeled by Inada (1971): One factor loses unambiguously, and all others gain (at least nominally). As for outputs, the fall in the wage rate causes the nugget to lose labor to all other sectors. Nonetheless, the favored capital-intensive sector in the nugget expands, both because of a move along a fixed transformation schedule in the nugget before the labor reallocation and because the nugget's loss of labor to the rest of the economy causes a further transfer of resources within the sector to this industry. Thus the price rise for the single (capital-intensive) industry in the nugget encourages an expansion of output in all industries in the economy save the labor-intensive industry in the nugget.

Consider, finally, a price rise in some industry produced in a sector not containing the nugget. Now the repercussions get contained. The 2×2 nugget faces fixed world prices for the commodities it produces, implying no change in the wage rate and thus no change in any return to capital except in the single favored sector. This we may label as the case of "Isolated Rents". The price rise, of course, attracts labor to the favored sector, but all this labor is supplied by the nugget, causing an expansion there of the capital-intensive commodity and a reduction of the labor-intensive commodity. The rise in price has allowed two industries to expand at the expense of the third, with all other sectors left undisturbed.

A rich variety of outcomes, both in income distribution and in outputs, thus emerges, depending upon the endogenously determined production structure. With all commodities traded, it becomes natural to ask about the necessity of a Dutch-Disease phenomenon, whereby a rise in the price of one traded commodity causes outputs in other active industries to contract. This is certainly the case for the pair of commodities found in the nugget should the price change take place there. If it does, however, industries in all other sectors will experience a Dutch-Disease

contraction if and only if the favored nugget sector is labor-intensive. The point of contact these other sectors have with the nugget is through the labor market, so that the spread effect on their outputs depends entirely on the behavior of the wage rate. If a nugget exists but the price rise is for a produced industry in a different sector, all other non-nugget industries are insulated from this change, but the labor-intensive commodity in the nugget is adversely affected.

The patterns of output response to price changes in the case in which some sector (say the n^{th}) contains a nugget so that the same number of productive activities $(n+1)$ survive as the number of factors, is displayed in the output substitution matrix, S :

$$
\begin{array}{lll}
 & & \begin{array}{cccccccc} \multicolumn{7}{c}{(n-1)\text{ sectors}} & \begin{array}{c}n\text{th}\\ \text{sector}\end{array} \end{array} \\
 & & \left[\begin{array}{ccccccc|cc}
+ & & & & & & & + & - \\
 & + & & & & & & + & - \\
 & & + & & & & & + & - \\
 & & & \ddots & & & & \vdots & \vdots \\
 & & & & \ddots & & & \vdots & \vdots \\
 & & & & & \ddots & & \vdots & \vdots \\
 & & & & & & + & + & - \\
\hline
+ & + & + & \cdots & \cdots & \cdots & + & + & - \\
- & - & - & \cdots & \cdots & \cdots & - & - & +
\end{array}\right] \\
\mathrm{S} = & \begin{array}{l}(n-1)\\ \text{sectors}\end{array} & \\
 & \begin{array}{ll} n\text{th} & x_1^{(n)} \\ \text{sector} & x_2^{(n)} \end{array} &
\end{array}
$$

$x_2^{(n)}$ labor-intensive

$$\hat{x} = \mathrm{S}\hat{\mathrm{p}}$$

The positive sign of the diagonal terms of S reveals that the output in any industry responds positively to a price increase for that industry. Off-diagonal elements in the j^{th} column disclose the fate of other industries in the economy when p_j rises. The n^{th} sector contains the nugget, and the first industry in that sector, $x_1^{(n)}$, is assumed to be capital-intensive relative to the second.[5]

With reference to output-price matrix, S, the price change most closely associated with Dutch Disease phenomena would be an increase in the price of the labor-intensive industry in the nugget $(x_2^{(n)})$; own-output rises and labor is released from all other sectors of the economy. By contrast, a price rise for the capital-intensive industry in the nugget hurts the other (labor-intensive) industry in the nugget but, since the wage rate is depressed, all other industries in the economy are allowed to expand. The first $(n-1)$ columns of S depict the "isolated rent" phenomenon; the

[5]Consider the matrix, $[\alpha]$, which links the change in relative factor returns to changes in commodity prices, such that $\hat{w} = \alpha\hat{p}$, where w_1, ..., w_{n-1} indicate returns to specific types of capital in sectors 1, ..., $n-1$, $w_1^{(n)}$ is the return to capital in the nth sector and $w_2^{(n)}$ is the wage rate, w. $[\alpha]$ has the same sign pattern as $[S]$ except the last two rows (not counting the last two columns) contain all zeroes.

industry favored by the price rise expands, all other non-nugget industries experience no output change, but in the nugget the labor-intensive industry contracts, releasing labor both to the favored industry and to the capital-intensive industry in the nugget. Of the output response patterns thus illustrated by the S-matrix, the one most closely approximating the alternative $(N+1) \times N$ specific factors structure is the one in which the favored industry is the labor-intensive activity in the nugget; a single output rises at the expense of all other industries.

4 Finite Shocks and Transmission Mechanisms

The movement from autarky to free trade suggests the potential existence of many productive activities ruled out by one set of prices but capable of being competitively viable at other sets. Price shocks that are not "small" are capable of inducing a significant alteration in the pattern of production (and trade). Concerns over the Dutch Disease phenomenon highlight the importance of identifying the channels through which new-found successes in some industries brought about by external price shocks get transmitted to other industries. As we show, much depends upon whether these other industries lie in the same sector or elsewhere in the economy.

A useful starting point is the demand curve for labor from a particular sector, as illustrated in Figure 3.[6] Consider a commodity such as x_2^i, neither the most capital-intensive nor the most labor-intensive commodity in sector i. A finite rise in p_2^i in world markets causes a shift in sector i's demand schedule, reflected in the position of the dotted curves in Figure 5. Two characteristics of this shift are noteworthy. First, in the range of wage rates for which x_2^i was initially produced, the price rise encourages a greater demand for labor. Secondly, the range of wages which allow positive production of x_2^i is increased at both ends. As illustrated in Figure 5 such a price rise cuts into the range of wages for which only commodity one, more capital-intensive than two, or only commodity three (more labor-intensive) would be produced. A sufficient rise in commodity 2's price could wipe out the possibility of industry 3, say, being viable at any wage rate.[7]

Perhaps the most surprising feature illustrated in Figure 5 is the possibility that a price rise for industry 2 in sector i could reduce that sector's demand for labor. For example, initially production might have been located at point B, with the i^{th} sector only producing commodity 3. The price rise for x_2^i could eventuate in a move to point C, with a switch from industry 3 to more capital-intensive industry 2, thereby reducing sector i's demand for labor and the wage rate.

Equilibrium in the economy's labor market can be analyzed by confronting sector i's demand curve for labor with that of the rest of the economy. One possibility is illustrated in Figure 6. Initial equilibrium is at A, with sector i displaying a productive nugget in which commodities 1 and 2 are produced and all other sectors are

[6]This kind of diagram has also been utilized by Deardorff (1984).

[7]Further detail should be noted: corner point A' showing incipient production of commodity 1 after the increase in commodity 2's price, lies northwest of corner point A associated with original prices. The rationale: If the sector initially produces only commodity 2, the relative vertical shift in the demand curve equals the percentage rise in p_2^i, whereas if both x_1^i and x_2^i are produced, the relative vertical shift exceeds the price rise, a reflection of the magnification effect.

completely specialized to their "best" traded good corresponding to the equilibrium wage at A. The increase in the world price of sector i's second commodity causes production of x_1^i to cease and production of x_2^i to expand, with labor drawn both from x_1^i and from the rest of the economy, driving up the wage rate. Adjustments in perhaps several other sectors entail switches to more capital intensive goods, with some sector displaying a nugget in which a pair of commodities is produced.

Other cases could be illustrated, but the pattern is clear: The possibility of a Dutch Disease response in another industry when the world price of industry 2 in sector i rises depends on whether this other industry shares the same kind of capital as x_2^i. Of course if commodity 2 is initially not produced in sector i, the price rise may be insufficient to warrant its production in the new equilibrium. But, suppose it is produced. Then any other industry previously producing in that sector is either wiped out or finds its output diminished. As Figure 5 illustrates, the wage rate may fall (in the move from B to C), but this is of no comfort to other industries in sector i, even those that are more labor-intensive, since such a fall must reflect the movement of labor out of such industries towards the more capital-intensive industry whose price has risen.

The fate of industries in the rest of the economy is not generally as severe. These industries are linked to the favored sector only through a single market — that for labor. An increase in the wage rate, as illustrated in Figure 6, causes Dutch Disease distress to industries that are initially active, but there may exist more capital-intensive industries in these sectors which benefit from the change. In effect, all these other sectors experience two factor price changes: the wage rate rises but the rental that must be paid to sector-specific capitals falls. On the other hand, an externally-induced price change which leads to a fall in the wage rate benefits some industries in the rest of the economy which are more labor-intensive than the ones whose activity has been eliminated by the price rise in sector i.

5 Non-traded Goods and Crowding-Out

In order to analyze the nature of the equilibrium production pattern when not all commodities are traded on world markets we examine the consequences of having some commodity in sector i change its status from being fully traded to having natural or artificial transport costs or barriers (such as prohibitive import quotas) imposed so that local consumption must be locally produced. Does positive production of such a commodity crowd out any other industry in this sector, precluding it from competing in world markets? The country must export something, but export activities in other sectors do exist with industries that provide export earnings.

The possibilities are analyzed in Figure 7, a diagram which, like previous Figure 6, confronts sector i's demand for labor with that in all other sectors combined. The demand curve for the rest of the economy has been purged of any flats in order to simplify the analysis. As well, we suppose that only a single traded commodity, T^i, exists in sector i; the issue is whether it will be produced at all. Finally, at this stage of the analysis we assume that the single non-traded commodity in sector i, N^i, is labor-intensive compared with T^i.

Given the world price of T^i, whether or not it will be produced depends on the

market price of non-tradeables in sector i. Point A in Figure 7 is associated with a relatively high price of non-tradeables, one which allows only incipient production of T^i; call this price p'_N. If the price of non-tradeables were to fall somewhat from this level, sector i's demand curve for labor would shift inwards, so that a new equilibrium would exist at point C, with a lower wage rate. This price drop for non-tradeables has allowed production of T^i to co-exist with that of N^i, although sector i now attracts less labor overall. Further reductions in the price of non-tradeables in sector i cause output N^i to fall until point B is reached. At that low price (p''_N), output of non-tradeables vanishes, and sector i only produces T^i.

The range of prices for which sector i tolerates simultaneous production activity in tradeables and non-tradeables, the range p''_N to p'_N, is illustrated by the supply curve for non-tradeables, S_N, in Figure 8. Below p''_N output of non-tradeables is closed down, whereas above p'_N the favorable prices for non-tradeables has crowded out the possiblity of traded goods production. Note that the S_N curve above p'_N becomes more inelastic, a reflection of the fact that there is no longer another industry in sector i (T^i) from which resources (labor and sector-specific K^i) can be drawn. Instead, increases in N^i can be fueled only by attracting labor from the rest of the economy. Figure 8 shows an initial equilibrium at point E, but a sufficient rise in demand for non-tradeables could wipe out the tradeable industry in this sector.

If the non-tradeable industry in sector i had been capital-intensive, some modification in this scenario would be required. Figure 7 would have to be re-drawn to show N^i produced at higher wages, and T^i at lower. In Figure 8, increases in the price of non-tradeables between p''_N and p'_N would be accompanied by a fall in the wage rate and a loss of labor to the rest of the economy, a loss which, a la Rybczynski, promotes production of capital-intensive non-tradeables.

If sector i's non-tradeable sector had initially been freely traded, much can be gleaned from the trading pattern in such a state, assuming local demand conditions and technology to be invariant to the changed nature of impediments to trade. Thus if production of N^i were not initially viable, as a traded good it must have been imported. Therefore changing its status to a non-traded good must result in a price increase to sustain production. The price could lie anywhere above p''_N, with a co-existing traded goods industry if demand is not too strong. If the industry that becomes non- traded were originally viable as a traded industry, it might nonetheless have been imported. In this case a price rise as a non-tradeable is to be expected. However, suppose it was originally produced and exported. Conversion to non-traded goods status must lower its price. If initially it had shared a nugget with another traded good, the price fall as it becomes non-traded must encourage the production of the other traded good in the nugget. Thus the change in market status of an industry from an exported tradeable to the non-tradeable category helps production of another tradeable in the nugget whereas, if the good had originally been imported, the other tradeable produced in that sector finds its production reduced or, if p_N rises above p'_N, the industry is wiped out.

6 Non-Traded Goods and the Dutch Disease

The doctrine of comparative advantage proclaims the importance of the relative ranking of industries; if one traded sector improves its status via a price rise or productivity improvement, other tradeables move down in the relative ranking. In its starkest form the Dutch Disease proclaims that an increase in the fortunes of one traded sector spells contraction or elimination for others.

If all goods are tradeables, in our model these stark predictions are not always fulfilled. The exceptions require the existence of a nugget. In such a case the increase in the price of any traded good outside the nugget has no effect on the wage rate. The latter is determined in the nugget in standard 2×2 fashion. Returns to capital in the favored sector rise and industries in other sectors outside the nugget are insulated from the price rise. The favored sector expands by attracting labor from the nugget. Thus, most industries are left undisturbed, the Dutch Disease hits the labor-intensive industry in the nugget, and its contraction fuels not only an expansion in the traded sector initially favored by a price rise but also an expansion in the other industry in the nugget. A price rise for one of the traded industries in the nugget does cause all other industries to contract if it is the labor-intensive industry, but if, instead, the capital intensive industry in the nugget experiences a favorable price rise in world markets, the wage rate falls, and this is of positive benefit to all traded industries outside the nugget. The labor-intensive nugget industry is the sole loser, and this case represents the most radical departure from the pattern predicted by the Dutch Disease.

The existence of non-tradeables complicates the response. As often remarked, a non-tradeable industry is in many ways shielded from the brisk competition of world markets. It may even gain from a situation in which an export industry is favored by a price rise. The resultant favorable real income effects may so cause the price of non-tradeables to rise that output of non-tradeables expands despite any cost increases triggered by the export price rise. Indeed, as pointed out by Corden and Neary (1982), the rate of return to capital employed by the non-traded sector may rise by an even greater extent than in the booming export sector.

Our focus in this section is not directly on the fate of the non-tradeable sector. Instead, we analyze how the existence of non-tradeables alters the channels described earlier whereby the Dutch Disease gets spread (or thwarted) from a favored traded industry to other traded sectors. A useful starting point is the scenario in which no nuggets exist and, in the absence of non-tradeables, no resource transfers of any kind would take place in the small, price-taking economy. This is the case in which the exogenous rise in a commodity's price is insufficient to cause it to be produced in this economy. But such a price increase does represent a deterioration of the terms of trade, and if non-tradeables are normal, demand for non-tradeables may shift inwards. There is a caveat, however, in the form of a cross-effect in consumer demand between the traded import experiencing the price rise and non-tradeables. If these are good substitutes, the net effect could be a rightward shift in the demand for non-tradeables. If income effects are more important, the price of non-tradeables is driven down, and all traded productive industries actually gain labor since the wage rate falls. In this sense the non-traded industry serves as a "reservoir" from

which other industries can extract labor. Alternatively, if high substitutability in demand causes the price of non-tradeables to rise, other tradeables are hit by the subsequent wage increase; the non-traded industry acts more like a "sponge" soaking up labor from the other sectors.

Continuing with the scenario in which the world price of a traded good not produced in the home country rises, suppose the non-traded good shares a nugget with some traded good (whose price is unchanged). Assuming income effects are stronger than cross-substitution effects, the resulting fall in the demand for non-tradeables would reduce p_N, but the effect of such a change on all tradeables depends on factor intensities in the nugget. The companion traded industry in the nugget must in any case expand, but this entails a contraction in all other traded industries if and only if non-tradeables are capital-intensive. If a nugget exists with two traded industries (with the non-traded good found in a separate sector), the economy's wage rate is frozen at the level determined by world prices of the goods produced in the nugget. But assuming (again) that income effects dominate in reducing the price of non-tradeables (produced outside the nugget), such a price change now is cauterized in its effect on other sectors; the price fall gets absorbed completely by a magnified reduction in rents to the sector-specific type of capital used by the non-traded industry. The labor released by the non- traded sector gets absorbed by the nugget, causing the appropriate asymmetric output response for the two tradeables produced there.[8]

Of more relevance in appraising the Dutch Disease phenomenon is a rise in the world price of a commodity produced at home. If the commodity is nonetheless imported, the income effects are detrimental, although not to the extent of the earlier scenario where imports supply the entire local demand. With weaker income effects, the cross-effect in demand, presumably shifting demand onto the non-tradeable, has more chance of raising p_N. If the commodity is exported, perhaps the most interesting setting for the Dutch Disease phenomenon, the price of non-tradeables must rise. The effect this has on the wage rate must be combined with the effect on wages of the initial rise in the price of the favored tradeable before the impact on other traded goods can be appraised.

Suppose, therefore, that the price of an exportable rises, and that this commodity does not lie in a nugget. If there exists a nugget with a pair of tradeables elsewhere in the economy, the wage rate is frozen so that all tradeables outside the nugget other than the favored traded good are insulated. Assuming the non-tradeable lies outside the nugget, its price is bid up, and the newly produced rents are all captured by its sector-specific capital. Thus two types of rent rise, and the non-tradeable joins the favored sector in drawing labor away from the nugget, at the magnified expense of the labor-intensive industry in the nugget. If, instead, a nugget exists but consists of one tradeable and the non-tradeable, the wage rate is no longer frozen. Figures 9

[8]It is possible that the non-traded good shares a nugget with two tradeables. In that case a downward shift in the demand for non-tradeables does not affect its price, the wage rate, or the return to any type of capital. Output changes of tradeables in the nugget depend on the ranking of factor intensities there. For example, if the capital/labor ratio of non-tradeables lies between those of the two tradeables, both their outputs would expand if the demand for non-tradeables falls. No other outputs are disturbed. Details of such interactions when the nugget is the only sector are found in Jones (1974).

and 10 depict some of the possibilities that may transpire if the non-tradeable lies in the nugget.

The non-tradeable is the labor-intensive nugget industry in Figure 9. The upper diagram shows an initial equilibrium at A, disturbed by a rise in price of some produced export good lying outside the nugget. The bottom diagram illustrates the original equilibrium at point F where demand and supply for non-tradeables match. The improvement in the terms of trade, coupled with a normal cross-effect in demand away from the favored export commodity, has shifted the demand curve out to D'_N. There is, as well, an inward shift in the supply curve of non-tradeables that is also attributable to the rise in price of the favored export commodity. At given p_N this price rise does not affect wages, but it does siphon labor out of the nugget, and this loss must reduce the output of labor-intensive x_N at given price. The rightward shift in D_N and leftward shift in S_N must raise the price of non-tradeables; as shown in Figure 9 by point G, the output of non-tradeables may actually fall. In any case in the upper diagram the broken demand for labor curve for sector i shifts as drawn, with a wage increase from A to B a magnified reflection of the rise in the price of non-tradeables. Dutch Disease is rampant — all non-nugget export industries except the favored one have contracted, and the non-tradeable industry has also contracted despite a price (and demand) rise. The capital-intensive traded industry in the nugget could either contract or expand.

Figure 10 traces through the adjustment if the non-traded nugget industry is capital-intensive. The initial equilibrium, once again shown by points A and F in the two graphs, respectively, is disturbed by an outward shift in the demand for labor in the favored export sector (and thus for the entire$\sum_{s\neq i} L^s$ schedule). At initial price for non-tradeables this would shift the S'_N schedule to the right since the departure of labor from the nugget causes capital-intensive non-tradeables to expand.[9] Combined with the outward shift of demand as the terms of trade improve, the supply shift encourages a rise in non-tradeable output from F to G. However, the bottom graph in Figure 10 shows the possibility that the price of non-tradeables may actually fall. This price fall is reflected in the shift in the labor-demand schedule for nugget sector i in the top graph, with the wage increase in moving from A to B a consequence of the fall in capital- intensive non-tradeables price. Dutch Disease is once again rampant since the wage increase squeezes other tradeables — despite the fall in the price of non-tradeables in Figure 10 (or the contraction of the non-tradeable sector in Figure 9.)

As a final case suppose the favored export industry is found in a nugget with the non-tradeable. If the export industry is capital-intensive and if p_N were kept constant, our earlier analysis highlighted this as the case in which all other tradeables gain since the wage rate would have to fall — all at the expense of non-tradeables. But with demand for non-tradeables shifting out, the price of non-tradeables must rise.[10] The fate of other tradeable industries depends on whether the rise in the

[9]That part of the S_N schedule at higher p_N, where the traded industry in the nugget has been driven out, would shift leftwards with the loss of labor from sector i. Thus the S_N and S'_n curves intersect.

[10]It is unlikely that non-tradeables would rise in price by more than the rise in price for the export industry in the nugget. Without income effects a comparable rise in both nugget prices would raise the wage rate by the same amount, bringing in labor from other sectors and expanding

price of non-tradeables is sufficient to increase the wage rate.[11]

If the export industry is labor-intensive in the nugget and p_N were constant, the wage would by driven up by a magnified amount and all other industries would lose — the extreme form of Dutch Disease. With non-tradeables also produced in the nugget the price must rise — both because demand shifts out and because the inflow of labor to the nugget caused by the wage increase penalizes capital-intensive non-tradeables. Indeed, if p_N rises to keep pace with the world-inspired rise in the export price, the supply of non-tradeables would still fall short of the original amount. The reason: the wage rate would rise by the same relative amount as the price of exports (instead of by a magnified amount), so that the nugget has drawn labor from the rest of the economy. This eventuates in a lower production of capital-intensive non-tradeables than initially. Unless non-tradeables are extremely good substitutes with other tradeables in demand, the non- tradeable industry would find its price driven up even relative to the favored export sectors. The existence of a capital-intensive non-tradeable industry in the nugget has not prevented all non-favored tradeables from succumbing to the Dutch Disease.

7 Real Exchange Rates and the Terms of Trade

The real exchange rate has often been defined as the price ratio between non-tradeables and a market basket of tradeables. An appreciation of the real exchange rate is an increase in the ratio p_N/p_T, where p_T is the price index for the tradeables basket. It has frequently been asserted that an improvement in the terms of trade leads to (or is accompanied by) an appreciation of the real exchange rate. As others have recently argued [Edwards and van Wijnbergen (1987), Neary (1988) and (1990)], there is no necessity for this relationship to hold. Here we remark briefly on the manner in which complementarities in production, associated with the existence of a nugget in the production structure, bear upon the relationship between the terms of trade and the real exchange rate.

Demand as well as production structure are relevant for this issue. To simplify, suppose all goods are net substitutes in demand. That is, suppose that an increase in any commodity price at given levels of real income, which causes "own" demand to fall, causes a positive spill-over in demand for all other commodities. The consequence in a simple exchange model with one export good (X), one import good (M), and a non-traded commodity (N) whose price must adjust to clear markets is that ignoring income effects, if the terms of trade improve,[12] $\hat{p}_X > \hat{p}_N > \hat{p}_M$

Therefore p_T, the tradeables price index representing some composite of p_X and p_M, may or may not rise relative to p_N. Income effects, however, do lend a presumption and, it can be argued, are crucial. Assuming all goods are normal, an improvement in the terms of trade will shift the demand curve outwards and serve

especially the supply of labor-intensive non-tradeables. In addition, consumers would shift away from non-tradeables since all other prices (except for the favored exportable) have not risen in price. Income effects would have to be powerful to offset such a gap in excess supply.

[11]The wage rate remains unchanged if, in sector i, $\hat{p}_N$ equals $(\theta^i_{KN}/\theta^i_{KT})\hat{p}^i_T$, where the θ'srepresent distributive shares. Their ratio is a fraction in this case.

[12]See, for example, Jones (1976).

further to increase p_N. (By assumption p_X and p_M are determined in larger world markets). This makes it more likely that the real exchange rate appreciates.

Of concern here is the manner in which the production structure alters this conclusion. If trade induces an $(N+1) \times N$ commodity structure of the specific-factors kind, with one of the sectors producing the non-traded good, the production structure lends support to the agnosticism about the relationship between changes in the terms of trade and the real exchange rate voiced above for the exchange model (ignoring income effects) when goods are net substitutes in demand. The rationale for this view is that an increase in the price of any tradeable reduces all other outputs at initial prices, and thus tends to raise the price of any commodity which serves only a national market. That is, the change in the price of non-tradeables is once again trapped between the rise in an export item and the no-change exhibited by other traded-goods prices.

The existence of a nugget has potential to alter this conclusion. Refer again to the S-matrix of output responses (along any column) to a rise in a single price of the commodity on the diagonal. Complementarity in production is revealed by positive elements off the diagonal such as the first $(n-1)$ elements in the nth row or nth column. Suppose, first, that the nugget consists of two traded commodities and that the non-traded commodity is the sole industry in some other (non-nugget) sector. If the capital-intensive commodity in the nugget ($x_1^{(n)}$ in the S-matrix) is an export commodity and increases in price on world markets, the output of the non-tradeable (and all non-nugget industries) will rise as labor is drawn away from the labor-intensive industry in the nugget.[13] Although the favorable income effect once again encourages a price rise for non-tradeables, the increased production tends to reduce p_N. If the latter effect dominates, an improvement in the terms of trade will have worsened the real exchange rate.

Alternatively, consider the scenario in which there is a nugget which contains the non-tradeable, and that it is capital intensive relative to the other industry in the nugget. If there is a rise in the world price of some export commodity not in the nugget, output of the non-tradeable would, at initial prices, also increase in complementary fashion. Once again these supply changes encourage a fall in the price of non-tradeables in the face of a terms-of-trade improvement.

Consideration of the specific-factors outcome or of all the other possibilities in the S-matrix reflecting a substitutive relationship between non- tradeables and exportables reveals the tenuous character of these exceptions to the positive relationship between the terms of trade and the real exchange rate. Of more importance, in our view, is that the production links among sectors exhibited in the S-matrix are invariant to whether the industry represents an export activity or import-competing activity. If the latter, in the cases of complementarity discussed above it is a deterioration (instead of improvement) in the terms of trade which is accompanied by a fall in the real exchange rate. Income effects, however, consistently work towards supporting a positive connection between terms of trade improvements and real exchange rate appreciation.

[13]This case is cited by Neary (1990) for the three-commodity Gruen- Corden model.

8 Concluding Remarks

Production structures in the theory of international trade are often imposed by assumption. However, the opening up of commodity markets to trade frees up the necessity of as diverse a production base as a nation would wish in autarky. Both the number of productive activities and the selection of those which survive in a competitive world are endogenous outcomes of conditions in world markets. We started with a rich array of sectors in autarky, with N different sectors each utilizing a separate type of capital but accommodating a variety of industries, and all activities employing as well a homogeneous type of labor whose return is thus uniform throughout the economy. That is, each sector represented a many-commodity, two-factor version of Heckscher- Ohlin structure. Free trade in all commodities resulted in a shutting down of most industries in each sector. The resulting structure exhibited either the survival of only a single "best" industry in each sector — an $(N+1) \times N$ version of the specific-factors model — or such a solution for all sectors except one, in which labor and the type of capital specific to that sector are actively employed by a pair of industries — a 2×2 Heckscher-Ohlin "nugget". The latter possibility, in full an $(N+1) \times (N+1)$ productive structure, represents the appropriate extension to many sectors of the simple three-commodity model put forth over twenty years ago by Fred Gruen and Max Corden.

These two alternative structures were compared, first, as to the manner in which a small price change in one affected outputs in all the others (and the distribution of income). Secondly, we considered finite shocks to the economy. If the wage rate falls, some industries which would have expanded if these shocks had been small instead are wiped out and replaced by a more labor-intensive industry in that sector. If the wage rate rises, an initially active industry in a sector may be replaced by a more capital-intensive industry using the same type of capital. Such finite wage changes may "pass through" one or more levels which would support simultaneous production of two industries in a nugget sector.

Non-traded productive activities can be embodied in this framework. We analyzed in detail the circumstances under which a nugget might exist in which a traded industry and a non-traded industry share a common type of capital.

Although this may occur, such a traded industry would be crowded out if the non-traded price rises sufficiently. The case of a single non-traded industry was the only scenario investigated, but it should be stressed that although only one nugget can in general exist if all goods are traded, any number of nuggets may operate simultaneously as long as at most only a single nugget contains more than one traded commodity. If demand conditions warrant, non-traded commodities may be produced at prices dictated by factor prices which are linked to world market prices for traded goods.

The phenomenon labelled the "Dutch Disease" refers to the loss of resources available to some traded industries when world prices rise for others. As with many general phenomena there are exceptions, and these are reflections of the possibility complementarity in the production structure. Of special interest was the role of non-tradeables in providing a "reservoir" of resources available to traded industries in some circumstances, or acting like a "sponge" to absorb resources and exacer-

bate the Dutch Disease difficulties faced by fixed-price traded industries in other circumstances.

Income effects tend to support the proposition that an improvement in the terms of trade is accompanied by an appreciation of the real exchange rate. On the side of production links, our structure is capable of exhibiting complementarity between a traded commodity and a non-traded activity if one of them is in a nugget in the Gruen-Corden outcome. The difficulty in tying this phenomenon into a systematic negative relationship between the terms of trade and the real exchange rate is that it requires the produced traded industry to be an export activity instead of an import-competing activity. It can be argued that in the present model there does exist a presumption that any traded industry engages in exports since only the "best" traded good in each sector is produced, with the rest being imported. However, complementarity seems no more likely than substitutability.

The pair of endogenous production outcomes analyzed here — the specific-factors model and the generalized Gruen-Corden structure containing a Heckscher-Ohlin 2×2 nugget — exhibit a rich variety of links among factor prices and industry outputs. More general settings can be envisioned. These involve the existence of industries utilizing a great number of inputs, some possessing a national market, others more restricted in their domain. However, trade theory often prefers to deal with more simple structures in which some hope of obtaining understandable comparative static results exist. The structures dealt with in our model are more robust in terms of dimension than the more standard models while, at the same time, allowing the force of trade and competition to determine which variant of more simple versions prevails in equilibrium.

Figures

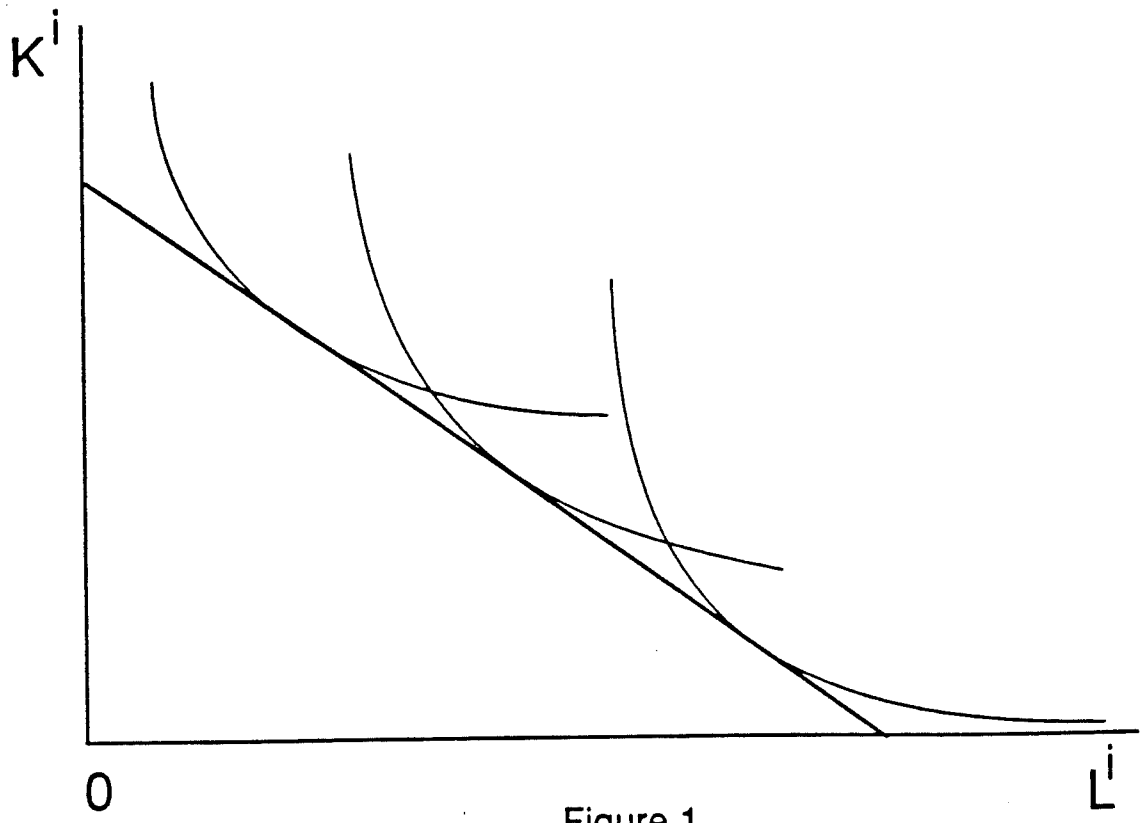
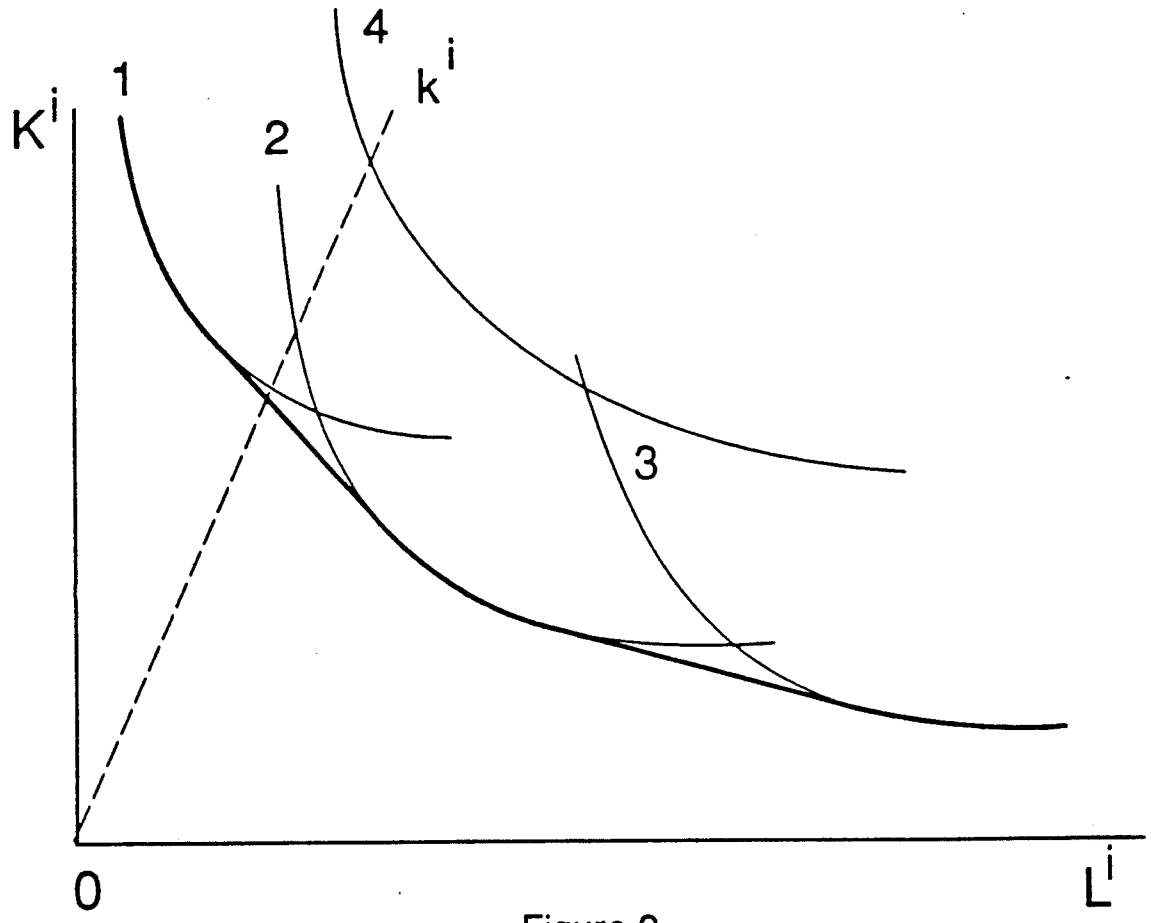


Figure 1



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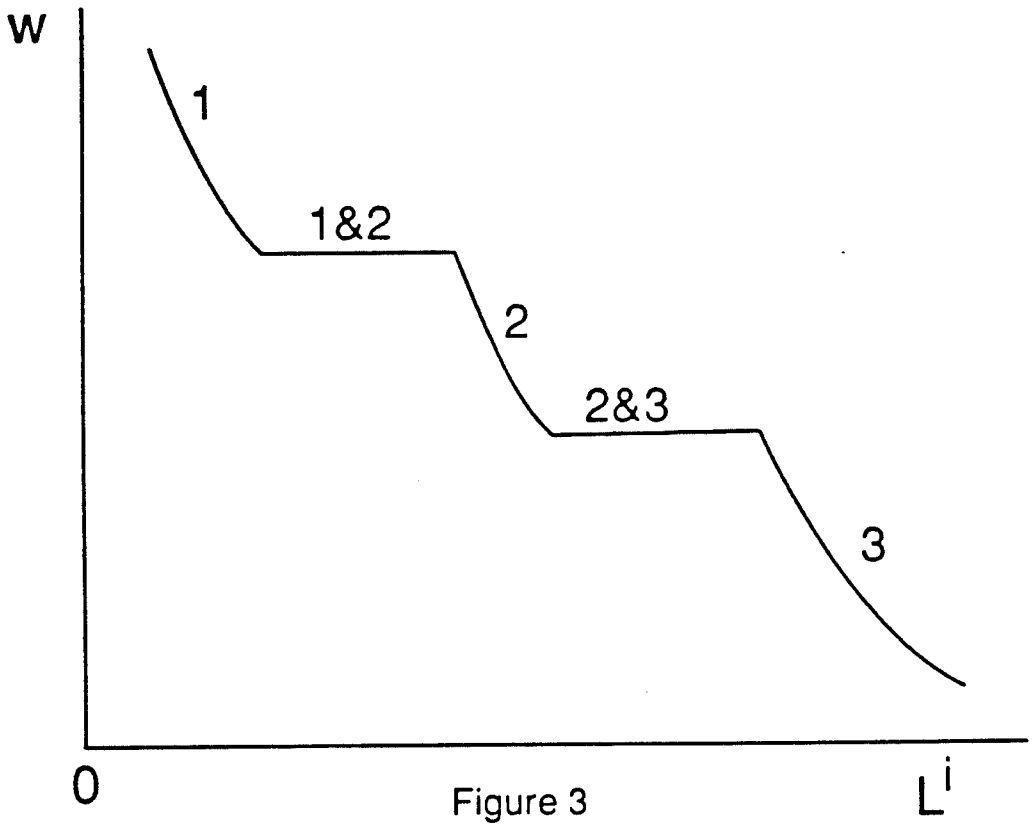

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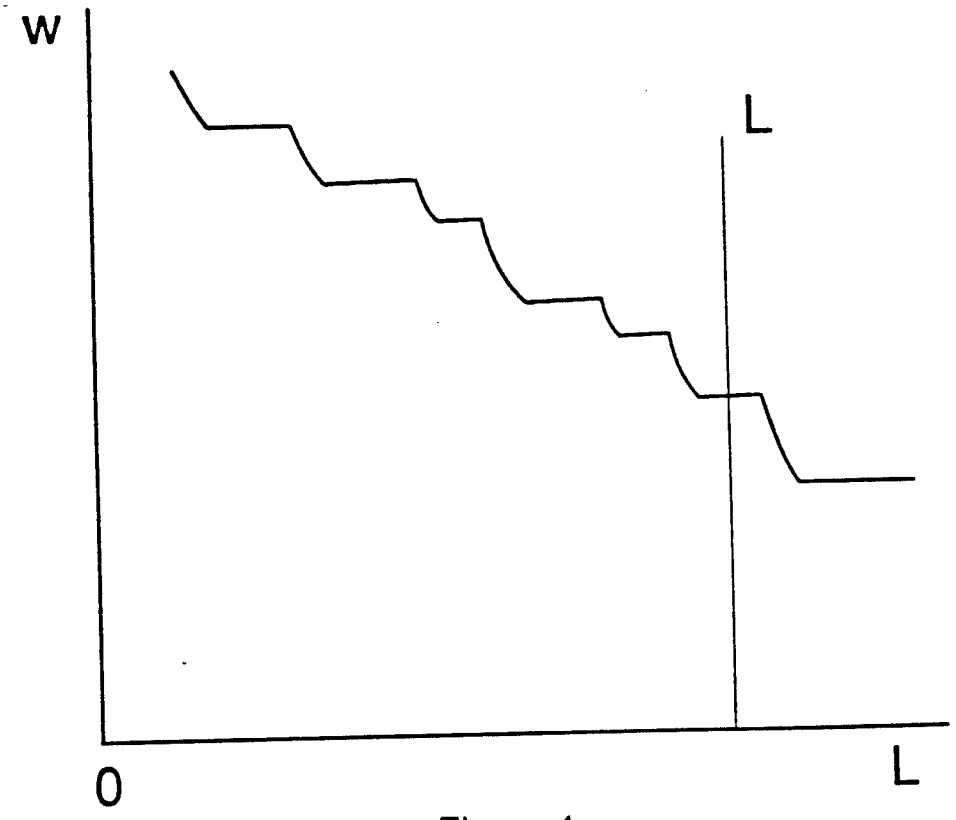

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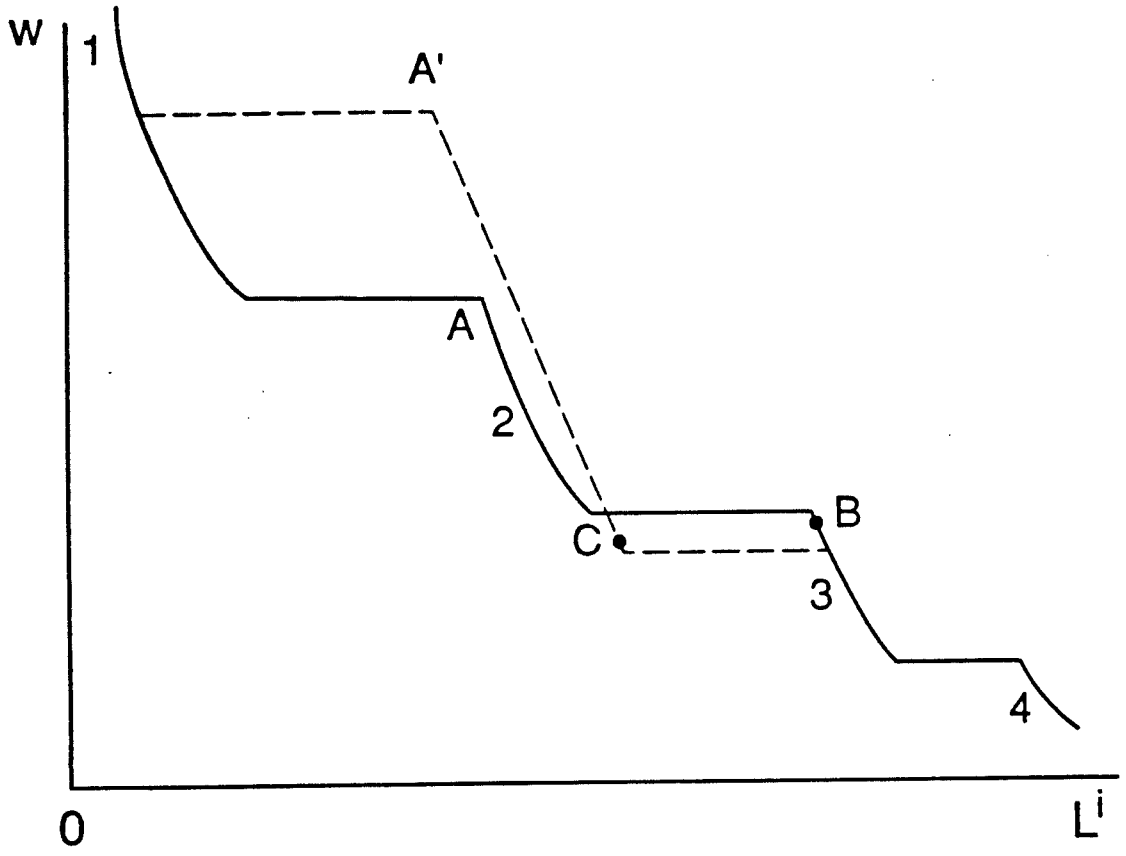

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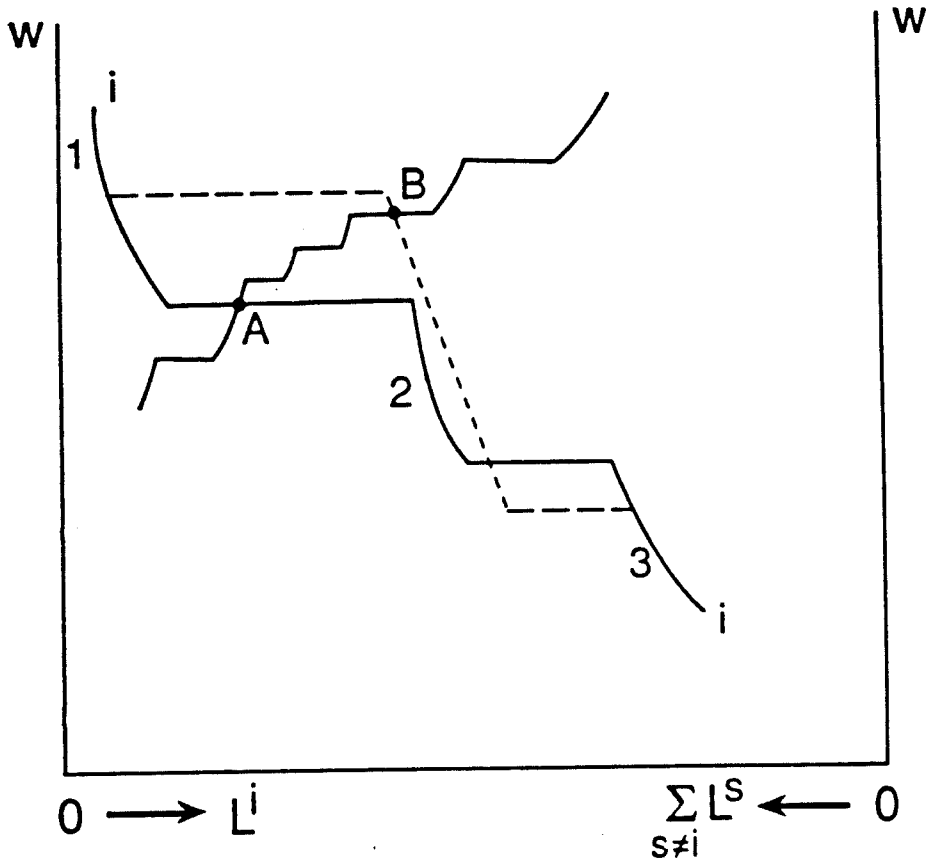

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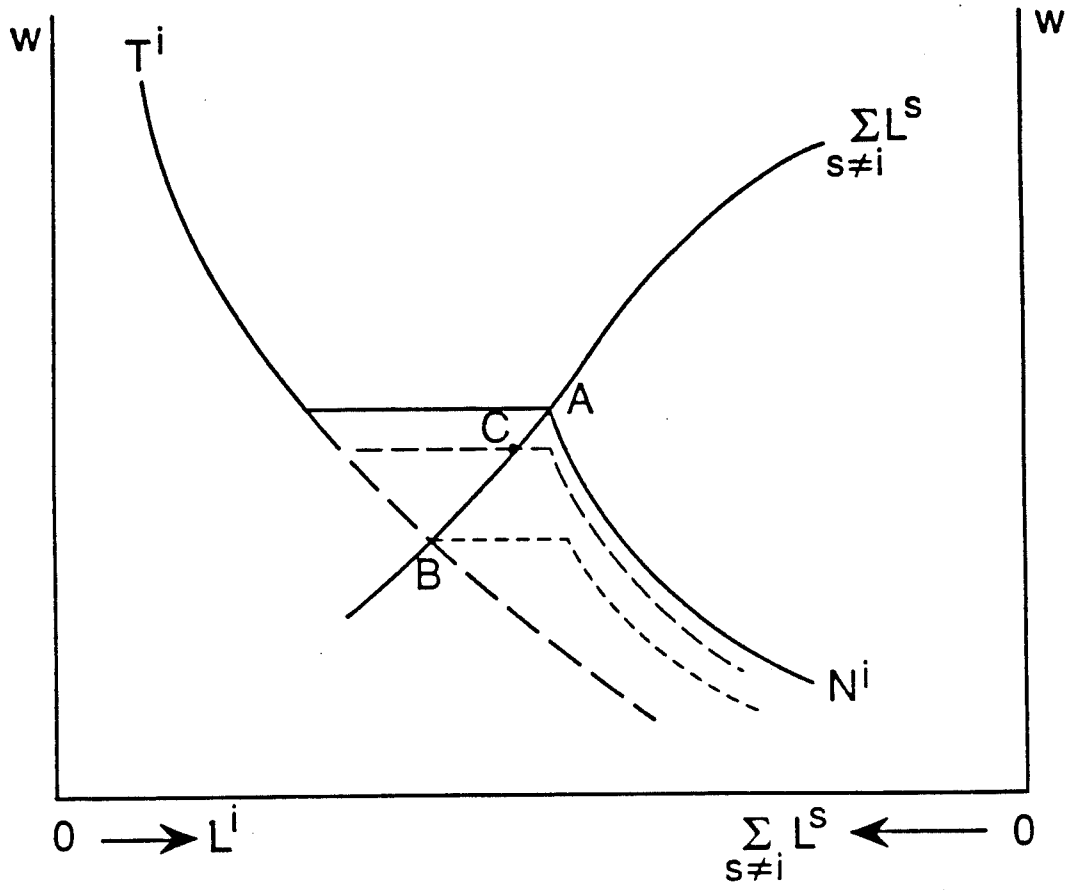

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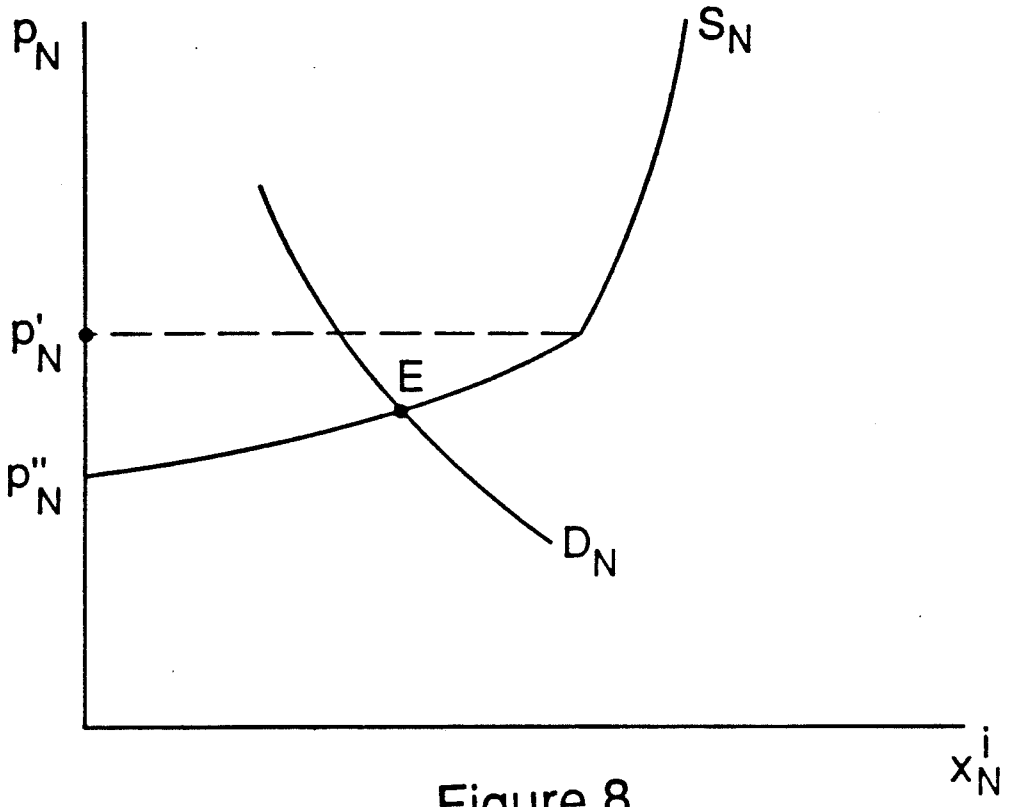
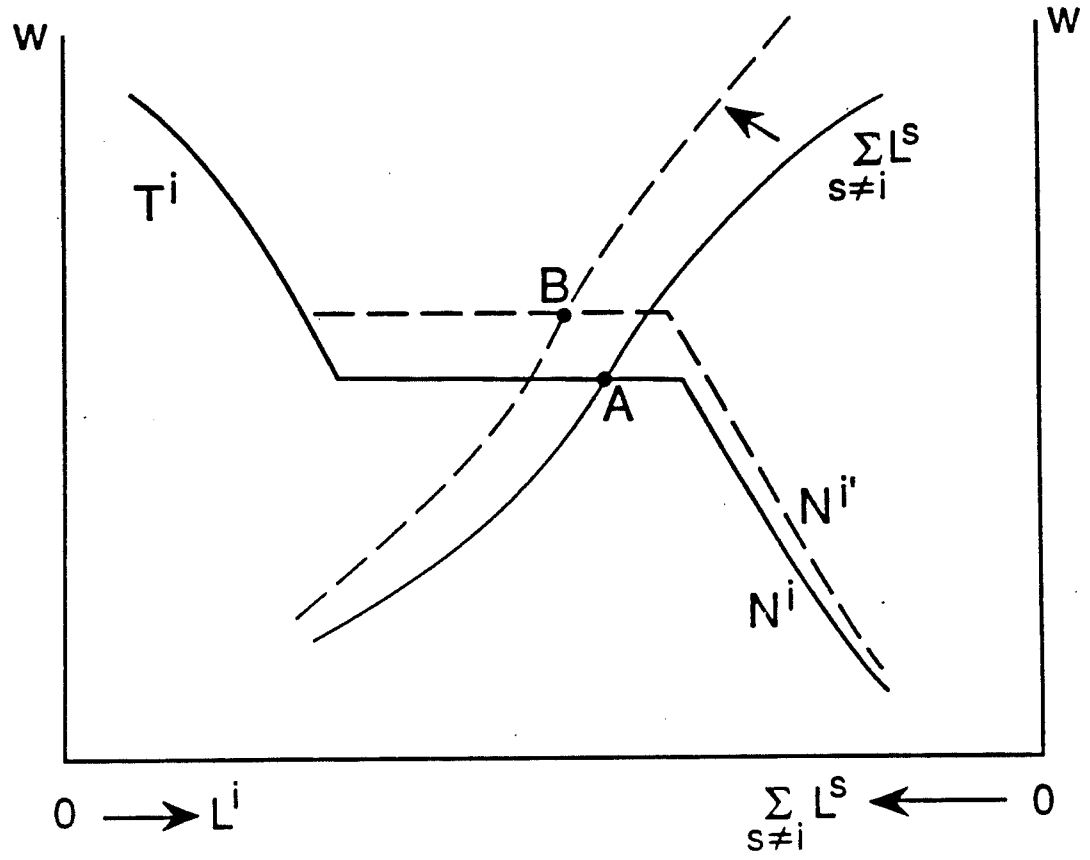


Figure 8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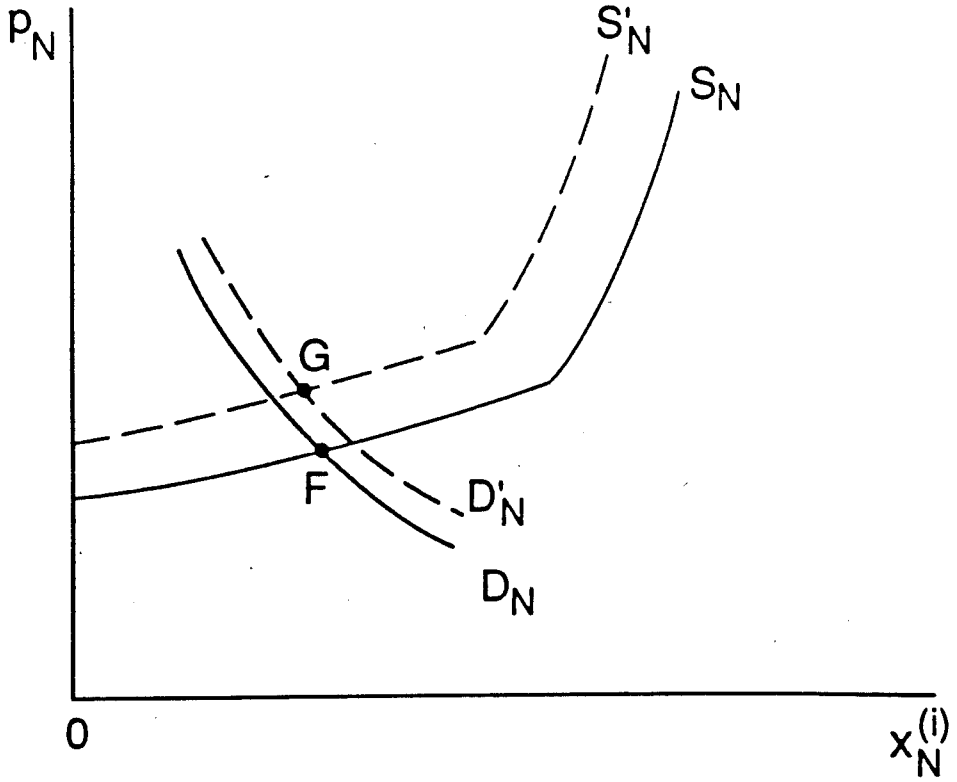
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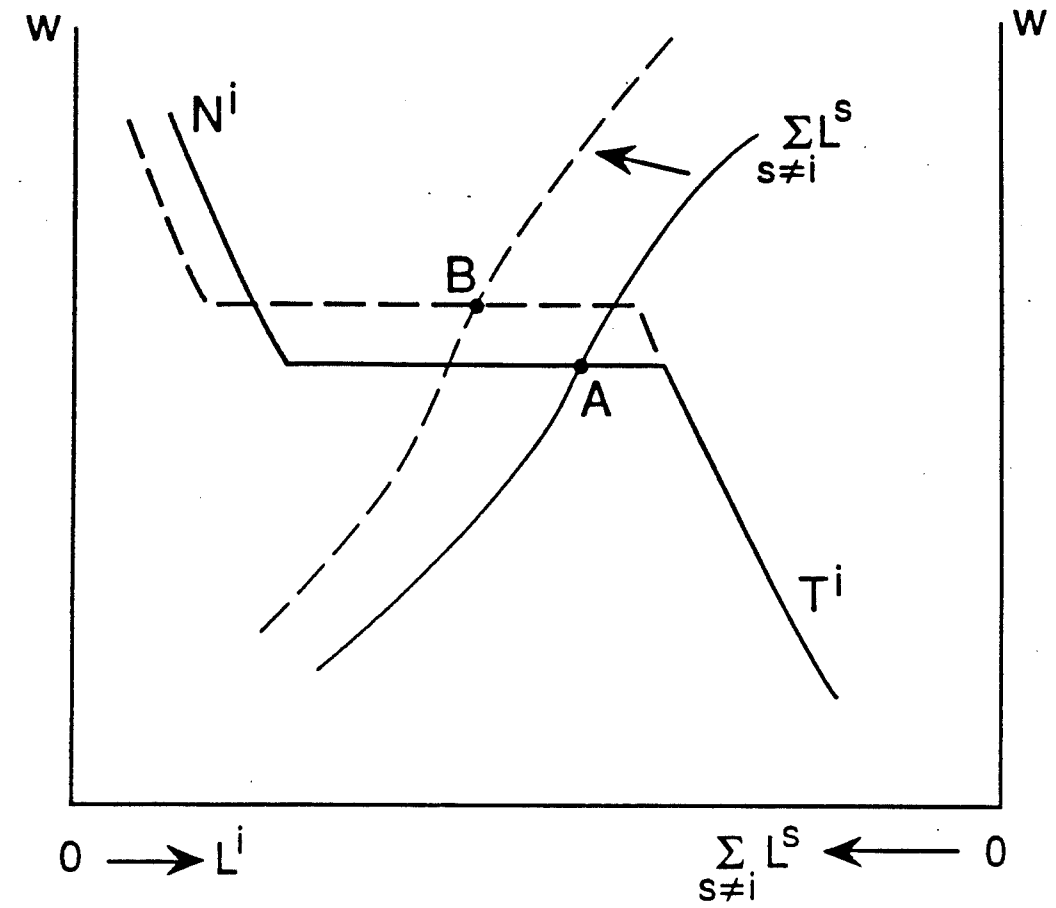
Figure 9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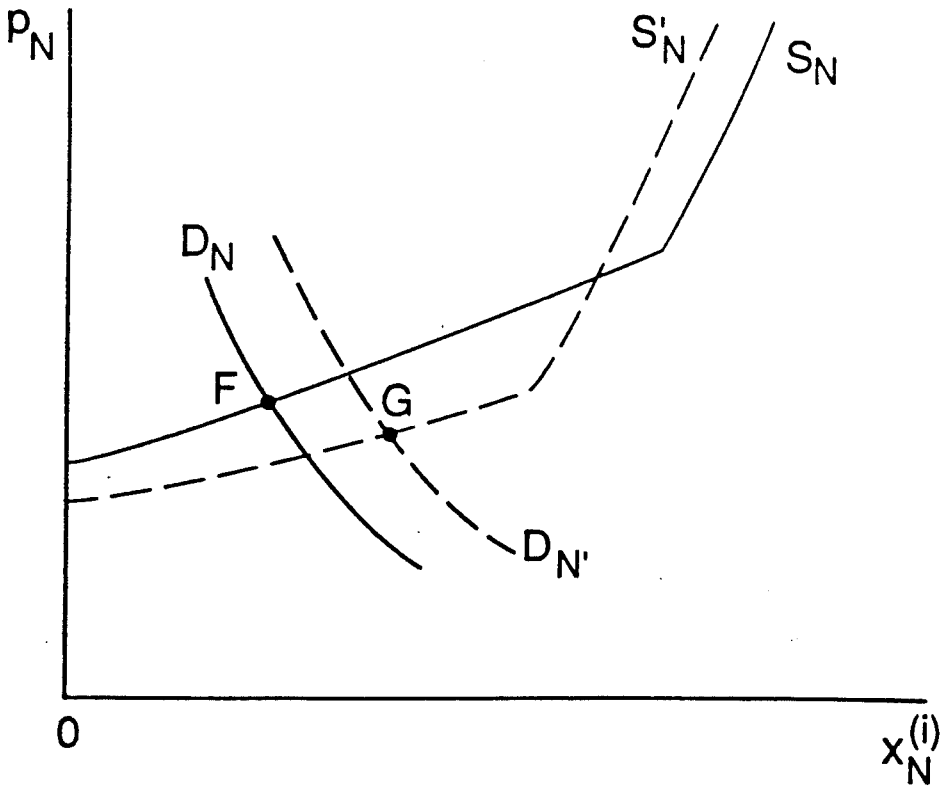
p_N
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S_N
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$D_{N'}$
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Figure 10

References

CORDEN, W.M. AND J.P. NEARY (1982): "Booming Sector and Deindustrialisation in a Small Open Economy," *Economic Journal,* 92, 825-48.

DEARDORFF, A. (1984) "An Exposition and Exploration of Krueger's Trade Model," *Canadian Journal of Economics,* November, 731-46.

EDWARDS, S. AND S. VAN WIJNBERGEN (1987): "Tariffs, The Real Exchange Rate and the Terms of Trade: On Two Popular Propositions in International Economics," *Oxford Economic Papers,* 39, 458-64.

GRUEN, F. AND W.M. CORDEN (1970): "A Tariff that Worsens the Terms of Trade," in I. McDougall and R. Snape (eds), *Studies in International Economics,* North-Holland, Amsterdam.

INADA, K. (1971): "The Production Coefficient Matrix and the Stolper- Samuelson Condition," *Econometrica,* 39, 219-40.

JONES, R.W. (1974): "The Small Country in a Many-Commodity World," *Australian Economic Papers,* (December), 225-36, reprinted in Ch. 2 in R.W. Jones: *International Trade: Essays in Theory* (North-Holland, 1979).

JONES, R.W. (1975): "Income Distribution and Effective Protection in a Multi-Commodity Trade Model," *Journal of Economic Theory,* (August), 1- 15.

JONES, R.W. (1976): "The Terms of Trade and Transfers: The Relevance of the Literature," Ch. 4 in Leipziger, D. (ed), *The International Monetary System and the Developing Nations* (A.I.D., Washington, D.C.), reprinted as Ch. 11 in Jones, R. W., *International Trade: Essays in Theory* (North-Holland, 1979).

JONES, R.W. AND S. MARJIT (1991): "The Stolper-Samuelson Theorem, the Leamer Triangle and the Produced Mobile Factor Structure," in Takayama, A. (ed), *Trade, Policy, and International Adjustments* (Academic Press).

JONES, R.W. AND R.J. RUFFIN (1975): "Trade Patterns with Capital Mobility," in M. Parkin and A. Nobay (eds), *Current Economic Problems* (Cambridge) 307-32, with abridged version as Ch. 13 in Jones, R. W., *International Trade: Essays in Theory* (North-Holland, 1979).

KHAN, M.A. (1991): "Ethnic Groups and the Heckscher-Ohlin-Samuelson Trade Model," *Economic Theory,* forthcoming.

KRUEGER, A. (1977): "Growth, Distortions, and Patterns of Trade Among Many Countries," *Princeton Studies in International Finance,* No. 40.

MARJIT, S. (1990): "A Simple Production Model in Trade and its Applications," *Economic Letters,* 257-260.

NEARY, J.P. (1978): "Short-run Capital Specificity and the Pure Theory of International Trade," *Economic Journal,* 88, 488-510.

NEARY, J.P. (1988): "Determinants of the Equilibrium Real Exchange Rate," *American Economic Review,* 78, 210-15.

NEARY, J.P. (1990): "Comments on 'Exchange Rate Policies in Developing Countries,' " unpublished.

SANYAL, K. AND R.W. JONES (1982): "The Theory of Trade in Middle Products," *American Economic Review,* 72, 16-31.