

Chapter III

THE LEONTIEF PARADOX

It is now more than a decade ago, Professor Leontief made the first extensive test of the Heckscher-Ohlin theorem.¹ His surprising discovery that a representative bundle of the United States exports has relatively larger labour content compared to capital content was quite effective in jeopardising the theory. Economists were busy repairing the damages to the Heckscher-Ohlin theory through alternative explanations and hypotheses to the so-called 'Leontief Paradox.' This contributed much to theoretical and empirical research to explain the commodity pattern of a country's trade. The purpose of this chapter is to evaluate Leontief's study of the United States foreign trade and the various hypotheses that have been advanced to explain the paradox.

Professor Leontief on the Pattern of the United States Foreign Trade

(Professor Leontief, in his celebrated article of 1953 set out to investigate empirically the Heckscher-Ohlin theory

¹ Leontief, W. W.: "Domestic production and foreign trade: the American capital position re-examined", in Proceedings of the American Philosophical Society, Vol. 97, 1953. Reprinted in Readings in International Trade, edited by Jagdish Bhagwati, Penguin Modern Economics, 1969, pp. 93-139.

using the American trade structure. The methodology employed is an interesting application of his own invention, input-output model. Using this model, Leontief imagines a situation in which the United States decides to decrease both her exports and competitive imports proportionately by one million dollars each. But a cut of one million in the United States competitive imports would ultimately mean that her industries will have to produce an additional one million worth of goods domestically. In such a case what is the capital and labour content (both direct and indirect), of this one million worth of import replacements? Similarly, what is the amount of labour and capital (direct and indirect) released following a reduction in exports by one million worth of dollars.²

²For deriving these two, Leontief employs a 200 by 200 input-output table based on 1947 inter-industry structure, but aggregated to 50 sectors for computational facility, 38 sectors of which participate in foreign trade. The inverse of this matrix is pre-multiplied by direct capital and labour coefficients. (The economic significance of these two coefficients is that they express the direct requirements of capital and labour for \$ 1 worth of output. The labour coefficient is expressed in terms of non-differentiated man years of labour. The capital represents only items like machinery, buildings and other fixtures and inventories and not everything other than labour.) That added columnwise gives a row vector for each indicating the direct and indirect capital and labour content for \$ 1 worth of output. This row vector, when, premultiplied by the vector of exports (proportionately reduced to one million) and competitive imports (one million worth) gives the direct and indirect capital and labour content for one million worth of exports and competitive imports. Imports are categorised into competitive and non-competitive, the latter group consisting items like coffee, tea, jute and few other items which are not easily substitutable in the United States. These non-competitive imports are excluded from the final calculations.

Leontief's findings are given below in Table 1. It emerges from Table 1 that an average one million dollars worth of American exports use less capital and more labour than would

Table 1. Capital and labour requirements per million dollars of U.S. exports and competitive import replacements, 1947.

	Exports	Import Replacements
Capital (dollars in 1947 prices)	2550780	3091339
Labour (Man-years)	182.313	170.004

Source: See Leontief. Op.Cit.,

be required if the same amount of import replacements are produced domestically. This implies that the United States participates in International trade in order to dispose her surplus factor, labour and economise the scarce factor, capital. This is contrary to the expectation and the long standing conventional assumption that the United States is capital rich.

Professor Leontief, unsatisfied with the paradoxical result, attempted to reconcile his findings with the Heckschen-Ohlin theory. For this, he rules out the assumptions of internationally homogeneous labour and comparative technological parity and replaces it by an alternative assumption

that "in any combination with a given quantity of capital, one man-year of American labour is equivalent to, say, three man-years of foreign labour."³ This reasoning permits Leontief to make quantitative alterations in his empirical findings. After such an alteration, the effective labour supply in the United States would increase to 195 million of equivalent foreign man-years which would imply that the capital supply per qualitatively identical labour is comparatively smaller in the United States than that of many other countries. Thus a final conciliation with the Heckscher-Ohlin theory shows that the United States is a relatively labour abundant country and engages in trade to save her scarce capital.

In his second report⁴ on the continuing investigation of factor structure of American foreign trade, Professor Leontief introduced a number of refinements. First, he tried in response to wide reaction against his first paper, to justify his methodology theoretically through a linearized version of the neo-classical theory of International trade. He pleads that knowledge regarding the effective production capabilities

³See Leontief. Op.Cit., p.127. Leontief's reasons for the high superiority of American labour are purely suggestive. He attributes it to entrepreneurship, superior organisation and other factors like education and general climate of America's production-oriented society.

⁴Leontief, W. W.: "Factor proportions and the structure of American Trade: Further theoretical and empirical analysis." Review of Economics and Statistics, November 1956. pp.386-407.

of one of the trading countries is sufficient for his problem because of the non-availability of such wealth of data at this stage regarding (a) the endowment of each of the trading countries with the so-called primary factor of production. (b) the shapes of the production functions i.e. of the input-output relationships which govern in each country, the transformation of these primary resources into various goods and services and (c) preferences determining in each area the choice among alternative bundles of finished commodities which it could actually attain through alternative combinations of domestic production and foreign trade.

Second, he introduced a number of changes in the bases of data used and the analytical procedure employed: (a) the indirect capital and labour requirements, which in the earlier paper were based on the inverse of a smaller, aggregated 50 sector matrix, are now based on the complete 192 industry matrix, (b) the input-coefficients, which reflected only the "current cost" flows in the earlier paper, now included the long run cost flows⁵ such as, "flows of buildings, machinery and other durables which each industry has to receive in order to maintain intact the stocks of fixed capital on which its productivity capacity depends."⁵ (c) the measurement of labour which was described in terms of undifferentiated man-

⁵See Leontief: Second Report. Op.Cit., p.393.

years in the earlier paper, now incorporated a breakdown of labour inputs by major skill and occupational groups. (d) Leontief introduced a theoretical refinement in his latest computation which he calls "balance of payments correction in respect of non-competitive imports." In his earlier study, it was assumed that labour and capital employed to produce one million dollars' worth of exports are sufficient to exchange for one million dollars' worth of competitive imports. However this may not be so since the production of either type of good in the United States requires imports of non-competitive imports in addition to labour and capital which again must be paid by an equivalent quantity of exports. This means that the United States will have to sell less than or more than one million, exports to get in exchange one million worth of imports. Two adjustments are mentioned: (i) these additional exports will serve to pay for the direct and indirect requirements of non-competitive imports, (ii) a cut in the domestic output of competitive imports, caused by an increase in competitive imports will release some imports of non-competitive imports which are previously absorbed in their production. After taking into account both these adjustments in his computations, Leontief comes to the conclusion that "for an economy as self-sufficient as that of the United States, the balance of payments correction for non-competitive imports

is very small."⁶ (e) There is a detailed discussion regarding non-competitive imports with more conceptual clarity which was lacking in his earlier report. He attempts to specify a close relation between those imports and natural resources, but "the absence of comprehensive statistical information regarding their supply and utilisation" makes the inclusion of this third factor into the input-output competitions still impracticable. However, he makes a tentative attempt to evaluate the effect of factors other than labour and capital on the pattern of the United States foreign trade by transferring sectors comprising of raw and semi-fabricated imports from the competitive category to non-competitive category. He also makes a number of separate computations for all the sectors of the economy except the service sectors.⁷ / Despite all these alterations and refinements, Leontief's basic conclusion that the capital labour ratio of the United States exports is low compared to her import replacements, remained the same as in the first paper.)

⁶ See Leontief: Op.Cit., p. 395.

⁷ The exclusion of service sectors is with the purpose of eliminating the bias in the computed results due to low capital output ratio for wholesale trade etc., entering only the exports which would increase the labour requirements and reduce the capital requirements per unit of the United States exports. It will have an opposite effect on the factor requirements of competitive imports to the United States.

Hypotheses Explaining the Paradox

The theoretical and empirical research carried out in the last one and half decade on Professor Leontief's study has brought out a number of hypotheses explaining the paradox. These maintain that the actual pattern of the United States foreign trade can be accounted for: (i) Methodological and procedural deficiencies in the Leontief analysis, (ii) Statistical deficiencies in Leontief's computations, (iii) Factor intensity reversals sufficient enough to upset the Heckscher-Ohlin proposition, (iv) Demand based explanation, (v) Natural resource scarcity in the United States coupled with a strong complementarity relation between natural resource and capital, (vi) Influence of tariffs and non-tariff distortions in trade, (vii) A relatively high proportion of skilled labour in the United States, and (viii) Research and Development factor in the United States industries.

1. Methodological and procedural deficiencies:

Ellsworth, Jones and Valvanis-Vail view that the Leontief paradox is a sinequanon of his methodology. Of all, Ellsworth has been the most critical.⁸ Firstly, Ellsworth states, that to determine whether the United States is capital intensive or labour-intensive, one must find out the relative capital

⁸Ellsworth, P. T.: "The structure of American foreign trade: A new view examined." Review of Economics and Statistics, August 1954. pp.279-285.

that the import-replacements of the United States are capital intensive.

Thirdly, Ellsworth believes that identical relative factor productivity is consistent with the Heckscher-Ohlin theorem because, if either factor, say labour differed in productivity in different countries, different production functions would be relevant. "A country with scarce labour and abundant capital, if its labour were several times as productive as that of its trading partners, need not tend to specialise in the production of capital-intensive products, but might adopt methods requiring relatively extensive use of its more productive factors, labour."¹¹ According to Ellsworth, labour has to be regarded everywhere inherently the same in quality and more realistic explanation of higher productivity of American labour has to be sought in more abundant supplies of the co-operating factors - entrepreneurship, natural resources and capital. He argues that relative factor prices expressed in terms of a common currency is a better indicator to determine the comparative advantage.

Valvains-Vail¹² attributes the paradox to the application of static input-output model to the problems of International trade. His view is that we cannot infer from factor combination in rigid proportions whether every factor can be completely

¹¹ See Ellsworth. Op.Cit., p.281.

¹² Valvains-Vail. "Leontief's Scarce Factor Paradox." Journal of Political Economy. December 1954. pp. 523-528.

used up, either with trade or in its absence. If there is full employment before trade in each country, he argues, then it is difficult to say whether world output be more after trade, since it is likely that output of some commodities will increase while that of others will decrease. It implies that the static input-output model can be used only when trade does not decrease the world output of any commodity which is a very rare and special case. This also does not permit the use of dynamic input-output model because dynamic model is either incompatible with trade or, if compatible, does not tell us anything about the patterns of trade from a mere study of factor scarcity.

2. Statistical deficiencies:

Statistical deficiencies in Leontief's computations are interpreted as reasons for the paradox by Swerling, Diab, Buchanan and Vaccara.

Swerling¹³ dislikes Leontief's system of weighing the export and import sectors through a proportionate distribution. He claims that such a weighing system gives undue weightage to certain sectors. One effect of such a conversion on proportionate basis is "the pre-eminent position of agriculture and fisheries on the import side in the statistical ^{al}claculations even though the sector enjoyed a net export surplus in absolute

¹³Boris, C. Swerling. "Capital shortage and labour surplus in the United States". Review of Economics and Statistics, August 1954. pp. 286-289.

terms."¹⁴ He believes that a correct procedure might be to take weights based on the ratio of net exports or net import to domestic consumption. Secondly, he claims that Leontief's quantitative results are biased because of the postward disorganization in production and the year 1947 cannot be accepted as a year for generalization. Thirdly, he postulates that the capital requirements of United States exports are "seriously biased downward because most exports contribute something to wholesale trade, which has one of the lowest capital-labour ratios."¹⁵

Normal Buchanan¹⁶ finds deficiency in Leontief's calculation of capital coefficients. He states, "If the Leontief model were truly a two factor model it would have to include land as a part of the capital input."¹⁷ He claims that the the inclusion of land along with capital will inflate the capital requirements to agriculture and fishery, food and hindered products and tobacco manufactures which accounted for

¹⁴See Swerling. Op.Cit., p. 287.

¹⁵See Swerling. Op.Cit., p.287. Leontief partially answered all these criticisms in his second paper (1956) by excluding the agriculture and fisheries and service sectors from the computations and basing his calculation for 1951.

¹⁶Normal Buchanan. "Lines on the Leontief paradox." Economia Internazionale, November 1955. pp.791-797.

¹⁷See Buchanan. Op.Cit., pp. 791-797.

22 per cent of one million dollars worth of exports and 38 per cent of imports. Leontief paradox is a sinequanon of this omission of land factor as capital-input. Further, he argues that the capital-coefficient in the Leontief model are not really capital coefficients in the sense of International trade theory, but are investment requirement coefficients i.e. "the amount of investment in capital goods per unit of value product that is used, on the average, in the various industries."¹⁸ The consequence is that, though the investment requirement coefficient of Leontief include both direct and indirect investment requirements, it is doubted whether the depreciation rate for capital in all industries can be assumed to be approximately the same. If this doubt is true, then Leontief's capital coefficient is not an index of capital cost per unit of output except for the short run problems.

A further detailed examination on the relevance of Leontief's capital coefficients is presented by Diab.¹⁹ He pleads that the capital coefficient of agriculture and fisheries sector is high. Therefore it has inflated Leontief's final results because these sectors occupy a high proportion per million dollars of imports. He is equally critical of Leontief's technique of deriving these capital coefficients.

¹⁸See Buchanan. Op.Cit., pp. 791-797.

¹⁹Diab, M.A. The United States Capital Position and the Structure of the Foreign Trade. Amsterdam, North Holland Publishing Company. 1956. pp. 52-53.

He computed a new set of capital coefficients based on the more realistic assumption that the capital coefficient of agriculture and fisheries could hardly exceed 1.5244 dollar per dollar as against Leontief's 2.5244. With this new capital coefficients for agriculture and fisheries sector, the capital stock of this sector comes to 75 billion dollars as against the magnitude of 125 billion dollars under Leontief's coefficient for this sector. His final results, after the required computations, show that the disparity between capital content of export and import replacements have narrowed down to \$ 2279500 and \$ 2599831 respectively as against Leontief's \$ 2550780 and \$ 3091339. He writes, "This is primarily so, in view of the fact that products of agriculture and fisheries occupy directly and indirectly, a higher proportion of imports per million dollars than they do in exports, hence the smaller is the capital coefficient of that sector the less quantitatively apparent would be the contention that the United States exports use less capital per dollar than do imports if they are to be produced at home."²⁰

Further Diab argues that Leontief's capital and labour coefficients must be based on units of value added, rather than on units of final product. He says, "Only on this basis that any meaningful inter-industry comparison of capital-intensity

²⁰See Diab. Op.Cit., p.52. But despite these adjustments, Diab's figures do not improve upon Leontief's conclusion.

can be made with a view to employ the results in economic analysis."²¹

Vaccara's prosecution is that the commodity basket of an industry's import is an approximation of its domestic output, but the imported commodity basket, consisting of labour-intensive commodities, may not be so.²² Therefore Leontief's results show a downward bias for labour requirements for import replacements.

3. Factor-intensity reversals:

Another explanation of the Leontief paradox stems from the possibility of factor-intensity reversals. Minhas, in one of his pathbreaking article in 1962,²³ questioned the very validity of Samuelson's strong factor-intensity assumption (implied in the Heckscher-Ohlin theorem), the non-acceptance of which makes the theorem invalid. Minhas, after refuting the strong factor-intensity assumption, demonstrated how a given pair of two isoquants intersect more than once. A commodity in this case, cannot be definitely defined as labour-

²¹ See Diab. Op.Cit.

²² Vaccara. "Factor proportions and the structure of American trade. Further theoretical and empirical analysis - Comment." Review of Economics and Statistics, XL (Supplement February 1958), No. 1, Part 2. pp. 118-119.

²³ Minhas, B.A.: "The homohypallagic production function, factor-intensity reversals and the Heckscher-Ohlin theorem." Journal of Political Economy, Vol.70, April 1962. pp.138-156.

intensive everywhere, unless the relative factor prices are specified. Minhas states, "In agreement with the results of recent theoretical research, it is concluded that, in general, neither the direction of trade nor the effects of trade on factor prices can be unambiguously established and evidence is produced to show that exceptions to Heckscher-Ohlin propositions are not empirically implausible."²⁴

To demonstrate the "factor-intensity reversal" Minhas fits his CES production function²⁵ to twenty four industries classified at the three-digit level in the International standard industrial classification by employing the inter-country cross sectional data. The number of countries covered in the investigation varies from 11 to 19 and the data which is collected from the Census of manufactures for these countries, pertain to different years between 1950 and 1955. The elasticity of substitution computed for the twenty four industries are shown to vary from 0.7211 to 1.0114. He puts to test only six of the twenty four industries and finds five

²⁴See Minhas. Op.Cit., p. 140.

²⁵This is written as $V_i = [A_i K^{-\beta_i} + \alpha_i L^{-\beta_i}]^{-\frac{1}{\beta_i}} \dots (1)$

Where V_i stands for value added in industry i deflated by the price of commodity i ; K and L stand for capital and labour respectively; A_i , α_i , and β_i are the parameters.

Minhas states that this CES production function includes both the Cobb-Douglas and the fixed coefficients production with special cases. For $\beta = 0$, the elasticity of substitution is equal to unity and the limit of (1) as $\beta \rightarrow 0$ is in fact Cobb-Douglas function.

"crossovers"²⁶ out of fifteen such possible points.

Minhas, not being content with these results where there were only a few cases of factor-intensity reversals, proceeds further to another extensive test of ranking comparable industries in the United States and Japan according to their respective capital-intensity. The underlying principle of the relative ranking test is that such rankings of industries according to capital-intensity in any two countries must exactly match if the assumption that "whatever the ratio of wage rate to capital cost the optimal ratio of capital to labour in any given industry 'i' is always greater or less than in any other industry 'j' were true."²⁷ If it does not match, i.e. the ranking according to relative factor-intensity changes with different configurations of relative factor prices, then, *ceteris paribus*, the strong factor-intensity assumption cannot be upheld. This would in fact prove the factor reversal case.

The rankings for twenty similar industries of the United States (1947) and Japan (1951) based on total (direct and

²⁶ Thus he shows the cross overs between paper industry (271) and dairy products (202) at the critical value of \$1350; between textiles (231, 232) and non-ferrous metals (341) at the critical value of \$1350; between dairy products (202) and non-ferrous metals (341) at the critical values of \$ 8665; between paper and pulp industry (271) and chemical industry (311) at the critical value \$ 5370; and between basic chemicals (311) and grain mill products (205) at \$ 20400.

²⁷ See Minhas. Op.Cit., p.146.

indirect) capital and labour requirements yielded a Spearman rank correlation of 0.328 which is less than unity while the strong factor intensity assumption implies a value equal to unity. Similarly a ranking based on direct capital and labour intensity provided a Spearman rank correlation coefficient of 0.730 which again is less than unity. Such low values establish the dissimilarity between the rankings of comparable industries in the two countries. The degree of dissimilarity is not much in the latter correlation coefficient but still there is considerable difference between unity and 0.730 which tends to establish case for factor reversals.²⁸

What is the significance of this factor intensity reversals for factor endowments and trade pattern? Minhas' explanation is: "The intervening reversal in factor-intensities makes it impossible to identify the relative capital or labour-intensive good without specifying the range of variation in relative factor prices. Furthermore, the statement that a country exports those commodities that are produced with relatively

²⁸ A strong criticism has been labelled by David Strafford Ball against the ranking test of Minhas. See David Strafford Ball: "Factor intensity reversals, in International comparison of factor costs and factor use." Journal of Political Economy, February 1966. pp.77-80.

Professor Leontief himself, while evaluating Minhas' work, made additional computations for 21 of the same 24 industries using Minhas' data. However, his observations do not corroborate with those of Minhas. Leontief's test showed him that only 17 cross overs do take place out of 210 possibilities. (See Leontief: "International factor costs and factor use", American Economic Review. LIV, June 1964. pp.335-345)

large amounts of the country's relative abundant factor (defined in either of the two senses mentioned above) becomes meaningless."²⁹ Minhas claims further that it is incorrect to derive a country's relative factor endowments from the relative factor-intensities of exports and import substitutes.

4. Demand biased reasoning:

The main exponents of this reasoning have been Valva~~is~~^{is}-Vail, Romney Robinson and R.W. Jones. Their reflections on the transformation curve geometry lead them to believe that a nation may not export the product using more of its abundant factor if demand conditions are such that consumption is biased relatively more towards that product than the country's[?] productive capacity. The United States imports capital-intensive goods because the nature of her demand is such as to require imports of capital-intensive goods. Thus Valva~~is~~^{is}-Vail states: "Physical abundance and scarcity, though easy to detect, are theoretically useless, economic abundance and scarcity, though useful, are difficult to detect operationally."³⁰

✓ 5. Natural resource scarcity:

The third factor explanation to the Leontief paradox has been advanced both by M.A. Diab and Jaroslav Vanek. Leontief

²⁹See Minhas. Op.Cit., pp.150-151.

³⁰See Valva~~is~~^{is}-Vail. Op.Cit., p. 528.

himself was aware of this limitation when he confessed that "absence of comprehensive statistical information concerning their supply and utilization makes an explicit inclusion of natural resources into our input-output computations, along with capital and labour, as yet impracticable."³¹

Diab's explanation is that the activities depending upon natural resources are relatively more capital-intensive than other activities and the United States is a net importer of such natural resource products. He divides the products traded by the United States into manufacturing and non-manufacturing group depending upon the proportion of natural resource content of these products. There he finds a relative pre-dominance of non-manufacturing group in the United States, competitive import replacements constituting 65 per cent of the total in comparison to 15 per cent in the case of exports. He believes; "The United States import products of such high capital-intensive industries not because they are highly capital-intensive per se, but either because some of its natural resources are poor in quality, or because its supply is not sufficient to meet the domestic demand, or because the vastness of its territory makes it more feasible for producers to import their requirements from adjacent countries than to ship from other parts of the country."³²

³¹ See Leontief. Op.Cit., p. 395.

³² See Diab. Op.Cit.

Vanek measured the resource product inputs of the United States imports and exports through a plausible assumption that the value of resource product content is equal to resource content.³³ His computations further substantiates Diab's contention of relative scarcity of natural resources in the United States. Vanek's main findings are summarised in Table 2.

Table 2. Domestic capital, labour and natural resource requirements per million dollars' worth of American exports and competitive import replacements, 1947.

Requirements	Exports	Imports
Capital (dollars)	2550780	3091339
Labour (man-years)	182.313	170.004
Natural Resource products (dollars)	340000	630000

Source: See Jaroslav Vanek. Op.Cit., p.132.

From Table 2, it follows, that if the United States were to replace her competitive imports by one million worth of domestic production, a greater amount of resource products (\$ 630000) would be required compared to similar requirements for her exports (\$ 340000). Vanek orders the ratios between export and import competing requirements of capital (C),

³³Jaroslav Vanek. Op.Cit.

labour (L) and natural resources (T) from the highest to lowest and they compare as below:

$$L : C : T = 1.07 : 0.83 : 0.54$$

This implies that the United States is well endowed with labour, but natural resources are scarce. He observes a strong complementarity between capital and natural resource factor. This led him to the conclusion that although the United States is capital abundant "relatively less of its productive services is exported than would be needed for replacing our imports, because resources, which are our scarce factor, can enter productive process only in conjunction with large amounts of capital."³⁴

6. A relatively high proportion of skilled labour:

This explanation was initially put forward by Leontief himself when he equated one American labour to three foreign labourers.³⁵ In his second paper, he elaborated this interpretation by disaggregating labour requirement per million dollars of trade according to skill class and showing the larger concentration of skilled labour in export production than in import competing production.

³⁴Jaroslav Vanek. Op.Cit. p.135

³⁵See Leontief. Op.Cit., p.127.

Later Kravis³⁶ discovered that wages in export industries tend to be higher than in import-competing industries in the United States. This can be fitted to the model if we grant that wage differentials are the product of skill differences and trade flows are the reflections of differential application of education and training to human labour.

Somewhat later, Bhagawati³⁷ suggested that human capital should be treated as a factor input like physical capital, in evaluating trade patterns.

In recent years the skill theme has found empirical application by Keesing, Kensen, Yudin, Waehlerer and Yahr. These advocates have proceeded on two different lines in order to explain the significance of differential supplies of labour skills on the trade pattern of a country. On the one hand, Keesing³⁸ related trade flows to skill differentials based on inter-industry employment of different kinds of labour. He treated different qualities of labour as separate productive

³⁶Kravis Irving. "Wages and foreign trade." Review of Economics and Statistics. XXXIV, February 1956. pp.14-30.

³⁷Jagadish Bhagawati. "The pure theory of International trade: A survey" Reprinted in Surveys of Economic Theory, American Economic Association, Royal Economic Society, Vol. II, 1965. pp.156-239.

³⁸Donald B. Keesing. "Labour skills and International trade: Evaluating many trade flows with a single measuring device." Review of Economics and Statistics. XLVII, August 1965. pp.287-293. "Labour skills and structure of trade in manufactures" The Open Economy. edited by P. Kenen and Roger Lawrence. Columbia University Press, 1968. pp.3-18.

factors and then used the ratio of skilled to unskilled labour in a two factor, multi-country model of trade structure. Further he measured the skill content of exports and imports for the United States, seven other European countries and Japan using the United States skill coefficients and ordered the countries according to direct skill requirements in export production and import competing production. His rank ordering according to skill requirements for export production is virtually reversed in import production. From this he concluded that "the availability of labour skills does strongly influence the pattern of International trade in industrial goods."³⁹ On the other hand Kenen, Yudin and Waehlerer, following Kravis, related trade flows to skill differentials based on inter-industry wage differentials. Kenen's experiment on the United States data of capitalising the excess of wages earned by various types of skilled labour above the wage of unskilled labourers for estimating the value of human capital in export and import replacements showed surprisingly the reversal of paradox when the estimate of human capital was

³⁹See Keesing. "Labour skills and International trade." Op.Cit., p. 293.

added to Leontief's physical capital estimates.⁴⁰ Waehlerer, after constructing the average occupational indices for the export and import-competing groups for 59 manufacturing industries found that export industries, on an average, have a higher occupational index than the import-competing industries.⁴¹ Haufbaur, while assessing the link between trade flows and skill endowments, measures first the American skill embodied in different manufactured exports and secondly the relative national abundance of trained manpower.⁴² He observed, when professional labour force is matched with skill ratios in trade, the Sperman correlation is .695 while the weighted correlation is .822; when it is matched with wage rates, the correlations are .784 and .960 respectively, thus both inter-

⁴⁰ Kenen, P.: "Nature, capital and trade." Journal of Political Economy, October 1965. pp.437-460.

Kenen states that one of the drawback of compating human capital by capitalising income differentials at a single discount rate is that it involves an assumption that all income differences to be the result of differences in education and other forms of human investment. Another point is whether it is proper to combine the estimates of human and physical capital for determining the capital labour ratio in trade oriented production since such a procedure rests upon the assumption that the capital moves freely between physical goods and human agents of production in the long run. This assumption may be valid for a developed country like the United States, but may not be so far the developing countries because of market imperfections.

⁴¹ Waehlerer, Helen. "Wage rates, labour skills and United States foreign trade". in the Open Economy. edited by P.Kenen and R. Lawrence. Columbia University Press, 1968. pp.19-39.

⁴² Hufbaur, G.C.: "Factor endowments, national size and changing technology: their impact on the commodity composition of trade in manufactured good." In National Bureau Conference on Technology and Competition in International Trade, New York. October 11 and 12, 1968. pp. 19-20.

preparations yieldⁱⁿ good results. Baldwin's study adds further to the belief that American export production embodies higher skill content than in import competing production.⁴³ His educational breakdown indicates that American export production involves more proportions of individuals with 9-12 years of education than in import competing production. The correlation analysis shows that there is a significant positive relationship between the proportions of engineers, scientists, craftsmen and farmers in an industry and the net world export surplus in the industry. But while adding the human capital to the physical capital, Baldwin observes that it "is not sufficient to reverse the Leontief results for all industries combined, but does reverse it when the natural resource industries are excluded."⁴⁴

7. Research and Development factor:

Keesing together with Vernon, Gruber and others have pointed the significance of research activities in explaining the trade pattern. Keesing examined the hypothesis that Research and Development activity is associated with American competitive ability in manufacturing industries and also

⁴³Baldwin, Robert E. Determinants of the commodity structure of United States trade, SSRI series, University of Wisconsin. 1969 pp. 17-18.


⁴⁴See Baldwin. Op.Cit., p.17.

tested this hypothesis against other hypothesis advanced to explain American trade pattern.⁴⁵ His method was to work out the percentage of scientists and engineers engaged in Research and Development activities for eighteen industries in 1961 and compare it with 1962 United States exports as a percentage of group of ten country's exports. He finds both to be highly correlated. He gets his results further confirmed after relating the funds spent on Research and Development activities in twenty two product fields individually to the percentage of value added by the corresponding industry in 1960. His another observation is that the production of United States manufactured exports require 2.87 per cent of labour force engaged in Research and Development activities while to replace manufactured imports it would have been just 1.21 per cent of the labour force so engaged.

Gruber, Mehta and Vernon⁴⁶ also find a high correlation when they relate research effort of industries to United States trade performance in 1962. They observed that five industries with the greatest 'research effort' are also the five industries with the most favourable trade position. These five

⁴⁵Keesing, D. B.: "The impact of research and development on United States trade." in Open Economy. edited by R. Kenen and R. Lawrence. Columbia University Press, 1968. pp.175-189.

⁴⁶Gruber, W.W., Mehta, D., and Vernon R.: "The research and development factor in international trade and international investment of United States industries." Journal of Political Economy. February 1967. pp.20-37.



industries accounted for 72.0 per cent of the nation's exports of manufactured goods, though they were responsible for only 39.1 per cent of nation's total sales of such goods. These same five industries accounted for 89.1 per cent of the nation's Research and Development expenditures and 75.6 per cent of the company financed research and development expenditures. This implies that industries with high 'research effort' occupy a strong export position while low export position is occupied by industries with low research inputs.

8. Tariff and non-tariff distortions:

The fact that tariff and non-tariff distorting measures account for Leontief paradox has been expounded by Travis.⁴⁷ After showing the correctness of Leontief's test and verifying the truth of other explanations to the paradox, he states: "Protection is therefore the most plausible of the theoretically and empirically possible explanations of the Leontief paradox. It requires no special assumptions in order to hold, and at the same time it explains the very characteristics of United States imports that are potentially the most dangerous to Leontief's method. It also explains other characteristics which do not accord with actual American relative factor endowments."⁴⁸ Baldwin confirms this hypothesis while retesting

⁴⁷ Travis, W. P.: The theory of protection, Harvard University Press, 1964.

⁴⁸ Ibid., p.171.

the Heckscher-Ohlin theory using the American trade structure.⁴⁹ He examined the effects of import duties on the capital/labour ratio in import-competing production by assigning import demand elasticities to various industries in the input-output table and calculating a new per million dollar bundle of import under the assumption that average duty in each industry is reduced to zero. His observation was that the capital/labour ratio with the new commodity composition of imports is about 8 per cent lower than under the actual import bundle. But he is sceptical of the view that a removal of all trade distorting measures may confirm the expectation of the Heckscher-Ohlin theorem for the United States. He remarks: "Based on my own assessment of the relative importance of tariff and non-tariff barriers to trade, I would hazard the guess that this would fail to make the capital/labour ratio in export production significantly higher than import competing production and probaly would not even reverse the Leontief paradox."⁵⁰

Another theory of market imperfection is Diab's explanation that commodities produced by American firms and their subsidiaries with the aid of American capital, know how and skilled technicians and managers, should be regarded as part of United States internal trade and not as imports.⁵¹ Since

⁴⁹See Baldwin. Op.Cit., p.20.

⁵⁰Ibid., p.20.

⁵¹See Diab. Op.Cit.

the American investments abroad are in capital-intensive natural resource products especially minerals, and which are increasing year by year, the paradox might be dissolved if these are excluded from the trade pattern.

Conclusion

We can conclude by stating that it is time now to discard the two factor analysis of Heckscher-Ohlin theory in favour of multi-factor trade models. A more dynamic theory of International trade should take into account the variables such as skill differences of labour force and relative differences of human capital, natural resource conditions, technological differences, transportation costs, commercial policies, scale economics, and product differentiation. Only then relative abundance of factors will have any meaning in explaining the trade pattern of a country. In the words of Caves "perhaps some day a super charged economist, with supersonic calculating equipment backed by a supersaturated foundation will perform this task."⁵²

⁵²Caves, Richard. Trade and economic structure, Harvard University Press, 1963. p.282.