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Author(s): J. Peter Neary

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SHORT-RUN CAPITAL SPECIFICITY AND THE PURE THEORY OF INTERNATIONAL TRADE*

I. INTRODUCTION

Among its many abstractions from reality, the pure theory of international trade, associated with the names of Heckscher, Ohlin, and Samuelson, assumes that both capital and labour are costlessly and instantaneously transferable between sectors. More recently, however, beginning with articles by Jones (1971 *b*) and Samuelson (1971 *a, b*), a number of writers have returned to an older tradition, traceable in the works of Marshall, Ohlin himself, and Harrod, which assumes that, in the short run at least, capital goods are sector-specific. In the light of this tradition, the Heckscher–Ohlin–Samuelson model is seen as describing positions of long-run equilibrium only. In the short run any disturbance will lead to a reallocation of the labour force between sectors. But capital in each sector is a fixed factor, and so differences emerge between the rentals in the two sectors. Over a longer time-horizon capital will flow between sectors in response to these rental differentials, tending eventually (unless another disturbance intervenes) to a new long-run equilibrium with all capital goods earning the same rental.

This view of the adjustment process, which I propose to call the “short-run capital specificity” hypothesis, is hardly novel; apart from the earlier writers already cited it is implicit, for example, in Harberger (1962) and Kemp and Jones (1962). However, as formalised in recent work, especially by Mayer (1974) and Mussa (1974), it provides a plausible hypothesis about the economy’s response to exogenous disturbances. Moreover these writers have shown that it may be used to explain why there is no necessary contradiction between the somewhat counter-intuitive predictions of traditional international trade theory, and the more “commonsensical” views of politicians, businessmen and trade-union leaders.

The aim of this paper is threefold. First, it presents a new diagrammatic technique to illustrate the short-run capital specificity adjustment process in a small open economy. This technique is used in sections 2–4 to demonstrate the process of adjustment towards long-run equilibrium, following changes in commodity prices, population, and the level of factor market distortions. Sections 2 and 3 expound the findings of Mussa and Mayer on the effects of changes in the terms of trade and in total factor supplies, noting some extensions of these writers’ analyses. Section 4 then applies the technique to the consideration of changes in the level of factor market distortions. It is shown that conflicts between long-run and short-run interests may arise in this case: for example, workers in a labour-intensive sector may have an incentive to press for higher wages, despite the fact that in the long run their action will lower wages in both sectors.

* At various stages of writing this paper, I benefitted from the comments and suggestions of John Black, Dermot McAleese, Alan Richeimer, Frances Ruane, Maurice Scott, Alasdair Smith, and Nick Stern.

Second, the implications of the short-run capital specificity adjustment process are examined in the context of an open economy with pre-existing factor market distortions. Much of the recent literature in this area (see especially Jones (1971 *a*) and Magee (1976)) has been concerned with the elucidation of a number of paradoxes which can arise in the presence of such factor market distortions, of which two of the more notable are a perverse price-output response and a perverse distortion-output response. Section 5 begins by giving a new diagrammatic exposition of these paradoxes, and then shows that, if the economy is assumed to adjust according to the short-run capital specificity hypothesis, then *these paradoxes will never be observed*, because they correspond to *dynamically unstable* long-run equilibria. For devotees of the Heckscher–Ohlin–Samuelson model, this is an encouraging conclusion, since it implies that the long-run predictions of that model in the presence of factor market distortions are much more consistent with simple economic intuition than had been thought. The analysis of this section complements that of a companion paper, Neary (1978 *b*), where the same conclusions are shown to hold under a wider class of disequilibrium adjustment mechanisms.

The third aim of the paper is to point out the central role of the assumption of intersectoral capital mobility in traditional international trade theory. Section 6 surveys a number of cases, additional to those in sections 2–4, where this assumption is responsible for “paradoxical” or counter-intuitive conclusions. It is argued in section 7 that both common sense and the implications of observed self-interested behaviour on the part of market participants make this assumption inappropriate in the short run; and that the peculiar nature of the primary factor capital which it assumes – a fixed stock of homogeneous, infinitely long-lived, and perfectly mobile machines – makes it suspect in the long run.

2. SHORT-RUN AND LONG-RUN RESPONSE TO CHANGES IN THE TERMS OF TRADE

We begin by introducing the diagrammatic technique to be used in this paper. Essentially this combines two diagrams: the Edgeworth–Bowley production box, introduced to international trade theory by Stolper and Samuelson (1941), and the sector-specific capital diagram, familiar in writings on economic development, and used by Jones (1971 *b*) and Mussa (1974). As shown in Fig. 1, measuring the economy’s labour force on the horizontal axis of the Edgeworth–Bowley box enables us to place the two diagrams vertically above one another, and thus to examine simultaneously the short-run and long-run consequences of any exogenous change.

The usual assumptions of the two-sector model of international trade are built into Fig. 1, where the initial equilibrium is indicated by the points A_0 and B_0 in the upper and lower parts of the figure respectively. The economy produces two goods, X and Y , under perfectly competitive conditions in both commodity and factor markets, using fixed supplies of the two factors, labour and capital, and subject to constant returns to scale. In the long run, both factors are completely mobile between sectors. In the short run, however, there are diminishing returns

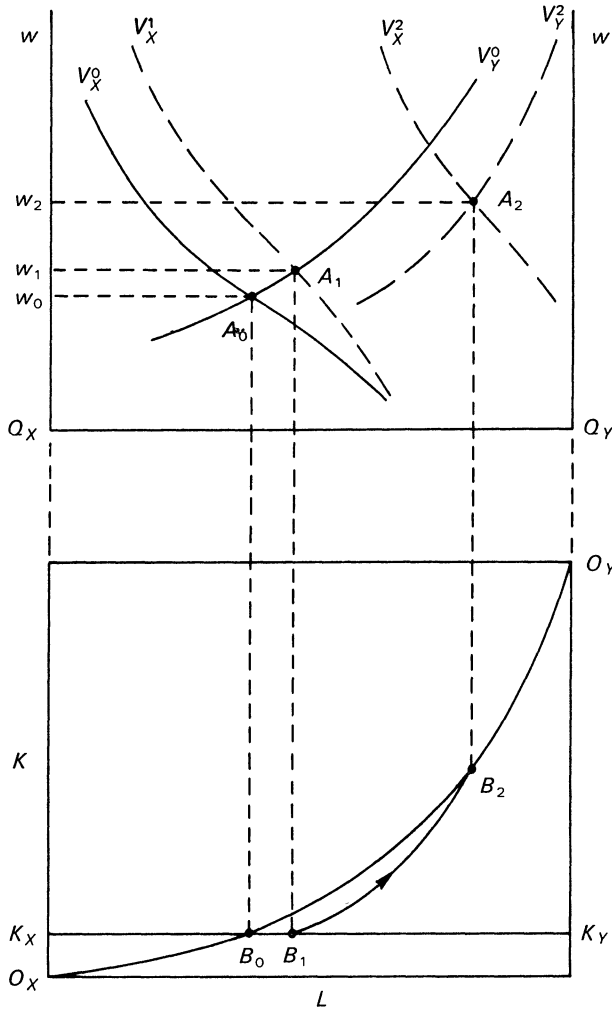


Fig. 1. Short-run and long-run adjustment to an increase in the relative price of the labour-intensive good X.

to labour in each sector, because of the fixity of capital goods. Hence, entrepreneurs in each sector maximise profits by increasing employment until the value marginal product of labour equals the wage. Assuming that the wage rate adjusts to ensure full employment at all times, the initial wage rate and labour force allocation is therefore determined by the intersection of the two value marginal product of labour schedules, V_X^0 and V_Y^0 , at A_0 in the upper part of Fig. 1. The location of these schedules depends on the initial commodity prices, and on the initial allocation of capital to each sector, with the latter represented by the distances $O_X K_X$ and $O_Y K_Y$ in the lower part of the figure. Finally, the fact that the initial position is one of long-run as well as of short-run equilibrium is shown by the fact that B_0 , the point in the lower part of the diagram which corresponds to A_0 , lies on the contract curve of the Edgeworth-Bowley box. This

contract curve lies below the diagonal of the box, reflecting our last assumption, that X is the relatively labour-intensive sector.

Consider now the effect of a displacement of this initial equilibrium by a once-and-for-all change in the terms of trade, involving an increase in the relative price of X . With capital sector-specific in the short run, we may begin by examining the upper part of Fig. 1. Choosing good Y as numeraire, the value marginal product of labour in Y schedule, V_Y^0 , is unaffected, whereas the corresponding schedule for the X sector shifts upwards, from V_X^0 to V_X^1 , by the same proportional amount as the price increase. Therefore the new short-run equilibrium will be that represented by the points A_1 and B_1 . (The latter point satisfies the restrictions that it lies vertically below A_1 , and on the same capital allocation line, $K_X K_Y$, as B_0 .) Labour has moved out of Y into X , and since the amount of capital in X is unchanged, the output of X has increased: thus even in the short run the economy responds to the rise in the relative price of X by expanding its output, to an extent determined by the slopes of the two value marginal product of labour schedules.

The short-run reactions of factor prices to this change have been considered in detail by Mussa (1974). The wage rate increases in terms of Y but falls in terms of X (this may be seen from the fact that the capital-labour ratio rises in sector Y but falls in sector X), so that the effect on the real income of wage earners is not independent of their consumption pattern. As for the rentals on capital, that in the X sector increases in terms of both goods, whereas that in the Y sector falls in terms of both. However, while all of these changes are of interest from the point of view of income distribution, the crucial fact from the point of view of resource allocation is that the capital rental in X has increased relative to that in Y . This may also be seen from the lower part of the diagram: since B_1 lies below the efficiency locus, it follows that the rental wage ratio is relatively higher in X , and since the same wage prevails in each sector this means that the rental must be higher in X than in Y . Given our assumed adjustment process therefore, competitive pressures will lead in the "medium run" to a reallocation of capital from the low to the high rental sector.¹ In the lower part of the diagram, this has the effect of causing the capital allocation line to shift upwards; in the upper part, both the V_X^1 and V_Y^0 schedules shift to the right, since an increase (decrease) in the quantity of capital in a sector must lead the marginal product of labour to rise (fall) at all levels of employment.

To establish the effects of this capital reallocation on factor rewards and on factor usage in each sector, we note first that the transfer of a given amount of capital from Y to X leads the former sector to seek to shed labour and the latter to try to acquire labour.² Since X is the relatively labour-intensive sector, the quantity of labour it wishes to acquire will, at the initial factor prices, exceed that which the Y sector is willing to give up. Excess demand for labour in the economy as a whole therefore develops, and so the wage rate is bid up. With both com-

¹ The timing and speed of this reallocation will depend on a variety of considerations including reallocation costs and entrepreneurial wage and price expectations. For a study which examines these aspects in greater detail, see Mussa (1975).

² I am very grateful to Alasdair Smith, whose comments suggested a major simplification of the remainder of this section.

modity prices constant, the increase in the wage must reduce the rental in each sector. This follows from the fact that the proportional change in the price of each good is a weighted average of the changes in factor prices in each sector, the weights being the share of each factor in the value of output of that sector:

$$\hat{p}_X = \theta_{LX} \hat{w} + \theta_{KX} \hat{r}_X, \quad (1)$$

$$\hat{p}_Y = \theta_{LY} \hat{w} + \theta_{KY} \hat{r}_Y. \quad (2)$$

Since the wage rental ratio rises in each sector as capital reallocates, both capital-labour ratios must also rise. The economy therefore moves away from B_1 in a north-easterly direction, along the path shown by a heavy line, which satisfies the properties that at every point along it the slope of the path is greater than the slope of the ray from O_X to that point, and less than the slope of the ray from O_Y to that point. This path may be called a “*labour-market equilibrium locus*”, because although it is characterised throughout by disequilibrium in the capital market, the labour market is in equilibrium at all points along it (in the sense that full employment of labour and a uniform wage rate prevail).

Finally, what happens to the intersectoral rental differential as the economy moves along this locus? The fact that X is the relatively labour-intensive sector means that the distributive share of labour is greater in X than in Y ; hence to keep relative commodity prices constant, it is necessary for the rental in X to fall by more than that in Y . This may be seen by setting the proportional changes in price in equations (1) and (2) equal to zero, and manipulating the equations to obtain:

$$\hat{r}_X - \hat{r}_Y = -\frac{\theta}{\theta_{KX}\theta_{KY}} \hat{w}, \quad (3)$$

where θ is the determinant of the matrix of sectoral shares, which is positive in this case, because X is relatively labour-intensive.¹ Equation (3) shows that, as a result of the transfer of capital between sectors and the consequent increase in the wage, the gap between the rentals in the two sectors has been partially closed. This process of capital reallocation continues until the gap is fully closed; at which time a new long-run equilibrium, corresponding to the points A_2 and B_2 , is attained. This new equilibrium is exactly that predicted by Stolper and Samuelson (1941), at which, relative to the initial equilibrium at A_0 and B_0 , the wage has risen and the rental common to both sectors has fallen in terms of each good. Thus the short run effect of the price change in increasing the rental on capital in the X sector is eroded, and eventually reversed, in the course of the adjustment process, as capital flows into the X sector in response to the higher return obtainable there.

Having examined the case where X is relatively labour-intensive, the case where it is relatively capital-intensive is straightforward. It is illustrated in Fig. 2. Perhaps the most important feature is that the initial reaction to the increase in the relative price of X is qualitatively identical to that in Fig. 1: as before, the wage rises initially in terms of Y , while the rentals on capital in X and Y rise and

¹ I.e. $\theta = \begin{vmatrix} \theta_{LX} & \theta_{LY} \\ \theta_{KX} & \theta_{KY} \end{vmatrix} = \begin{vmatrix} \theta_{LX} & \theta_{LY} \\ 1 - \theta_{LX} & 1 - \theta_{LY} \end{vmatrix} = \theta_{LX} - \theta_{LY}$.

fall respectively in terms of both goods. It is only in the course of the adjustment process that relative factor intensities play a role, as the verbal description above will have made clear. In this case, the movement of capital into the relatively capital-intensive sector reduces the demand for labour in the economy; hence the rental in both sectors rises, and the common wage rate falls, throughout the

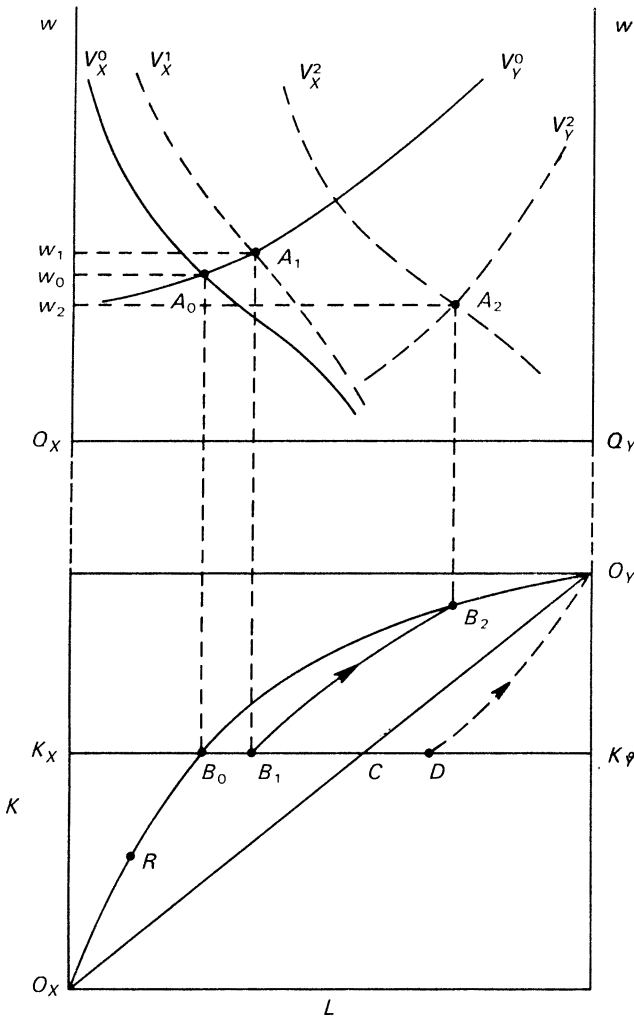


Fig. 2. Short-run and long-run adjustment to an increase in the relative price of the capital-intensive good X.

adjustment process. The capital-labour ratio in each sector therefore falls as capital reallocates, and so the path of adjustment from B_1 to B_2 is less steeply sloped at any point than the ray from O_X to that point, and more steeply sloped than the corresponding ray from O_Y . At the new long-run equilibrium (represented by A_2 and B_2) the wage will be lower than its initial value of w_0 . But, despite this, it is possible for labour actually to favour the change on completely

rational grounds, if its consumption pattern is sufficiently biased towards Y , and if either the speed of capital reallocation is sufficiently slow, or the rate at which labour discounts its future consumption to the present is sufficiently high.

The only additional qualification which must be made to the case where X is initially relatively capital-intensive, is that a sufficiently large price increase could cause the new short-run equilibrium point to lie to the right of C in the Edgeworth–Bowley box, thus reversing the initial factor intensity ranking of the two sectors. This possibility was pointed out by Mussa (1974, p. 1200, footnote 10), who claimed that such a factor intensity reversal would only be temporary, and that the factor allocation point in the Edgeworth–Bowley box would eventually recross the diagonal. However, this is incorrect: if the new short-run equilibrium occurs at a point such as D , to the right of C in Fig. 2, the factor allocation point will *not* recross the diagonal, but will move instead towards O_Y along the labour-market equilibrium locus indicated by the dashed line. The Y industry will eventually be completely eliminated, and the economy will specialise in the production of X . This follows from the fact (already established above) that, as capital reallocates, the expansion of the now labour-intensive sector X increases the wage rental ratio in both sectors. Hence the capital-labour ratio in sector Y cannot fall during the adjustment process, as it would have to if the labour-market equilibrium locus were to cross the diagonal.

In summary, this section has illustrated the conclusions of Mayer and Mussa that an increase in the relative price of X under the short-run capital specificity adjustment process will always imply a conflict between the short-run and long-run interests of at least one group of factor income recipients: when X is relatively labour-intensive, this is true of the owners of sector X capital, and when X is relatively capital-intensive it is true of both wage-earners and owners of sector Y capital. In addition it has been shown that, contrary to the suggestion of Mussa, a change in the terms of trade can never lead to a temporary reversal of the relative factor intensities of the two sectors, since the price change required to induce a short-run factor intensity reversal is more than sufficient to induce complete specialisation in the long run.

3. SHORT-RUN AND LONG-RUN RESPONSE TO CHANGES IN FACTOR ENDOWMENTS

The next case to be considered is that of a once-and-for-all increase in population, as examined by Mayer (1974). In Fig. 3 the initial equilibrium is at A_0 and B_0 , with X the relatively capital-intensive sector. Suppose now that the labour force (assumed to be identical to the population) increases by an amount equal to the distance $Q_Y^0 Q_Y^1$. With unchanged capital allocations, the V_Y^0 schedule is shifted to the right by the full extent of the population increase, leading to a new short-run equilibrium at A_1 , corresponding to the point B_1 in the production box.¹ It is clear from the diagram that the wage falls, and hence at constant (absolute and relative) commodity prices, the rental in each sector must rise. Moreover, from

¹ The point B_1 is above the new contract curve (not drawn) of the enlarged production box, since at B_1 the wage rental ratio in X exceeds that in Y .

equation (3) it follows that the rental must increase by a greater proportional amount in the relatively labour-intensive sector. Hence, in the “medium run”, capital moves along the labour-market equilibrium locus $B_1 B_2$ from the capital-intensive sector X into the labour-intensive sector Y , causing the wage rate to increase steadily, and the rental to fall in each sector, with the gap between the two rentals narrowing and finally being eliminated.

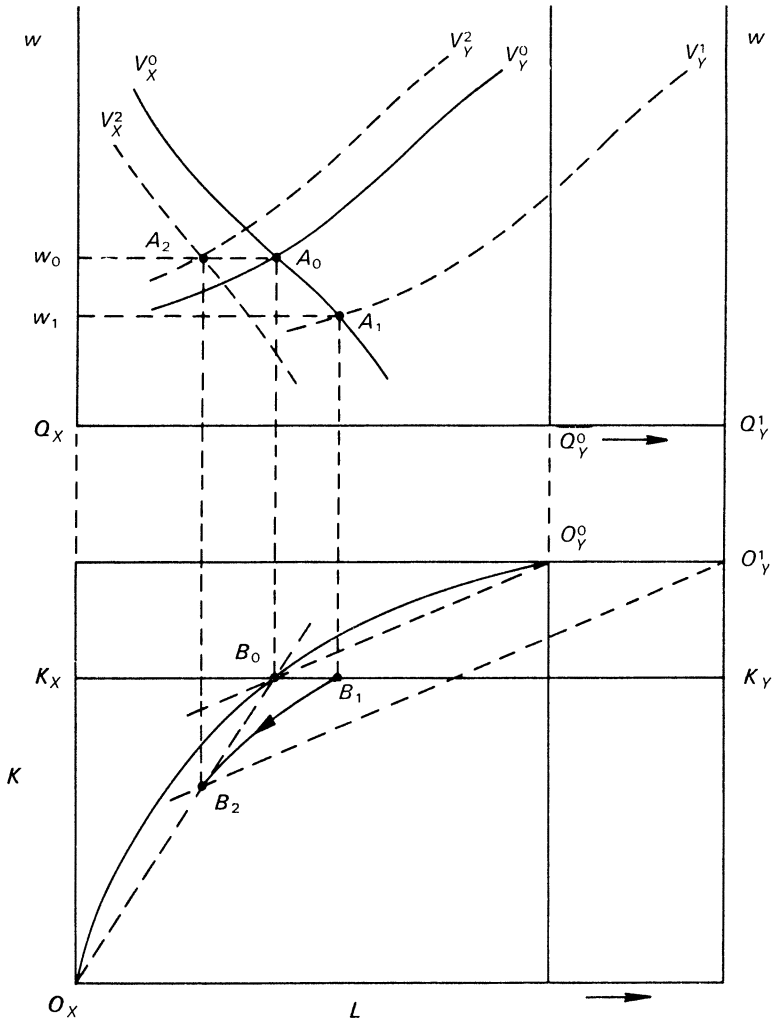


Fig. 3. Short-run and long-run adjustment to population growth.

From the Rybczynski theorem (Rybczynski, 1955) we know that the final long-run equilibrium must be at B_2 in the production box: with unchanged commodity prices and rentals equalised between sectors, relative factor prices, and hence factor proportions in each sector, must be identical to those which prevailed before the population increase. This may also be seen from the upper part of the diagram: the V_X and V_Y schedules have both shifted to the left to

intersect at A_2 , restoring the original wage w_0 . Despite this long-run independence of the wage from the size of population, however, if workers have any positive discount rate, they will (for example) oppose immigration in a small open economy on perfectly rational grounds. Furthermore, the strong Rybczynski prediction, that at constant relative commodity prices the output of the capital-intensive sector must fall, is shown to be a long-run result only: with sector-specific capital in the short run, the increased employment in X represented by the move from A_0 to A_1 means that the output of X will initially *rise* as a result of the population growth.

The case where X is relatively labour-intensive may be examined in the same way. As in section 2, this makes no qualitative difference to the new short-run equilibrium; but from equation (3) the intersectoral differential in capital rentals will be the opposite to the case just considered, leading to the familiar Rybczynski result of a fall in the output of Y in the long (though not in the short) run. Finally, the same diagrammatic technique may also be applied to the case of capital accumulation. Assuming the new capital is initially usable in one sector only, say X , it will displace the value marginal product of labour schedule of that sector to the right. Thus in the short run the wage rate will increase and so from equation (3) the rental in the relatively capital-intensive sector will increase by more than that in the other sector. Hence, assuming that both the initial and the new capital goods become mobile in the long run, capital will move into the relatively capital-intensive sector, until a new long-run equilibrium is attained where the original factor prices are restored. If X is the relatively capital-intensive sector, its output will increase both in the short and the long run. But if it is relatively labour-intensive, its output must fall in the long run. Indeed, in the latter case, not only the proportional, but the absolute amount of capital in use in X will be less in the final long-run equilibrium than that quantity which it used before the initial capital accumulation.

4. SHORT-RUN AND LONG-RUN ADJUSTMENT TO CHANGES IN FACTOR MARKET DISTORTIONS¹

In this section we apply the same framework of analysis to an examination of the process of adjustment to a change in the level of a factor market distortion, such as a trade-union imposed wage differential or a sector-specific factor tax. We continue to assume that the economy has no influence over its terms of trade. Moreover, we assume that the factor market distortion is introduced in a situation where factor markets are initially distortion-free. This assumption, of no pre-existing distortions, is a crucial one, and the consequences of relaxing it are examined in section 5.

We consider first the case of a wage differential, where the high-wage sector is relatively labour-intensive. In Fig. 4 the initial equilibrium is at A_0 and B_0 , with the same wage rate prevailing in each sector.² Suppose now that workers in Y

¹ Since this section was written, I have found a somewhat similar analysis in Hu (1973).

² I am very grateful to Dermot McAleese, who pointed out a serious error in an earlier version of this diagram.

become unionised, and succeed in obtaining a wage which exceeds that in the X sector by a proportionate amount measured by the distortion parameter α :

$$w_Y = \alpha w_X \quad (\alpha > 1). \tag{4}$$

This change has no immediate effect on the V_X^0 and V_Y^0 schedules in the top half of Fig. 4: with an unchanged capital allocation they continue to represent the

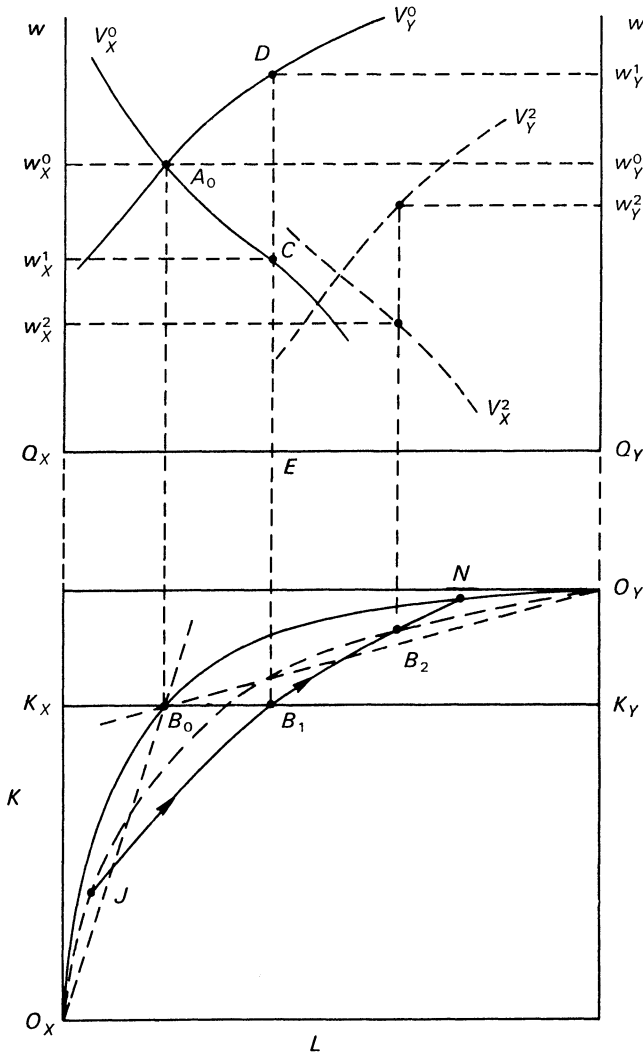


Fig. 4. Short-run and long-run adjustment to the introduction of a wage differential in favour of the labour-intensive sector Y .

value marginal product of labour in each sector. However, the effect of the union action is to drive a wedge between the value marginal products which can prevail in equilibrium in each sector. Faced with the obligation to pay higher wages, entrepreneurs in the Y sector will shed labour, and so a new short-run equilibrium will be established where the ratio between the value marginal

product of labour in the two sectors – that is, the ratio between the distances DE and CE – equals the distortion parameter, α . Clearly, the initial impact of the differential is, in qualitative terms, independent of the relative factor intensities of the two sectors: the wage in the unionised sector rises and that in the X sector falls, and each of these changes is less, proportionately, than the change in the differential.

Turning to the lower part of Fig. 4, one effect of the introduction of the wage differential is to shift the contract curve downwards as shown, since in long-run equilibrium the X sector now faces a lower effective wage rental ratio than the Y sector. The new distorted contract curve must therefore cut the initial capital allocation line, $K_X K_Y$, to the right of B_0 . However, it cannot cut it at or to the right of the new short-run equilibrium point B_1 , because the short-run fall in the X sector wage rate combined with the rise in the Y sector wage rate must at constant output prices lead to an intersectoral rental differential in favour of sector X ; hence B_1 must lie below the distorted contract curve. From a similar reasoning to that in section 2, it follows that in the medium run capital will reallocate from the unionised sector Y into the X sector, moving the economy upwards and to the right along the labour market equilibrium locus through B_1 ; and as capital reallocates into the relatively capital-intensive sector the wage rate is reduced in both sectors, and the intersectoral rental differential is narrowed.

Where will the new long run equilibrium occur? Evidently it must be at B_2 , the intersection of the labour-market equilibrium locus and the distorted contract curve to the northeast of B_1 , where the intersectoral rental differential is finally eliminated.¹ (The intersection to the southwest, at J , will be considered in the next section.) Moreover, as Magee (1971) has shown (and as will be demonstrated in the next section), the capital-labour ratio must fall in both sectors between the old and the new long-run equilibria; hence B_2 must lie above the ray $O_Y B_0$. It follows that the long-run effect of unionisation in the labour-intensive sector is to increase the rental and lower the wage in both sectors (implying that non-union wages must fall by more than the proportional wage differential²). This of course is the well-known result, derived in various ways by Harberger (1962), Johnson and Mieszkowski (1970), Jones (1971*a*) and Magee (1971), that an increase in the differential paid to a factor in the sector which uses it intensively may, and, when commodity prices are constant, must, reduce the factor's reward in both sectors. However, we have shown that this result is a long-run one only, for the short-run effect of the union action was to increase the wage in the Y sector. Hence, contrary to the implication of the result just mentioned, it may be perfectly rational for a union in a relatively labour-intensive sector to press for higher wages, if its discount rate is high enough, and the process

¹ If the initial move from B_0 to B_1 had been caused by an increase in the relative price of X , the new long-run equilibrium would lie on the original efficiency locus at N . Thus, comparing a price change and a wage differential change, each of which has the same short-run effect, the long-run effect of the price change is greater than that of the wage differential change. This is intuitively plausible, since wage costs are a smaller percentage of variable costs in the long run than in the short run.

² This is another example of what Jones (1965) has called the "magnification effect" in the two sector model with intersectoral capital mobility, which does not arise when capital is sector-specific.

of capital reallocation sufficiently slow. Similar results may be derived for the case where the unionised sector is relatively capital-intensive: in the long run, labour in both sectors must gain, but once again a conflict between short-run and long-run interests arises, this time in the case of labour in X .

Finally, what can be said of distortions in the capital market, such as a corporate income tax of the kind studied by Harberger (1962)? The imposition of such a tax has no effect on resource allocation in the short run: since capital in the taxed sector is a fixed factor, its income amounts to a Marshallian quasi-rent, the taxation of which will have no immediate impact on behaviour.¹ However, the resulting differential between the net rentals in the two sectors will lead eventually to a reallocation of capital away from the taxed sector. This shows an important difference between the short-run consequences of a capital and a labour tax, which follows from our assumption about the relative adjustment speeds of the two factors: the imposition of a capital market distortion has no immediate effect on resource allocation, whereas that of a labour market distortion leads to an immediate contraction of the sector obliged to pay the higher wage. In the long run, on the other hand, there is a basic symmetry between the two types of distortion, at fixed commodity prices, in the sense that qualitatively the same effects will follow the imposition of a tax (or a trade union differential) on labour in sector Y as will follow the granting of a *subsidy* to capital in the other sector.

5. PRE-EXISTING DISTORTIONS AND THE REVERSAL OF VALUE AND PHYSICAL FACTOR INTENSITY RANKINGS

In the previous section we explicitly confined attention to the situation where a factor market distortion is introduced to factor markets which are initially undistorted. For "small" pre-existing distortions the analysis already given continues to hold without modifications. However, for a sufficiently large initial distortion (precisely how large depends in a complicated manner on various characteristics of the economy) many recent writers have shown that the long-run conclusions of the last section, as well as some other results of the Heckscher–Ohlin–Samuelson model, will no longer hold. (See, for example, Jones, 1971*a*; Bhagwati and Srinivasan, 1971; Magee, 1976.) The source of many (though not all) of these departures from orthodoxy is a particular feature which the economy may exhibit in the presence of initial factor market distortions, namely a lack of correspondence between the value and physical factor intensity rankings of the two sectors. The purpose of the present section is to show that, under the short-run capital specificity adjustment process, this feature is necessarily associated with *dynamic instability* of long-run equilibrium in a small open economy, which implies that the comparative static paradoxes discussed by the authors mentioned are theoretical *curiosa* which will "almost never" be observed.

We begin by elucidating the meaning and significance of the two senses of factor intensity. Sector X is said to be relatively labour-intensive in the *physical*

¹ As is well known, this statement is crucially dependent on the validity of the assumption of profit maximisation.

sense if its observed capital–labour ratio is lower (in equilibrium) than that of the other sector (which is represented in the diagrams above by the contract curve’s lying below the diagonal of the Edgeworth–Bowley box); whereas sector X is said to be labour-intensive in the *value* sense if the share of payments to labour in the value of its output is higher than that in the other sector (which corresponds to a positive value of the determinant θ in equation (3)). When factor prices are equalised between sectors, that is, when factor markets are undistorted, the ranking of the sectors by these two concepts of factor intensity must be the same. But with an intersectoral divergence between marginal rates of substitution, either or both of these rankings can be reversed from their undistorted levels.¹ If *both* physical and value factor intensity rankings differ from their undistorted levels, the usual long-run predictions of the Heckscher–Ohlin–Samuelson model are unaffected. But if only one is changed, so that the rankings of the two sectors by physical and value factor intensity differ (i.e. one sector is capital-intensive in physical terms but labour-intensive in value terms), then many of the most familiar comparative static properties of the Heckscher–Ohlin–Samuelson model no longer hold. As Jones (1971 *a*) has emphasised, the reason for this is that it is the physical factor intensities which provide the link between the “real” variables of the model (i.e. factor endowments and output levels), while the value factor intensities link the “financial” variables (i.e. commodity and factor prices). When the rankings of the two sectors by these two factor intensity concepts differ, the link between the “real” and “financial” sides of the economy is broken, and various paradoxes can result.

Two of the most surprising of the paradoxes which appear when the value and physical factor intensity rankings of the sectors differ are: (1) a *perverse price–output response*: at constant factor market distortion levels, an increase in the relative price of one commodity will *lower* its output; and (2) a *perverse distortion–output response*: at constant commodity prices, an increase in the differential paid on either factor in one sector will *increase* the output of that sector.² While other authors have given algebraic proofs of these paradoxes, they may be demonstrated geometrically as follows, making use of the unit cost function diagrams in Figs. 5 and 6.³ In Fig. 5, which assumes no initial factor market distortions, c_X and c_Y are the unit cost functions for sectors X and Y respectively, corresponding to the initial relative commodity prices. The *slope* of each of these curves at any point is the capital–labour ratio which will be adopted in the corresponding sector when costs are minimised subject to the factor prices represented by the co-ordinates of that point; similarly, the *elasticity* of each of these curves at any point is the ratio of capital’s to labour’s share in the value of output when the sector faces these factor prices. Therefore, at the initial equili-

¹ For example, while the undistorted efficiency locus must lie on one side of (or else coincide with) the diagonal in the Edgeworth–Bowley production box, a sufficiently large distortion may shift it to the other side of the diagonal, so changing the relative physical factor intensities of the two sectors.

² To appreciate the paradoxical nature of (2), note that it implies that, at constant commodity prices, an increase in a subsidy paid to one sector (whether an output or an input subsidy) will reduce the output of that sector and its employment of both factors. See Neary (1978 *a*).

³ This diagram may be viewed as the “dual” of the Lerner–Pearce diagram. For a recent exposition, which discusses its properties in detail and shows its usefulness in deriving many trade theorems, see Woodland (1977).

brium A , where both sectors pay the same factor prices, w^0 and r^0 , sector X is relatively capital-intensive in both physical and value senses.

With no initial factor market distortions, the “normal” price–output and distortion–output responses of the economy may be demonstrated by combining Fig. 5 with the Edgeworth–Bowley boxes of Figs. 2 and 4. Thus, an increase in the

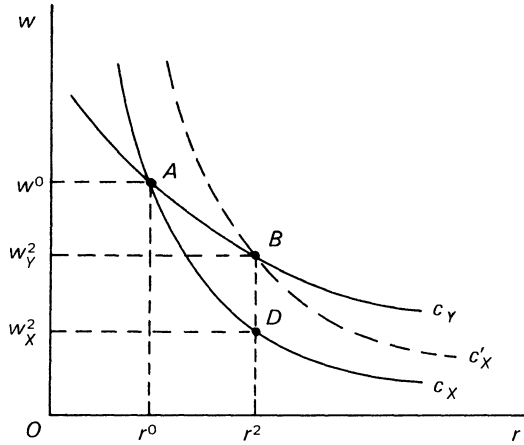


Fig. 5. Long-run effects of a change in relative prices and of the introduction of a wage differential, when factor markets are initially undistorted.

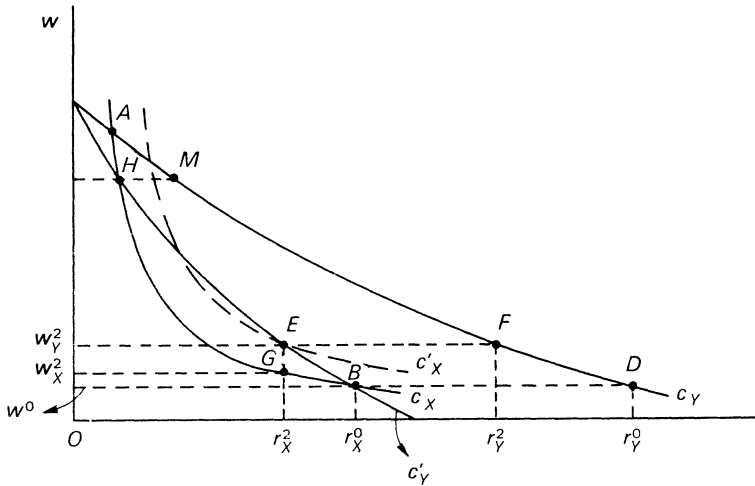


Fig. 6. Long-run effects of a change in relative prices and of the introduction of a wage differential, when initial factor market distortions are such that the value and physical factor intensity rankings of the two sectors differ.

price of X shifts c_X radially outwards from the origin, by an amount equal to the proportional magnitude of the price change. At the new long-run equilibrium, B , the usual Stolper–Samuelson conclusions of an increase in the real rental and a fall in the real wage (recalling that X is relatively capital-intensive) may be derived. Moreover, since the common wage rental ratio (represented by a ray

from the origin to B) has fallen, the capital–labour ratio in each sector must also have fallen. Hence, in the lower part of Fig. 2, the new long-run production point must lie along the contract curve to the right of B_0 , implying an increase in the output of X . Similarly, the introduction of a wage differential in favour of sector Y is represented in Fig. 5 by a movement from A to B for sector Y and from A to D for sector X . Once again the “effective” wage rental ratio (i.e. the ratio of the marginal product of labour to that of capital) has fallen in each sector, and so both capital–labour ratios must also fall. This confirms the assertion in section 4 above, that the new long-run equilibrium in Fig. 4 following the introduction of the differential must lie above the ray $O_X B_0$. It is evident that the output of sector Y has fallen, implying a “normal” distortion–output response.

The situation is very different when pre-existing distortions are sufficient to reverse the value and physical factor intensity rankings, however, as Fig. 6 demonstrates. If each sector were to pay the same factor prices, equilibrium would be at A , but instead the presence of a substantial *capital* market distortion with sector Y paying a higher rental leads to an initial equilibrium at B for sector X and D for sector Y .¹ This equilibrium is determined by the intersection of c_X and c'_Y , where c'_Y is a leftwards displacement of c_Y by the same proportionate amount as the initial capital market distortion (i.e. r_Y^0/r_X^0). The slope of c_X at B is greater than that of c_Y at D , implying that (as at the “undistorted” equilibrium A) sector X is relatively capital-intensive in the physical sense. However, the elasticity of c_X at B is *less* than that of c_Y at D , since it is easily checked that the latter is equal to the elasticity of c'_Y at B . Therefore, while X is relatively capital-intensive in the physical sense, it is relatively *labour*-intensive in the value sense, because the higher rental which sector Y is obliged to pay inflates the share of capital in the value of its output. The paradoxical conclusions are now easily derived. An increase in the price of X shifts c_X outwards to c'_X and implies a new long-run equilibrium with sector X at E and sector Y at F . The “effective” wage rental ratio, and hence the capital–labour ratio, has therefore increased in both sectors, and this implies that in Fig. 2 the new long-run equilibrium must lie on the contract curve, but to the left of B_0 , at a point such as R . Thus, the increase in the price of the commodity which is relatively labour-intensive (in value terms) increases the real wage, by the usual Stolper–Samuelson mechanism; but for this to be consistent with factor market equilibrium requires an expansion of the sector which is labour-intensive in physical terms, which implies a fall in the output of X , i.e. a perverse price–output response.

Similarly, the introduction of a wage differential in favour of sector Y may be decomposed into a *Stolper–Samuelson effect* which shifts equilibrium in Fig. 6 from B and D to E and F ; and a *pure wage differential effect*, which ensures that the equilibrium for sector X takes place not at E but at G , on the initial unit cost function, c_X . Hence, in the new long-run equilibrium, sector Y at F pays a higher wage *and* a higher rental than sector X at G ; the “effective” wage rental ratio, and so the capital–labour ratio in each sector has risen; and therefore the economy must have moved in Fig. 4 to a point such as J on the new contract curve, implying a

¹ Note that the initial equilibrium could alternatively be at H and M , instead of at B and D . It will be shown below that the equilibrium at H and M is stable, whereas that at B and D is not.

perverse distortion–output response, since sector Y which was obliged to pay a higher wage has in fact expanded.

So far, I have simply provided a new exposition of the effects of a difference between the value and physical factor intensity rankings: Figs. 5 and 6 have been exclusively concerned with comparisons between long-run equilibria, and have given no attention to the passage from one such equilibrium to another. Referring, however, to the discussion in sections 2 and 4, it is easily seen that, under the short-run capital specificity adjustment process, the economy will *never* converge towards the new long-run equilibria indicated by the above comparative static

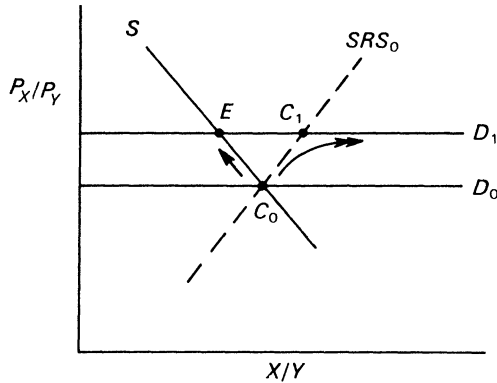


Fig. 7. Effects of a change in relative prices when the value and physical factor intensity rankings differ.

reasoning in the paradoxical cases. Consider, for example, the case of an increase in the relative price of X . The discussion in section 2 of the response to such a change is unaffected by a difference between value and physical rankings: when X is physically capital-intensive, the new short-run equilibrium will still occur at B_1 in Fig. 2, and since this point is below the contract curve of the box, there is an incentive for capital to reallocate from sector Y into sector X . Hence the capital allocation line $K_X K_Y$ in Fig. 2 will move upwards in the Edgeworth–Bowley box, and the factor allocation point will move along the labour-market equilibrium locus in the opposite direction to the new long-run equilibrium predicted by the comparative static analysis.

This contrast between the dynamic and the comparative static analyses is illustrated in relative output–relative price space in Fig. 7. The initial equilibrium is at C_0 , the intersection of the demand curve D_0 (horizontal because of the small country assumption) and the supply curve S , which is downward sloping reflecting the perverse price–output response. An increase in the relative price of X , represented by an upward shift of the demand curve to D_1 , should, according to the comparative static analysis, lead to a new long-run equilibrium at E , involving a fall in the relative output of X . But the dynamic adjustment process just outlined asserts to the contrary: the economy will first move along the short-run supply curve SRS_0 to the point C_1 ; and then, as capital reallocates into the X sector, that short-run supply curve will gradually move to the right, leading to a sequence of short-run equilibria as indicated by the double-headed arrow.

Eventually, as is clear from the production box analysis, a new long-run equilibrium will be attained either at a point where the long-run supply curve turns up again to intersect the new demand curve (this intersection would correspond to point B_2 in Fig. 2); or the supply curve never turns up, in which case the economy will be driven to specialise in the production of X (corresponding to a factor allocation at point O_Y in Fig. 2). In both cases the paradoxical price–output response will never be observed.

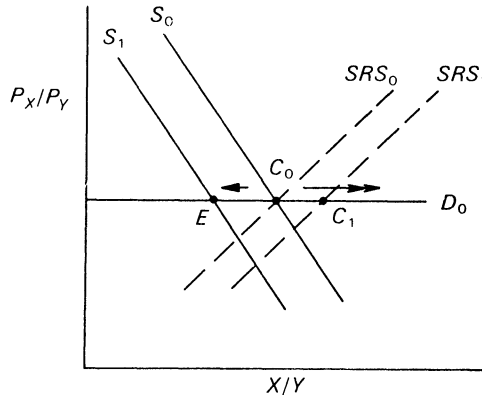


Fig. 8. Effects of a change in the level of a factor market distortion, when the value and physical factor intensity rankings differ.

An identical argument applies to the effects of a change in distortion levels. The comparative static analysis predicts that the new long run equilibrium in Fig. 4 will be at a point such as J ; but, following the first move from B_0 to B_1 , capital will move out of sector Y , and the factor allocation point will move in a north-easterly direction, towards a new equilibrium either at a point such as B_2 or (if no such point exists) at O_Y . In relative output–relative price space, as shown in Fig. 8, the long-run supply curve shifts to the left, reflecting a perverse distortion–output response. But the dynamic analysis shows that the equilibrium will initially move from C_0 to C_1 , as the short-run supply curve shifts from SRS_0 to SRS_1 ; and following the reallocation of capital into sector X the equilibrium will move to the right along the demand curve, as indicated by the double-headed arrow.

Evidently a similar analysis could be carried out for the effect of any exogenous change in an economy where the value and physical factor intensity rankings differ. The common feature of all these cases is that every long-run equilibrium in the Edgeworth–Bowley box corresponds to an intersection of the contract curve and a labour–market equilibrium locus (both of which must be upward-sloping); but from the simple dynamic adjustment mechanism implicit in the short-run capital specificity hypothesis, such equilibria are stable only when the labour-market equilibrium locus is *more* steeply sloped than the contract curve. This condition in turn implies that the rankings of the two sectors by value and physical factor intensities must be the same. Hence, we may conclude that the

long-run comparative static paradoxes which have received so much attention in recent writings are associated with unstable long-run equilibria only, and will therefore “almost never” be observed in practice.¹

6. INTERSECTORAL CAPITAL MOBILITY AND “PARADOXES” IN INTERNATIONAL TRADE THEORY: A SURVEY

Sections 2–4 above examined three of the more striking predictions of the Heckscher–Ohlin–Samuelson model of a small open economy – that protection has an unambiguous effect on the real wage, population growth leaves wages unchanged and reduces the output of one sector, and unionisation in the relatively labour-intensive sector reduces both union and non-union wages – and showed that they do not hold when capital is assumed to be sector-specific. The purpose of the present section is to survey a number of additional cases where the assumption of sector-specific capital (*SSC*) leads to more intuitively plausible results than the assumption of intersectoral capital mobility (*ICM*). It will be seen that adopting this perspective serves to synthesise a substantial portion of international trade theory. (Needless to say, the list is not intended to be exhaustive.)²

(i) *Technological progress and income distribution.* Findlay and Grubert (1959) and Johnson (1970, pp. 46–7) showed that, with *ICM*, technological progress in the relatively capital-intensive sector must lower the real wage at constant commodity prices. With *SSC*, however, McCulloch (1976) has shown that technological progress in *either* sector must benefit labour (except in an extreme case where the technological progress is Hicksian labour-saving, and the potential for factor substitution in the progressing sector is implausibly low).

(ii) *Technological progress and the terms of trade.* Findlay and Grubert also showed that with *ICM* technological progress in one sector is not necessarily “ultra-biased” (i.e. the output of the other sector need not fall), and hence it has an ambiguous impact on the terms of trade, if it “saves” the factor which that sector uses relatively *less* intensively. (For example, if exportables are capital-intensive, the effect on the terms of trade of labour-saving progress in exportables or of capital-saving progress in importables cannot be predicted without a knowledge of domestic demand patterns.) By contrast, with *SSC*, technological progress in one sector is usually ultrabiased (except in the extreme case mentioned in (i) above), and hence its effect on the terms of trade is in the “expected” direction (i.e. they improve following progress in the import-competing sector and deteriorate following progress in exportables). Thus the assumption of *SSC* serves to rehabilitate partially the much-maligned claim of Hicks (1953) that import-biased technological progress in the United States would improve the U.S. terms of trade.

¹ Although this conclusion has only been demonstrated here for a particular adjustment mechanism, I have shown in Neary (1978*b*) that it continues to hold under a more general mechanism which allows for non-instantaneous adjustment in the labour market.

² Not all the results for the specific capital model mentioned in this list have been published. Where references are not given, substantiation of the assertions made may be obtained from the author.

(iii) *Income distribution and the offer curve.* Johnson (1959) showed that if labour and capital income recipients have different consumption patterns, it is possible with *ICM* for imports to behave as a Giffen good in aggregate consumption, implying complicated shapes for the offer curve, and introducing the possibilities of multiple trade equilibria and reversals of trade direction. From a purely formal point of view, this phenomenon is identical with the redistributive effect which endangers the uniqueness of momentary equilibrium in Uzawa's two sector model of economic growth (which, of course, assumes *ICM*); see Hahn (1965). In both cases the paradoxical outcomes are possible when each factor has a higher marginal propensity to consume the commodity in the production of which it is used relatively intensively. Once again, however, these problems do not arise with *SSC* (at least when full employment is assumed).

(iv) *Harris–Todaro model.* In their analysis of rural–urban migration in response to differences between the actual wage in agriculture and the expected wage in urban areas, Harris and Todaro (1970) assumed *SSC*. However, subsequent work has extended their model to allow *ICM*, and has discovered the possibility of a number of “paradoxes”: an increase in the urban minimum wage can increase manufacturing output and employment (Corden and Findlay, 1975); urban unemployment may increase following capital accumulation and fall following population growth (*loc. cit.*); and the model is unstable if the urban sector is labour abundant relative to the rural sector (Neary, 1977). None of these pathological outcomes is possible in the original Harris–Todaro case with *SSC*.

(v) *Devaluation with rigid wages.* Jones and Corden (1976) have examined the effect of devaluation on the trade balance of a small open economy in a two-sector model which distinguishes between traded and non-traded goods rather than between exportables and importables. Assuming continual government intervention to maintain full employment and a constant nominal wage, they found that a devaluation always leads to a trade surplus under *SSC*, but (paradoxically) to a trade deficit under *ICM* when tradeables are relatively labour-intensive. Moreover, under the short-run capital specificity hypothesis, long-run equilibrium is unstable in the paradoxical case. Similar conclusions under *ICM* have been found by Helpman (1976) in a model which resembles that of Jones and Corden but allows the level of employment to vary.

(vi) *Variable factor supplies and specialisation.* The introduction into the *ICM* model of variable factor supplies which respond positively to their real return increases the likelihood that even a relatively small change in the terms of trade will lead the economy to specialise in one or other commodity (see Martin, 1976). In the limit, when one factor is in infinitely elastic supply at a given return (i.e. when the economy faces a binding minimum wage or rental constraint) there is only one relative commodity price ratio which is consistent with non-specialisation (see Brecher, 1974). With *SSC*, however, specialisation is much less likely: although Caves (1971, p. 18) claimed that if the capital goods specific to each sector were internationally mobile, one country would have to specialise, Amano (1977) has shown that this is not necessarily the case.

(vii) *Many-factor, many-commodity generalisations.* The elegance of the properties of the 2×2 model with *ICM* have led to many attempts to generalise them to

models with many goods and factors (all of the latter being assumed to be perfectly mobile between all sectors). (See Ethier, 1974, for a recent survey and extension.) Without wishing to denigrate the intellectual activity which has been expended on this, it is probably fair to say that the results in this area have been disappointing: the properties of the two-good two-mobile-factor model do not appear to generalise in any simple way to the many-goods many-factors case. By contrast, the extension of the *SSC* model to many commodities is relatively straightforward (see Mussa, 1974; and Jones, 1975).

The preceding survey provides convincing evidence, if any were needed, that *ICM* is the source of many of the counter-intuitive results or "paradoxes" to be found in international trade theory.¹ Another way of expressing the same point is that *SSC* provides a rigorous general equilibrium foundation for partial equilibrium analysis as far as the supply side of the economy is concerned, whereas with *ICM* partial equilibrium reasoning will frequently be misleading (see Samuelson, 1971*a*). At the very least, these observations provide a convenient unifying principle for much of international trade theory.

7. A CRITIQUE OF THE ASSUMPTION OF INTERSECTORAL CAPITAL MOBILITY

The preceding sections have interpreted the assumption of *SSC* as referring to the short run, and the Heckscher–Ohlin–Samuelson assumption of *ICM* as referring to the long run. However, it is tempting to go further and to argue that there is *no* time horizon over which the assumption of *ICM* is appropriate. For short-run analysis it is clear that *SSC* is more satisfactory;² this is confirmed by the fact that it is more consistent with the apparent perceptions of industry and trade-union lobbyists (see Magee, 1977). Of course, for medium- and long-run analysis, *SSC* is quite unrealistic: changes in exogenous variables which give rise to intersectoral differences in quasi-rents must lead sooner or later to intersectoral resource reallocation if competitive pressures are allowed to operate. It is here, however, that a major difficulty with the assumption of *ICM* becomes apparent: in practice, medium-run resource reallocation does not for the most part take the form of a diversion of physical capital equipment from one use to another, with the total stock of homogeneous, infinitely long-lived machines remaining constant throughout. Rather it appears frequently to take the form of a slowing down in the rate of replacement of depreciating capital goods in the declining sector, coinciding with a rechannelling of new investment towards the expanding

¹ It may be conjectured that *ICM* is the source of *all* the paradoxes which are peculiar to international trade theory, with the exception of those which arise from the failure to adopt first-best policies, and which therefore fall under the head of the theory of the second best. The latter include both those paradoxes which arise from the failure to follow first best *trade* policies (such as the Metzler paradox and the Bhagwati (1958) form of immiserising growth), and those which arise from the failure to follow first best *domestic* policies (such as various welfare paradoxes which are possible in the presence of factor market distortions, all of which may be viewed as special cases of the immiserising growth phenomenon; see Bhagwati (1973)).

² This is not to say that the assumptions underlying the short-run capital specificity hypothesis are completely satisfactory: for example, though immobile between sectors, capital is assumed to be no less substitutable for labour in the short run than it is in the long run. However, since shift lengths are variable even in the very short run, this assumption may not be excessively unrealistic.

sector. Once it is recognised that investment requires abstinence from consumption, it is clear that, except under very strong assumptions, this process will lead to a change in the total capital stock between the old and the new long-run equilibria. Hence the usual long-run Heckscher–Ohlin–Samuelson predictions will not follow in general.¹ Pending the development of a more satisfactory way of modelling the process of medium-run intersectoral resource allocation, this suggests that the Heckscher–Ohlin–Samuelson model should be treated with more caution and less esteem than is currently the case in international trade theory.

8. SUMMARY AND CONCLUSION

This paper has presented a simple geometric technique to illustrate the process of adjustment towards long-run equilibrium in a two-sector economy where capital is sector-specific in the short run. The technique was used to show how such an economy would react to changes in commodity prices, in factor endowments, and in the level of factor market distortions. It was shown that the rational pursuit by market participants of their own self-interest could lead to behaviour very different from that implied by traditional “long-run” international trade theory.

The technique was also applied to analyse the behaviour of the Heckscher–Ohlin–Samuelson model of a small open economy with pre-existing factor market distortions. It was shown that if such an economy is assumed to adjust according to the short-run capital specificity adjustment process, then an equilibrium where the rankings of the two sectors by physical and value factor intensities differ must be dynamically unstable. This means that a number of paradoxes which have attracted much attention in recent writings, such as a perverse price–output response and a perverse distortion–output response, will “almost never” be observed.

Finally, attention was drawn to the pivotal role of the assumption of intersectoral capital mobility in international trade theory: this assumption was shown to be largely responsible for a propensity to generate paradoxes which is seen by many as an unattractive feature of the theory. It was argued that the assumption is inappropriate over any time horizon: in the short run capital goods are not mobile, while in the medium and long runs their total stock is not fixed.

It would perhaps be going too far to suggest, paraphrasing Jevons’s remark about Ricardo, that the influence of Heckscher, Ohlin and Samuelson has shunted the car of international trade theory on to a wrong line.² Nevertheless, in a broader historical perspective, the concentration by trade theorists in the post-war period on an especially simple form of intersectoral capital mobility

¹ Even retaining the assumption of reallocation of a fixed stock of homogeneous machines between sectors, the Heckscher–Ohlin–Samuelson predictions will not hold in the long run if the two sectors face different costs of reallocation. See Mussa (1975).

² Such a suggestion would also be unfair to the originators of the theory. The analyses of Heckscher and Ohlin were considerably richer and less formalised than the theory which bears their name, while Ohlin at least can be interpreted as having assumed sector-specificity of capital, as Samuelson recently pointed out in his retraction of his own earlier views on factor price equalisation. See Samuelson (1971*b*).

may well be seen as a mistake, not merely because it is unrealistic (since this must be true to some extent of all assumptions) but because it focuses attention on a particular time horizon which bears little or no relation to any economically relevant time period. A more satisfactory way of conceptualising the effects of exogenous changes on medium run resource allocation is required.

Nuffield College, Oxford

J. PETER NEARY

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