The Heckscher-Ohlin Model and the Tariff Structures of the Industrial Countries

1. *Purpose of the paper.* — Some recent empirical researches on the tariff structure of industrial countries have again drawn the attention of scholars to the problem of the empirical relevance of the Heckscher-Ohlin (1) theory of trade and — incidentally — to the related question of the legitimacy of the discrimination charge levelled by the "third world" against the tariff schedules of the developed countries (2). One of the outstanding implications of the Heckscher-Ohlin model is that the relatively scarce factor of an economy — labor in the case of most industrial countries — has

(1) Cf. E. Heckscher, "The Effect of Foreign Trade on the Distribution of Income", *Ekonomisk Tidskrift*, XXI, 1919, pp. 497-512, reprinted in *Readings in the Theory of International Trade*, Blakiston, Philadelphia, 1949, pp. 272-300; and B. Ohlin, *Interregional and International Trade*, Harvard University Press, Cambridge, 1933. On the H-O model, see also the excellent summary by P. T. Ellsworth, *International Economics*, Macmillan, New York, 1938, Chaps. V and VI; P. A. Samuelson, "International Trade and the Equalization of Factor Prices", *Economic Journal*, LVIII, June 1948, pp. 163-84; Id., "International Factor Price Equalization Once Again", *Economic Journal*, LIX, June 1949, p. 182; A. P. Lerner, "Factor Prices and International Trade", *Economica*, XIX, February 1952, pp. 1-15; I. F. Pearce, "A Note on Mr. Lerner's Paper", *ibid.*, pp. 16-18; S. F. James and I. F. Pearce, "The Factor Price Equalization Myth", *Review of Economic Studies*, No. 49, 1951-52, pp. 111-20; R. Robinson, "Factor Proportions and Comparative Advantage: Part I", *Quarterly Journal of Economics*, LXX, May 1956, pp. 169-192; R. W. Jones, "Factor Proportions and the Heckscher-Ohlin Theorem", *Review of Economic Studies*, No. 63, 1956-57, pp. 1-10; H. G. Johnson, "Factor Endowments, International Trade and Factor Prices", *Manchester School of Economic and Social Studies*, XXIV, September 1957, pp. 270-283. For more recent developments, cf. J. Bhagwati, "The Pure Theory of International Trade", *Economic Journal*, LXXIV, March 1964, pp. 17-26; W. M. Corden, "Recent Developments in the Theory of International Trade", Princeton, International Finance Section, 1965, pp. 24-34; M. Michaely, "Factor Proportions in International Trade", *Kyklos*, XVII, 1964, pp. 529-50.

(2) During the 1964 Geneva UNCTAD conference, the developing countries forcefully maintained that the tariff-structure of the industrial countries is such as to protect with relatively higher duties the labor-intensive manufactures which are generally of particular interest to the Third World. Cf. U.N., *Trade and Development: Trade in Manufactures*, New York, 1964, p. 11 and *passim*.

a strong incentive to seek protection from international competition. Thus, systematically higher tariffs on labor-intensive manufactures could prove the empirical relevance of the factor-proportions theory of trade. However, G. Basevi, in a recent work on U.S. tariffs, found that the relationship between labor intensity and protection is not definite, but "*it seems negative rather than positive*" (3). Similarly, B. Balassa, after evaluating the effective protection rates (4) on 36 manufacturing sectors for several industrial countries, found "*no definite relationship between labor intensiveness and effective rates of duties*" (5). According to the latter author, these conclusions are explained by the inadequacy of Heckscher-Ohlin-type theories that rely on a single principle in attempting to explain international trade (6).

The present paper's purpose is to prove that these findings are based on the use of an inadequate definition of the factor-proportions concept. A correct identification of labor-intensive and capital-intensive manufactures leads to fully different conclusions, which do not require the rejection of the factor-proportions theory of trade, and show that the tariff schedules of some industrial countries (E.E.C. countries and the U.S. at least) are clearly biased against imports of manufactures from developing countries.

2. "*Physical*" *and* "*human*" *capital.* — The finding of an appropriate index for measuring labor intensiveness is a difficult problem to tackle. In much empirical work it is not uncommon to measure the relative labor — and capital — intensity in various industries in terms of the stock of physical capital per worker or — more frequently — of the share of wages in the value of output. This latter is Balassa's (and Basevi's) index of labor intensity (7).

(3) G. Basevi, "The U.S. Tariff Structure: Estimate of Effective Rates of Protection of U.S. Industries and Industrial Labor", *Review of Economics and Statistics*, March 1966, p. 159.

(4) Cf. paragraph 3.

(5) B. Balassa, "Tariff Protection in Industrial Countries: An Evaluation", *Journal of Political Economy*, December 1965, p. 585. The results arrived at by the author would justify a conclusion like Basevi's (namely, that the relationship between tariffs and labor-intensiveness "*seems*" to be *negative*). The Spearman rank correlation coefficient between labor-inputs and effective tariffs varies from −0.08 to −0.14 for the European countries and the U.S., and is of −0.41 for Japan.

(6) Cf. B. Balassa, *op. cit.*, p. 585.

(7) Balassa's index of labor intensiveness is the share of wages plus employer-financed social security payments in the value of output. Basevi's index ("dollars of payroll per dollar of output") is similar to Balassa's.

In that case, it should come as no surprise that no definite relationship, or a negative one, is found between protection and manufactures' labor-input. On the one hand, skill-intensive industries, such as those in the export sector of the economy (8), are relatively less protected: for these industries, competitive in the international markets, the inducement to seek high tariffs is not substantial. On the other hand, higher wages are normally associated with higher skill levels (9). Consequently, it is fairly likely that an indefinite, or even negative, relationship between tariffs and labor-intensity will be obtained, if the latter is assessed in terms of the share of wages in the value of output.

The share of wages in the value of output is an appropriate index of labor intensiveness only if homogeneous labor units are employed at equal wages throughout the industries. Let us suppose that industry X requires ten man-years per million dollars of value added, and industry Y twenty man-years. If labor skill requirements are the same in both, and wages are equal for equal skills in both, industry Y is relatively more labor-intensive than industry X, no matter how labor-intensiveness is assessed: either as physical input in relation to output, or as wages' share of value added. Suppose, however, that industry X requires highly skilled labor units, so that the average wages in X are twice as high as in Y's: if labor-intensiveness is measured in terms of wages' share, both X and Y would appear to require exactly the same labor-input (10). This example illustrates the ambiguity of those approaches which measure the relative factor-intensities in different industries in terms of wages' share: in such a way there is a failure to take account of important differences in requirements of labor skills. Actually, the labor-force is a heterogeneous aggregate, and a very important component of what is commonly considered "labor" may, more appropriately,

(8) Cf. W. Leontief, « Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis », *Review of Economics and Statistics*, November 1956, p. 399; I. B. Kravis, "Wages and Foreign Trade", *Review of Economics and Statistics*, April 1956, pp. 14-30; P. B. Kenen, "Nature Capital and Trade", *Journal of Political Economy*, October 1965, pp. 437-60; D. B. Keesing, "Labor Skills and International Trade: Evaluating Many Trade Flows with a Single Measuring Device", *Review of Economics and Statistics*, August 1965, pp. 287-294; Id., "Labor Skills and Comparative Advantage", *American Economic Review, Papers and Proceedings*, May 1966, pp. 249-258.

(9) Cf. paragraph 4.

(10) The example is taken from D. S. Ball, « United States Effective Tariffs and Labor's Share », *Journal of Political Economy*, April 1967, pp. 183-87.

be described as "human capital" (11). Particularly if the issue is the empirical relevance of the Heckscher-Ohlin model (which requires the assumption of homonegeous labor), it is essential to think of the labor-force as if it were composed of (homogeneous) unskilled labor units, to each unit of which are added, according to the industries, varying amounts "human capital" (skill) and of physical capital (machinery and other physical assets). Thus, the concept of the labor force is restricted to include (totally) unskilled labor units only, whereas the concept of capital is extended so as to include "human capital", as well as physical assets. If capital-labor ratios are measured on the basis of this approach, which appears to be the correct one, it can easily be shown that the U.S.'s and E.E.C.'s tariff-levels tend to be systematically higher on labor-intensive manufactures.

3. *Measurement of factor intensities.* — The approach adopted for measuring capital and labor intensities in different industries is based on a suggestion by H. B. Lary (12). It employs a simple technique to measure inputs of both human and physical capital, in different industries of the U.S. manufacturing sector, on a common basis (dollars per employee), assuming that in inter-industry comparisons the wage and the non-wage component of value added per employee are reasonably good proxies for human capital (skill) and physical capital (machinery, other physical assets), respectively. One resulting classification principle is the following: those industries where both the wage and the non-wage part of value added per employee are below the corresponding U.S. averages for the manufacturing sector may be regarded as relatively intensive in the use of labor.

Table A-1 of the Appendix reproduces the results obtained by this approach. The basic statistical data come from the U.S. 1964

(11) The extension of the definition of capital-input to include human wealth is mainly due to T. W. Schultz ("Reflections on Investment in Man", *Journal of Political Economy*, LXX, Suppl. October 1962) and G. S. Becker ("Investment in Human Capital: A Theoretical Analysis", *Journal of Political Economy*, LXX, Suppl. October 1962). Moreover, see P. B. Kenen, "Growth Theory, Trade Theory, and International Investment", in *Trade and Development*, Etudes et Travaux de l'Institut Universitaire de Haute Etudes Internationales, No. 4, Ginevra, 1963, p. 31 ff., reproduced in P. B. Kenen, "Nature, Capital, and Trade", *op. cit.* Cf. also G. S. Becker, *Human Capital*, N.B.E.R., New York, 1965.

(12) H. B. Lary, « Trade of the LDC's: Manufactures Point the Way », *Columbia Journal of World Business*, Vol. 1, No. 3, p. 70 ff.

Survey of Manufactures, and consist of value added by manufacture in different industries, separated into its wage and non-wage components, and divided by employment. To make tariff-levels comparisons possible, the industry groups as defined in the *U.S. Standard Industrial Classification* (SIC) were converted into the corresponding *Standard International Trade Classification* "*groups*" (13): this exercise presented some difficulties, since SIC's groups are different from and frequently more analytical than SITC's (14).

However, the real difficulties were encountered at the conceptual level. Two major objections could be raised against the present approach: 1) the use of value added per employee may not be an adequate index for measuring inter-industry differences in requirements of human and physical capital; 2) the pattern of industries by factor intensities in the United States may not hold good for other countries.

The first objection is easily answered. Several empirical studies have shown that inter-industry differences in labor earnings largely reflect differences in the quality of labor. Ball (15) in particular examined and empirically tested the assumption that higher wages may result not from higher skill levels but from other conditions as, for instance, union strength. The assumption had to be rejected. In twenty U.S. industries, the rank correlation coefficient between average wages and the percentage of skilled workers was +.940, and that between average wages of production workers and the percentage of skilled workers +.932. Thus, average wages can be considered a reasonably good index of skill intensity (16).

The second objection requires a more articulate answer. In recent years, considerable prominence has been given to the view that *factor reversals* may be common between countries, and empirically relevant (17). Unless technology dictates a unique and fixed capital-labor ratio for each industry, inter-country differences in factor costs will induce all industries to use more labor in relation to capital in poor, low-wage countries than in rich ones. But if this substitution tendency is far stronger in some industries than in others, as assumed in the factor-reversals thesis, the ranking of industries by factor intensity would then also differ from country to country. In that case, one of Heckscher-Ohlin model's fundamental assumptions — the so-called "*strong factor-intensity assumption*", which implies the uniqueness and invariability of industries' ranking by factor intensity and its complete independence from relative factor prices — would be invalidated. Different elasticities of substitution between capital and labor in different industries would make it impossible to state that a given industry "*i*" is relatively more intensive in the use of capital than industry "*j*", independently of the value of relative factor prices: there will always exist a critical value of these prices at which factor proportions vary and the two industries interchange their place in the ranking by factor-intensity. Thus, the problem is to determine if, given the elasticities of substitution in various industries, those critical values are empirically observable. Arrow, Chenery, Minhas, and Solow (18), after discarding the Cobb-Douglas function (which excludes reversals by definition) in favor of a production function that admits the possibility of different substitution elasticities in different industries — the constant elasticity of substitution (CES) production function (19) — suggest that factor-intensity reversals

(13) For the classification system, cf. U.N., *Standard International Trade Classification, Revised*, Statistical Papers Series M, No. 34, New York, 1961. The SITC groups considered are those included in *Sections* 5 (Chemicals), 6 (Manufactured goods classified chiefly by material, nonferrous metals excluded), 7 (Machinery and transport equipment), and 8 (Miscellaneous manufactured articles).

(14) Luckily, the case of SITC groups including both labor-intensive and capital-intensive manufactures did not occur frequently. When it did, the "mixed" groups were *tout court* excluded from Table A-1, which therefore presents 83 positions only.

(15) Cf. D. S. Ball, *op. cit.*, p. 186.

(16) Similar conclusions are reached also by L. W. Weiss, "Concentration and Labor Earnings", *American Economic Review*, March 1966.

(17) Cf. K. J. Arrow, H. B. Chenery, B. S. Minhas, R. M. Solow, "Capital-Labor Substitution and Economic Efficiency", *Review of Economics and Statistics*, XLIII, August 1961, pp. 225-250; and, particularly B. S. Minhas, "An International Comparison of Factor Costs and Factor Use", North-Holland Publishing Co., Amsterdam, 1963, Ch. IV.

(18) Cf. Arrow, Chenery, Minhas, Solow, *op. cit.*

(19) The unitary elasticity of substitution of the Cobb-Douglas production function excludes factor reversals by definition since it implies identical elasticities of substitution in all industries: in response to a given change in relative prices of the two factors, capital is substituted for labor and vice versa, but the downward or upward shifts of the capital-labor input ratios are so uniform as not to disturb the relative position of the individual industries on the capital labor intensity scale. However, if a *uniform* substitutability in all industries is considered, as Arrow *et al.* do, as very improbable, one could reach out for a new production function allowing for different substitution elasticities in different industries. The C.E.S. production function can be written in the following form:

$$P=(AK^{-b}+aL^{-b})^{-1/b}$$

where P represents the output; K and L and respectively for the inputs of capital and labor; and A, *a*, and *b* are constants which are supposed to reflect the technical characteristics of could take place in an empirically relevant range of variation of relative factor prices. Their tentative conclusions are unequivocally reasserted by Minhas (20). Minhas presents evidence of factor-intensity reversals in two sets of tests. In the first set, utilizing parametric estimates of substitution and distribution parameters of CES production functions, Minhas sets out to demonstrate that, in fact, factor reversals can be expected to occur within the practically relevant range of relative factor prices so often as to vitiate the analytical usefulness of conventional distinctions between capital- and labor-intensive industries. Minhas' second test is non-parametric. The validity of the assumption that, whatever the ratio of wage rate to capital cost, the optimal capital-labor ratio in any given industry "*i*" is always greater or less than in any other industry "*j*" requires that the rankings of industries by capital intensity should exactly match, even for countries — as, for example, the U.S. and Japan — characterized by substantial differences in relative factor costs. Minhas finds that the capital-labor ratios in 20 industries common to Japan and the U.S. do not display a strong rank ordering: since he obtains Spearman rank correlation coefficients of +.328 (using direct plus indirect capital) and of +.730 (using direct capital only), he rejects the "strong factor-intensity assumption", suggesting that the nature of technology is not such as to exclude the practical possibility of factor-reversals.

The tests by Arrow *et al.* and particularly Minhas', are very ingenious, but far from conclusive. In the first place, the general theoretical framework within which these tests have been carried

the particular production process. Let us suppose that industries *i* and *j* produce according to C.E.S. production functions. If *w* is the wage rate, and *r* the rate of interest, the ratio of optimal (profit-maximizing) factor intensities may be written as follows:

$$(K/L)_i/(K/L)_j = A\ (w/r)^{s_i - s_j}$$

where s_i and s_j are the elasticities of substitution, and A is a constant. Setting $(K/L)_i/(K/L)_j = x$, and differentiating with respect to (w/r):

$$dx/d(w/r) = (s_i - s_j)\ A\ (w/r)^{s_i - s_j - 1}$$

that is, capital-labor ratios become less sensitive to differences in relative factor prices as elasticities of substitution approach the same value. Hence, if industries produce according to C.E.S. production functions, the probability of factor reversal — when relative factor-price differentials are given — is a function of the dispersion of the elasticities of substitution about their mean. By definition, this probability is zero in Cobb-Douglas ($s_i = s_j = 1$) and Leontief-type ($s_i = s_j = 0$) production functions.

(20) B. S. Minhas, *op. cit.*, p. 35 ff.

out may be questioned. Fuchs (21) suggests that the empirical data used by Arrow *et al.* do not constitute a sufficient basis for rejecting the use of a Cobb-Douglas function. On the contrary, under a more reasonable interpretation, these data are substantially consistent with the Cobb-Douglas assumption of a unitary elasticity of substitution (22). The countries analyzed by Arrow *et al.* are very diverse, ranging from the most advanced to those with underdeveloped economies. This raises the question of whether a single production function is appropriate for such a heterogeneous group of countries. It is possible that we are dealing with two or more different populations, each with an elasticity of unity, but with different "intercepts": when they are combined, there is a downward bias which produces a slope of less than one. To check this hypothesis, Fuchs fits a single equation across all countries for each industry, including a dummy variable to allow for differences between developing and advanced countries. The results show elasticities of substitution typically very close to unity (only in two industries out of 24 is the elasticity estimate significantly less than unity).

On the other hand, the validity of the parametric test is questioned in an important contribution by Leontief (23). The five reversals listed by Minhas depend fundamentally on his estimated values of industry elasticities of substitution and the ratio of distribution parameters of the CES function. Using alternative estimates of this ratio, Leontief finds that only 17 of the 210 theoretically possible reversals take place within the wide range of factor price ratios, limited on the one end by those observed in the U.S. and on the other by those reported from India. Moreover, most of these 17 reversals occur between industries so technologically similar that for all practical purposes their capital-labor intensities could be considered identical. Hence, the picture emerging from Leontief's computations does not confirm Minhas' emphatically stated conclusion that the strong factor-intensity assumption (and the conventional distinction between capital- and labor-intensive industries) is of limited practical validity.

(21) V. R. Fuchs, « Capital-Labor Substitution: A Note", *Review of Economics and Statistics*, XLV, November 1963, pp. 436-38.

(22) V. R. Fuchs, *op. cit.*, p. 437.

(23) W. W. Leontief, "International Factor Costs and Factor Use", *American Economic Review*, LIV, June 1964, pp. 335-345. For a critical appraisal of Leontief's estimates, cf. P. Shapiro, "International Factor Costs and Factor Use: Comment", *American Economic Review*, June 1966, pp. 546-549.

Nor has criticism spared Minhas' non-parametric tests. Ball (24) showed that by deleting agricultural and foodstuffs industries from Minhas' sample (an adjustment made necessary by the great international dissimilarity in technical know-how, natural resources conditions, relative efficiency, and reliability of factor inputs measures), Spearman rank correlation coefficients increased from +.328 to +.765 (direct plus indirect capital), and from +.730 to +.826 (direct capital only). A still higher correlation of +.920 was obtained in a sample of 18 " non-primary " industries. If it cannot be argued that the industries rankings are so exactly matching as to prove strong factor-intensity, nevertheless they are not so dissimilar as to validate Minhas' conclusive statements. Similar results are reached by Moroney (25), by testing the degree of concordance of the rankings of capital-labor ratios in the U.S. manufacturing sector on the basis of inter-regional data: Kendall's coefficients of concordance vary (according to the regional groupings and the industries surveyed) from +.8955 to +.9228. These results indicate that the regional rankings of capital-labor ratios are very similar.

The reinterpretations of Arrow's and Minhas' tests by Fuchs, Leontief, Ball and Moroney suggest that the strong factor-intensity hypothesis cannot be rejected as empirically unsound. This remark is further strengthened by the argument that the Heckscher-Ohlin model is crucially based upon the very restrictive assumption of *homogeneous* labor-inputs throughout the various countries, whereas Arrow *et al.* and Minhas adopt a conventional definition of capital-labor ratios, simply assuming, quite unrealistically, that a man-year of labor in one part of the world is equivalent to a man-year of labor in any other part (26). It is fairly likely that the results of their tests would have been different had their definition of capital been stretched to include — as is done in the present paper — " human " capital as well as physical assets (27).

In conclusion, the evidence presented seems to support Samuelson's feeling that factor-intensity reversal has much less empirical

(24) D. S. Ball, " Factor-Intensity Reversals in International Comparison of Factor Use ", *Journal of Political Economy*, LXXIV, February 1966, pp. 77-80.

(25) J. R. Moroney, " The Strong-Factor-Intensity Hypothesis: A Multisectoral Test ", *Journal of Political Economy*, LXXV, June, 1967, pp. 241-249.

(26) Cf. also W. Leontief, *op. cit.*, pp. 343-344.

(27) Cf. H. B. Lary, *op. cit.*, Graph 2, p. 73. Lary shows that, even under extremely different relative factor endowments and factor costs, the ranking of industries by labor or (human and physical) capital intensity is much the same from country to country.

importance than theoretical interest (28). Arrow's and Minhas' arguments are too controversial to disprove the factual assumption of the modern theory of trade that a meaningful distinction can be made between labor-intensive and capital-intensive industries, and that any such distinction, based on U.S. data, could hold true for other countries as well.

4. *Nominal and " effective " rates of duties.* — The indexes of factor-intensities described in paragraph 3 must now be related to the nominal (weighted) tariff rates and to the " effective " protective rates applied by the EEC (Common External Tariff) and the U.S.

The nominal weighted averages of duties on each SITC group considered are shown in Table A-2 of the Appendix, and are based on data coming from a tariff study of CED (Committee for Economic Development) (29). All duties are weighted by the imports of the country in question, which is equivalent to expressing the amount of duty as a percentage of the value of imports. It is well known that this approach often provides distorted results (30). However, since it can be assumed that the distortion will be systematic, its existence does not impair the validity of the analysis, whose objective is not an inter-country comparison of tariff-levels, but a comparison of tariff-levels *inside* one and the same tariff-structure.

(28) P. A. Samuelson, " A Comment on Factor Price Equalization ", *Review of Economic Studies*, XIX, 1951-52, pp. 121-122.

(29) C.E.D., Comparative Tariffs and Trade: The United States and the European Common Market, Suppl. Paper No. 14, Washington, 1963.

(30) To a certain extent, the distortion could be lessened by weighting tariffs by the value of " world " imports (rather than by " own " imports). However, this approach singularly compounds the classification and nomenclature problems. Ideally, one should weight tariffs not by real imports, but by the imports which would take place in the absence of duties, a solution which is out of the realm of practical implementation. Among the attempts to measure the height of custom duties, see U.K. Board of Trade, Publications (2d ser., Cd. 2.337), 1905; League of Nations, " Tariff Level Indices ", in *Economic Record*, December 1934. After the second world war, cf. R. Bertrand, " Comparaison du niveau des tarifs douaniers des pays du Marché Commun ", Cahiers de l'Institut de Science Economique Appliquée, Serie R, No. 2, February 1958; the basic study, Political and Economic Planning, *Atlantic Tariffs and Trade*, London, 1962; M. Mesnage, " Comparaison statistique du tarif douanier commun de la CEE, du tarifs des Etats-Unis d'Amerique et du tarif du Royaume-Uni de Grande-Bretagne et de l'Irlande du Nord ", *Informations Statistiques*, Office Statistique des Communautés Européennes, No. 3, 1963; Research and Policy Committee of the C.E.D., The Heights of United States and E.E.C. Tariffs, *Trade Negotiations for a Better Free World Economy: A Statement on National Policy*, Washington, 1964.

The effective rates of tariffs shown in Table A-3 of the Appendix deserve a separate comment (31). The effective protective rate is the percentage increase in value added per unit in an economic activity which is made possible by the tariff-structure, relative to the situation in the absence of tariffs. It depends not only on the nominal tariff on the commodity produced by the activity in question, but also on the inputs coefficients and the tariffs on the inputs. The effective protective rate and the nominal tariff-rate are equal only when the weighted average of duties on material inputs is the same as the tariff on the final product (32). The calculation of the effective rates of protection requires comparable data on nominal duties and input-output coefficients net of duties. In regard to the former, we used the nominal weighted CED tariffs, adjusted so as to take into account the different basis of evaluation of imports and the reductions accomplished in the "Dillon Round" of tariff negotiations. As to the latter, we referred to the 1965 input-output tables for the EEC countries (33). Since no comparable input-output table was available for the U.S., standardized coefficients were used, relying largely on the input-output tables of the Benelux countries and the

(31) On the effective rates of protection, cf. C. L. BARBER, "Canadian Tariff Policy", in *Canadian Journal of Economics and Political Science*, Vol. XXI, November 1955, p. 513 ff.; W. M. CORDEN, "The Tariff", in *The Economics of Australian Industry*, Melbourne, Melbourne University Press, pp. 162-165; W. P. TRAVIS, *The Theory of Trade and Protection*, Cambridge, Harvard University Press, pp. 187-225; H. G. JOHNSON, "The Theory of Tariff Structure, With Reference to World Trade and Development", in *Trade and Development*, Etudes et Travaux de l'Institut Universitaire de Hautes Etudes Internationales, No. 4, Ginevra, 1965, pp. 9-29; W. M. CORDEN, « The Effective Protective Rate, the Uniform Tariff Equivalent and the Average Tariff", in *The Economic Record*, June 1966, pp. 200-218; Id., "The Structure of a Tariff System and the Effective Protective Rate", in *Journal of Political Economy*, June 1966, No. 3, pp. 221-237. Among the empirical researches, see B. BALASSA, "Tariff Protection in Industrial Countries: An Evaluation", in *Journal of Political Economy*, cit.; G. BASEVI, "The U.S. Tariff Structure: Estimate of Effective Rates of Protection of U.S. Industries and Industrial Labor", cit.

(32) The formula for calculating the effective protective rate on importable product j requiring several inputs ($i=1, 2, \dots, n$) is the following:

$$z_j = \frac{t_j - \sum_{i=1}^{n} a_{ij} t_i}{1 - \sum_{i=1}^{n} a_{ij}}$$

where z_j = effective protective rate for activity j; a_{ij} = share of i in the value of j; t_j = nominal tariff rate on j; t_i = nominal tariff rate on i.

(33) Cf. Office Statistique des Communautés Européennes, « Tableaux Entrées-Sorties pour les pays de la CEE", *Informations Statistiques*, December 1965.

Federal Republic of Germany (34): even in 1959, these countries had very low rates of protection on most items, and hence the distortion in the technical coefficients could be presumed relatively small. The application of identical input-output coefficients for all countries is obviously open to criticism, if there are differences in the relative input prices or non-neutral differences in the technical conditions of productions. The use of standardized coefficients for different countries is justified if the amounts of capital and labor employed per unit of their respective outputs are technologically fixed; or if all countries have identical production functions with unitary elasticity of substitution in all industries (35); or if inter-country differences in efficiency are neutral in a Harrodian sense (production functions differ only by a multiplicative constant). These assumptions, though often unrealistic, have frequently been made in empirical research (36).

In calculating the effective protective rates shown in Table A-3, separate consideration was given to all material inputs contributing at least 2 per cent of the value of output. For the inputs contributing less than 2 per cent, we calculated a weighted average of tariffs, which was then used in the computations. Non-material inputs (trade, transportation, etc.) have been considered as material inputs subject to zero duty.

5. *Econometric tests.* — The techniques of econometric analysis can now be employed to test the relationship between nominal (Table A-2) and effective (Table A-3) protective rates on each group (or each class) of manufactured goods on the one hand, and an

(34) The limited number (26 only) of effective rates of duties listed in Table A-3 is due to the high level of aggregation of the breakdown used in the E.E.C. input-output tables, whose industries groupings (called "classes" in the text) are usually much broader than (and often quite different from) the SITC groups. This made the task of establishing the exact correspondence between the two classification systems rather difficult, forcing us to discard those "classes" of manufactures for which no reliable index of capital-intensity (cf. Table A-1) could be found.

(35) The input-output coefficients are expressed in value rather than in quantity terms: hence, assuming a Cobb-Douglas, they indicate *relative shares*. Let $P = A\,L^{\alpha}\,K^{1-\alpha}$, where P=output, A=scale factor, L=labor, K=capital, α and $(1-\alpha)$ the relative shares of labor and capital, respectively. Since $\alpha=(L/P)\,(dL/dP)$, and $(1-\alpha)=(K/P)\,(dK/dP)$, and in equilibrium conditions, $(dL/dP)=w$ (wage-rate), and $(dK/dP)=r$ (interest-rate) α and $(1-\alpha)$ are, respectively, the relative cost of labor and capital in the value of output $[(\alpha=(L.w)/P; (1-\alpha)=K.r)/P]$. Since α and $(1-\alpha)$ are constant, intercountry differences in the relative prices of inputs would not affect the coefficients.

(36) Cf. B. BALASSA, *op. cit.*, p. 578.

appropriate index of human and physical capital intensity (Table A-1) for such group (or class) on the other. The hypothesis to be tested is that the height of duties levied by the advanced countries under consideration (E.E.C. and U.S.) is inversely related to the amounts of both human and physical capital input embodied in the various groups (or classes) of manufactures.

The following relationships have been tested:

$$Y_{ij} = a_j + b_{1j}X_{1ij} + u_{ij} \qquad (I, 1)$$

$$Y_{ij} = a_j + b_{2j}X_{2ij} + u_{ij} \qquad (I, 2)$$

$$Y_{ij} = a_j + b_{3j}X_{3ij} + u_{ij} \qquad (I, 3)$$

where (37):

Y = nominal (or effective) tariff rate on group SITC (or class) "*i*" of country "*j*";

X_1 = index of intensity of *human* capital input in group (or class) "*i*" of country "*j*";

X_2 = index of intensity of *physical* capital input in group (or class) "*i*" of country "*j*";

X_3 = index of overall intensity of both human and physical capital input in group (or class) "*i*" of country "*j*" (38)

u = error, assumed to be normally distributed.

The results of the tests are shown in Table 1 (nominal tariffs) and in Table 2 (effective tariffs). They bear out the following considerations:

(a) the algebraic sign of parameter "b" is *negative* in all regressions, without exceptions;

(b) all coefficients of equation (I, 1), (I, 2), and (I, 3) for E.E.C. and U.S.A. in Table 1 are statistically significant at the .05 level. In Table 2, only parameters "b_2" and "b_3" for E.E.C., and parameter "b_2" for the U.S. are statistically significant at less than the .05 level.

(37) For the nominal weighted rates of duties, $i = 1, 2, \ldots, 83$ (cf. Table A-1); for the effective rates, $i = 1, 2, \ldots, 26$ (cf. Table A-3).

(38) For index X_3 see the data in the third column of Table A-1.

Thus, the empirical evidence is strongly consistent with the hypothesis of a *negative* relationship between nominal and effective tariff-levels and capital-intensity (or, vice versa, with the hypothesis of a *positive* relationship between tariff-levels and labor-intensity). Such relationship, as can be seen from Tables 1 and 2, is stronger and clearer in equation (I, 1), whose independent variable is "human" capital only. It should also be noted that when the effective rates of protection are related to physical capital only [equation (I, 2)] the coefficients are not significant, though they have the expected algebraic sign. This is a very important point: in fact it explains why in much empirical work on the tariff-structure of industrial countries a clear positive relationship between tariff-levels and labor-intensiveness was rarely found. Comparison of equation (I, 1) with equation (I, 2) suggests, as was anticipated in the opening paragraph, that these findings are solely due to the use of a conventional definition of capital input (defined in such a way as to include physical assets only).

6. *Final Observations.* — If factor intensities of different industries are re-defined by a correct identification of capital and labor inputs, the findings of the present paper suggest that the Heckscher-Ohlin theory of trade, in spite of its unquestionable inadequacies (39), cannot be rejected as empirically unsound. The tariff-structures of major industrial countries, abundant in both human (40) and physical capital, appear to be such as to afford a moderate protection to those industries in which the countries in question enjoy a comparative advantage, and a very stiff protection to those lines of production requiring a higher proportion of their relatively scarce factor (unskilled labor). The opposite findings by other authors, and specifically the *negative* relationship between protection and labor-intensiveness, appear to be due to the methodological

(39) According to Robinson, *op. cit.*, the fundamental weaknesses of the Heckscher-Ohlin model are: (i) the restrictions imposed on the shape of the production functions; (ii) the even more restrictive assumptions concerning the shape of the taste functions; (iii) the assumption that factor supplies are fixed in total amount and are perfectly price inelastic. The latter is the most exacting assumption of all, since it is inconsistent with the "long-run" nature of the theory concerned with comparative advantage (cf. Robinson, *op. cit.*, p. 192).

(40) Schultz ("Reflections on Investment in Man", *cit.*, p. 6) estimates that huge sums have been invested in the U.S. in the training of the labor-force: these « human » investments may well have reached the same order of magnitude as "physical" assets investments.

decision to relate the effective rates of duties to a heterogeneous aggregate, made up partly by unskilled labor, and partly (and predominantly) by " human " capital.

Our results also allow a more considerate judgement to be expressed on the legitimacy of the discrimination charge directed by the developing countries against the tariff-structure of the industrial countries. What seems to emerge from the analysis of tariff policies of major industrial countries is a common behaviorial pattern directed to adjust the rates of duties in such a way as to counterbalance (and perhaps neutralize) the competitive advantage — due particularly to the relative abundance of unskilled labor — on which the developing world could rely in the difficult endeavor to build efficient, and much needed, export-oriented industries.

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Modena

Table 1

NOMINAL WEIGHTED TARIFFS (E.E.C. and U.S.). Regression Equations (I, 1), (I, 2) and (I, 3) (1)

Countries	European Economic Community			United States of America		
Variables \ Equations	(I, 1)	(I, 2)	(I, 3)	(I, 1)	(I, 2)	(I, 3)
1. Nominal weighted tariff rate	1.0	1.0	1.0	1.0	1.0	1.0
2. Intercept	24.94	16.33	17.82	37.03	18.34	21.29
3. Index of " human " capital	− 0.1045** (0.0297)	—	—	− 0.2204** (0.0490)	—	—
4. Index of " physical " capital	—	− 0.0152* (0.0075)	—	—	− 0.0271* (0.0131)	—
5. Overall index of both " human " and « physical » capital	—	—	− 0.0303* (0.0126)	—	—	− 0.0568* (0.0215)
6. Correlation coefficient	0.368	0.219	0.261	0.227	0.228	0.285
7. Degrees of freedom	81	81	81	81	81	81

Table 2

EFFECTIVE PROTECTIVE RATES (E.E.C. and U.S.). Regression Equations (I, 1), (I, 2) and (I, 3) (1)

Countries	European Economic Community			United States of America		
Variables \ Equations	(I, 1)	(I, 2)	(I, 3)	(I, 1)	(I, 2)	(I, 3)
1. Nominal weighted tariff rate	1.0	1.0	1.0	1.0	1.0	1.0
2. Intercept	45.23	26.89	32.78	71.21	30.29	43.46
3. Index of " human " capital	− 0.2322* (0.0910)	—	—	− 0.5221** (0.1313)	—	—
4. Index of " physical " capital	—	− 0.0454 (0.0477)	—	—	− 0.1060 (0.0779)	—
5. Overall index of both " human " and « physical » capital	—	—	− 0.1092 (0.0691)	—	—	− 0.2482* (0.1096)
6. Correlation coefficient	0.461	0.190	0.306	0.624	0.267	0.419
7. Degrees of freedom	24	24	24	24	24	24

(1) Numbers in parentheses are the standard errors of the coefficients.
(*) Significant at the 0.05 level. (**) Significatnt at the 0.01 level.

TABLE A-1

Indexes of " human " and " physical " capital-intensity in different U.S. manufacturing industries. Wage and non-wage component of value added per employee, expressed as a percentage of the average for the whole manufacturing sector.

SITC Group	Wage Component of value added	Non-wage Component of value added	Average of the wage and non-wage component of value added	SITC Group	Wage Component of value added	Non-wage Component of value added	Average of the wage and non-wage component of value added
512	116.9	285.1	204.5	677	10.6	61.7	85.1
514	116.9	285.1	204.5	678	110.6	61.7	85.1
515	116.9	285.1	204.5	679	110.6	61.7	85.1
521	126.9	274.1	203.6	691	102.5	66.4	83.7
531	116.9	285.1	204.5	692	102.7	79.6	90.7
532	116.9	285.1	204.5	693	102.7	79.6	90.7
533	116.9	285.1	204.5	694	112.2	93.3	102.4
541	116.9	285.1	204.5	695	99.0	89.0	98.8
553	116.9	285.1	204.5	696	83.8	62.2	72.7
554	116.9	285.1	204.5	697	99.7	79.6	89.5
561	116.9	285.1	204.5	698	104.6	94.5	99.3
571	116.9	285.1	204.5	711	115.1	91.8	103.0
581	87.7	79.7	86.5	712	115.1	91.8	103.0
599	116.9	285.1	204.5	714	115.1	91.8	103.0
611	65.9	46.2	55.6	715	115.1	91.8	103.0
612	65.9	46.2	55.6	717	94.5	60.2	76.6
613	65.9	46.2	55.6	718	115.1	91.8	103.0
621	99.3	82.3	90.4	719	103.4	68.8	85.4
629	99.1	87.5	93.0	722	108.4	108.9	108.7
631	75.4	50.0	62.2	724	99.0	89.5	94.3
632	75.5	50.0	62.2	729	99.5	89.3	94.5
633	75.4	50.0	62.2	731	114.2	104.8	109.3
641	93.1	84.2	88.4	732	127.9	167.6	148.6
642	97.1	63.5	79.6	733	90.6	70.0	79.9
651	69,6	54.1	61.6	734	131.7	66.6	97.8
652	69.6	54.1	61.6	735	79.5	55.2	65.7
653	69.6	54.1	61.6	812	99.0	95.2	97.0
654	69.6	54.1	61.6	821	79.5	55.2	66.9
655	69.6	54.1	61.6	831	65.9	46.2	55.6
656	69.6	54.1	61.6	841	60.2	40.7	50.0
657	76.1	106.1	91.7	842	60.0	40.7	50.0
661	85.0	59.6	71.7	851	65.9	46.2	55.6
662	85.0	59.6	71.7	861	101.5	86.6	93.5
663	96.9	99.8	98.6	864	89.3	62.5	74.1
664	132.9	139.0	105.9	891	88.6	53.0	70.0
665	94.3	77.8	85.7	892	104.5	85.7	94.7
666	88.1	52.1	69.3	893	87.7	79.7	83.5
671	127.7	122.8	125.2	894	72.0	72.9	72.5
672	127.7	122.8	125.2	895	86.9	89.2	88.1
673	127.7	122.8	125.2	897	91.0	66.3	78.1
674	110.6	61.7	85.1	899	81.7	72.0	76.7
675	110.6	61.7	85.1				

SOURCES: *Annual Survey of Manufactures 1964: General Statistics for Industry Groups and Industries*, U.S. Bureau of the Census, Washington, 1965; 1963 *Census of Manufactures: Industry Statistics*, U.S. Bureau of the Census, Washington, 1966.

TABLE A-2

Nominal weighted tariffs applied by the U.S. and the E.E.C. (Common External Tariff)

SITC Group	Average Tariff Rate		SITC Group	Average Tariff Rate	
	United States	European Economic Community		United States	European Economic Community
512	17.82	15.05	655	8.06	16.10
513	2.81	12.62	656	27.43	20.17
514	7.12	10.18	657	20.20	35.75
515	0.05	1.99	661	7.24	8.38
521	0.78	2.95	662	16.30	10.36
531	38.99	16.98	663	10.87	13.86
532	0.21	5.51	664	14.37	13.40
533	13.04	16.66	665	32.44	20.99
541	13.95	14.84	666	39.40	23.96
551	4.96	6.84	667	4.82	0.01
553	20.70	18.10	671	4.78	5.38
554	7.28	17.15	672	11.74	(2) 6.58
561	0.00	5.63	673	5.54	7.97
571	25.33	16.73	674	10.51	7.02
581	23.13	19.48	675	8.90	9.38
599	7.61	11.67	676	1.50	9.00
			677	7.69	10.00
611	10.85	7.24	678	3.45	(2) 13.99
612	11.65	15.48	679	7.17	14.00
613	11.10	8.60	681	0.00	0.10
621	10.40	16.16	691	12.50	14.59
629	11.23	19.30	692	12.45	16.75
631	16.42	12.50	693	9.50	15.54
632	12.16	14.43	694	3.65	16.42
633	24.26	20.00	695	19.96	13.48
641	0.58	15.11	696	28.38	16.05
642	15.14	19.13	697	8.84	(3) 17.93
651	21.98	9.48	698	18.51	17.14
652	18.83	(1) 16.88			
653	25.17	(1) 17.71	711	11.66	14.05
654	35.60	17.57	712	0.12	(4) 16.28

(1) The rate listed for group 652 does not consider subdivision 652.2 (3), which is instead included in group 653.

(2) The rate listed for group 672 does not take into account subgroup 672.9 which is included in group 678.

(3) The rate listed for group 697 does not include subdivision 697.2 (1) which is included in group 812.

(4) The rate listed for group 712 includes subgroups 732.5.

Continued Table A-2

SITC Group	Average Tariff Rate: United States	Average Tariff Rate: European Economic Community	SITC Group	Average Tariff Rate: United States	Average Tariff Rate: European Economic Community
714	7.31	12.63	831	20.60	19.10
715	15.24	9.74	841	27.69	20.32
717	11.93	12.31	842	22.40	23.88
718	12.02	12.83	851	14.73	19.96
719	12.50	14.03	861	22.77	(5-6) 16.46
722	13.37	14.57	862	8.34	20.06
723	17.21	17.20	863	12.50	4.36
724	13.35	18.58	864	37.18	12.65
725	14.05	15.35	891	15.26	17.53
726	10.68	(5) 16.00	892	4.05	3.38
729	13.64	(6) 17.06	893	23.60	21.30
731	14.28	13.39	894	27.68	22.23
732	8.82	(4) 21.98	895	24.60	17.66
733	20.66	18.12	896	0.31	0.00
734	12.50	12.66	897	33.66	13.93
735	7.70	0.52	899	31.13	15.66
812	27.75	(3) 17.70			
821	14.22	18.04			

(5) The rate listed for group 726 does not include subgroup 726.1, considered under group 861.

(6) The rate on group 726 includes also subdivision 861.8 (1).

Note — Table A-2 is based upon a reelaboration of the data quoted in the C.E.D.'s study, *Comparative Tariffs and Trade: The United States and the European Market*, Supplementary Paper No. 14, March 1963. This study shows the EEC (CET) and the US tariffs for the four-digit BTN (Brussels Tariff Nomenclature) headings, which have then been expressed in terms of the three-digit items of the SITC classification.

Table A-3

Effective rates of protection applied by the U.S. and the E.E.C.

Class of manufactures	Effective Tariffs: US	Effective Tariffs: EEC
1. Thread and yarn (excluding synthetic fibres)	46.68	25.22
2. Textile fabrics	31.36	33.42
3. Synthetic fibres and materials	81.29	31.37
4. Clothing, including fur clothing	42.15	32.65
5. Other textile articles	47.38	33.39
6. Footwear	20.92	33.95
7. Wood and cork manufactures (including furniture)	24.83	27.76
8. Paper and paperboard and manufactures thereof	− 0.70	22.05
9. Printed matter	5.56	− 3.21
10. Leather and leather goods (except footwear)	22.41	13.71
11. Rubber and asbestos goods	9.37	34.35
12. Plastic materials and articles	15.58	29.63
13. Clearing agents and perfumes	14.18	15.42
14. Non-metallic mineral products	17.59	17.21
15. Agricultural machinery	− 5.20	24.70
16. Machinery and appliances other than electrical	17.92	18.42
17. Electrical machinery, apparatus and appliances	20.07	25.68
18. Ships and boats	6.04	−11.68
19. Railway vehicles	24.23	21.44
20. Road motor vehicles (excluding motorcycles)	8.17	29.57
21. Bicycles and motorcycles	16.54	27.27
22. Aircraft	14.76	15.47
23. Watches, clocks and precision instruments	38.94	20.93
24. Musical instruments, toys games and sporting goods	31.36	26.57
25. Pig iron, ferro-alloys, ingots and other primary forms	8.24	35.49
26. Iron and steel bars, rods, shapes, plates and sheets	2.99	21.70

Sources: Committee for Economic Development, *Comparative Tariffs and Trade: The United States and the European Common Market*, Suppl. Paper No. 14, March 1963; Office Statistiques des Communautés Européennes, " Tableaux 'Entrées-Sorties' pour les pays de la CEE ", in *Informations Statistiques*, December 1965.