The Leontief Paradox and the United Kingdom Patterns of Trade in Manufactures

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Abstract: The Heckscher-Ohlin model is concerned mainly with the causes and structure of international trade. According to this model trade arises because countries possess factors of production in different proportions. This leads to differences in factor prices which in turn lead to differences in the relative costs of producing goods. Countries relatively well endowed with capital, for example, will have a comparative advantage in the production of capital intensive goods and will export these and import goods which are labour intensive. Many empirical tests have been carried out to see whether the trade of various countries conforms to the predictions of the model. This paper provides one such test and is concerned with the trade of the United Kingdom. It concludes that, broadly speaking, United Kingdom trade is consistent with the Heckscher-Ohlin model.

A RECENT article by Hodd (1967) examined whether the observed pattern of United Kingdom trade was consistent with that predicted by the Heckscher-Ohlin theorem. Briefly, this theorem states that, in a two-country, two commodity, two-factor world, each country will have a comparative advantage in the product intensive in the use of the relatively abundant factor. Hodd concludes that United Kingdom trade was not consistent with the theorem. The present study also examines the pattern of United Kingdom trade in the light of the Heckscher-Ohlin theorem. However, the base year for the inquiry is more recent than that used by Hodd (1963 as opposed to 1947 and 1948), there is a higher degree of disaggregation of economic activity, and there are some differences of interpretation and methodology. Furthermore, the results of the present study differ from those of Hodd; the pattern of United Kingdom trade

is not found to be inconsistent with the predictions of the Heckscher-Ohlin theorem.

The present study broadly follows the methods of previous investigators. Specifically, the investigation takes the form of examining whether an average unit of value of a country's exports is capital or labour intensive compared with an average unit of value of import replacements. There are, however, some differences between this study and its predecessors (see, for example, Leontief, (1953); Leontief, (1956); Tatemoto and Ichimura, (1959); Wahl, (1961)). First, only trade in manufactured goods is considered. While United Kingdom exports consist mainly of manufactured goods, imports of manufactures comprised in 1963 less than 40 per cent of total imports. The exclusion of primary products is therefore important and requires justification. In this context, there is one important way in which primary production in general differs from manufacturing. This is that land, taken in its widest sense to include all natural resources, is normally an important input into primary production while most of the costs in manufacturing are incurred through payments to labour or capital. The pattern of comparative advantage in primary products does not, therefore, solely depend on countries' relative endowment of capital and labour. Since the work of Leontief (1953) the Heckscher-Ohlin model has generally been examined in terms of endowments of capital and labour with the exception of Vanek's (1963) study of the influence of natural resources on the trade patterns of the United States. It can therefore be argued that trade in primary products is not particularly likely to concur with the model as normally interpreted and such trade should be excluded.

The second difference between this study and some of its predecessors concerns the interpretation of the Heckscher-Ohlin theorem in a multi-country trading situation. When there are only two countries, then one country must be capital or labour abundant compared with the other (or factor endowments could be the same). If there are, say, three countries and these are ranked in order of capital abundance, the country ranking second must be labour abundant compared to that ranked first and capital abundant compared to that ranked third. One way of coping with this is that suggested by Lancaster (1957) who states that ". . . With more than two countries, any country is relatively abundant in a factor if the ratio of the endowment of that factor to the endowment of the other factor exceeds the ratio between the total world supplies of the two factors". The implication is that the "rest of the world" can legitimately be considered as one country. For a country's trade to be consistent with the Heckscher-Ohlin theorem, and assuming the country to be capital abundant as defined by Lancaster, then its total exports ought to be capital intensive compared with its total imports. This view appears to be shared by Hodd who states that ". . . a country that is capital abundant relative to the rest of the world will be a net exporter of capital services and a net importer of labour services". However, Hodd goes on to test the Heckscher-Ohlin theorem in a bilateral fashion (i.e., examining the relative factor intensity of exports to, and imports from, different countries or groups of countries).

Such an approach does not seem consistent with the above quotation, although it is argued below that the bilateral approach is the correct one.

As explicitly recognised by Bhagwati (1964), there is little guidance in the literature as to how the Heckscher-Ohlin theorem ought to be interpreted in a multi-country trading situation. The following attempts to rectify this omission.

Suppose there are three countries, A, B and C. A is assumed to be capital abundant and C labour abundant. B has a capital to labour ratio between that of A and C. In other words, B is labour abundant compared with A and capital abundant compared with C. Suppose also there are three goods, x, y and z. z is capital intensive compared with y and y is capital intensive compared with x (z is therefore capital intensive compared with x). It is assumed that there are no factor intensity reversals. This structure of factor endowments and factor intensities will produce a certain structure of commodity prices assuming that demand conditions are roughly similar in the three countries. Because y is labour intensive compared with z, the relative price of y in terms of z will be higher in B than in C (because B is capital abundant compared with C). Also, the relative price of y in terms of z will be higher in A than in B because A is capital abundant compared with B. Thus, the following structure of prices must hold:

$$\frac{Py}{Pz}A > \frac{Py}{Pz}B > \frac{Py}{Pz}C \tag{1}$$

Good x is labour intensive compared with y, so that the relative price of x in terms of y will be highest in the capital abundant country (A), lowest in the labour abundant country (C) and intermediate in B. Thus:

$$\frac{Px}{Py}A > \frac{Px}{Py}B > \frac{Px}{Py}C \tag{2}$$

It follows from (1) and (2) that:

$$\frac{Px}{Pz}A > \frac{Px}{Pz}B > \frac{Px}{Pz}C \tag{3}$$

This structure of commodity prices does not enable us to predict the precise pattern of trade when trade is opened up between A, B and C, but it does impose some important restrictions on the pattern that can emerge. In what follows, it will be assumed that all commodities are traded. It will also be assumed that

factor prices are not equalised after trade as a result either of specialisation or of transport costs or tariffs.[1]

The relative price of z (in terms of either x or y) is lower in A than in B or C while the relative price of x (in terms of y or z) is higher in A than in B or C. Similarly, the relative price of x is lower and the relative price of z higher in C than in A or B. A could not gain from the export of x and import of z and C could not gain from the export of z and the import of x. A must export z and import x and C must export x and import z.

Under normal assumptions, if a country exports a particular product (because that product is produced relatively cheaply), it will not at the same time import it. This is the only restriction that can be put on country B's structure of trade. B does not have an unambiguous comparative advantage in a production of any good over both other countries. But we know that country A will export z, so that if country B exports only z, it cannot export to A. Similarly, country C will export x, so if B exports only x, it cannot export to C.

In this study, we shall only be interested in trading situations where countries both export to, and import from, one another. This, of course, is the normal case in reality. Only in the following circumstance will B both export to, and import from, A and C. This is that B exports y to A and C and imports z from A and x from C. Country B's imports from C (x) will be labour intensive compared with exports to C (y) and B's imports from country A (z) will be capital intensive compared with exports to A (y).

Thus, in a trading situation where there are more than two countries, it can be stated that the Heckscher-Ohlin theorem predicts that a country's exports to countries with a higher capital to labour endowment ratio will be labour intensive compared with imports from these countries. Conversely, exports to countries with a lower capital to labour endowment ratio will be capital intensive compared with imports from these countries. This is the most general conclusion applying

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1. The reason for assuming that factor prices are not equalised relates to a point made by Melvin (1968). He shows that, when two countries are trading in a three good situation and factor price equalisation takes place, the structure of production and trade in each country becomes indeterminate. This is because a given product and factor price ratio is not accompanied by a unique combination of output as in the two-good case. The composition of output can be varied (in a specified way) while maintaining given factor and product prices. When two countries come together in a free trade relationship with the same product and factor prices a given structure of consumption can be supported by a number of alternative production structures in each country. For instance, suppose the production of good x is increased in country A with changes in the production of y and z which allow the same product and factor prices to prevail. If product and factor prices are the same in country B there can be changes of the same magnitude but in the opposite direction in production of all three goods with unchanged product and factor prices so that the total quantities of the three goods available for consumption remain the same. But if factor prices are not equalised as a result of trade this does not apply and the arguments used here will hold. Normally, with different factor prices, changes in the structure of production in one country such that factor and product prices remain unchanged will not produce exactly compensatory movements in production in the other country. In other words, a given pattern of consumption will not be supportable by more than one structure of production in each country.

to all trading countries. Regarding the trade of country A (which is unambiguously capital abundant) and country C (which is unambiguously labour abundant) rather more can be said. Because A is only trading with countries with a lower capital to labour endowment ratio exports to all countries (total exports) will be capital intensive compared with imports from all countries (total imports). Similarly with C where total exports will be labour intensive compared with total imports. Because country B will import relatively capital intensive goods from A (compared with exports to A) and relatively labour intensive goods from C, no such conclusion as to the relative factor intensity of the total exports and imports of country B can be reached.

The final conclusion can be illustrated by reference to the trade of countries A and C. A's imports from both B and C are labour intensive compared with exports to these countries. But the capital to labour ratio employed by A's imports from B divided by that ratio employed by A's exports to $B(\frac{K}{L}y / \frac{K}{L}z)$ is greater than the capital to labour ratio employed by A's imports from C divided by that ratio employed by A's exports to $C(\frac{K}{L}x / \frac{K}{L}z)$. Conversely, C's imports from both A and B are capital intensive compared with exports to these countries but C's imports from B are labour intensive (relative to exports to B) compared with C's imports from A (relative to exports to A). Generally, it can be stated that exports to a particular country will employ a higher capital to labour ratio relative to imports the greater is the labour to capital endowment ratio of that country.

Thus, it is normally the case that the Heckscher-Ohlin theorem has to be interpreted bilaterally. Only in the case where a country is capital or labour abundant compared with all other countries with which it trades will it follow from the Heckscher-Ohlin theorem that total exports are capital or labour intensive compared with imports.

The method used to measure the relative factor intensities of the different products is another area where the present study differs from its predecessors. Leontief (1953 and 1956) and his followers generally measured the amount of labour (in man years) and the amount of capital (in value) involved in the production of a value unit of output. There are difficult problems of computation involved in measuring inputs of capital. (There are also difficult problems of principle involved in the way that international economists choose to look at the concept of capital as a factor of production. These will be ignored here.) The practical difficulties in the present study where there is such a high degree of disaggregation, proved insurmountable and alternative measures of factor intensity had to be found. Two measures were, in fact, used: first, the share of labour income in value added and second, labour input per unit of value added. This second measure (or more usually its reciprocal which is known as the Lary statistic (Lary, 1968) (has several times been used for a similar purpose (for example

in McGilvray and Simpson's studies (1972 and 1973) of Irish foreign trade). These measures are legitimate given the assumptions of the Heckscher-Ohlin model. First, if the share of labour income is higher in the production of one commodity (x) than in another (y) then, because factors of production are paid the same in both industries (the assumption of factor mobility) and because the value of output that is not paid to labour must be paid to capital (the assumptions of two factors of production and perfect competition), it must follow that commodity x is labour intensive compared with commodity (y).[2] Second, if the number of units of labour employed per unit of value added is greater in the production of one commodity (x) than in another (y) then, using similar arguments, x must be labour intensive compared with y.

Thus either of the measures of factor intensity listed above are perfectly adequate given the validity of the Heckscher-Ohlin assumptions. But a word of caution is necessary here. If the Heckscher-Ohlin assumptions do hold in their entirety, then the conclusions of that model must hold also. The testing of the predictions of the model can be regarded, in part, as an attempt to examine whether the assumptions of the analysis represent a useful approximation to reality. The less the assumptions of the Heckscher-Ohlin model are relied on in testing the applicability of that model to the real world the better. The method of measurement of factor intensities used in this present study does not, therefore, represent good practice but is, in this case, unavoidable.

Details of the method of computing the factor intensities of exports and import replacements are given in the appendix.

For United Kingdom trade to be consistent with the Heckscher-Ohlin theorem then, in its trade with relatively capital abundant countries, exports ought to be labour intensive compared with imports. From column 1 of Table I it appears that ten of the fifteen countries are capital abundant compared with the United Kingdom (the United States, West Germany, France, Belgium, The Netherlands, Switzerland, Canada, Denmark, Sweden and Norway). When the share of labour income is used as an indicator of factor intensity (column 6), United Kingdom exports to nine of the ten countries are labour intensive compared with imports (the exception being Denmark). When labour requirements are used as a measure of factor intensity (column 7), United Kingdom exports to six of the ten countries are labour intensive compared with imports (the exceptions being France, Belgium, Switzerland and Denmark).

In its trade with relatively labour abundant countries, United Kingdom exports should be capital intensive compared with imports. Five countries are labour abundant compared to the United Kingdom: Italy, Japan, Spain, Ireland and Austria. Using the share of labour income as an indicator of factor intensity, exports to three of these are capital intensive compared with imports (the excep-

2. There is also the implicit assumption that a given value of x may employ more units of labour in production than the same value of y but that it cannot employ more capital than y also. This will hold given the normal competitive conditions.

TABLE 1: *Relative factor endowments and relative factor intensities*

Trade with:	$\dfrac{K}{L} \Big/ \dfrac{K}{L}$ UK	Share of labour income in:		Labour input in:		Share of labour income $\dfrac{X}{M}$	Labour requirements $\dfrac{X}{M}$
		Exports	Imports	Exports	Imports		
		(£'s per £1,000 of output)		(man years per £m of output)			
US	2·796	541·4	519·9	733·9	679·1	1·110	1·081
W. Germany	1·243	538·5	513·3	724·0	679·9	1·083	1·070
France	1·219	538·6	521·4	693·6	722·1	1·040	0·960
Italy	0·733	533·4	537·4	690·3	804·8	0·965	0·858
Belgium	1·373	523·4	514·8	665·8	724·6	1·028	0·919
The Netherlands	1·506	524·5	494·8	685·1	665·8	1·061	1·029
Japan	0·651	523·5	539·9	712·7	778·2	0·937	0·916
Spain	0·418	537·7	516·4	679·1	753·1	1·018	0·902
Switzerland	1·761	520·1	520·0	700·1	720·2	1·010	0·972
Canada	2·943	544·2	522·1	747·6	683·0	1·046	1·095
Ireland	0·588	525·5	534·5	717·4	857·7	0·951	0·856
Austria	0·881	524·3	533·2	682·2	767·3	1·016	0·889
Sweden	1·854	529·9	514·6	704·7	696·3	1·057	1·012
Denmark	1·166	527·6	538·1	695·4	747·4	0·908	0·930
Norway	2·194	569·3	520·6	750·7	664·8	1·122	1·129

tions being Spain and Austria). Using labour requirements, United Kingdom exports to all these are capital intensive compared with imports. It can be noted here that McGilvray and Simpson's (1972) results on the factor requirements of Irish exports to, and imports from, the United Kingdom concur with these found here. Output per man in both export and import replacement industries was lower than in the corresponding industries in the United Kingdom but was relatively lower in exports than in import replacements. In relative terms the difference in output per man between exports and import replacements was about the same whether looked at from a United Kingdom or an Irish point of view.

Thus, using the share of labour income as an indicator of factor intensity, United Kingdom trade with twelve of the fifteen countries appears consistent with the Heckscher-Ohlin theorem. When labour requirements are used, United Kingdom trade with eleven of the fifteen countries appears consistent with the theorem. If the Heckscher-Ohlin theorem were totally irrelevant to actual trade patterns, it would still be the case that the trade of about half the countries would appear to correspond with the theorem. The fact that substantially more than half correspond indicates that the Heckscher-Ohlin theorem is relevant to the United Kingdom pattern of trade. However, comparing columns 2 and 3 of Table 1 and also columns 4 and 5, it can be seen that the differences between the factor intensities of exports to, and imports from, the fifteen countries are normally rather small.

Employing arguments developed above, it is possible to go further. There should be a positive relation between the relative capital to labour endowment ratios of the various countries and the relative factor intensity of United Kingdom exports to, and imports from, these countries. There should, in other words, be a positive correlation between columns 1 and 6 and between columns 1 and 7 of Table 1. Such a correlation does exist. Using labour requirements as an indicator of factor intensity the correlation coefficient is $r = +0.837$ indicating quite a strong relation. Using the share of labour income the relation appears less strong with a correlation coefficient of $r = +0.533$. It may be noted that Hufbauer (1970) performed a similar type of test in a rather different context by correlating the capital intensity of the exports of twenty-four important trading countries with their capital to labour endowment ratios. The resulting correlation coefficient was $+0.7$.

In summary, the present study attempts to test whether United Kingdom trade in manufactures is consistent with the pattern predicted by the Heckscher-Ohlin theorem. It was argued that this theorem ought to be interpreted in a bilateral fashion and that the relative factor intensity of United Kingdom exports to, and imports from, her trading partners ought to be compared with the relative factor endowments of those countries. When this was done it was found that in most cases trade patterns were consistent with the Heckscher-Ohlin theorem.

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APPENDIX

In the present study, manufacturing industry in the United Kingdom was disaggregated into ninety-five sectors. Most, though not all, comprised one minimum List Heading of the Standard Industrial Classification. The main source of industrial information was the UK Census of Production, 1963 (Board of Trade, 1968). To carry out a test of the Heckscher-Ohlin theorem in the Leontief manner, an inverted input output matrix is necessary. A table of input coefficients was obtained from Census data (which listed purchases of different commodities by Minimum List Heading industries), and, after some adjustment to take account of the fact that the above data were concerned only with firms having 25 or more employees, this matrix was subtracted from a unit matrix and inverted to give $(I-A)^{-1}$. The rows of the inverse were then multiplied by the ratio of net to gross output in each industry. The columns of this matrix do not sum to unity, but to less than unity because only manufactured inputs are being taken into account.[3]

3. An inverted matrix of 70 sectors was subsequently published by the CSO (1970) but was not available when the present work was started.

Information on labour income and labour requirement per unit of net output of each of the ninety-five industries was obtained from the Census of Production. This was organised into a two-row, ninety-five column matrix which was then postmultiplied by the inverse $(I-A)^{-1}$. The first row of the resulting two-row, ninety-five column matrix shows the labour income generated in manufacturing by the production of one value unit of each commodity. The second row is similar but refers to labour requirements. Because not all the value of commodities originate in manufacturing, the figures for labour income and labour requirements are usually less than the data from which they derive. To correct this, each column of this matrix was divided by the appropriate sum of the rows of the inverse $(I-A)^{-1}$. This is equivalent to assuming that all the value of output in each sector is produced by the manufacturing sector.

Next, it was necessary to obtain information on the structure of trade of the United Kingdom with various trading partners. United Kingdom trade with fifteen countries was considered. The data were obtained from the Annual Statement of Trade, 1963 (H.M. Customs and Excise, 1965). These data were organised in the form of a matrix with ninety-five rows, one for each sector. Each pair of columns represented UK exports to, and imports from, one country so that, in all, there were 30 columns.

The trade matrix was then pre-multiplied by the matrix of factor intensities, the result being a matrix of two rows and thirty columns. The first row shows the total labour income generated by UK exports to, and imports from, each of the fifteen countries and the second row conveys the same information with respect to total labour input. Each element in each row was divided by the value of exports and imports so as to give the average share of labour income per £1,000 of exports or imports and the labour requirement for £1 million of exports or imports.

Next, it was necessary to estimate the factor endowments of the fifteen countries and compare them with the endowments of the UK. With regard to the supply of labour the necessary statistics were available from the Year Book of Labour Statistics (International Labour Office, 1969). As regards the supply of capital, statistics were obtained from OECD (1970) sources on National Accounts. Annual investment figures (at constant prices) for different countries were summed after being converted to pounds sterling at current exchange rates over fifteen years to give rough estimates of capital stock. Capital to labour endowment ratios were obtained for these countries and were divided by the UK capital to labour endowment ratio. If the resulting quotient exceeded one, then the country concerned is capital abundant compared with the UK and if it is less than one, the country is labour abundant compared to the UK. Again, the larger the amount by which the quotient exceeds one, the more capital abundant will an economy be compared to the UK.

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